

# Croatian Soil Monitoring Programme : project Development of the Croatian Soil Monitoring Programme with a pilot project : LIFE05 TCY/CRO/000105

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# CROATIAN SOIL MONITORING PROGRAMME

Project

Development of the Croatian Soil  
Monitoring Programme with a pilot project  
LIFE05 TCY/CRO/000105



CROATIAN  
ENVIRONMENT AGENCY



Croatian Environment Agency

Project Development of the Croatian Soil Monitoring Programme with a Pilot Project

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LIFE05 TCY/CRO/000105

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# Foreword,

Dear Sirs and Madams,

We are proud to present the final result of a three years implementation of the *Project Development of the Croatian Soil Monitoring Programme with a Pilot Project (LIFE05 TCY/CRO/000105)*.

The necessity for establishment of functional and continual soil monitoring system was recognised at the very beginnings of the Croatian Environment Agency's work. Faced, on the one side, with the obligation to monitor the condition of environment, including soil, and with inaccessibility of necessary data on the other side, we have set forward a series of activities. One of the first was to initiate this demanding Project whose goal was to elaborate document which were to ensure the uniformity of soil data and their periodical gathering. Co-financing by pre-accession funds of the European Union was required for elaborating the Programme, as well as for practical testing. For this reason, the Project lasted for three years. During the first year, a draft Programme was elaborated, and the next two years, it was tested on representative field locations and in the laboratories.

Upon completion of the Pilot Project, a Draft Soil Monitoring Programme was finalised and was submitted to members of the Steering Committee for evaluation. It is important to emphasise that Steering Committee included representatives of relevant Ministries, Project Management Team included representatives of expert and scientific institutions. The Partner in the Project, the Faculty of Agriculture of the University of Zagreb, directed the activities from the professional point of view, and with a rich experience in soil monitoring.

At the same time, the Agency, with its own funds, conducted a project for development of the Croatian Soil Information System (CROSIS). A database was elaborated and harmonised with report forms of the Soil Monitoring Programme, and first data sets were entered.

During the implementation of Project tasks and the development of the Croatian Soil Monitoring Programme, natural diversity and specific agro-ecological properties of Croatia have been taken into consideration. Events in the area of soil protection in the EU countries have been followed with special attention, and relevant documents and legal regulations that the Republic of Croatia is to adopt in the process of accession to the European Union have been taken into consideration as well. The Project has elaborated, with special attention, the feasibility of soil monitoring from the institutional and financial aspects.

The Croatian Soil Monitoring Programme is the basis for the establishment of the Croatian Soil Monitoring System which shall ensure monitoring and comparability of soil condition data, as per reporting obligations on the condition of environment of the Republic of Croatia, as well as per internationally undertaken obligations.

The goal of these activities is to ensure continual availability of data - accurate, verified and complete - required for the evaluation of the soil condition and for sustainable management and soil protection policies implementation.

However, this work shall not be considered completed until the Regulation on Soil Monitoring is adopted of which the Croatian Soil Monitoring Programme will be an integral part.

We hope that the Programme and the Regulation will be adopted by the Croatian Government in the near future, so that the System itself might start operating and ensuring necessary data and information.

Savka Kučar Dragičević, PhD  
Croatian Environment Agency, Director





# Introduction

The soil is generally defined as a surface layer of the earth's crust made of mineral particles, organic matter, water, air and living organisms. Soil connects the earth, air and water and hosts a larger part of biosphere. Due to extremely slow process of creation, it is considered as non-renewable, or in the best case, conditionally renewable resource. Soil has numerous functions indispensable for life on Earth; it provides nourishment, biomass, raw material, habitats and gene reserves; it stores, filtrates and exchanges nutrients, water and carbon. It is a very complex medium, subject to degradation processes and threats which, in a very short period of time may seriously jeopardise and disable its functions. The consequences may manifest through the loss of soil fertility, biological diversity, air and water quality, and climate changes.

The Environment Protection Act (OG 110/07) states:

- Article 10: „*Soil is non-renewable ... and must be used in a sustainable way with protection of its functions. Unfavourable effects to soil must be avoided in the largest possible extent.*
- Article 20: (1) *Soil protection includes preservation of health and functions of soil, prevention of damage of soil, monitoring of the condition and changes of the soil quality and recovery and renovation of damaged soils and sites.* (2) *Pollution or soil damage is considered as a harmful impact on the environment, and the establishment of acceptable limiting values of soil quality is based on special regulations.*

Threats to soil are complex and although unevenly distributed, they are present in the wider area of the European continent. Because of simplicity, they are presented separately, but in reality, they are mutually connected. When several threats act at the same time, their effect increases. If not prevented, they finally may lead to soil degradation. Certain processes of soil degradation have natural causes, but their progress is accelerated by human activities.

Data on the properties of soil, measured and observed in mutual interaction in space and time quantify certain threats to the soil and its functions;

- Decline of organic matter and biological diversity - is evaluated by the content of total carbon, the ratio of carbon and nitrogen, and the bulk density of soil.
- Soil erosion - depends on the bulk density of soil, density of hard phase, total porosity, soil porosity for water and the content of total carbon.
- Contamination of soil - observes the total and accessible content of heavy metals and potentially toxic elements, as well as persistent organic pollutants (PAH, PCB, triazine herbicides, organochlorinated pesticides).
- Soil compaction - is defined by bulk density of soil, particle size distribution, capacity of soil for air, capacity of soil for water, structure, soil porosity for water and the content of total carbon.
- Salinisation - depends on the soil acidity, electrical conductivity, salt content, capacity of cation exchange, soil porosity for water, capacity of soil for water, chemical composition of drainage water and the content of total carbon.
- Landslides - depends on particle size distribution, structure and soil porosity for water.

The first step in the soil protection, the preservation of natural functions of soil and the prevention of degradation processes is monitoring of the condition and changes of soil properties. Therefore, soil monitoring implies continual monitoring of certain parameters of soil with purpose of gathering information on changes of the condition and characteristics of soil, and identifying the form and intensity of soil degradation. Without the development of the

system by which information on negative changes in the soil would be gathered periodically, there can be no timely response to prevent or alleviate such changes.

The fundamental international agreement on soil protection in the Republic of Croatia is the Act on Confirmation of the United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa (UNCCD), (OG-IT 11/00). The Convention was adopted in Paris in 1994, and entered into force in 1996. In Republic of Croatia the Convention entered into force on January 4th 2001.

The significance of soil monitoring was emphasised by the European Union which, by implementing the Sixth Community Environment Action Programme: "Environment 2010: Our Future, Our Choice" (*Decision No 1600/2002/EC of the European Parliament and of the Council of July 22nd 2002 laying down the Sixth Community Environment Action Programme*), raised the significance of soil protection to the level of water and air protection.

By Thematic Strategy for Soil Protection (Thematic Strategy for Soil Protection, Communication COM(2006)231), the European Commission identified eight most important threats to the soil: erosion, organic matter decline, contamination, salinisation, compaction, biological diversity decline, sealing, flooding and landslides.

As a result of four years work of five Technical Working Groups and Advisory Forum, on 22 September 2006, the European Commission proposed to the European Parliament and the Council of European Union an Outline Directive for soil protection (*Proposal for a Directive of the European Parliament and of the Council establishing a framework for the protection of soil and amending Directive 2004/35/EC, COM(2006)232*) whose goal is to ensure soil protection based on principles of protection of soil functions, prevention of soil degradation, alleviation of effects of degradation and repair of depredated soils.

In the period of five years from the day of entry into force of this Directive, all EU Member States have to identify risk areas considering the previously stated threats to the soil.

The establishment of the Croatian Soil Monitoring System was recommended as early as in 1993 within the Programme for the Protection of Croatian Soil (Bašić et al.) which, unfortunately, has never become a part of the Croatian legislation.

In 2001, the Croatian Government established the Institute for Soil in Osijek with the primary activity to identify and to monitor the condition of agricultural lands. The Regulation on the Establishment of the Institute for Soil (OG 100/01):

Article 3. „Services of the Institute are the following tasks and activities:

1. *determination of the condition of contamination of agricultural land (inventarisation);*
2. *monitoring of the condition of agricultural land by which the condition of all changes in agricultural land is monitored (physical, chemical and biological), and notably the content of pollutants in agricultural land;*
3. *establishment of an information system for contaminated agricultural land;...*”

The Agricultural Land ACT (OG 66/01, 87/02, 90/05, draft June 2008) confirms the role of the Institute for Soil as an institution responsible for determining the damage and monitoring of the condition of agricultural land:

Article 4. „In order to protect agricultural land from contamination, testing and monitoring of the condition of damage of agricultural land by pollutants is being conducted and includes:

1. *determination of the condition of contamination of agricultural land (inventarisation),*
2. *monitoring of the condition of agricultural land by which the condition of all changes in agricultural land is monitored (physical, chemical and biological), and notably the content*



*of pollutants in agricultural land,*

3. *establishment of an information system for contaminated agricultural land.*

*Activities from paragraph 1 of this Article are conducted by the public institution, the Institute for Soil (hereafter: Institute) founded by the Government of the Republic of Croatia.”*

Monitoring of forestry soil is prescribed by Rulebook on the mode of data collection, network of points, keeping the register, conditions for using data on damage of forest ecosystems (OG 129/06) within the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests), on Level I and Level II Network, pursuant to Convention on Long-Range Transboundary Air Pollution – CLRTAP (OG-IT 12/93). Forestry Institute in Jastrebarsko has been assigned as National Coordination Centre for evaluation and monitoring of impact of atmospheric pollution and other factors on forestry ecosystems.

Continues the National Environment Strategy (OG 46/02), which, as a priority in the field of soil, emphasises the establishment of the Soil Monitoring System at the national level: “What needs to be done... C. To establish systematic soils monitoring in the Republic of Croatia...”

In 2002, the Government of the Republic of Croatia established the Croatian Environment Agency. The Regulation on the Establishment of the Croatian Environment Agency (OG 75/02) specifies the activities of the Agency:

*„The activities of the Agency include the tasks of gathering and consolidating obtained data on environment, processing of these data and elaboration of reports, monitoring of the condition of environment, managing of databases on environment, reporting on environment, and notably:*

- or state authorities, the Government and the Croatian Parliament, ensures information necessary for efficient implementation of the environment protection policies,*
- develops and coordinates a unique information system for environment protection related to the system of monitoring the condition of environment in the Republic of Croatia, and gathers data on environment,*
- establishes and maintains referent centres with data bases relevant for monitoring of the condition of environment (socio-economic data, threats to environment, condition and quality of environment),*
- develops procedures for processing gathered data on the environment and their evaluation (modelling, predictions and visualisation),*
- performs expert and advisory affairs in determination of content, methodology and monitoring of the condition of environment, managing and monitoring projects and programmes for environment protection,...”*

The Environment Protection Act (OG 110/07) emphasises once again the need to monitor the condition and changes of soil, and to monitor emissions into the soil:

- Article 20: “Soil protection includes the preservation of health and functions of the soil, prevention of soil damage, monitoring of the condition and changes of the quality of soil and repair and renewal of damaged soils and sites.”*
- Article 120: “Monitoring of the condition of environment includes: monitoring of emissions i.e. the quality of air, water, sea, soil, plant and animal life, and exploitation of mineral raw materials...”*

Besides above mentioned Programme for the Protection of Croatian Soil from 1993 which did not obtain a legal support, until today, there were no other attempts to establish a systematic soil monitoring at the national level, not even in monitoring of agricultural land. The existing individual data have been gathered and analysed by using various, often incomparable methods, on small agricultural or forest areas, within various *scientific and*

research projects and studies, and for various needs of institutions or as a consequence of ecological incidents. Data are stored on various locations - in government and scientific institutions and elsewhere. The majority of historical data is not stored on digital media (but in printed materials), so there is a potential risk that even information on existence of some data may be lost. The data flow to the Croatian Environment Agency has also never been established. The Environment Protection Act not earlier than in 2007 has specified the obligations to submit data to the Environment Information System.

In the absence of data on the condition of soil for the needs of reporting on the condition of environment, in 2005, the Croatian Environment Agency, in cooperation with the Faculty of Agriculture of the University in Zagreb, applied the Project Development of the Croatian Soil Monitoring Programme with a Pilot Project to the contest of the European Commission for co-financing of projects in the field of development of policies and programmes of environment protection, through the financial instrument LIFE Third Countries. The European Commission approved co-financing of the Project in the maximum duration of three years. In January 2006, the implementation of project tasks and activities, and gathering of collaborators on the Project began.

The Project Management Team was constituted of the employees of the Agency and the Faculty of Agriculture who actively participated in Project implementation, as well as representatives of relevant institutions whose activity is related to the soil. The role of the Project Management Team was to ensure the quality implementation of expert segments of the Project, based on the past experience and achieved working results, with administrative coordination of the Agency. Members of Project Management Team were:

- Croatian Environment Agency: Hana Mesić, B.Sc.; Andreja Čidić, B.Sc.
- Faculty of Agriculture of the University of Zagreb: professor Ivica Kisić PhD, professor Milan Mesić PhD, professor Stjepan Husnjak PhD, professor Ferdo Bašić PhD, professor Davor Romić PhD.
- Faculty of Agriculture, Osijek: Blaženka Bertić PhD.
- Institute for Soil, Osijek: Domagoj Klaić, B.Sc.; Branka Komesarović, MSc.
- Faculty of Forestry of the University of Zagreb: professor Nikola Pernar PhD.

The Steering Committee of the Project was constituted of representatives of interested parties, state institutions, which were to have a key role in adopting legal measures for implementing the Soil Monitoring Programme, and which are at the same time potential main users of soil monitoring data. Members of the Steering Committee were:

- Ministry of Agriculture, Forestry and Water Management: Ana Budanko Penavić, B.Sc.
- Ministry of Environment Protection, Physical Planning and Construction, Department for Soil Protection: Marija Vihovanec, B.Sc.
- Ministry of Science, Education and Sport (Institute for Tourism and Agriculture, Poreč): professor Đordano Peršurić, PhD.
- Croatian waters, Department for Water Management: Đorđa Medić, B.Sc.
- Faculty of Agriculture of the University of Zagreb: professor Tomislav Ćosić, PhD,
- Croatian Environment Agency: Rene Vukelić, B.Sc.

In accordance with the name of the Project, the main objective was to elaborate the Croatian Soil Monitoring Programme which is to define parameters to be gathered at soil monitoring stations and points, to recommend methods, standards and time dynamics for gathering, analysis, processing and transfer of soil data, to propose locations for spatial positioning of stations and points for soil monitoring, and to recommend an institutional framework and financial structure of the Soil Monitoring System at the national level.



In December 2006, one of the first results of the Project: “The Soil Monitoring Manual - first edition/working version” (CEA, 2006) was published. The Manual unites categories and parameters for monitoring of agricultural, forestry and contaminated soils. Considering the natural diversity of Croatia, geographical characteristics, diversity of geological and lithological properties of soil, agro-ecological conditions, and based on the existing expert basis and experiences of European countries, criteria have been recommended for the selection of locations for future soil monitoring stations and points, procedures of field works and soil sampling, list of parameters, methods and standards (both Croatian and international) for physical, chemical and biological soil analysis, and a time frame and dynamics for gathering of soil data.

By implementing the Pilot Projects for monitoring of agricultural, forestry and contaminated soils, the applicability of recommended field and laboratory procedures for soil monitoring has been tested: establishment of monitoring stations and points, soil sampling, preparation and analysis of samples in accordance with recommended standards. The results of the Pilot Projects implementation were presented in the publication “Implementation Summary of the Pilot Projects for Monitoring of Agricultural, Forestry and Contaminated Soil” (CEA, 2008).

Besides the Agency and the Faculty of Agriculture, during three years implementation of complex project tasks and activities, relevant expert and scientific institutions participated in the realisation: the Institute for Soil, the Faculty of Forestry of the University of Zagreb, Forest Research Institute Jastrebarsko, the Faculty of Mining, Geology and Petroleum Engineering of the University of Zagreb, the Croatian Geological Survey, the Croatian Centre for Cleaner Production, and Ekoneg - Energy and Environmental Protection Institute.

The Croatian Soil Monitoring Programme is composed of three materials and elaborates monitoring procedures for agricultural soil, forestry soil and potentially contaminated and contaminated locations, taking into account the specificities of soil sampling, special parameters and different time dynamics of monitoring parameters considering the mode of soil usage. For each soil category, Programme proposes an institutional framework and obligations for soil monitoring implementation, recommends Referent Centres taking into account the existing legal regulations, and elaborates cost assessment and recommends sources of funding of the Soil Monitoring System at the national level.

At the same time with the development of the Croatian Soil Monitoring Programme, the Croatian Environment Agency initiated the establishment of the Croatian Soil Information System (CROSIS). A spatio-temporal georeferenced informatical Database on Croatian Soil has been elaborated. Besides central database which will contain available existing pedological data mostly gained from scientific and research projects and studies, Internet interface has been developed enabling the entry and processing of soil monitoring data and establishment of undisturbed data flow and data availability.





# I. Croatian Agricultural Soil Monitoring Programme

## 1. Introduction

The development of agriculture is one of the key factors for the development of the Croatian economy, and rich natural resources give Croatia large possibilities. More than 3 million hectares of Croatian land is used for various agricultural purposes: plant production, livestock farming and fishery. Unfortunately, data on land management, and notably on the soil quality, are not available for most of agricultural land.

The system of qualitative and repeatable gathering and processing of soil quality data does not exist in Croatia.

Therefore it is not possible to evaluate and quantify the impact of agricultural activities on environment, or to make political decisions which would achieve balance between agriculture and environment (sustainable agriculture policy), that is necessary not only for environment protection, but also for development of agriculture for future generations.

Many European countries have established soil monitoring systems, based on former soil inventarisations, as well as on new surveys. Period between 1950 and 1990 gave the most fruitful researches and collection of data on nature, distribution and properties of agricultural soils throughout Europe. Most of these researches were motivated by requirements for increasing agricultural production, and gained results are helping nowadays in understanding





of soil processes and in finding ways to efficiently protect agricultural soil from numerous negative influences.

Data collected by Agricultural Soil Monitoring System shall provide exceptional contribution in development of regulations for sustainable management of agricultural land, characteristic for different agro-climatic conditions of Croatian agricultural sub-regions.

Project “Development of the Croatian Soil Monitoring Programme with a Pilot project” specially regarded agricultural soil monitoring issues. The employees of the Institute for soil, public institution which was established to protect and monitor agricultural land in Croatia, have collaborated in creation of Manual for agricultural soil monitoring, selection of locations of monitoring stations and implementation of the Pilot project for monitoring of agricultural soil.

Croatian Agricultural Soil Monitoring Programme describes soil research procedures, defines locations of future monitoring stations and recommends institutional framework and cost estimate of Agricultural Soil Monitoring System at national level.

Along to descriptions of agricultural soil monitoring procedures, enclosed are standardised forms for entry and storage of data on stations, sampling and soil analyses. Forms are based on Guidelines for soil description (FAO, fourth edition, 2006). Structure of forms for agricultural soil monitoring enables simple and harmonised data input into Croatian Soil Information System – CROSIS.

The Programme relies on numerous former soil researches in Croatia, as well as on existing legislation of the Republic of Croatia.

## 2. Overview of agricultural soils monitoring in the Republic of Croatia and the existing regulations

The Agricultural Soils Monitoring System in Croatia has not been established to date, despite intercession of scientific and professional community. In 1993, a group of authors (Bašić et al.) elaborated a Programme of Protection of Soils in Croatia which unfortunately never became a part of the Croatian legislation. The same Programme significantly contributed to a successful implementation of the Project “Development of the Croatian Soil Monitoring Programme with a Pilot Project”.

During the last decade, certain scientists, within their scientific projects, elaborated the issue of agricultural soil monitoring at the local level - Conditions and monitoring of soil contamination in Zagreb-county (Romić et al., 1999-2004); Soil monitoring on sites influenced by CPS Molve, annual reports (Bašić et al., 1991-2006). However, agricultural soil monitoring at the entire territory of the Republic of Croatia has not been initiated to date.

The Pilot Project conducted within the Project “Development of the Croatian Soil Monitoring Programme with a Pilot Project”, has evaluated advantages and disadvantages of the soil monitoring system described by the Croatian Soil Monitoring Manual - first edition/working version.

The Institute for Soil conducted the Pilot Project for monitoring of agricultural soils in the period between December 2006 - February 2008. Considering the specificity of agricultural production and differences in usage and management of agricultural land, the Pilot Project included soil monitoring at six monitoring stations and three different locations: intensive agricultural production, perennial fruit plantation and the vegetable production. Parameters of soil (physical and chemical) describing changes of the soil functions and possible soil degradation processes have been monitored.

The locations for the Pilot Project for monitoring of agricultural soils were selected by the recommendations of the Project Management Team, pursuant to the Chapter 2 of the mentioned Manual: Criteria for the selection of sites for monitoring agricultural soils. For the selection of monitoring stations, two representative agricultural sub-regions have been selected, Western Pannonian (P-3) - location Popovača - Potok and Eastern Pannonian (P-1) - locations Donji Miholjac and Satnica.

The Pilot Project included preliminary work in the office (collecting of data about stations), preliminary and main field work (stations establishment and soil sampling), laboratory works (chemical and physical analyses of soil and drainage water), and reporting on the Project implementation.

By implementing the Pilot Project for monitoring of agricultural soils, practical feasibility of certain steps of soil monitoring procedure pursuant to recommendations of the Manual has been confirmed, as well as the high expertise of involved institutions. The course of the implementation and obtained results of the Pilot Project significantly contributed in gaining of new knowledge and experience, and eased the development of this Programme.

Fundamental legal acts that regulate protection of agricultural soil are:

- The Law on Agriculture (OG 66/01, 83/02):
  - Article 31: *„The protection of agricultural land from pollution includes registration, prevention and repair of damage of agricultural soils created by pollution in order to enable production of safe food and to protect the environment.”*



- Agricultural Land Act (OG 66/01, 87/02, 90/05):
  - Article 4: *„In order to protect agricultural land from pollution, testing and monitoring of the condition of contamination of agricultural land by noxious substances is being conducted which includes:*
    1. *determination of the condition of pollution of agricultural land (inventarisation),*
    2. *monitoring of the condition of agricultural land by which the condition of all changes in agricultural land (physical, chemical and biological) is being monitored, and notably the content of noxious substances in agricultural land.*
    3. *establishment of information system of contaminated agricultural land.**The activities from paragraph 1 of this Article are conducted by the public institution, the Soil Institute (hereafter: Institute), founded by the Government of the Republic of Croatia.”*

Subsequently to Article 4 of the Agricultural Land Act, Government of Republic of Croatia founded the Institute for Soil, with head office in Osijek, in 2001. Its activities are prescribed by Regulation on the Establishment of the Institute for Soil (OG100/01):

- Article 3: *„Activity of the Institute is composed of the following activities and tasks:*
  1. *determination of contamination level of agricultural land (inventarisation);*
  2. *monitoring of the condition of agricultural land and all of its changes (physical, chemical and biological), and notably the content of noxious substances in agricultural land;*
  3. *establishment of the information system of contaminated agricultural land;*
  4. *conducting expert jobs and the organisation of testing of fertility of agricultural land;*
  5. *recommendations of acceptable fertilization;*
  6. *analyses of agricultural land, as well as organic and mineral fertilisers;*
  7. *monitoring of the content of contamination in agricultural land;*
  8. *integral protection of agricultural land;*
  9. *determination and monitoring of the application of standards and minimal professional bases for radical melioration interventions of agricultural land;*
  10. *monitoring of the condition and provision of protection of the most valuable agricultural land;*
  11. *monitoring of the damage at agricultural land created by the use of raw materials from agricultural land;*
  12. *conducting of other activities and tasks specified by the Articles of Association and the Law on Agricultural Land.”*

Croatian Environment Agency has in 2005 initiated development of the Croatian Soil Monitoring System, with aim of collecting soil data for needs of reporting on condition of environment, and conducting other activities prescribed by Regulation on the Establishment of the Croatian Environment Agency and Regulation on the Environmental Information System.

- Regulation on the Establishment of the Croatian Environment Agency (OG 75/02):
  - Article 4: *„The activity of the Agency includes collecting and unification of collected data on environment, processing of these data and elaboration of reports, monitoring of the condition of environment, keeping data bases on environment and reporting on environment, and notably:*
    - *to provide for the state administration offices, the Government and the Croatian Parliament information necessary for efficient implementation of the environment protection policies,*
    - *to develop and coordinate a unique information system for environment protection connected with the system for monitoring of the environment condition in the Republic of Croatia, and to gather data on environment,*
    - *to establish and maintain Referent Centres with data bases relevant for monitoring of the environment condition (socio-economic data, impact on environment, condition and quality of environment),*
    - *to develop procedures for processing collected data on environment and their assessment (modelling, predictions and visualisations),*

– to perform expert and advisory activities when determining the content, methodology and the mode of monitoring of the environment condition, and to determine, keep and monitor projects and programmes for environment protection...”

- Environmental Protection Act (NN110/07) in article 123. introduces changes in procedure of appointment of Referent Centres of the Agency :

- *“With purpose of monitoring environment and for needs of Environmental protection Information system and reporting, based on minister’s proposition, the Government appoints Referent Centres of the Agency by special decision.*
- *Referent Centres, from paragraph 1. of this article, collect and analyze data on environment monitoring, including indicators from National list of Indicators, for which they are obliged. Referent Centres promptly supply the data on environment monitoring, indicators and results of analyses to the Agency.”*

- Regulation on the Environmental Information System (OG 68/08):

- *Article 7: „(1) For the establishment, keeping, developing, coordinating and maintaining a unique information system, the Croatian Environment Agency (hereafter: Agency):*
  - *develops a Programme for keeping Information System in cooperation with the Central State Office for e-Croatia,*
  - *elaborates the National list of indicators,*
  - *ensures the elaboration and keeps a joint information-communication network of the Information System,*
  - *gives recommendations for harmonisation of the Information System with information systems of thematic areas and subareas,*
  - *proposes measures for harmonisation and inclusion of the Information System to the European system for data exchange on the environment,*
  - *recommends information, software and communication equipment,*
  - *monitors and gives recommendations for access to data and information on environment.*
- (2) *The Agency provides a reliable and safe exchange of data and information in electronic form, and unhindered and continual access to data and information through Internet portal of the Environment Information System.”*

A discussion in Croatian Parliament about new Agricultural Land Act have been announced to take place in December 2008. In this Act again is emphasised the importance of systematic data collection on agricultural land and data storage in Information sub-system for maintaining and preserving of agricultural land, and role of the Institute for Soil in Osijek.

- *Article 4: „The Ministry in charge for agriculture (hereafter: Ministry), shall establish the Information System of Data on Agricultural Land in the Republic of Croatia (hereafter: Information System) with the view to more efficient management of agricultural land and monitoring of agricultural land market.*

*The Information System is composed of the following subsystems:*

1. *Information Subsystem on disposal of agricultural land owned by the state,*
2. *Information Subsystem on disposal of agricultural land owned by individual and legal persons,*
3. *Information Subsystem on maintenance and protection of agricultural land.”*

- *Article 7: „In order to protect agricultural land from contamination, testing and monitoring of the condition of contamination of agricultural land by noxious substances is being conducted and include:*

1. *determination of the condition of contamination of agricultural land (inventarisatio),*
2. *monitoring of the condition of agricultural land and all of its changes (physical, chemical and biological), and notably the content of noxious substances in agricultural land.*

*The activities from paragraph 1 of this Article are conducted by a public institution, the Institute for Soil (hereafter: Institute).”*



## 3. Agricultural Soil Monitoring Programme

### 3.1. Definition and description of agricultural soil monitoring stations

Monitoring of agricultural soils is organised on stations of the first and second level.

**The First Level Station** is the area for soil monitoring which, by its geomorphological location, pedosystematic unit and usage, represents an agricultural sub-region in which it is located. In the surrounding of the Level I station (up to 10 km of distance), the main meteorological station is located with data on the direction and speed of wind, temperature, relative air humidity and quantity of precipitations. The nearness of meteorological stations enables the harmonisation of monitoring of climate, hydrological and soil parameters. The Level I monitoring stations are arranged through the entire territory of the Republic of Croatia so that each agricultural sub-region is represented by one station at least.

In addition to parameters and dynamics of monitoring usual for all monitoring stations, the Level I stations analyse drainage water from lysimeter (pH value, electrical conductivity, content of anions and cations).

The Level I soil monitoring station is consisted of:

1. **Plot** in a square form of 750 m<sup>2</sup> at whose diagonals are located points for single soil sampling,
2. **Soil profile** from which samples are taken in disturbed and undisturbed condition and data are collected on endomorphological properties of soil,
3. **Lysimeter** installed in the soil for collection of drainage water.

**The Second Level Stations** represent places for soil monitoring arranged within particular sub-region in a such a way that they represent, as much as possible, their agro-ecological conditions. The number of the Level II stations in each sub-region depends on the size of their agricultural areas. The Level II soil monitoring stations is composed of:

1. **Plots** in a square form of 750 m<sup>2</sup> at whose diagonals are located points for single soil sampling,
2. **Soil profile** from which samples are taken in disturbed and undisturbed condition and data are collected on endomorphological properties of soil.

#### 3.1.1. Description of agricultural soil monitoring station

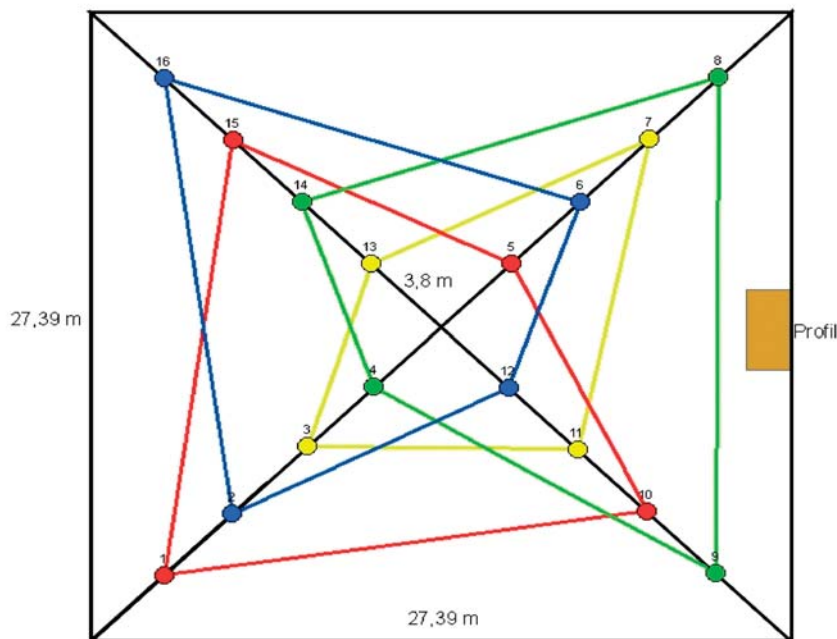
A monitoring station is in the form of a square in the area of 750 m<sup>2</sup> (27,39 x 27,39 m) and is located at agricultural parcel which size is not less than 5000 m<sup>2</sup>. The station is located on a representative part of agricultural parcel selected for monitoring, away from its border or untypical parts. The sides of the square are directed north-south and east-west. The soil profile is opened on the inner side of the eastern side of the plot, so that it is at the same distance from the north-east and south-east angle of the plot. 16 plots for single soil sampling by a probe are located on diagonals of the plot (8 of them at each diagonal), at the distance from their intersection 3.80, 7.60, 11.40 and 15.20 m.

All single samples are connected to 4 composite samples according to the Scheme 1:

1. first composite sample is created by merging samples 1, 5, 10 and 15,
2. second composite sample is created by merging samples 2, 6, 12 and 16,
3. third composite sample is created by merging samples 3, 7, 11 and 13,
4. fourth composite sample is created by merging samples 4, 8, 9 and 14.



Apart from these 4 samples, 1 composite sample obtained by merging parts of samples of all single points is analysed. Thus, each of 5 composite samples foreseen for analysis represents an average of the station which considerably contributes to quality of data.



**Scheme 1. Joining of individual samples into composite ones**

Soil profile is opened during establishment of stations and after the period of 24 years. The place of soil profile opening, is shifted each 24 years for 5 m alongside the stations, in the clock wise direction.

Composite samples from single points are taken every three years, i.e. six years, when additional parameters are analysed.

In order to ensure submeter precision of sampling during many years, angles of stations are located by GPS, a high precision device (less than 1 m). Location of angles by a GPS device enables accuracy of the repeated soil sampling, data managing in GIS surrounding, and testing of the Precision Farming System. The GPS device must have the possibility to precisely determine geographical coordinates of angles of the station by an external antenna, real-time signal correction (EGNOS and additional stationary device) and technology of rejecting multiple fake signals. The GPS software must be equipped for entering precise topographic maps and adjustable for a fast input of data during description of station and profile. Office software must be compatible for a fast and efficient transformation of GPS coordinates from one coordination system to another, as well as for subsequent corrections of signal by using permanent points of geodetic base of the Republic of Croatia, by which the precision of positioning is additionally ensured.

Angles of stations are recorded geodetically and located on a Croatian Basic Map at the scale of 1:5000. Spatial data are gathered in projection coordination system of cross Mercator (Gauss-Krüger) projection - abbreviated HTRS96/TM, with the middle meridian  $16^{\circ}30'$  and linear scale on the middle meridian 0.9999 (Official Cartographic Projection of the Republic of Croatia for cadastre and detailed state topographic cartography).





## 3.2. Selection of locations for agricultural soil monitoring stations

The objective selection of locations representative for areas in which they are positioned by usage, geomorphological properties and lay-out of pedosystemic units has been obtained by careful selection of methodology and sources of existing data in GIS surroundings.

Based on sizes of selected agricultural areas of certain sub-regions, in each agricultural sub-region (Table 1) should be placed one Level I station, and the number of Level II stations depends on economic factors.

1. The maximum number of monitoring stations – enables intensive agricultural soil monitoring on high costs.
2. The optimum number of monitoring stations – enables optimum relation between expected soil monitoring data and costs.
3. The minimum number of monitoring stations – represents minimum number of monitoring stations in each agricultural sub-region.

**Table 1. Maximum, optimum and minimum number of monitoring stations**

| Agricultural sub-region  | Monitoring areas | Maximum number |          | Optimum number |          | Minimum number |          |
|--------------------------|------------------|----------------|----------|----------------|----------|----------------|----------|
|                          | Area (ha)        | Level I        | Level II | Level I        | Level II | Level I        | Level II |
| P-1                      | 283.904,74       | 1              | 18       | 1              | 17       | 1              | 16       |
| P-2                      | 163.382,61       | 1              | 10       | 1              | 9        | 1              | 8        |
| P-3                      | 373.644,53       | 1              | 25       | 1              | 23       | 1              | 21       |
| P-4                      | 118.204,75       | 1              | 7        | 1              | 6        | 1              | 5        |
| G-1                      | 77.546,05        | 1              | 4        | 1              | 3        | 1              | 2        |
| G-2                      | 75.368,11        | 1              | 4        | 1              | 3        | 1              | 2        |
| J-1                      | 105.180,36       | 1              | 6        | 1              | 5        | 1              | 4        |
| J-2                      | 140.895,68       | 1              | 9        | 1              | 8        | 1              | 7        |
| J-3                      | 136.805,36       | 1              | 8        | 1              | 7        | 1              | 6        |
| Total number of stations |                  | 9              | 91       | 9              | 81       | 9              | 71       |
| TOTAL                    | 1.474.932,19     | 100            |          | 90             |          | 80             |          |

### 3.2.1. Overview of locations selection for agricultural soil monitoring stations

In order to ensure representativeness for each agricultural sub-region when selecting locations for agricultural soil monitoring stations, the following criteria applied:

1. stations have to represent as many as possible of relief characteristics and pedosystemic units of sub-regions,
2. stations have to be located on soils on which the usage and management are representative for each sub-region,
3. stations are to include areas with negative impacts from natural original within sub-regions,
4. when selecting stations, the vicinity of the existing or planned facilities for environment monitoring should be taken into consideration,

5. stations are to be located in areas where property issues are resolved and where modifications of spatial plans are not foreseen (construction of roads and facilities), in order to be available for long-term monitoring.

Pursuant to previously stated criteria, areas and sites suitable for locating stations for agricultural soil monitoring have been determined, and a map of the area of most suitable conditions for positioning of locations with a proposal of maximum, optimum and minimum number of stations has been made.

With the objective to select the most suitable locations for positioning monitoring stations, the following materials and data sources have been used:

- **Regionalisation of the Croatian Agriculture (Bašić et al., 1998-2001)** - Although small by its area, the Republic of Croatia is under the influence of various climatic conditions and contains materials of various geological and lithological properties. When heterogeneous forms of relief are added to it, it is obvious that Croatia is made of a wide range of soil types of different degree of fertility.

Considering this natural diversity, Croatia has been divided to three clearly defined regions: Pannonian, Mountainous and Adriatic. Each agro-ecological region has specific climate conditions and specific conditions of formation and evolution of soil. Each region is additionally divided to sub-regions which offer various conditions for cultivation of plants. The Pannonian region is divided to Eastern, Central, Western and North-western; Mountainous to Pre-mountainous and Mountainous; and the Adriatic to Northern, Central and Southern.

- From **CORINE Land Cover 2000**, data have been obtained on the condition of land cover in Croatia. Data are based on standard classification and methodology which enables the elaboration of a study of Europe land cover, and simplifies the comparison of data and results among countries.

Agricultural areas used while elaborating proposals for locations of monitoring stations are divided to four groups:

1. Arable land (not irrigated arable land, permanently irrigated land)
2. Perennial cultures (vineyards, orchards, olive-grooves)
3. Pastures
4. Various agricultural areas (complex of cultivated parcels, predominantly agricultural land with larger areas of natural vegetation).

After the selection of 8 agricultural categories of land cover, the obtained map has been overlapped with each agricultural sub-region separately (ArcGIS Desktop 9.1), with the aim to harmonise borders of polygon of land cover with borders of agricultural sub-regions. The results of overlapping are exact areas of each category of soil usage for each sub-region separately.

- Then, the **soil map of suitability of soil for cultivation in the Republic of Croatia in the scale 1 : 300 000** has been created based on the Basic soil map at the scale of 1 : 50 000. By overlapping the soil map with the maps of areas of agricultural categories of land cover of each sub-region separately (ArcGIS Desktop 9.1), a map of pedosystemic units has been obtained on which agricultural production is taking place. From the obtained map, in each sub-region, polygons of more important pedosystemic units have been sorted out. The total of 35 pedosystemic units have been sorted out and divided to three compartments according to the current soil classification.
- **Digital relief model of the Republic of Croatia based on SRTM-3 recordings (Hengl T., 2004):** A digital relief model of the Republic of Croatia has been made by connecting



35 blocks of the so-called SRTM-3 data which have been downloaded from the EROS' FTP server. Each block covers 1x15 of geographical amplitude/length or about 110x110 km. Original data in hgt format have been imported to ILWIS, and then glued up and geo-referenced (Hengl T., 2004). By merging data on the height above sea-level with data from previously obtained map of significant pedosystematic units with agricultural production, average values of heights above sea-level of sub-regions and all selected pedosystematic units have been obtained. By selecting a polygon of pedosystematic units whose average value of the height above sea-level deviates from the average value of the height above sea-level of the sub-region to which they belong in the value larger than the standard deviation for this sub-region (ArcGIS Desktop 9.1), a map of the area of pedosystematic units of heights above sea-level has been obtained, representative for each sub-region. By overlapping that map with the map of agricultural categories of land cover, areas of agricultural categories based on representative pedosystematic units and heights above sea-level of each agricultural sub-region respectively have been obtained. The mentioned map represents the areas of the Republic of Croatia suitable for monitoring of agricultural soils.

- **Positioning of meteorological stations** - According to the Soil Monitoring Manual, during establishment of stations, and then every 24 years, it is necessary to collect data on average monthly temperatures of air and monthly amounts of precipitations (20 year average). In order to collect requested data, a criterion has been set that all stations should be located within 10 km from the closest meteorological station. Data on precipitations and air temperatures gathered in this way shall significantly contribute to prediction of the course, direction and intensity of changes of processes in the soil, as well as to a more successful development of strategies which assist their possible prevention or attenuation. By creation of concentric circles of 10 km in radius around each meteorological station, a map of the area whose distance from the closes meteorological stations does not exceed 10 km has been created. By overlapping each map of the area of monitoring with the map of areas at the distance less than 10 km from a meteorological stations, 9 new maps of agricultural areas suitable for soil monitoring have been obtained. New areas are not at the distance of more than 10 km from the closest meteorological station.

Before going out to the field, locations of all monitoring stations have been determined in the office. Locations have been determined for each sub-region separately based on previously obtained carts in GIS surrounding, and based on topographic maps at the scale of 1 : 100 000, whereby parts of areas of each agricultural category (CORINE Land Cover) have been taken into consideration, as well as portions of areas of each selected pedosystemic unit within one sub-region. The positioning of locations attempted to include the most important geomorphological entities within each sub-region.

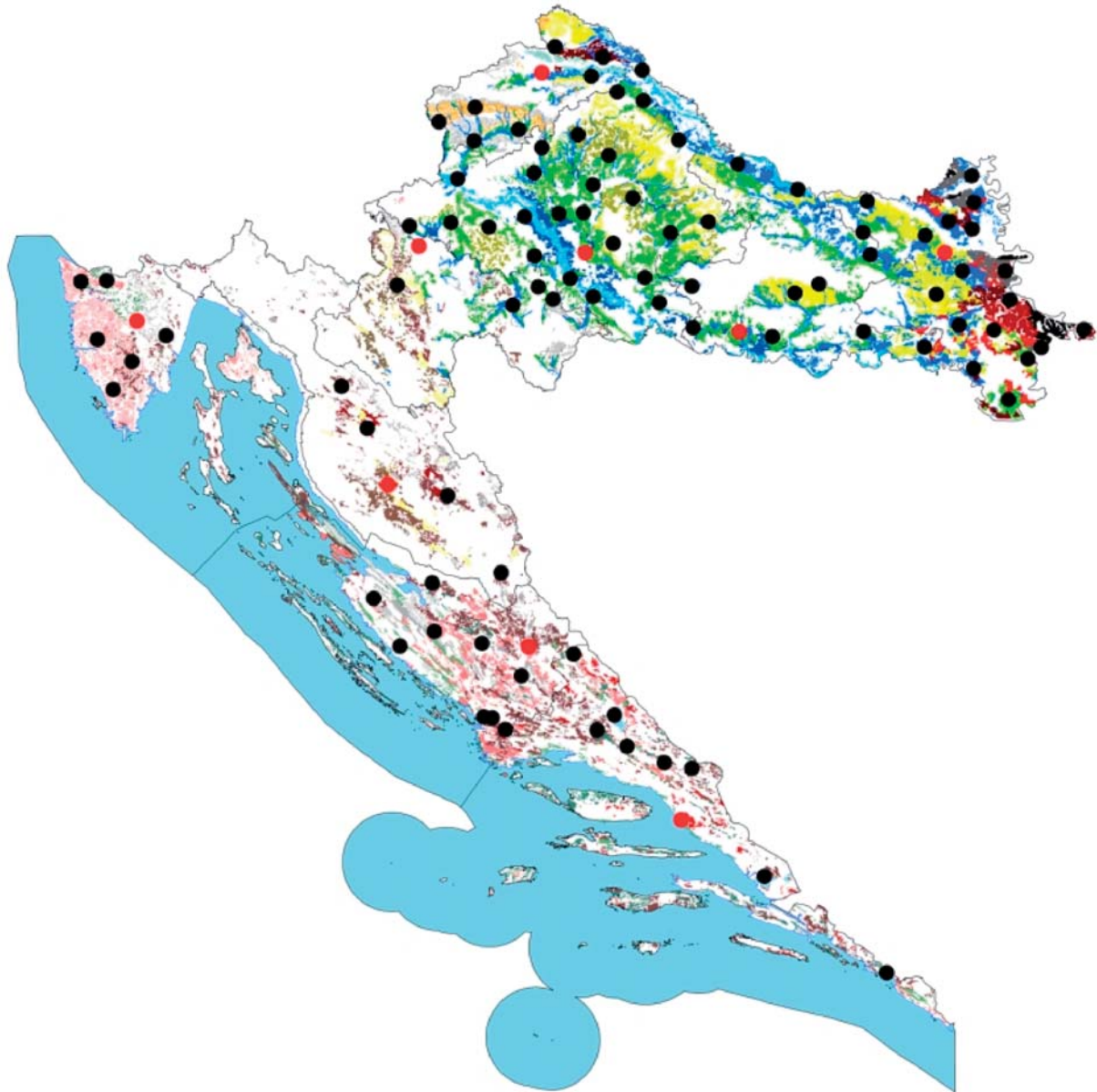
All locations for agricultural soil monitoring stations have been verified by field trips in August and September 2007. The verification determined whether locations are really representative for areas in which they are located and whether they are suitable for positioning of monitoring stations. By reviewing field characteristics of locations, data from the map of land cover (CORINE Land Cover) and the Soil Map have been confirmed. After reviewing each location, the most suitable site for establishment of the location has been determined, and has been marked by a GPS device. All locations have been photographed.

The determination of property issues at parcels foreseen for the establishment of stations is made during preparatory works of stations establishing, therefore, the proposed locations are subject to modifications within given conditions (geomorphology, pedosystemic unit, and the mode of use).

Figure 2 shows the map of Croatia with the layout of the maximum number (100) of agricultural soil monitoring stations:

1. Red dots (9) are Level I stations (one in each agricultural region),
2. Black dots (91) are Level II stations.

Table 2. contains the list of maximum number of selected locations for positioning of agricultural soil monitoring stations including the related data.



## 2. Layout of the maximum number (100) of agricultural soil monitoring stations



Table 2. List of maximum number of selected locations for positioning of agricultural soil monitoring stations including the related data

| NAME     | ALTITUDE | Y       | X       | LAT      | LONG     | AREA         | LAND COVER (CORINE)           | LAND USE    | DOMINANT PEDOSYSTEMATIC UNIT               | LEVEL    |
|----------|----------|---------|---------|----------|----------|--------------|-------------------------------|-------------|--------------------------------------------|----------|
| HR_P1_1  | 143      | 5010198 | 2726511 | 45,20890 | 19,38452 | Ilok         | vineyards                     | vineyard    | Chernozem on loess                         | Level II |
| HR_P1_2  | 84       | 5002114 | 2707356 | 45,14210 | 19,13750 | Tovarnik     | not irrigated arable land     | arable land | Humogley, partly hydromeliorated           | Level II |
| HR_P1_3  | 86       | 4997132 | 2701381 | 45,09903 | 19,05957 | Nijemci      | not irrigated arable land     | arable land | Luvisol on loess, semi-gleyic              | Level II |
| HR_P1_4  | 81       | 4978706 | 2692729 | 44,93572 | 18,94265 | Drenovci     | not irrigated arable land     | arable land | Pseudogley on level terrain                | Level II |
| HR_P1_5  | 87       | 4992806 | 2676991 | 45,06664 | 18,74829 | Županja      | not irrigated arable land     | arable land | Eugley, partly hydromeliorated             | Level II |
| HR_P1_6  | 89       | 5010022 | 2686143 | 45,21914 | 18,87087 | Privlaka     | pastures                      | pasture     | Luvisol on loess, semi-gleyic              | Level II |
| HR_P1_7  | 101      | 5023444 | 2693264 | 45,33793 | 18,96672 | Vukovar      | not irrigated arable land     | arable land | Eutric cambisol on loess                   | Level II |
| HR_P1_8  | 85       | 5036368 | 2691250 | 45,45470 | 18,94604 | Vera         | not irrigated arable land     | arable land | Chernozem on loess, semigleyic and typical | Level II |
| HR_P1_9  | 84       | 5079177 | 2676146 | 45,84408 | 18,76994 | Draz         | complex of cultivated parcels | arable land | Halomorphic                                | Level II |
| HR_P1_10 | 88       | 5012181 | 2670459 | 45,24253 | 18,67199 | Retkovci     | not irrigated arable land     | arable land | Eugley, partly hydromeliorated             | Level II |
| HR_P1_11 | 101      | 5025974 | 2660339 | 45,36899 | 18,54760 | Semeljci     | complex of cultivated parcels | arable land | Luvisol on loess, semi-gleyic              | Level II |
| HR_P1_12 | 89       | 5036388 | 2672046 | 45,45988 | 18,70063 | Antunovac    | not irrigated arable land     | arable land | Eugley, partly hydromeliorated             | Level II |
| HR_P1_13 | 67       | 5044808 | 2664023 | 45,53755 | 18,60089 | Cepin        | not irrigated arable land     | arable land | Luvisol on loess, semi-gleyic              | Level I  |
| HR_P1_14 | 79       | 5055328 | 2676380 | 45,62915 | 18,76285 | Bilje        | complex of cultivated parcels | arable land | Eutric cambisol                            | Level II |
| HR_P1_15 | 87       | 5067231 | 2677131 | 45,73602 | 18,77682 | K. Vinogradi | mostly agricultural land      | arable land | Humogley, partly hydromeliorated           | Level II |
| HR_P1_16 | 74       | 5058559 | 2665700 | 45,66084 | 18,62703 | Ceminac      | not irrigated arable land     | arable land | Eugley, partly hydromeliorated             | Level II |
| HR_P1_17 | 90       | 5052333 | 2655433 | 45,60721 | 18,49333 | Satnica V.   | complex of cultivated parcels | orchard     | Luvisol on loess                           | Level II |
| HR_P1_18 | 101      | 5053726 | 2627284 | 45,62548 | 18,13286 | Beničanci    | not irrigated arable land     | arable land | Eugley, partly hydromeliorated             | Level II |
| HR_P1_19 | 91       | 5067801 | 2629216 | 45,75175 | 18,16139 | D. Miholjac  | complex of cultivated parcels | arable land | Luvisol on loess                           | Level II |
| HR_P2_1  | 90       | 5002323 | 2654934 | 45,15743 | 18,47124 | Gundinci     | complex of cultivated parcels | arable land | Luvisol on loess, semi-gleyic              | Level II |
| HR_P2_2  | 163      | 5009367 | 2627562 | 45,22630 | 18,12493 | S. Brod      | mostly agricultural land      | arable land | Pseudogley on slope                        | Level II |
| HR_P2_3  | 102      | 5043756 | 2630643 | 45,53515 | 18,17327 | Jelisavac    | complex of cultivated parcels | arable land | Eugley, partly hydromeliorated             | Level II |
| HR_P2_4  | 223      | 5030580 | 2607615 | 45,42052 | 17,87554 | Kurjevo      | vineyards                     | vineyard    | Distric cambisol on clastites              | Level II |
| HR_P2_5  | 185      | 5026640 | 2596708 | 45,38666 | 17,73538 | Jakšić       | complex of cultivated parcels | arable land | Luvisol on loess                           | Level II |
| HR_P2_6  | 123      | 5007017 | 2586660 | 45,21137 | 17,60362 | S.P. Selo    | complex of cultivated parcels | arable land | Pseudogley on level terrain                | Level II |
| HR_P2_7  | 112      | 5009222 | 2571845 | 45,23289 | 17,41530 | N. Gradiška  | not irrigated arable land     | arable land | Eugley, partly hydromeliorated             | Level I  |
| HR_P2_8  | 98       | 5010926 | 2551144 | 45,25003 | 17,15177 | Okučani      | mostly agricultural land      | arable land | Eugley vertic                              | Level II |
| HR_P2_9  | 145      | 5029573 | 2550517 | 45,41792 | 17,14568 | Lipik        | not irrigated arable land     | arable land | Pseudogley on level terrain                | Level II |
| HR_P2_10 | 95       | 5072974 | 2598047 | 45,80343 | 17,76179 | Sopje        | complex of cultivated parcels | arable land | Fluvisol, defended from floods             | Level II |
| HR_P2_11 | 107      | 5084393 | 2571298 | 45,90947 | 17,41930 | Virovitica   | not irrigated arable land     | arable land | Eugley, partly hydromeliorated             | Level II |
| HR_P3_1  | 144      | 5058454 | 2557922 | 45,67728 | 17,24373 | Grubišno P.  | complex of cultivated parcels | arable land | Luvisol on loess                           | Level II |
| HR_P3_2  | 125      | 5053592 | 2540969 | 45,63473 | 17,02565 | Garešnica    | not irrigated arable land     | arable land | Pseudogley on level terrain                | Level II |
| HR_P3_3  | 107      | 5033489 | 2529451 | 45,45437 | 16,87667 | Kutina       | mostly agricultural land      | arable land | Pseudogley on level terrain                | Level II |





|          |     |         |         |          |          |              |                               |             |                                              |          |
|----------|-----|---------|---------|----------|----------|--------------|-------------------------------|-------------|----------------------------------------------|----------|
| HR_P3_4  | 119 | 5022305 | 2535863 | 45,35341 | 16,95786 | Novska       | complex of cultivated parcels | pasture     | Eugley, partly hydromeliolated               | Level II |
| HR_P3_5  | 100 | 5024961 | 2506192 | 45,37820 | 16,57909 | Sunja        | complex of cultivated parcels | arable land | Eugley, partly hydromeliolated               | Level II |
| HR_P3_6  | 115 | 5080426 | 2479699 | 45,87717 | 16,23839 | Zagreb       | complex of cultivated parcels | arable land | Eugley, partly hydromeliolated               | Level II |
| HR_P3_7  | 92  | 5044701 | 2502692 | 45,55591 | 16,53449 | Potok        | not irrigated arable land     | arable land | Eugley vertic                                | Level I  |
| HR_P3_8  | 141 | 5048832 | 2515252 | 45,59293 | 16,69554 | Popovača     | complex of cultivated parcels | arable land | Luvisol on loess                             | Level II |
| HR_P3_9  | 124 | 5062587 | 2501794 | 45,71690 | 16,52306 | Čazma        | complex of cultivated parcels | arable land | Pseudogley on slope                          | Level II |
| HR_P3_10 | 133 | 5069131 | 2523925 | 45,77539 | 16,80774 | Ivanjska     | complex of cultivated parcels | arable land | Luvisol pseudogleyic on loess                | Level II |
| HR_P3_11 | 113 | 5074980 | 2506062 | 45,82843 | 16,57804 | Vrbovec      | complex of cultivated parcels | pasture     | Pseudogley on slope                          | Level II |
| HR_P3_12 | 133 | 5088176 | 2513191 | 45,94710 | 16,67020 | Bjelovar     | complex of cultivated parcels | arable land | Pseudogley on level terrain                  | Level II |
| HR_P3_13 | 120 | 5095179 | 2544681 | 46,00880 | 17,07714 | Đurđevac     | not irrigated arable land     | arable land | Luvisol pseudogleyic on loess                | Level II |
| HR_P3_14 | 121 | 5112856 | 2528736 | 46,16874 | 16,87225 | Koprivnica   | complex of cultivated parcels | arable land | Pseudogley on level terrain                  | Level II |
| HR_P3_15 | 141 | 5116687 | 2517039 | 46,20361 | 16,72087 | Rasinja      | pastures                      | arable land | Eugley, partly hydromeliolated               | Level II |
| HR_P3_16 | 146 | 5097509 | 2499408 | 46,03122 | 16,49236 | Križevci     | complex of cultivated parcels | pasture     | Luvisol pseudogleyic on loess                | Level II |
| HR_P3_17 | 125 | 5091759 | 2483135 | 45,97926 | 16,28227 | Zelina       | pastures                      | pasture     | Eugley, partly hydromeliolated               | Level II |
| HR_P3_18 | 130 | 5126420 | 2528294 | 46,29084 | 16,86734 | Legrad       | complex of cultivated parcels | arable land | Fluvisol, defended from floods               | Level II |
| HR_P3_19 | 100 | 5033115 | 2495881 | 45,45161 | 16,44733 | Sisak        | complex of cultivated parcels | arable land | Fluvisol, defended from floods               | Level II |
| HR_P3_20 | 102 | 5043267 | 2479918 | 45,54272 | 16,24276 | Lekenik      | complex of cultivated parcels | arable land | Pseudogley on level terrain                  | Level II |
| HR_P3_21 | 104 | 5062168 | 2490863 | 45,71307 | 16,38260 | Ivanić Grad  | complex of cultivated parcels | arable land | Pseudogley on level terrain                  | Level II |
| HR_P3_22 | 100 | 5060903 | 2475416 | 45,70131 | 16,18420 | V. Gorica    | complex of cultivated parcels | arable land | Eugley vertic                                | Level II |
| HR_P3_23 | 145 | 5056176 | 2459346 | 45,65801 | 15,97816 | Zagreb       | mostly agricultural land      | pasture     | Luvisol pseudogleyic on loess                | Level II |
| HR_P3_24 | 136 | 5058071 | 2442327 | 45,67385 | 15,75950 | Jastrebarsko | complex of cultivated parcels | arable land | Pseudogley on level terrain                  | Level II |
| HR_P3_25 | 147 | 5056619 | 2423744 | 45,65899 | 15,52117 | Ozalj        | complex of cultivated parcels | arable land | Eugley, partly hydromeliolated               | Level II |
| HR_P3_26 | 127 | 5077786 | 2445206 | 45,85153 | 15,79423 | Zaprešić     | mostly agricultural land      | arable land | Fluvisol, defended from floods               | Level II |
| HR_P4_1  | 153 | 5132221 | 2510717 | 46,34355 | 16,63927 | Prelog       | complex of cultivated parcels | arable land | Eutric cambisol                              | Level II |
| HR_P4_2  | 158 | 5123711 | 2505360 | 46,26703 | 16,56956 | Ludbreg      | complex of cultivated parcels | arable land | Humofluvisol                                 | Level II |
| HR_P4_3  | 175 | 5125352 | 2483081 | 46,28160 | 16,28038 | Varaždin     | complex of cultivated parcels | arable land | Eugley, partly hydromeliolated               | Level I  |
| HR_P4_4  | 174 | 5136981 | 2489023 | 46,38638 | 16,35723 | Čakovec      | complex of cultivated parcels | arable land | Luvisol on loess                             | Level II |
| HR_P4_5  | 171 | 5099779 | 2472751 | 46,05111 | 16,14776 | Z. Bistrica  | complex of cultivated parcels | arable land | Pseudogley on slope                          | Level II |
| HR_P4_6  | 137 | 5094826 | 2452694 | 46,00544 | 15,88900 | Zabok        | pastures                      | pasture     | Eugley, partly hydromeliolated               | Level II |
| HR_P4_7  | 237 | 5103260 | 2496980 | 46,08008 | 15,68493 | Kumrovec     | pastures                      | pasture     | Rendzina on loess (flysch) or soft limestone | Level II |
| HR_P4_8  | 210 | 5109846 | 2453197 | 46,14065 | 15,89401 | Krapina      | complex of cultivated parcels | arable land | Luvisol typical on loess and soft limestone  | Level II |
| HR_G1_1  | 216 | 5023724 | 2488160 | 45,36699 | 16,34881 | Petrinja     | mostly agricultural land      | arable land | Rendzina on loess (flysch) or soft limestone | Level II |
| HR_G1_2  | 170 | 5029277 | 2481535 | 45,41683 | 16,26400 | Petrinja     | complex of cultivated parcels | arable land | Pseudogley on slope                          | Level II |



|          |     |         |         |          |          |              |                               |             |                                                          |          |
|----------|-----|---------|---------|----------|----------|--------------|-------------------------------|-------------|----------------------------------------------------------|----------|
| HR_G1_3  | 117 | 5021180 | 2470073 | 45,34356 | 16,11799 | Glina        | complex of cultivated parcels | pasture     | Eugley, partly hydromeliolated                           | Level II |
| HR_G1_4  | 199 | 5030113 | 2418305 | 45,41983 | 15,45579 | Duga Resa    | complex of cultivated parcels | pasture     | Cambisol on dolomite                                     | Level II |
| HR_G1_5  | 219 | 5047593 | 2427867 | 45,57820 | 15,57541 | Karlovac     | pastures                      | pasture     | District cambisol on loess and holocene                  | Level I  |
| HR_G2_1  | 495 | 4984801 | 2393219 | 45,00868 | 15,14494 | Brinje       | mostly agricultural land      | arable land | District cambisol on loess and holocene                  | Level II |
| HR_G2_2  | 460 | 4965913 | 2404734 | 44,84032 | 15,29460 | Otočac       | complex of cultivated parcels | arable land | Eutric cambisol on eruptive rocks                        | Level II |
| HR_G2_3  | 569 | 4940744 | 2414072 | 44,61497 | 15,41696 | Lički Osik   | complex of cultivated parcels | orchard     | District cambisol on loess and holocene                  | Level I  |
| HR_G2_4  | 663 | 4935732 | 2440949 | 44,57256 | 15,75626 | Udbina       | pastures                      | pasture     | Rendzina on gravel                                       | Level II |
| HR_G2_5  | 660 | 4901208 | 2464815 | 44,26331 | 16,05918 | Otrac        | pastures                      | pasture     | Rendzina on dolomite and limestone                       | Level II |
| HR_J1_1  | 114 | 5031756 | 2276094 | 45,40354 | 13,63888 | Buje         | vineyards                     | vineyard    | Vertisol on loess and soft limestone                     | Level II |
| HR_J1_2  | 289 | 5032194 | 2287689 | 45,41109 | 13,78668 | Oprtalj      | pastures                      | pasture     | Terra rossa shallow and medium deep                      | Level II |
| HR_J1_3  | 277 | 5013996 | 2301299 | 45,25144 | 13,96774 | Pazin        | mostly agricultural land      | arable land | Anthropogenic on flysch and karst synclines and colluvia | Level I  |
| HR_J1_4  | 34  | 5007423 | 2314447 | 45,19592 | 14,13761 | Labin        | mostly agricultural land      | arable land | Rendzina on loess (flysch) or soft limestone             | Level II |
| HR_J1_5  | 160 | 5005726 | 2283583 | 45,17186 | 13,74581 | Lovrec       | complex of cultivated parcels | vineyard    | Terra rossa loessed and typically deep                   | Level II |
| HR_J1_6  | 332 | 4995859 | 2299099 | 45,08772 | 13,94703 | Svetvincenat | pastures                      | pasture     | Cambisol on limestone                                    | Level II |
| HR_J1_7  | 133 | 4983239 | 2290740 | 44,97181 | 13,84618 | Vodnjan      | complex of cultivated parcels | arable land | Terra rossa loessed and typically deep                   | Level II |
| HR_J2_1  | 73  | 4889689 | 2407649 | 44,15462 | 15,34510 | Zadar        | complex of cultivated parcels | olive-grove | Rendzina on loess (flysch) or soft limestone (           | Level II |
| HR_J2_2  | 104 | 4896621 | 2433947 | 44,21987 | 15,67305 | Obrovac      | pastures                      | pasture     | Cambisol on limestone                                    | Level II |
| HR_J2_3  | 233 | 4874897 | 2434865 | 44,02438 | 15,68723 | Benkovac     | complex of cultivated parcels | arable land | Litosol                                                  | Level II |
| HR_J2_4  | 7   | 4868244 | 2419540 | 43,96298 | 15,49703 | Biograd      | complex of cultivated parcels | arable land | Hydromeliolated                                          | Level II |
| HR_J2_5  | 231 | 4869563 | 2456355 | 43,97795 | 15,95581 | Kistanje     | complex of cultivated parcels | vineyard    | Rendzina on limestone regolith                           | Level II |
| HR_J2_6  | 229 | 4867924 | 2477188 | 43,96414 | 16,21563 | Knin         | complex of cultivated parcels | pasture     | Rendzina on gravel                                       | Level I  |
| HR_J2_7  | 256 | 4855062 | 2473993 | 43,84823 | 16,17643 | Drniš        | complex of cultivated parcels | arable land | Eugley, partly hydromeliolated                           | Level II |
| HR_J2_8  | 85  | 4836126 | 2460899 | 43,67716 | 16,01491 | Šibenik      | complex of cultivated parcels | vineyard    | Anthropogenic on flysch and karst synclines and colluvia | Level II |
| HR_J2_9  | 273 | 4830913 | 2466830 | 43,63051 | 16,08881 | Lepenica     | mostly agricultural land      | vineyard    | Cambisol on limestone                                    | Level II |
| HR_J2_10 | 11  | 4836581 | 2457157 | 43,68105 | 15,96846 | Šibenik      | complex of cultivated parcels | vineyard    | Anthropogenic on flysch and karst synclines and colluvia | Level II |
| HR_J3_1  | 2   | 4765046 | 2583188 | 43,03358 | 17,52119 | Opuzen       | complex of cultivated parcels | arable land | Hydromeliolated                                          | Level II |
| HR_J3_2  | 393 | 4864788 | 2497433 | 43,93625 | 16,46801 | Vrlika       | pastures                      | pasture     | Rendzina on dolomite and limestone                       | Level II |
| HR_J3_3  | 306 | 4837416 | 2515789 | 43,68964 | 16,69592 | Sinj         | continually irrigated land    | arable land | Hydromeliolated                                          | Level II |
| HR_J3_4  | 351 | 4830625 | 2507928 | 43,62862 | 16,59828 | Dugopolje    | complex of cultivated parcels | pasture     | Anthropogenic on karst                                   | Level II |
| HR_J3_5  | 382 | 4823416 | 2521411 | 43,56344 | 16,76513 | Trilj        | mostly agricultural land      | vineyard    | Terra rossa shallow and medium deep                      | Level II |
| HR_J3_6  | 495 | 4816005 | 2538209 | 43,49604 | 16,97260 | Cista Provo  | pastures                      | pasture     | Anthropogenic on karst                                   | Level II |
| HR_J3_7  | 285 | 4813528 | 2550496 | 43,47300 | 17,12434 | Prološko b.  | complex of cultivated parcels | pasture     | Rendzina on gravel                                       | Level II |
| HR_J3_8  | 20  | 4790481 | 2545724 | 43,26579 | 17,06342 | Tučepi       | olive groves                  | olive-grove | Anthropogenic on flysch and karst synclines and colluvia | Level I  |
| HR_J3_9  | 23  | 4721940 | 2637991 | 42,63759 | 18,18312 | Dubrovnik    | mostly agricultural land      | arable land | Anthropogenic on flysch and karst synclines and colluvia | Level II |

## 3.3. Soil sampling and soil description procedures for agricultural soil monitoring

### 3.3.1. General data on agricultural soil monitoring stations

Before the establishment of stations (opening and description of soil profile), it is necessary to gather general information on the agricultural soil monitoring station.

Gathered data are entered in the **Form for description of stations for agricultural soil monitoring P1; I. General data.**

| FORM FOR DESCRIPTION OF AGRICULTURAL SOIL MONITORING STATION - P1                                                                                                                                                                                                                        |                                           |   |          |          |                                   |          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|---|----------|----------|-----------------------------------|----------|
| I. General data                                                                                                                                                                                                                                                                          |                                           |   |          |          |                                   |          |
| 1.                                                                                                                                                                                                                                                                                       | Station identification number*            |   |          |          |                                   |          |
| 2.                                                                                                                                                                                                                                                                                       | Time of description of the station        |   |          | 5.       | Data on the owner of the parcel   |          |
| A                                                                                                                                                                                                                                                                                        | Date                                      |   | A        | Name     |                                   |          |
| B                                                                                                                                                                                                                                                                                        | Time                                      |   | B        | Address  |                                   |          |
| 3.                                                                                                                                                                                                                                                                                       | Data on the manager of description        |   |          | C        | Place                             |          |
| A                                                                                                                                                                                                                                                                                        | Full name                                 |   |          | D        | Contact person                    |          |
| B                                                                                                                                                                                                                                                                                        | Institution                               |   |          | E        | Telephone                         |          |
| C                                                                                                                                                                                                                                                                                        | Telephone                                 |   |          | 6.       | Administrative data on the parcel |          |
| 4.                                                                                                                                                                                                                                                                                       | Data on the location of the station       |   |          | A        | County                            |          |
| A                                                                                                                                                                                                                                                                                        | Closest populated settlement              |   |          | B        | Political municipality            |          |
| B                                                                                                                                                                                                                                                                                        | Distance from the closest settlement      |   |          | C        | Cadastral municipality            |          |
| C                                                                                                                                                                                                                                                                                        | Direction of movement from the settlement |   |          | D        | Cadastral plot                    |          |
| 7.                                                                                                                                                                                                                                                                                       | Geographical data on the station          |   | NE angle | NW angle | SW angle                          | SE angle |
| A                                                                                                                                                                                                                                                                                        | Plane coordinates (Gauss Krüger)          | X |          |          |                                   |          |
|                                                                                                                                                                                                                                                                                          |                                           | Y |          |          |                                   |          |
| B                                                                                                                                                                                                                                                                                        | Geographical coordinates (WGS 84)         | N |          |          |                                   |          |
|                                                                                                                                                                                                                                                                                          |                                           |   |          |          |                                   |          |
| C                                                                                                                                                                                                                                                                                        | Mark of list HOK-a M=1:5.000              |   |          |          |                                   |          |
| D                                                                                                                                                                                                                                                                                        | Height above sea level                    |   |          |          |                                   |          |
| * enables a rapid and simple access to description of habitat and soil profile of the station in the data base. It is made of a combination of numbers which indicate the state, agro-ecological region, sub-region and the station for monitoring within this region (Example: HR/P1/1) |                                           |   |          |          |                                   |          |

Then, data on the climate, relief, natural vegetation, use of soil, surface properties of soil and importations into soil are entered into Forms **II Factors for creation and evolution of soil - and III Surface properties of soil.**



| FORM FOR DESCRIPTION OF AGRICULTURAL SOIL MONITORING STATION - P1                                  |                                                  |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
|----------------------------------------------------------------------------------------------------|--------------------------------------------------|---------------------------------------|--|------------|-------------------------------------------|---|---|---|---|---|---|---|----|----|----|
| II. Factors for creation and evolution of soil                                                     |                                                  |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| <b>8.</b>                                                                                          | <b>Relief</b>                                    |                                       |  | <b>10.</b> | <b>*12 Nature of parent material</b>      |   |   |   |   |   |   |   |    |    |    |
| A                                                                                                  | *4                                               | Form of relief of the area            |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| B                                                                                                  | *5                                               | Position of the station               |  | <b>11.</b> | <b>*12 Geological age of soil</b>         |   |   |   |   |   |   |   |    |    |    |
| C                                                                                                  | *7                                               | Slope and exposition                  |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| D                                                                                                  | *6                                               | Shape of slope                        |  | <b>12.</b> | <b>Soil classification of the station</b> |   |   |   |   |   |   |   |    |    |    |
| <b>9.</b>                                                                                          | *11                                              | <b>Natural vegetation of the area</b> |  | A          | Škorić et al, 1985.                       |   |   |   |   |   |   |   |    |    |    |
|                                                                                                    |                                                  |                                       |  | B          | WRB, 2006.                                |   |   |   |   |   |   |   |    |    |    |
| <b>13.</b>                                                                                         | <b>Klima</b>                                     |                                       |  | 1          | 2                                         | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| A                                                                                                  | Mean air temperature (annual average $\geq 20$ ) |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| B                                                                                                  | Mean precipitations (annual average $\geq 20$ )  |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| C                                                                                                  | Length of vegetation period                      |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| D                                                                                                  | *2                                               | Current weather conditions            |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| E                                                                                                  | *2                                               | Past weather conditions               |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| F                                                                                                  | *3                                               | Water regime of the soil              |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| G                                                                                                  | *3                                               | Temperature regime of the soil        |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| <b>14.</b>                                                                                         | <b>Mode of use</b>                               |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| A                                                                                                  | *8                                               | Mode of use                           |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| B                                                                                                  | *9                                               | Dominant cultures                     |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| C                                                                                                  | Crops                                            |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| D                                                                                                  | Mode of cultivation                              |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| <b>15.</b>                                                                                         | <b>Inputs into soil</b>                          |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| A                                                                                                  | Fertilisation N (kg per year)                    |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| B                                                                                                  | Fertilisation P (kg per year)                    |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| C                                                                                                  | Fertilisation K (kg per year)                    |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| D                                                                                                  | Type of organic fertilisation                    |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| E                                                                                                  | Quantity of organic fertilisation (kg per year)  |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| F                                                                                                  | Type of soil enhancer                            |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| G                                                                                                  | Quantity of enhancers (kg per year)              |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| H                                                                                                  | Type of protective agent                         |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| I                                                                                                  | Quantity of active matter (l per year)           |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |
| * Enter the marks from the Table of the said numbers - Guidelines for soil description, FAO, 2006. |                                                  |                                       |  |            |                                           |   |   |   |   |   |   |   |    |    |    |

| FORM FOR DESCRIPTION OF AGRICULTURAL SOIL MONITORING STATION - P1 |                                   |                        |  |            |                       |                         |  |
|-------------------------------------------------------------------|-----------------------------------|------------------------|--|------------|-----------------------|-------------------------|--|
| III. Surface soil properties                                      |                                   |                        |  |            |                       |                         |  |
| <b>16.</b>                                                        | <b>Rockiness</b>                  |                        |  | <b>20.</b> | <b>Erosion</b>        |                         |  |
| A                                                                 | *14                               | Percentage of surface  |  | A          | *16                   | Nature of erosion       |  |
| B                                                                 | *14                               | Distance between rocks |  | B          | *17                   | Percentage of surface   |  |
| C                                                                 |                                   | Size of rocks          |  | C          | *18                   | Degree of erosion       |  |
| <b>17.</b>                                                        | <b>Gravelness</b>                 |                        |  | D          | *19                   | Activity of erosion     |  |
| A                                                                 | *15                               | Percentage of surface  |  | <b>21.</b> | <b>Surface crust</b>  |                         |  |
| B                                                                 | *15                               | Diameter of fragments  |  | A          | *20                   | Thickness               |  |
| <b>18.</b>                                                        | <b>Surface salt efflorescence</b> |                        |  | B          | *20                   | Hardness                |  |
| A                                                                 | *22                               | Percentage of surface  |  | <b>22.</b> | <b>Surface cracks</b> |                         |  |
| B                                                                 | *22                               | Thickness of layer     |  | A          | *21                   | Average width           |  |
| C                                                                 |                                   | Type of salt           |  | B          | *21                   | Average depth           |  |
| <b>19.</b>                                                        | <b>Faded sand on the surface</b>  |                        |  | C          | *21                   | Average mutual distance |  |
| A                                                                 | *23                               | Percentage of surface  |  |            |                       |                         |  |

\* Enter the marks from the Table of the mentioned numbers - Guidelines for soil description, FAO, 2006.

### 3.3.2. Sampling of soil profile

The soil profile is elaborated when the monitoring station is established, and again after 24 years. The profile is opened to the depth of parent material (and deeper, if necessary), i.e. up to the level of ground water, 1 m wide and 2 m long. The face of the profile is prepared (cleaned) for description, measurement tape is set from the surface to the bottom of the profile, and the profile and the landscape of the station are photographed. All data on the soil profile are entered into **Forms for description of agricultural soil monitoring stations – P1; IV Description of the soil profile, and V. Photo-documentation** and stored in filing folder of the station.

Manager of description of habitats and soil profile of the station classifies the soil as precisely as possible based on morphological properties. The final classification of the soil is based on analytical data obtained from the laboratory.

The classification of the soil is conducted according to the Classification of the soil of Yugoslavia (Škorić, A. et al., 1973, 1985) and according to WRB correlation (IUSS Working Group WRB, 2006). The classification according to the Škorić et al. is genetic and serves as a basis for production-ecological assessment of soils. It is based on soil properties which are morphologically visible or easily measured. The type of soil is the basic unit for Classification and it is determined by single-type structure of the profile (characteristic sequence of horizons), single-type basic transformation processes and migration of organic and mineral matter, as well as similar physical and chemical characteristics of certain horizons in terms of quality. Various types of soil with analogue development stages are gathered in higher units - classes, and various classes of one character of humidity and composition of water by which the soil is humidified are gathered in the highest units of Classifications - compartments (automorphic, hydromorphic, halomorphpic and subaqual soils). Division of soil types into lower units (subtypes, varieties, forms) is determined by those properties which cause variability of certain types of soil.

Based on the previous description of habitats and profile of the station, the soil classification includes:



1. Naming of the horizon of soil profile (sub-horizons, transitional horizons, complex horizons).
2. determination of compartment, class, type, subtype, variety and form of soil.

Soil classification according to the World Reference Base (WRB) starts from the following principles:

- The purpose of the Reference Base is not to replace the existing national classification systems, but to serve as a common language in international communication.
- Classification of soils is based on visible and measurable properties of soils which are defined by terms - diagnostic horizons, properties and materials of the soil.
- The selection of diagnostic properties of soil takes into consideration their relation with pedogenetic processes. The understanding of pedogenetic processes helps in a quality description of soils, but they are not used as a classification criteria.
- Climatic parameters are used only for interpretation purposes, they are not a part of definition of soils.
- Classification contains two categories of details:
  - o The first level is the Reference Base - made of 32 reference groups of soils which are determined by WRB Key
  - o The second level is WRB Classification System - whose combinations of groups of qualifiers (prefix and suffix) are added to the name of reference group of soils and enable a very precise description and classification of soil profiles.

Soil is classified in 3 steps:

1. Determination of diagnostic horizons, properties and materials;
2. Determination of Reference group of soils based on comparison of diagnostic horizons, properties and materials with WRB Key
3. Determination of qualifiers; prefixes (characteristic for certain Reference group) and suffixes (other qualifiers), and their specificities (degrees of expression).

Sampling of the soil profile is made pursuant to standards ISO 10381-2: 2002 - *Soil quality - Sampling - Part 2: Guidance on sampling techniques* and ISO 10381-4: 2003 - *Soil quality - Sampling - Part 4: Guidance on the procedure for investigation of natural, near-natural and cultivated sites*.

**Sampling of soil profile** is to include all determined horizons. From the face of the profile from which the profile description was made, soil samples for physical analyses are taken in disturbed and undisturbed condition (samples of known volume).

**Samples in disturbed condition** are taken from the lowest horizon of the profile, by knife, so as to represent the entire thickness of the horizon, but without ever passing its border. From each horizon, four composite samples are taken for various types of laboratory analyses (physical, chemical, microbiological and specially for NO<sub>3</sub><sup>-</sup>) and are stored in plastic bags. In pasture, samples are taken from the depth of 0-10, 10-20 and 20-30 cm, independently of genetic horizons. The mark on the bag must contain the number of station, depth of sampled horizon and the indication for which type of analysis it was taken. Due to possible subsequent modification of the horizon's symbol, it is not desirable to indicate it on the bag. The mass of one sample should not be less than 1 kg. When sampling soil in disturbed condition for microbiological analysis, it is necessary to ensure aerobic conditions of storage before laboratory analysis, in a refrigerator (+4°C).

**Samples in undisturbed condition** of known volume are taken with the aim to test physical properties of soil. They are taken by impressing a cylinder of 100 cm<sup>3</sup> vertically to a previously dug stair in the height of the horizon on the profiles face. Sampling in this case begins from the highest horizon, and for one average analysis result at least three cylinders should be taken



from one horizon. The height of the stair is determined in such a way so that cylinders, after impressing, include the central part of tested horizon. Factory marks of cylinders are entered in the Form for description of agricultural soil monitoring stations - P1 with a previously described horizon from which they were taken.

**Lysimeters** are set during opening of soil profile (one per each Level I station) below the efficient depth. Water samples from lysimeter are stored in a well closed plastic bottles and are previously conserved with 2-3 drops of toluene.

| FORM FOR DESCRIPTION OF AGRICULTURAL SOIL MONITORING STATION - P1 |              |                  |                             |           |            |                     |          |       |            |       |
|-------------------------------------------------------------------|--------------|------------------|-----------------------------|-----------|------------|---------------------|----------|-------|------------|-------|
| IV. Description of soil profile                                   |              |                  |                             |           |            |                     |          |       |            |       |
| No.                                                               | 23. Horizons |                  | 24. Lower border of horizon |           |            | 25. Rocks fragments |          |       |            |       |
|                                                                   | Mark         | Mark of cylinder | Depth                       | Clearness | Topography | Occurrence          | Diameter | Form  | Weathering | Type  |
|                                                                   | A **         | B ***            | A                           | B *24     | C *24      | A *26               | B *27    | C *28 | D *29      | E *30 |
| 1.                                                                |              |                  |                             |           |            |                     |          |       |            |       |
| 2.                                                                |              |                  |                             |           |            |                     |          |       |            |       |
| 3.                                                                |              |                  |                             |           |            |                     |          |       |            |       |
| 4.                                                                |              |                  |                             |           |            |                     |          |       |            |       |
| 5.                                                                |              |                  |                             |           |            |                     |          |       |            |       |
| 6.                                                                |              |                  |                             |           |            |                     |          |       |            |       |
| 7.                                                                |              |                  |                             |           |            |                     |          |       |            |       |

\* Enter the marks from the Table of the mentioned numbers - Guidelines for soil description, FAO, 2006.

\*\* Mark according to Škorić et al., 1985.

\*\*\* Factory mark of cylinder for sampling of soil in undisturbed condition

| No. | 26. Texture of fine earth fraction | 27. Degradation and humification of plant residues | 28. Soil colour                     |                 | 29. Mottles |       |        |          |        |
|-----|------------------------------------|----------------------------------------------------|-------------------------------------|-----------------|-------------|-------|--------|----------|--------|
|     |                                    |                                                    | Dry condition                       | Humid condition | Occurrence  | Size  | Colour | Contrast | Border |
|     | *25                                | *31                                                | Oznake iz Munsell Soil Color Charts |                 | A *32       | B *33 | C **** | D *34    | E *35  |
| 1.  |                                    |                                                    |                                     |                 |             |       |        |          |        |
| 2.  |                                    |                                                    |                                     |                 |             |       |        |          |        |
| 3.  |                                    |                                                    |                                     |                 |             |       |        |          |        |
| 4.  |                                    |                                                    |                                     |                 |             |       |        |          |        |
| 5.  |                                    |                                                    |                                     |                 |             |       |        |          |        |
| 6.  |                                    |                                                    |                                     |                 |             |       |        |          |        |
| 7.  |                                    |                                                    |                                     |                 |             |       |        |          |        |

\* Enter the marks from the Table of the mentioned numbers - Guidelines for soil description, FAO, 2006.

\*\*\*\* Simple descriptions of colours according to Munsell Soil Colour Charts



| No. | 30. Redox-potential (rH) | 31. Reduction conditions in the soil | 32. Easily soluble salts | 33. pH value of the soil | 34. Organic matter | 35. Carbonates |       | 36. Gypsum |       |
|-----|--------------------------|--------------------------------------|--------------------------|--------------------------|--------------------|----------------|-------|------------|-------|
|     |                          |                                      |                          |                          |                    | Content        | Form  | Content    | Form  |
|     | *36                      | *37                                  | *42                      |                          | *46                | A *38          | B *39 | A *40      | B *41 |
| 1.  |                          |                                      |                          |                          |                    |                |       |            |       |
| 2.  |                          |                                      |                          |                          |                    |                |       |            |       |
| 3.  |                          |                                      |                          |                          |                    |                |       |            |       |
| 4.  |                          |                                      |                          |                          |                    |                |       |            |       |
| 5.  |                          |                                      |                          |                          |                    |                |       |            |       |
| 6.  |                          |                                      |                          |                          |                    |                |       |            |       |
| 7.  |                          |                                      |                          |                          |                    |                |       |            |       |

\* Enter the marks from the Table of the mentioned numbers - Guidelines for soil description, FAO, 2006.

| No. | 37. Moisture status of soil | 38. Bulk density | 39. Soil structure |       |                    | 40. Soil consistency |                 |            |            |
|-----|-----------------------------|------------------|--------------------|-------|--------------------|----------------------|-----------------|------------|------------|
|     |                             |                  | Degree             | Type  | Size of aggregates | Dry condition        | Humid condition | Stickiness | Plasticity |
|     |                             |                  | A *47              | B *49 | C *50              | A *53                | B *54           | C *55      | D *56      |
| 1.  |                             |                  |                    |       |                    |                      |                 |            |            |
| 2.  |                             |                  |                    |       |                    |                      |                 |            |            |
| 3.  |                             |                  |                    |       |                    |                      |                 |            |            |
| 4.  |                             |                  |                    |       |                    |                      |                 |            |            |
| 5.  |                             |                  |                    |       |                    |                      |                 |            |            |
| 6.  |                             |                  |                    |       |                    |                      |                 |            |            |
| 7.  |                             |                  |                    |       |                    |                      |                 |            |            |

\* Enter the marks from the Table of the mentioned numbers - Guidelines for soil description, FAO, 2006.

| No. | 41. Porosity | 42. Pores |          |                              |                              | 43. Roots |                              |                              | 44. Other biological properties |       |
|-----|--------------|-----------|----------|------------------------------|------------------------------|-----------|------------------------------|------------------------------|---------------------------------|-------|
|     |              | Type      | Diameter | Number < 2mm/dm <sup>2</sup> | Number > 2mm/dm <sup>2</sup> | Diameter  | Number < 2mm/dm <sup>2</sup> | Number > 2mm/dm <sup>2</sup> | Quantity                        | Type  |
|     |              | A *61     | B *62    | C *63                        | D *63                        | A *79     | B *80                        | C *80                        | A *81                           | B *82 |
| 1.  |              |           |          |                              |                              |           |                              |                              |                                 |       |
| 2.  |              |           |          |                              |                              |           |                              |                              |                                 |       |
| 3.  |              |           |          |                              |                              |           |                              |                              |                                 |       |
| 4.  |              |           |          |                              |                              |           |                              |                              |                                 |       |
| 5.  |              |           |          |                              |                              |           |                              |                              |                                 |       |
| 6.  |              |           |          |                              |                              |           |                              |                              |                                 |       |
| 7.  |              |           |          |                              |                              |           |                              |                              |                                 |       |

\* Enter the marks from the Table of the mentioned numbers - Guidelines for soil description, FAO, 2006.

| No. | 45. Coatings |          |       |       |          | 46. Cementation/Compaction |            |                 |              |
|-----|--------------|----------|-------|-------|----------|----------------------------|------------|-----------------|--------------|
|     | Occurrence   | Contrast | Type  | Form  | Location | Degree                     | Continuity | Layer structure | Layer nature |
|     | A. *64       | B. *65   | C *66 | D *67 | E *68    | A *72                      | B *69      | C *70           | D *71        |
| 1.  |              |          |       |       |          |                            |            |                 |              |
| 2.  |              |          |       |       |          |                            |            |                 |              |
| 3.  |              |          |       |       |          |                            |            |                 |              |
| 4.  |              |          |       |       |          |                            |            |                 |              |
| 5.  |              |          |       |       |          |                            |            |                 |              |
| 6.  |              |          |       |       |          |                            |            |                 |              |
| 7.  |              |          |       |       |          |                            |            |                 |              |

\* Enter the marks from the Table of the mentioned numbers - Guidelines for soil description, FAO, 2006.

| No. | 47. Concentration of minerals |       |       |       |          |        |        |
|-----|-------------------------------|-------|-------|-------|----------|--------|--------|
|     | Occurrence                    | Type  | Form  | Size  | Hardness | Nature | Colour |
|     | A. *73                        | B *74 | C *75 | D *75 | E *76    | F *77  | G *78  |
| 1.  |                               |       |       |       |          |        |        |
| 2.  |                               |       |       |       |          |        |        |
| 3.  |                               |       |       |       |          |        |        |
| 4.  |                               |       |       |       |          |        |        |
| 5.  |                               |       |       |       |          |        |        |
| 6.  |                               |       |       |       |          |        |        |
| 7.  |                               |       |       |       |          |        |        |

\* Enter the marks from the Table of the mentioned numbers - Guidelines for soil description, FAO, 2006.

| No. | 48. Soil odour<br>*45 | 49. Human-transported material<br>*85 | 50. Artefacts |       |       |          |            |        |
|-----|-----------------------|---------------------------------------|---------------|-------|-------|----------|------------|--------|
|     |                       |                                       | Occurrence    | Type  | Size  | Hardness | Weathering | Colour |
|     |                       |                                       | A *26         | B *83 | C *27 | D *76    | E *29      | F *78  |
| 1.  |                       |                                       |               |       |       |          |            |        |
| 2.  |                       |                                       |               |       |       |          |            |        |
| 3.  |                       |                                       |               |       |       |          |            |        |
| 4.  |                       |                                       |               |       |       |          |            |        |
| 5.  |                       |                                       |               |       |       |          |            |        |
| 6.  |                       |                                       |               |       |       |          |            |        |
| 7.  |                       |                                       |               |       |       |          |            |        |

\* Enter the marks from the Table of the mentioned numbers - Guidelines for soil description, FAO, 2006.



| FORM FOR DESCRIPTION OF AGRICULTURAL SOIL MONITORING STATION - P1 |                             |     |                              |
|-------------------------------------------------------------------|-----------------------------|-----|------------------------------|
| V. Photographic documentation                                     |                             |     |                              |
| 51.                                                               | Photographs of the profiles | 52. | Photographs of the landscape |
|                                                                   |                             |     |                              |
|                                                                   |                             |     |                              |

### 3.3.3. Sampling of single samples and forming of composite samples

Sampling of single soil samples is made pursuant to standards ISO 10381-2: 2002 - *Soil quality - Sampling - Part 2: Guidance on sampling techniques* and ISO 10381-4: 2003 - *Soil quality - Sampling - Part 4: Guidance on the procedure for investigation of natural, near-natural and cultivated sites*.

The single sampling of station's points is made in the period between 15 July to 15 October (depending on the culture), by a pedological (Holland) probe from three depths determined in the profile, except in pasture, where samples are taken from the depths of 0-10, 10-20 and 20-30 cm, independently of borders of genetic horizons. When conducting vertical probe sampling, the soil from the probe is sorted from the surface to the deepest layer, on a clean surface with a measurement tape, which ensures a precise sampling by depth ( Figure 3 and 4).



Figure 3. and 4. Soil sampling by probe

The soil samples are stored into bags indicating the number of station, number of single sample, depth of sampling and label for which type of analysis it was taken. Part of each sample (it includes its entire depth) is stored to separate bag for composite sampling. The number of the station, depth of sampling and the label for which type of analysis it was taken are indicated on the bag.

All gathered data during description of habitat and profile of the station are entered in the **Forms for sampling of agricultural soil monitoring station - P2; I. General data, and II. Surface soil properties** – are filled every three years and stored in the station’s filing folder, together with the **Form for description of stations for monitoring agricultural soils P1.**

| FORM FOR SAMPLING OF AGRICULTURAL SOILS MONITORING STATION - P2                                         |                                                           |    |                                 |  |  |
|---------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|----|---------------------------------|--|--|
| I. General data                                                                                         |                                                           |    |                                 |  |  |
| 1.                                                                                                      | Station identification number                             |    |                                 |  |  |
| 2.                                                                                                      | Time of sampling                                          | 4. | Data on the owner of the parcel |  |  |
| A                                                                                                       | Date                                                      | A  | Name                            |  |  |
| B                                                                                                       | Time                                                      | B  | Address                         |  |  |
| 3.                                                                                                      | Data on the manager                                       | C  | Place                           |  |  |
| A                                                                                                       | Full name                                                 | D  | Contact person                  |  |  |
| B                                                                                                       | Institution                                               | E  | Telephone                       |  |  |
| C                                                                                                       | Telephone                                                 | 5. | Whether conditions              |  |  |
| A *2                                                                                                    | Current weather conditions                                |    |                                 |  |  |
| B *2                                                                                                    | Past weather conditions                                   |    |                                 |  |  |
| 6.                                                                                                      | Mode of use                                               |    |                                 |  |  |
| A *8                                                                                                    | Mode of use                                               |    |                                 |  |  |
| B *9                                                                                                    | Dominant cultures                                         |    |                                 |  |  |
| C                                                                                                       | Crops                                                     |    |                                 |  |  |
| D                                                                                                       | Mode of treatment                                         |    |                                 |  |  |
| 7.                                                                                                      | Inputs into soil                                          |    |                                 |  |  |
| A                                                                                                       | Fertilisation N (kg/annual growth ring)                   |    |                                 |  |  |
| B                                                                                                       | Fertilisation P (kg/annual growth ring)                   |    |                                 |  |  |
| C                                                                                                       | Fertilisation K (kg/annual growth ring)                   |    |                                 |  |  |
| D                                                                                                       | Type of organic fertilization                             |    |                                 |  |  |
| E                                                                                                       | Quantity of organic fertilisation (kg/annual growth ring) |    |                                 |  |  |
| F                                                                                                       | Type of soil enhancer                                     |    |                                 |  |  |
| G                                                                                                       | Quantity of enhancers (kg/annual growth ring)             |    |                                 |  |  |
| H                                                                                                       | Type of protective agent                                  |    |                                 |  |  |
| I                                                                                                       | Quantity of active matter (l/annual growth ring)          |    |                                 |  |  |
| * Enter the marks from the Table of the mentioned numbers - Guidelines for soil description, FAO, 2006. |                                                           |    |                                 |  |  |





| FORM FOR SAMPLING OF AGRICULTURAL SOILS MONITORING STATION - P2                                    |                                   |                        |  |            |                       |                         |  |
|----------------------------------------------------------------------------------------------------|-----------------------------------|------------------------|--|------------|-----------------------|-------------------------|--|
| II. Surface soil properties                                                                        |                                   |                        |  |            |                       |                         |  |
| <b>8.</b>                                                                                          | <b>Rockiness</b>                  |                        |  | <b>12.</b> | <b>Erosion</b>        |                         |  |
| A                                                                                                  | *14                               | Percentage of surface  |  | A          | *16                   | Nature of erosion       |  |
| B                                                                                                  | *14                               | Distance between rocks |  | B          | *17                   | Percentage of surface   |  |
| C                                                                                                  |                                   | Size of rocks          |  | C          | *18                   | Degree of erosion       |  |
| <b>9.</b>                                                                                          | <b>Gravelness</b>                 |                        |  | D          | *19                   | Activity of erosion     |  |
| A                                                                                                  | *15                               | Percentage of surface  |  | <b>13.</b> | <b>Surface crust</b>  |                         |  |
| B                                                                                                  | *15                               | Diameter of fragments  |  | A          | *20                   | Thickness               |  |
| <b>10.</b>                                                                                         | <b>Surface salt efflorescence</b> |                        |  | B          | *20                   | Hardness                |  |
| A                                                                                                  | *22                               | Percentage of surface  |  | <b>14.</b> | <b>Surface cracks</b> |                         |  |
| B                                                                                                  | *22                               | Thickness of layer     |  | A          | *21                   | Average width           |  |
| C                                                                                                  |                                   | Type of salt           |  | B          | *21                   | Average depth           |  |
| <b>11.</b>                                                                                         | <b>Faded sand on the surface</b>  |                        |  | C          | *21                   | Average mutual distance |  |
| A                                                                                                  | *23                               | Percentage of surface  |  |            |                       |                         |  |
| * Enter the marks from the Table of the said numbers - Guidelines for soil description, FAO, 2006. |                                   |                        |  |            |                       |                         |  |

### 3.3.4. Preparation of samples for analysis and storage of samples

Preparation of samples for analysis is conducted pursuant to the standard HRN ISO 11464:2004 - *Soil quality - Pre-treatment of samples for physical and chemical analyses*.

All samples taken in disturbed condition (except for those taken for analysis of available nitrogen) are stored in a storage room for soil samples in the period of six years after sampling, pursuant to the standard ISO/DIS 18512:2006 - *Soil quality – Guidance on long and short term storage of soil samples*.

### 3.3.5. Time dynamics of sampling

Dynamics of the monitoring stations establishment is also adjusted to agricultural sub-regions, so that data from one sub-region may make a logical entirety. During the first operational year of the Soil Monitoring System, stations of sub-regions P2, P4, G1 and J2 shall be established; during the second year, stations P1, G2 and J3 shall be established, and during the third year, stations P3 and J1 shall be established. Thereby, within three years, the data base for monitoring the entire territory of the Republic of Croatia is filled. The fourth, fifth and sixth year, parameters monitored every three years are elaborated in the same order of sub-regions, and the seventh, eighth and ninth year, parameters monitored every six years are elaborated. After nine years, the first monitoring cycle is completed.

### 3.4. List of parameters for physical, chemical and microbiological soil analysis

Parameters for chemical, physical and microbiological analysis presented in tables 3, 4 and 5 shall be tested at all monitoring stations during the first year of monitoring, and every third year, i.e. every sixth year (except for analysis of drainage water which is conducted only on the Level I stations, every year). Specially marked are parameters which shall be monitored only the first year (and every 24 year) of monitoring (when opening the profile), and the depths at which other parameters are monitored when sampling single points. Ecologic or effective depth of sampling is determined on field and represents the depth of physiologically active profile in which plant roots finds water, oxygen and needed elements.

In case of extreme differences in the monitoring results of a particular process (large spatial variabilities) at one monitoring station, the number of samples at the area of the stations increases in such a way so that each point makes one sample, and the number of parameters by which the process is monitored increases. The need to increase the number of samples and the type of additional parameters is estimated separately for every such extreme case upon its occurrence.

Samples for microbiological analysis for agricultural soil monitoring are taken from all depths of profiles and from the composite sample of plot.

For the analyses of the persistent organic pollutants in the soil, only one composite sample is taken when stations are established, and PAH and PCB are analysed every 9 years if they first values are insignificant (organochlorine pesticides and triazine herbicides are analysed every third year).

**Table 3. Physical parameters**

| Parameters                                      | Methods used in the Republic of Croatia | Recommended ISO standard | Station Level                                   | Time dynamics | Measuring depth  |
|-------------------------------------------------|-----------------------------------------|--------------------------|-------------------------------------------------|---------------|------------------|
| Particle size distribution                      | International A and B method            | HRN ISO 11277:2004       | P1, P2                                          | 1/24          | All layers       |
| Bulk density                                    | Kopeck rings                            | HRN ISO 11272:2004       | P1, P2                                          | 1/24          | Ecological depth |
| Maximum water capacity, pF 0                    | By Kopecki – gravimetric                | HRN ISO 11274:2004       | P1, P2                                          | 1/24          | Ecological depth |
| Water capacity, pF 2,5                          | Pressure plate extractor                | HRN ISO 11274:2004       | P1, P2                                          | 1/24          | Ecological depth |
| Wilting point, pF 4,2                           | Pressure plate extractor                | HRN ISO 11274:2004       | P1, P2                                          | 1/24          | Ecological depth |
| Physiological active and easily available water | Pressure plate extractor                | HRN ISO 11274:2004       | P1, P2                                          | 1/24          | Ecological depth |
| Particle density, porosity                      | Pyknometar, calculation                 | HRN ISO 11508:2004       | P1, P2                                          | 1/24          | Ecological depth |
| Water capacity                                  | By Kopecki – gravimetric                | HRN ISO 11465:2004       | P1, P2                                          | 1/24          | Ecological depth |
| Air capacity                                    | Calculation                             | HRN ISO 11465:2004       | P1, P2                                          | 1/24          | Ecological depth |
| Hydraulic conductivity                          | Serial determination – laboratory       | HRN ISO 17313:2004       | P1, P2                                          | 1/24          | Ecological depth |
| Stability                                       | In water, calculation                   |                          | P1, P2                                          | 1/24          | Ecological depth |
| Compaction                                      | Penetrometer                            |                          | P1, P2, T                                       | 1/3           | Ecological depth |
| L1 – Level I stations                           | L2 - Level II stations                  |                          | T - Monitoring points according to the scheme 1 |               |                  |



**Table 4. Chemical parameters**

| Parameters                                                                               | Methods used in the Republic of Croatia                               | Recommended ISO standard                                                              | Station Level | Time dynamics                                   | Measuring depth  |
|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------|-------------------------------------------------|------------------|
| Determination of pH                                                                      | Electrometric                                                         | HRN ISO 10390:2005                                                                    | L1, L2, T     | 1/3                                             | All layers       |
| Carbonate content                                                                        | Scheibler calcimeter – volumetric                                     | HRN ISO 10693:2004                                                                    | L1, L2, T     | 1/3                                             | All layers       |
| Exchangeable acidity, y1                                                                 | Modified method by Kappen                                             | ISO 14254: 2001                                                                       | L1, L2, T     | 1/3                                             | Ecological depth |
| KIK (CEC, Ca <sup>2+</sup> , Mg <sup>2+</sup> , Na <sup>+</sup> , K <sup>+</sup> )       | Amon-acetate method (pH=7)                                            | HRN ISO 11260:2005<br>HRN ISO 13536:2005                                              | L1, L2, T     | 1/6                                             | Ecological depth |
| Total carbon                                                                             | Bicromat method,<br>Tjurin method<br>Determination by Walkley-Black   | HRN ISO 10694:2004<br>HRN ISO 14235:2004                                              | L1, L2, T     | 1/3                                             | Ecological depth |
| Total nitrogen                                                                           | Modified method by Kjeldahl                                           | HRN ISO 11261:2004<br>HRN ISO 13878:2004                                              | L1, L2, T     | 1/3                                             | Ecological depth |
| Total sulphur                                                                            | Dry combustion                                                        | HRN ISO 15178:2005                                                                    | L1, L2, T     | 1/3                                             | Ecological depth |
| Nitrate nitrogen                                                                         | Zn method                                                             | HRN ISO 14255:2004                                                                    | L1, L2, T     | 1/3                                             | All layers       |
| Plant available phosphorus and potassium                                                 | AL-method,<br>Method by Olsen,<br>Method by Troug                     | ISO 19730:2008                                                                        | L1, L2, T     | 1/3                                             | Arable layer     |
| Trace metals soluble in aqua regia and EDTA                                              | In aqua regia, AAS<br>Modified method by Lakanen-Ervio,<br>DTPA, EDTA | HRN ISO 11047:2004<br>HRN ISO 11466:2004<br>HRN ISO 14870:2001                        | L1, L2, T     | 1/3                                             | Arable layer     |
| Electrical conductivity                                                                  | Electrometric                                                         | HRN ISO 11265:2004                                                                    | L1, L2, T     | 1/6                                             | All layers       |
| Drainage water quality (pH, EC, ions)                                                    | Electrometric,                                                        | HRN ISO 10523:1998<br>HRN ISO 7888:2001<br>HRN ISO 10304-1:1998<br>HRN ISO 14911:2001 | L1            | 1/3                                             | Ecological depth |
| Persistent organic pollutants (PAH, PCB, triazine herbicides, organochlorine pesticides) | Ion chromatography                                                    | HRN ISO 11369:1997<br>HRN EN ISO 6468:1996                                            | L1, L2, T     | 1/3                                             | Arable layer     |
| L1 – Level I stations                                                                    |                                                                       | L2 - Level II stations                                                                |               | T - Monitoring points according to the scheme 1 |                  |

**Table 5. Microbiological parameters**

| Parameters                 | Methods used in the Republic of Croatia         | Recommended ISO standard | Station Level | Time dynamics                                   | Measuring depth |
|----------------------------|-------------------------------------------------|--------------------------|---------------|-------------------------------------------------|-----------------|
| Cellulolytic activity      | Celluloses test                                 | ISO 23753-1-2:2005       | L1, L2, T     | 1/3/24                                          | All layers      |
| Activity of dehydrogenase  | Method with triphenyl-tetrazolium chloride(TTC) | ISO 23753-1-2:2005       | L1, L2, T     | 1/3/24                                          | All layers      |
| CO <sub>2</sub> production | Method with iodine-tetrazolium chloride (INT)   | HRN ISO 14240-1:2004     | L1, L2, T     | 1/3/24                                          | All layers      |
| L1 – Level I stations      |                                                 | L2 - Level II stations   |               | T - Monitoring points according to the scheme 1 |                 |

Results of laboratory analysis are entered in **Forms for analysis of agricultural soil monitoring station – P3:**

**I. Physical parameters,**

**II. Chemical parameters,**

**III. Microbiological parameters.**

Forms for analysis are stored in filing folder, together with all other previously filled Forms for monitoring stations.

| FORM FOR ANALYSIS OF AGRICULTURAL SOIL MONITORING STATION– P3 |                                       |                         |                     |                                       |                        |                           |                           |                  |                                                  |                        |                           |                           |                  |
|---------------------------------------------------------------|---------------------------------------|-------------------------|---------------------|---------------------------------------|------------------------|---------------------------|---------------------------|------------------|--------------------------------------------------|------------------------|---------------------------|---------------------------|------------------|
| I. Physical parameters                                        |                                       |                         |                     |                                       |                        |                           |                           |                  |                                                  |                        |                           |                           |                  |
| Station identification number:                                |                                       |                         | Laboratory:         |                                       |                        | Analyst:                  |                           |                  | Date of analysis:                                |                        |                           |                           |                  |
| No.                                                           | Mark of horizon/<br>composite samples | Lower border of horizon | Content of skeleton | Particle size distribution (in water) |                        |                           |                           |                  | Particle size distribution (in Na-pyrophosphate) |                        |                           |                           |                  |
|                                                               |                                       | cm                      | %vol                | Large sand (2,0-0,2 mm)               | Small sand (0,2-0,063) | Large powder (0,063-0,02) | Small powder (0,02-0,002) | Clay (<0,002 mm) | Large sand (2,0-0,2 mm)                          | Small sand (0,2-0,063) | Large powder (0,063-0,02) | Small powder (0,02-0,002) | Clay (<0,002 mm) |
| 1.                                                            |                                       |                         |                     |                                       |                        |                           |                           |                  |                                                  |                        |                           |                           |                  |
| 2.                                                            |                                       |                         |                     |                                       |                        |                           |                           |                  |                                                  |                        |                           |                           |                  |
| 3.                                                            |                                       |                         |                     |                                       |                        |                           |                           |                  |                                                  |                        |                           |                           |                  |
| 4.                                                            |                                       |                         |                     |                                       |                        |                           |                           |                  |                                                  |                        |                           |                           |                  |
| 5.                                                            |                                       |                         |                     |                                       |                        |                           |                           |                  |                                                  |                        |                           |                           |                  |
| 6.                                                            |                                       |                         |                     |                                       |                        |                           |                           |                  |                                                  |                        |                           |                           |                  |
| 7.                                                            |                                       |                         |                     |                                       |                        |                           |                           |                  |                                                  |                        |                           |                           |                  |

| No. | Textural mark | Bulk              |          | Total porosity | Soil capacity |        |    | Water constants |    |     |    | Stability of structural aggregates |       | Porosity (labor.) | Compaction (dig. penetr.) |
|-----|---------------|-------------------|----------|----------------|---------------|--------|----|-----------------|----|-----|----|------------------------------------|-------|-------------------|---------------------------|
|     |               | $\rho_v$          | $\rho_c$ |                | Max Kv        | Ret.Kv | Kz | Kv              | Tv | Fav | Lv | micro                              | macro |                   |                           |
|     |               | g/cm <sup>3</sup> |          | %vol           | %vol          |        |    | % mas           |    |     |    | %                                  |       | m/day             | MPa                       |
| 1.  |               |                   |          |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |
| 2.  |               |                   |          |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |
| 3.  |               |                   |          |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |
| 4.  |               |                   |          |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |
| 5.  |               |                   |          |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |
| 6.  |               |                   |          |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |
| 7.  |               |                   |          |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |



**FORM FOR ANALYSIS OF AGRICULTURAL SOIL MONITORING STATION- P3**  
**II. Chemical parameters**

| No.                   | Standard chemical properties |     |                   |                   |                    |      |       |   | Capacity of exchangeable cations |            |     |                  |                  |                 |                |
|-----------------------|------------------------------|-----|-------------------|-------------------|--------------------|------|-------|---|----------------------------------|------------|-----|------------------|------------------|-----------------|----------------|
|                       | pH of soil in                |     |                   | CaCO <sub>3</sub> | Hydrolytic acidity | EC   | N     | C | S                                | H          | KIK | Ca <sup>2+</sup> | Mg <sup>2+</sup> | Na <sup>+</sup> | K <sup>+</sup> |
|                       | H <sub>2</sub> O             | KCl | CaCl <sub>2</sub> | %                 | mmol/100g          | mS/m | mg/kg |   |                                  | mmol/100 g |     |                  |                  |                 |                |
| 1.                    |                              |     |                   |                   |                    |      |       |   |                                  |            |     |                  |                  |                 |                |
| 2.                    |                              |     |                   |                   |                    |      |       |   |                                  |            |     |                  |                  |                 |                |
| 3.                    |                              |     |                   |                   |                    |      |       |   |                                  |            |     |                  |                  |                 |                |
| 4.                    |                              |     |                   |                   |                    |      |       |   |                                  |            |     |                  |                  |                 |                |
| 5.                    |                              |     |                   |                   |                    |      |       |   |                                  |            |     |                  |                  |                 |                |
| 6.                    |                              |     |                   |                   |                    |      |       |   |                                  |            |     |                  |                  |                 |                |
| 7.                    |                              |     |                   |                   |                    |      |       |   |                                  |            |     |                  |                  |                 |                |
| Method/<br>ISO stand. |                              |     |                   |                   |                    |      |       |   |                                  |            |     |                  |                  |                 |                |

| No.                   | Accessible nutrients in the soil |                  |                    |                    |       |       |    |    |   |    |
|-----------------------|----------------------------------|------------------|--------------------|--------------------|-------|-------|----|----|---|----|
|                       | P <sub>2</sub> O <sub>5</sub>    | K <sub>2</sub> O | NO <sub>3</sub> -N | NO <sub>3</sub> -N | vlaga | Fe    | Cu | Zn | S | Mn |
|                       | mg/100 g                         |                  | mg/100 g           | kg/ha              | %     | mg/kg |    |    |   |    |
| 1.                    |                                  |                  |                    |                    |       |       |    |    |   |    |
| 2.                    |                                  |                  |                    |                    |       |       |    |    |   |    |
| 3.                    |                                  |                  |                    |                    |       |       |    |    |   |    |
| 4.                    |                                  |                  |                    |                    |       |       |    |    |   |    |
| 5.                    |                                  |                  |                    |                    |       |       |    |    |   |    |
| 6.                    |                                  |                  |                    |                    |       |       |    |    |   |    |
| 7.                    |                                  |                  |                    |                    |       |       |    |    |   |    |
| Method/<br>ISO stand. |                                  |                  |                    |                    |       |       |    |    |   |    |

| No.                   | Total heavy metals and potentially toxic elements |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
|-----------------------|---------------------------------------------------|----|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|
|                       | Fe                                                | Al | As | B | Cd | Co | Cr | Cu | Hg | Mn | Mo | Ni | Pb | Se | Sn | Sr | Zn |
|                       | mg/kg                                             |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 1.                    |                                                   |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 2.                    |                                                   |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 3.                    |                                                   |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 4.                    |                                                   |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 5.                    |                                                   |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 6.                    |                                                   |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 7.                    |                                                   |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Method/<br>ISO stand. |                                                   |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |



| Accessible heavy metals and potentially toxic elements |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
|--------------------------------------------------------|-------|----|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|
| No.                                                    | Fe    | Al | As | B | Cd | Co | Cr | Cu | Hg | Mn | Mo | Ni | Pb | Se | Sn | Sr | Zn |
|                                                        | mg/kg |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 1.                                                     |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 2.                                                     |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 3.                                                     |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 4.                                                     |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 5.                                                     |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 6.                                                     |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 7.                                                     |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Method/<br>ISO stand.                                  |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |

| Persistent organic pollutants (1) - Polycyclic aromatic hydrocarbons (PAH) |           |            |              |             |          |              |             |              |        |     |         |     |     |     |      |       |      |
|----------------------------------------------------------------------------|-----------|------------|--------------|-------------|----------|--------------|-------------|--------------|--------|-----|---------|-----|-----|-----|------|-------|------|
| No.                                                                        | Total PAH | Naphtalene | Acen-afilene | Acen-aftene | Fluorene | Phen-antrene | Anthra-cene | Fluor-antene | Pyrene | BaA | Krysene | BbF | BkF | BaP | DahA | BghiP | IcdP |
|                                                                            | mg/kg     |            |              |             |          |              |             |              |        |     |         |     |     |     |      |       |      |
| 1.                                                                         |           |            |              |             |          |              |             |              |        |     |         |     |     |     |      |       |      |
| 2.                                                                         |           |            |              |             |          |              |             |              |        |     |         |     |     |     |      |       |      |
| 3.                                                                         |           |            |              |             |          |              |             |              |        |     |         |     |     |     |      |       |      |
| 4.                                                                         |           |            |              |             |          |              |             |              |        |     |         |     |     |     |      |       |      |
| 5.                                                                         |           |            |              |             |          |              |             |              |        |     |         |     |     |     |      |       |      |
| 6.                                                                         |           |            |              |             |          |              |             |              |        |     |         |     |     |     |      |       |      |
| 7.                                                                         |           |            |              |             |          |              |             |              |        |     |         |     |     |     |      |       |      |
| Method/<br>ISO stand.                                                      |           |            |              |             |          |              |             |              |        |     |         |     |     |     |      |       |      |

| Persistent organic pollutants (2) - Organochlorinated pesticides (OCP) |       |     |         |               |         |           |         |                     |                |
|------------------------------------------------------------------------|-------|-----|---------|---------------|---------|-----------|---------|---------------------|----------------|
| No.                                                                    | HCH   | HCB | Lindane | Heptachlorine | Aldrine | Ideldrine | Endrine | DDT and derivatives | Metosychlorine |
|                                                                        | ng/kg |     |         |               |         |           |         |                     |                |
| 1.                                                                     |       |     |         |               |         |           |         |                     |                |
| 2.                                                                     |       |     |         |               |         |           |         |                     |                |
| 3.                                                                     |       |     |         |               |         |           |         |                     |                |
| 4.                                                                     |       |     |         |               |         |           |         |                     |                |
| 5.                                                                     |       |     |         |               |         |           |         |                     |                |
| 6.                                                                     |       |     |         |               |         |           |         |                     |                |
| 7.                                                                     |       |     |         |               |         |           |         |                     |                |
| Method/<br>ISO stand.                                                  |       |     |         |               |         |           |         |                     |                |



| Persistent organic pollutants (3) - Polychlorinated biphenyls (PCB) |           |        |        |         |         |         |         |         |         |
|---------------------------------------------------------------------|-----------|--------|--------|---------|---------|---------|---------|---------|---------|
| No.                                                                 | Total PCB | PCB 28 | PCB 52 | PCB 101 | PCB 102 | PCB 118 | PCB 138 | PCB 153 | PCB 180 |
|                                                                     | mg/kg     |        |        |         |         |         |         |         |         |
| 1.                                                                  |           |        |        |         |         |         |         |         |         |
| 2.                                                                  |           |        |        |         |         |         |         |         |         |
| 3.                                                                  |           |        |        |         |         |         |         |         |         |
| 4.                                                                  |           |        |        |         |         |         |         |         |         |
| 5.                                                                  |           |        |        |         |         |         |         |         |         |
| 6.                                                                  |           |        |        |         |         |         |         |         |         |
| 7.                                                                  |           |        |        |         |         |         |         |         |         |
| Method/<br>ISO stand.                                               |           |        |        |         |         |         |         |         |         |

| Persistent organic pollutants (4) - Triazine herbicides |                  |                       |          |          |           |                 |           |               |            |            |            |
|---------------------------------------------------------|------------------|-----------------------|----------|----------|-----------|-----------------|-----------|---------------|------------|------------|------------|
| No.                                                     | Desetil-atrazine | Deseizopro-palatraine | Atrazine | Simazine | Cianazine | Sebutil-anazine | Propazine | Terbutilazine | Prometrine | Terbutrine | Metamitron |
|                                                         | ng/kg            |                       |          |          |           |                 |           |               |            |            |            |
| 1.                                                      |                  |                       |          |          |           |                 |           |               |            |            |            |
| 2.                                                      |                  |                       |          |          |           |                 |           |               |            |            |            |
| 3.                                                      |                  |                       |          |          |           |                 |           |               |            |            |            |
| 4.                                                      |                  |                       |          |          |           |                 |           |               |            |            |            |
| 5.                                                      |                  |                       |          |          |           |                 |           |               |            |            |            |
| 6.                                                      |                  |                       |          |          |           |                 |           |               |            |            |            |
| 7.                                                      |                  |                       |          |          |           |                 |           |               |            |            |            |
| Method/<br>ISO stand.                                   |                  |                       |          |          |           |                 |           |               |            |            |            |

| Chemical composition of drainage water |    |             |                  |                  |                 |                |                 |                              |                |                   |                              |                              |                 |                               |                                             |                                              |
|----------------------------------------|----|-------------|------------------|------------------|-----------------|----------------|-----------------|------------------------------|----------------|-------------------|------------------------------|------------------------------|-----------------|-------------------------------|---------------------------------------------|----------------------------------------------|
| Lysimeter:                             |    | Laboratory: |                  |                  |                 | Analyst:       |                 |                              |                | Date of analysis: |                              |                              |                 |                               |                                             |                                              |
| No.                                    | pH | EC          | Cations          |                  |                 |                |                 |                              | Anions         |                   |                              |                              |                 |                               |                                             |                                              |
|                                        |    |             | Ca <sup>2+</sup> | Mg <sup>2+</sup> | Na <sup>+</sup> | K <sup>+</sup> | Li <sup>+</sup> | NH <sub>4</sub> <sup>+</sup> | F <sup>-</sup> | Cl <sup>-</sup>   | NO <sub>3</sub> <sup>-</sup> | NO <sub>2</sub> <sup>-</sup> | Br <sup>-</sup> | SO <sub>4</sub> <sup>2-</sup> | H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> | H <sub>2</sub> PO <sub>4</sub> <sup>2-</sup> |
|                                        |    | mS/m        | mg/L             |                  |                 |                |                 |                              | mg/L           |                   |                              |                              |                 |                               |                                             |                                              |
| 1.                                     |    |             |                  |                  |                 |                |                 |                              |                |                   |                              |                              |                 |                               |                                             |                                              |
| 2.                                     |    |             |                  |                  |                 |                |                 |                              |                |                   |                              |                              |                 |                               |                                             |                                              |
| Method/<br>ISO stand.                  |    |             |                  |                  |                 |                |                 |                              |                |                   |                              |                              |                 |                               |                                             |                                              |

| FORM FOR ANALYSIS OF AGRICULTURAL SOIL MONITORING STATION- P3<br>III Microbiological parameters |                       |          |                           |                   |                            |  |
|-------------------------------------------------------------------------------------------------|-----------------------|----------|---------------------------|-------------------|----------------------------|--|
| Laboratory:                                                                                     |                       | Analyst: |                           | Date of analysis: |                            |  |
| No.                                                                                             | Cellulolytic activity |          | Activity of dehydrogenase |                   | CO <sub>2</sub> production |  |
|                                                                                                 | Mg glu/g tla          |          | Mmol/100g                 |                   | ugTPF/g tla                |  |
| 1.                                                                                              |                       |          |                           |                   |                            |  |
| 2.                                                                                              |                       |          |                           |                   |                            |  |
| 3.                                                                                              |                       |          |                           |                   |                            |  |
| 4.                                                                                              |                       |          |                           |                   |                            |  |
| 5.                                                                                              |                       |          |                           |                   |                            |  |
| Method/<br>ISO stand.                                                                           |                       |          |                           |                   |                            |  |

## 3.5. Institutional framework and obligations for implementation of the Agricultural Soil Monitoring System

### 3.5.1. Proposal of Referent Centre and authorised institutions for System implementation

Nomination of the Referent Centre for agricultural soils monitoring in Croatia is defined by Article 123 of the Environmental Protection Act (OG 110/07).

When recognising potential institution which is to conduct activities of Referent Centre for implementation of agricultural soil monitoring, the existing legislation was primarily considered.

- Agricultural Land Act (OG 66/01, 87/02, 90/05):

- Article 4: *„In order to protect agricultural land from pollution, testing and monitoring of the condition of contamination of agricultural land by noxious substances is being conducted which includes:*

1. *determination of the condition of pollution of agricultural land (inventarisation),*
2. *monitoring of the condition of agricultural land by which the condition of all changes in agricultural land (physical, chemical and biological) is being monitored, and notably the content of noxious substances in agricultural land.*
3. *establishment of information system of contaminated agricultural land.*

*The activities from paragraph 1 of this Article are conducted by the public institution, the Soil Institute (hereafter: Institute), founded by the Government of the Republic of Croatia.”*

- Agricultural Land Act (new draft, Ministry of Agriculture, Fisheries and Rural Development June 2008):

- Article 4: *„The Ministry in charge of agriculture (hereafter: Ministry), shall establish the Information System of Data on Agricultural Land in the Republic of Croatia (hereafter: Information System) with the view to more efficient management of agricultural land and monitoring of the agricultural land market.*

*The Information System is composed of the following subsystems:*

1. *Information subsystem on disposal of agricultural land owned by the state*
2. *Information subsystem on disposal of agricultural land owned by physical and legal persons*
3. *Information subsystem on maintenance and protection of agricultural land.”*

- Article 7: *„In order to protect agricultural land from contamination, testing and monitoring of the condition of contamination of agricultural land by noxious substances is being conducted which includes:*

1. *determination of the condition of contamination of agricultural land (inventarisation),*
2. *monitoring of the condition of agricultural land and all of its modifications (physical, chemical and biological), and notably the content of noxious substances in agricultural land.*

*The activities from paragraph 1 of this Article are conducted by a public institution, the Institute for Soil (hereafter: Institute).”*

Considering the existing legal regulations, it is proposed to assign the Institute for Soil, Osijek, as Referent Centre for monitoring agricultural soil in Croatia.

The Referent Centre conducts and ensures the implementation of all activities related to



agricultural soil monitoring in cooperation with scientific and expert institutions authorised for laboratory analysis of soil. The authorisation is based on resolution on accomplishment of prescribed conditions and issued by the Ministry of Agriculture, Fishery and Rural Development, at the proposal of the Institute for Soil.

### 3.5.2. Data flow and access to data

The Referent Centre delivers data on the agricultural soil condition to data users, pursuant to legal regulations:

- Croatian Environment Agency,
- Ministry of Environment Protection, Physical Planning and Construction, and
- Ministry of Agriculture, Fishery and Rural Development.

For the needs of the soil condition monitoring, the Croatian Environment Agency has elaborated the Database on Croatian soils which enables direct input of data through Internet interface and is the integral part of the Environmental Information System.

The Referent Centre is responsible for accuracy and quality of delivered data, and has to ensure control and input of data to the Database on Croatian soils within the Croatian Soil Information System (CROSIS) in Croatian Environment Agency and to the Information System for Contaminated Agricultural Land in the Institute for Soil.

The Referent Centre submits a written Report on the implementation of agricultural soil monitoring to the Croatian Environment Agency; the Ministry for Environment Protection, Physical Planning and Construction; the Ministry of Agriculture, Fishery and Rural Development at the latest by 30 June of the current year, for the previous year.

The Referent Centre for agricultural soil monitoring is to be obliged to coordinate its annual work plans to Croatian Environment Agency annual work plans.

The availability of results of the System to other potential users is regulated by the Regulation on Environmental Information System (OG 60/2008).

## 3.6. Structure and sources of financing the agricultural soil monitoring based on optimum number of stations

### 3.6.1. Specification of costs for establishing one station, and monitoring every 3 and 6 years

Table 6 presents total costs for establishment of the Level I and II stations, and for monitoring the third and sixth year after the establishment.

Stated prices of analyses are in accordance with the price lists of the Institute of Soil, Department of General Agronomy of the Faculty of Agriculture of the University of Zagreb and Institute for Public Health of the City of Zagreb.

**Table 6. Estimated costs of one agricultural soil monitoring station (establishment of station, monitoring 3rd and 6th year after the establishment)**

| Type of costs                            | Description                     | Unit price (HRK) | Establishment of stations |             | Monitoring 3 years after establishment |             | Monitoring 6 years after establishment |             |
|------------------------------------------|---------------------------------|------------------|---------------------------|-------------|----------------------------------------|-------------|----------------------------------------|-------------|
|                                          |                                 |                  | Quant.                    | Price (HRK) | Quant.                                 | Price (HRK) | Quant.                                 | Price (HRK) |
| Lysimetres for collecting drainage water | Supply                          | 30.000,00        | 1                         | 30.000,00   |                                        |             |                                        |             |
|                                          | Installation                    | 5.000,00         | 1                         | 5.000,00    |                                        |             |                                        |             |
|                                          | Maintenance                     | 2.000,00         | 1                         | 2.000,00    | 1                                      | 2.000,00    | 1                                      | 2.000,00    |
| Travel costs                             | Mileage                         | 2,00             | 500                       | 1.000,00    | 500                                    | 1.000,00    | 500                                    | 1.000,00    |
|                                          | Daily allowances                | 170,00           | 6                         | 1.020,00    | 3                                      | 510,00      | 3                                      | 510,00      |
| Field and office work                    | Field work                      | 53,70            | 72                        | 3.866,40    | 24                                     | 1.288,80    | 24                                     | 1.288,80    |
|                                          | Office work                     | 53,70            | 72                        | 3.866,40    | 24                                     | 1.288,80    | 24                                     | 1.288,80    |
|                                          | Soil profile treatment          | 400,00           | 1                         | 400,00      |                                        |             |                                        |             |
|                                          | Sampling                        | 20,00            | 30                        | 600,00      | 30                                     | 600,00      | 30                                     | 600,00      |
|                                          | Services of geodesist           | 1.000,00         | 1                         | 1.000,00    | 1                                      | 1.000,00    | 1                                      | 1.000,00    |
| Material costs                           | Work pads                       | 1.000,00         | 1                         | 1.000,00    | 1                                      | 1.000,00    | 1                                      | 1.000,00    |
|                                          | Consumable material             | 500,00           | 1                         | 500,00      | 1                                      | 500,00      | 1                                      | 500,00      |
| Preparation of samples                   |                                 | 25,00            | 50                        | 1.250,00    | 30                                     | 750,00      | 30                                     | 750,00      |
| Physical analyses of soil                | Particle size distribution      | 200,00           | 4                         | 800,00      |                                        |             |                                        |             |
|                                          | Bulk density of soil            | 80,00            | 2                         | 160,00      |                                        |             |                                        |             |
|                                          | Max. capacity of soil for water | 25,00            | 2                         | 50,00       |                                        |             |                                        |             |
|                                          | Capacity of soil for water      | 35,00            | 2                         | 70,00       |                                        |             |                                        |             |
|                                          | Wilting point                   | 25,00            | 2                         | 50,00       |                                        |             |                                        |             |
|                                          | Easily available water          | 50,00            | 2                         | 100,00      |                                        |             |                                        |             |
|                                          | Particle density/porosity       | 90,00            | 2                         | 180,00      |                                        |             |                                        |             |
|                                          | Water capacity                  | 40,00            | 2                         | 80,00       |                                        |             |                                        |             |
|                                          | Capacity of soil for air        | 0,00             | 2                         | 0,00        |                                        |             |                                        |             |
|                                          | Soil permeability for water     | 50,00            | 2                         | 100,00      |                                        |             |                                        |             |





|                                                              |                                                   |          |    |           |    |           |    |           |
|--------------------------------------------------------------|---------------------------------------------------|----------|----|-----------|----|-----------|----|-----------|
|                                                              | Structural aggregates stability                   | 75,00    | 2  | 150,00    |    |           |    |           |
|                                                              | Soil compaction                                   | 35,00    | 12 | 420,00    | 10 | 350,00    | 10 | 350,00    |
| <b>Chemical analysis of soil</b>                             | Soil acidity (pH)                                 | 36,00    | 20 | 720,00    | 15 | 540,00    | 15 | 540,00    |
|                                                              | Carbonate content                                 | 30,00    | 20 | 600,00    | 15 | 450,00    | 15 | 450,00    |
|                                                              | Exchangeable acidity                              | 30,00    | 12 | 360,00    | 10 | 300,00    | 10 | 300,00    |
|                                                              | Cation exchange capacity                          | 100,00   | 12 | 1.200,00  |    |           | 10 | 1.000,00  |
|                                                              | Nitrates                                          | 70,00    | 20 | 1.400,00  | 15 | 1.050,00  | 15 | 1.050,00  |
|                                                              | Plant available elements                          | 66,00    | 6  | 396,00    | 5  | 330,00    | 5  | 330,00    |
|                                                              | C,H,N,S analysis                                  | 270,00   | 12 | 3.240,00  | 10 | 2.700,00  | 10 | 2.700,00  |
|                                                              | Analysis of lysimeter water                       | 879,00   | 1  | 879,00    | 1  | 879,00    | 1  | 879,00    |
|                                                              | Total heavy metals and potentially toxic elements | 2.010,00 | 6  | 12.060,00 | 5  | 10.050,00 | 5  | 10.050,00 |
|                                                              | Electrical conductivity                           | 18,00    | 20 | 360,00    |    |           | 15 | 270,00    |
|                                                              | Persistent organic pollutants                     | 3.100,00 | 2  | 6.200,00  | 1  | 3.100,00  | 1  | 3.100,00  |
| <b>Microbiological soil analysis</b>                         | Cellulolytic activity                             | 320,00   | 6  | 1.920,00  | 6  | 1.920,00  | 6  | 1.920,00  |
|                                                              | Activity of dehydrogenasa                         | 320,00   | 6  | 1.920,00  | 6  | 1.920,00  | 6  | 1.920,00  |
|                                                              | CO <sub>2</sub> production                        | 320,00   | 6  | 1.920,00  | 6  | 1.920,00  | 6  | 1.920,00  |
| <b>Total costs of Level 2 station (without lysimeters)</b>   |                                                   |          |    | 49.958,80 |    | 32.567,60 |    | 33.837,60 |
| <b>Total costs of Level 1 station (including lysimeters)</b> |                                                   |          |    | 87.837,80 |    | 35.446,60 |    | 36.716,60 |

### 3.6.2. Specification of total costs for monitoring agricultural soils for the period of 9 years

The optimum number of stations planned by the Programme is 90, of which 9 Level I stations (one in each sub-region) and 81 Level II stations (allocated in relation to the ratio of agricultural areas of certain sub-regions).

Table 7 presents total costs for monitoring agricultural soils at 90 stations, for the period of 9 years, pursuant to the specification from Table 6.

#### 7. Costs for monitoring agricultural soils for the period of 9 years (optimum number of stations)

| Year of monitoring                                                            | Job description                               | Sub-regions    | Number of Level 1 and Level 2 stations | Cost of Level 1 station | Cost of Level 2 station | Total cost (HRK)     |
|-------------------------------------------------------------------------------|-----------------------------------------------|----------------|----------------------------------------|-------------------------|-------------------------|----------------------|
| Preparation                                                                   | Education of employees                        | Sve podregije  | -                                      | -                       | -                       | 200.000,00           |
| 1st year                                                                      | Establishment of Level 1 and Level 2 stations | P2, P4, G1, J2 | 4 / 26                                 | 87.837,80               | 49.958,80               | 1.650.280,00         |
| 2nd year                                                                      |                                               | P1, G2, J3     | 3 / 27                                 | 87.837,80               | 49.958,80               | 1.612.401,00         |
| 3rd year                                                                      |                                               |                | 2 / 28                                 | 87.837,80               | 49.958,80               | 1.574.522,00         |
| <b>Total costs for the establishment of stations</b>                          |                                               |                |                                        |                         |                         | <b>5.037.203,00</b>  |
| 4th year                                                                      | Monitoring the 3rd year after establishment   | P2, P4, G1, J2 | 4 / 26                                 | 35.446,60               | 32.567,60               | 988.544,00           |
| 5th year                                                                      |                                               | P1, G2, J3     | 3 / 27                                 | 35.446,60               | 32.567,60               | 985.665,00           |
| 6th year                                                                      |                                               | P3, J1         | 2 / 28                                 | 35.446,60               | 32.567,60               | 982.786,00           |
| <b>Total costs for monitoring 3 years after the establishment of stations</b> |                                               |                |                                        |                         |                         | <b>2.956.995,00</b>  |
| 7th year                                                                      | Monitoring the 6th year after establishment   | P2, P4, G1, J2 | 4 / 26                                 | 36.716,60               | 33.837,60               | 1.026.644,00         |
| 8th year                                                                      |                                               | P1, G2, J3     | 3 / 27                                 | 36.716,60               | 33.837,60               | 1.023.765,00         |
| 9th year                                                                      |                                               | P3, J1         | 2 / 28                                 | 36.716,60               | 33.837,60               | 1.020.886,00         |
| <b>Total costs for monitoring 6 years after the establishment of stations</b> |                                               |                |                                        |                         |                         | <b>3.071.295,00</b>  |
| <b>TOTAL COSTS for the 9 year monitoring cycle</b>                            |                                               |                | <b>9 / 81</b>                          |                         |                         | <b>11.065.493,00</b> |

Costs for the data input to the Data base on Croatian Soils (Environmental Information System) and the Information System for Contaminated Agricultural Land are included in the costs stated in Table 6 (Description: Office work).



### 3.6.3. Sources of financing Agricultural Soils Monitoring System

The financial funds for implementing the Croatian Agricultural Soil Monitoring System, the input of data, and the maintenance of the Information System for Contaminated Agricultural Land, pursuant to the Agricultural Land Act (OG 66/01, 87/02, 90/05, draft June 2008) , are ensured by the Institute for Soil from the State budget.

Financial funds for elaborating results of the System and the maintenance of the Croatian Soil Information System within the Environmental Information System, pursuant to the Regulation on the Environmental Information System (OG 68/08) , are provided by the Croatian Environment Agency from the State budget.

<sup>1</sup> „...3. establishment of the Information System for contaminated agricultural land.”

<sup>2</sup> „...ensures the elaboration and conducts a joint information-communication network of the Information System,...”



## II Croatian Forestry Soil Monitoring Programme

### 1. Introduction

The first systematic monitoring of forest ecosystems at the European Union level was established in 1985 within the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests, abbreviated ICP Forests Programme, established under the UN and EU Convention on Long-range Transboundary Air Pollution (CLRTAP)<sup>1</sup>.

One year later, the European Union adopted a draft programme for the protection of forests from atmosphere pollution and, by the Council Regulation (EEC) No. 3528/86, set a legal framework for financing such programme. By later Commission Regulations (EC) 1696/87, 926/93, 1091/94, 1390/97, 1545/99, precise regulations have been established for the application of the Regulations from 1986. By the Regulation No. 2152/03, adopted by the European Parliament and the Council of the European Union in 2003, modifications of earlier Regulations as to the financing of the Programme were established.

The main task of ICP Forests Programme is to gather data on the condition of forest and their reaction to stress factors at regional, national and international level. The key role in the Programme is survey of the damage of forest ecosystems through visual assessment of branch defoliation and the loss of colour of assimilation apparatus (leaves, needles).

<sup>1</sup>Convention on Long-range Transboundary Air Pollution (OG - International Treaties No. 12/93)





Croatia has been involved in the ICP Forests since 1987. The assessment is made on plots of bio-indication Network (16 x 16 km) that constitute the Level I monitoring Network. Only the assessment of the condition of branches (phenological monitoring and monitoring of branch defoliation) has been made at Level I Network monitoring plots in accordance with the ICP Manual. Data have been regularly forwarded to the European centre for gathering data within ICP Forests Programme.

Although regulated by ICP Manual, forestry soil monitoring has never been systematically conducted in Croatia, since there was no legal obligation.

During development of Forestry Soil Monitoring Programme (within *Project Development of the Croatian Soil Monitoring Programme with a Pilot project*) particular importance was given to adjustment of forestry soil monitoring categories and parameters to ICP Forests guidelines, to assure harmonized collection of forestry soil data, usable for reporting on environment condition.

Project tasks: development of *The Soil Monitoring Manual first edition/working version* (CEA, 2006.), selection of plots for intensive forestry soil monitoring and implementation of the Pilot project for forestry soil monitoring have been conducted by the Faculty of Forestry University of Zagreb in co-operation with the Forest Research Institute Jastrebarsko.

Forestry Soil Monitoring Programme is completely synchronized to the *Rulebook on the mode of data collection, network of points, keeping the register, conditions for using data on damage of forest ecosystems* (OG 129//06) which prescribes monitoring of forestry ecosystems pursuant to ICP Forests Programme. Procedures of soil monitoring in forestry ecosystems have been described in detail and Forms for data entering have been created, pursuant to ICP Forest Programme. Structure of Forestry soil monitoring Forms enables simple and compatible data input for Croatian Soil Information System - CROSIS.

The Programme also recommends the extension of present activities of Forestry Institute Jastrebarsko and intensive forestry soil monitoring at 30 selected plots with 5 years time dynamics, to assure quicker data collection and monitoring of forestry soil condition and early warning insight on eventual threats.

## 2. Overview of forestry soil monitoring in the Republic of Croatia and the existing regulations

The Forest Research Institute Jastrebarsko as the National Coordination Centre, Faculty of Forestry University of Zagreb and the company Croatian forests d.o.o. have been included in the implementation of the ICP Forests Programme in the Republic of Croatia since the very beginning. Monitoring of the condition of branches is conducted by employees of the company Croatian forests d.o.o. who are trained through courses each year.

At each plot of the Level I Network of plots, only a taxonomic soil affiliation has been determined, and phenological and other observations of the condition of trees are conducted regularly during the year. However, monitoring of soil parameters is not conducted. ICP Forests Programme also includes the Level II of monitoring which has been conducted in Croatia in adapted form, irregularly on several plots, owing exclusively to the enthusiasm of several scientists.

Within the project “*Development of the Croatian Soil Monitoring Programme with a Pilot Project*”, the *Soil Monitoring Manual - first edition/working version* (CEA, 2006) has been publicized, describing in detail categories and parameters for forestry soil monitoring. The recommended procedure for soil monitoring has been tested by the Pilot Project for forestry soil monitoring, in the period between December 2006 and February 2008. ICP Forests plot no. 98, of the Level I Network, was selected for implementation of the Pilot Project. This plot is situated near phosphor-gypsum landfill in economic unit Kutina forests, in Lonjsko field in County of Sisak and Moslavina.

The Pilot project included all segments of forestry soil monitoring: office preparation work, field work, laboratory analysis of soil and reporting. At the same time practicality and functionality of those segments were tested.

Since November 2006, the *Rulebook on the mode of data collection, network of points, keeping the register, conditions for using data on damage of forest ecosystems* (OG 129/06) has been in force. The Rulebook prescribes monitoring of forest ecosystems pursuant to the ICP Forests Programme.

The Forest Research Institute, Jastrebarsko has been assigned as the National Coordination Centre for the Assessment and Monitoring of Atmospheric Pollution and other factors to forest ecosystems (Article 3 of the Rulebook).

For the needs of monitoring and reporting on the damage of forest ecosystems to local and international authorities and institutions, the National Centre shall organise and keep a unique Register of damage of forest ecosystems in electronic form (Article 5, paragraph 1) within two years from the day of the entry into force of the Rulebook (Article 21).

The beginning of forest ecosystems monitoring and forestry soil monitoring, pursuant to the *Rulebook on the mode of data collection, network of points, keeping the register, conditions for using data on damage of forest ecosystems* (OG 129//06) is expected in 2010. Therefore, according to Forestry Soil Monitoring Programme, intensive forestry soil monitoring should begin in 2015.





## 3. Forestry Soil Monitoring Programme

### 3.1. Definition and description of forestry soil monitoring plots

In accordance to the ICP Forests Programme forestry soil monitoring is conducted on 16 x 16 km plots. Field positioning of plots was carried out according to topographic map. Plots were marked on field pursuant to ICP Manual and coordinates were taken from topographic map 1:25.000. Some of plots were in 5. and some in 6. zone of coordinate system. Because of such method some errors were made and therefore some plots differ from referred coordinates in dozens and some in hundreds of meters.

Despite that fact, existing phenological monitoring and monitoring of condition of branches that have been carried out on Level I Network does not allow displacement of placed plots, instead it is recommended to measure real space attributes of existing points. At the same time that will be the base point for establishing Level I Register at the National Centre.

In accordance to the ICP Forests Programme, at the territory of the Republic of Croatia, 148 bioindication plots have been generated at the theoretical network of 16 x 16 km plots. Many of these plots fall outside of forest surfaces, and by the establishment of the final network of plots, they have been excluded, while the remaining plots kept their initial numerical signs. Some of plots are located in forest areas which were occupied and mined during the Independence war, and for this reason, no monitoring of the condition of branches has been made on these plots, while some other plots were damaged in fires.

Pursuant to the above, monitoring of the condition of branches in the Republic of Croatia is conducted at 95 plots since the beginning of their establishment (figure 2, table 1).

It is evaluated that by the establishment of the Register, another 15-30 plots are to be set, so monitoring will be conducted at 110 - 125 plots of Level I Network.

#### 3.1.1. Description of forestry soil monitoring plot

Positions of plots (coordinates) in the field are specified by a high precision GPS device.

When establishing plots, a cross system of 24 trees per plot is being used: through intersection of coordinates, two mutually vertical chains, 25 m long, are drafted in the lines of main directions of the world, at whose ends six closest trees are marked (predominant, dominant and co-dominant trees) by numbers from 1 to 24. Dead trees are registered as dead trees and are replaced during the next evaluation of branches by the closes tree, regardless of species. The first replacement tree is marked by number 31, the next with number 32 etc. (figure 1).

Sampling points are small plots of 25x25 cm, laid in the way that they represent the entire plot of Level I Network. One point is located in each of 4 groups of marked trees, and the fifth in the central part of the plot. Samples are formed as composite samples from 5 single samples. Single samples of organic and mineral layer are taken on the same points, whose position is modified in each new sampling (it is shifted by 90 degrees clockwise).

Sampling points are located in the outer third of the projection of branches of predominant, dominant and co-dominant tree, and if it concerns younger development stages of regular stands, then they are located between young dominant trees. In each new sampling, a new position of points is drawn into the scheme of the monitoring plot, taking into account that the sampling does not take place at the same point in the next 25 years.

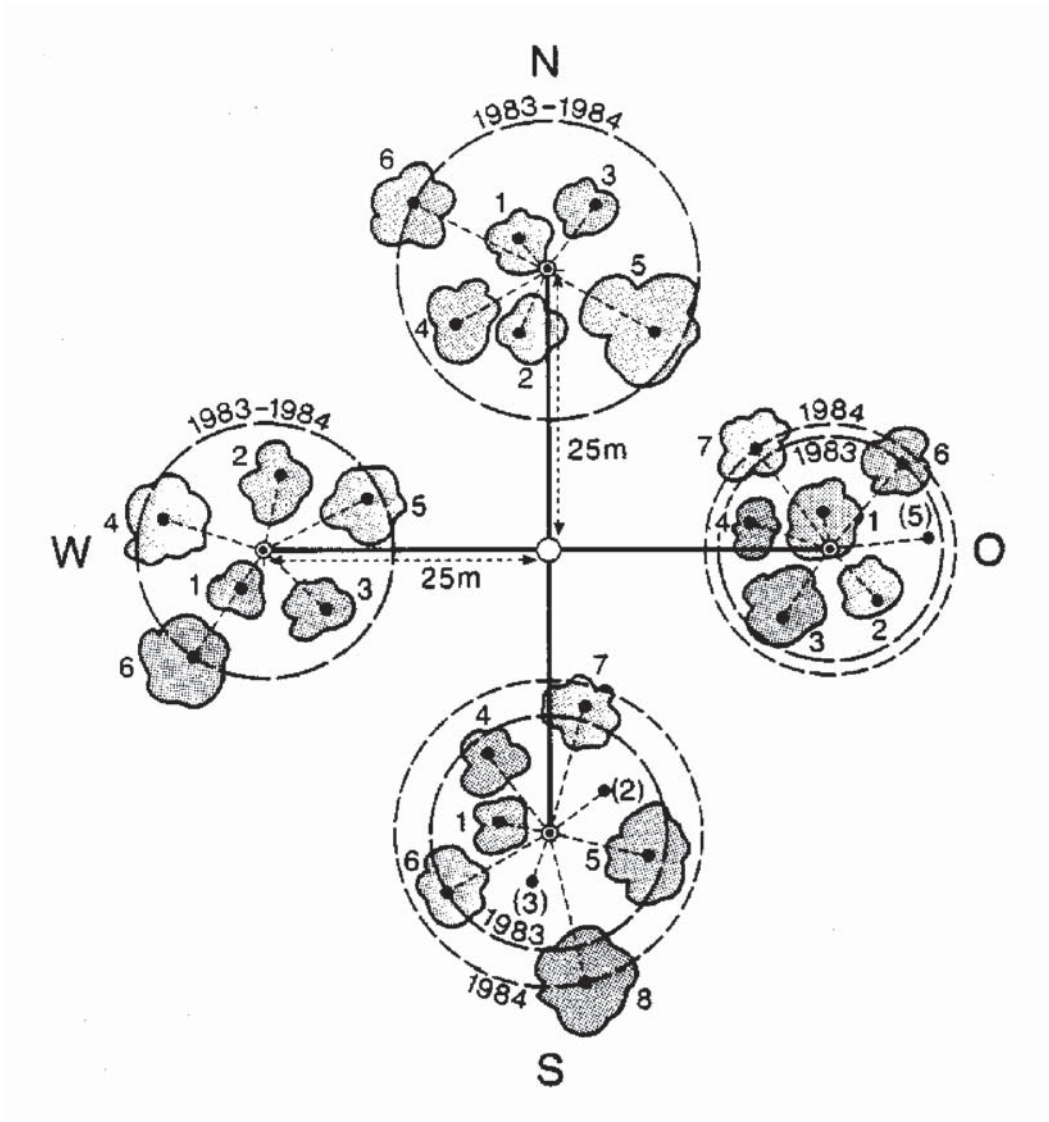


Figure 1. Ideal Scheme of monitoring plot with four groups of trees



## 3.2. Selection of plots for intensive forestry soil monitoring

Within monitoring of forest ecosystems specified by the *Rulebook on the mode of data collection, network of points, keeping the register, conditions for using data on damage of forest ecosystems (OG 129/06)*, it is foreseen to conduct monitoring of the soil condition at the Level I ICP Network every ten years (Article 8).

With the view to gathering data on the condition of forestry soil in a shorter time dynamics than foreseen ten years, the Project “Development of the Croatian Soil Monitoring Programme with a Pilot Project” has recommended intensive forestry soil monitoring at 30 selected plots (from the existing 95 plots) of the Level I Network, at which monitoring would be conducted every five years after the year in which a particular plot has been monitored pursuant to the *Rulebook*.

### 3.2.1. Overview of plots selection for intensive forestry soil monitoring

The 30 plots for intensive soil monitoring have been selected according to the following criteria:

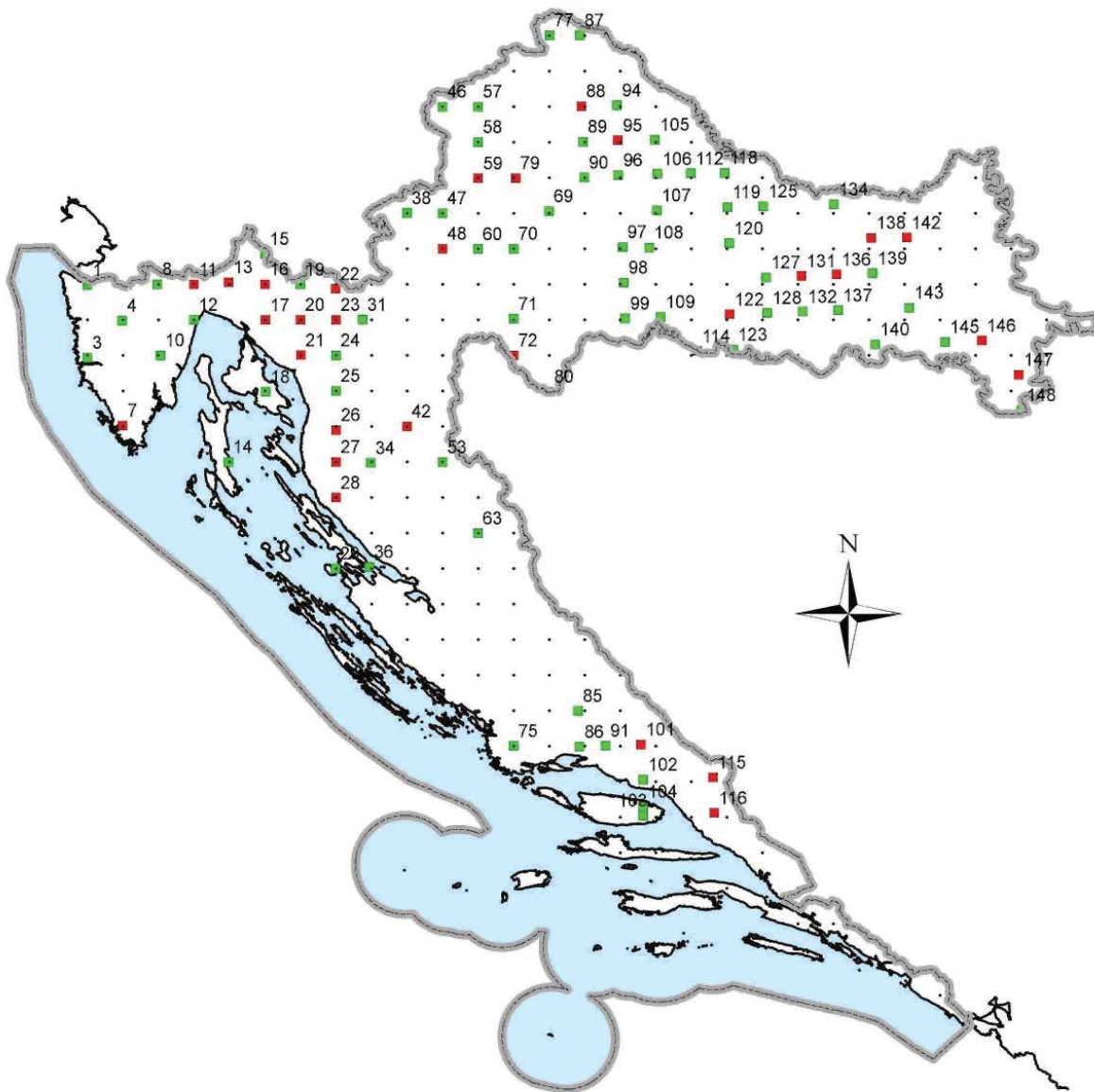
1. occurrence of massive drying of trees, i.e. their physiological weakening (significantly damaged tree is the one whose defoliation is larger than 25%) - based on the past monitoring of the condition of branches, with the emphasis on year 2005 (the last year for which data on monitoring of the condition of branches have been processed);
2. size of forest complex;
3. plant community and economically significant tree species (all more important plant communities are included, depending on their participation in the total forest surface);
4. as even distribution as possible within primary Level I Network at the territory of Croatia.

At 18 selected plots, the primary criterion was a significant tree damage (criterion 1), and other 12 plots have been selected based on synergy effect of the remaining 3 criteria.

Figure 2. shows the map of Croatia with the layout of 95 plots of ICP Forests Network. Some of altogether 148 plots of theoretical Network, are not active because they are not located in forest area, then in urban and industrial areas, or they are located in mined fields where access to these plots is impossible.

There are 95 active plots on Level I Network at which monitoring of the condition of branches is being conducted. Plots at which it is recommended to monitor forest soils intensively are marked by red colour.

Table 1. contains the list of 95 active plots for monitoring forestry ecosystems on ICP Forests Level I Network. 30 selected plots for intensive forestry soil monitoring are shaded.



**Legend:**

- Theoretical network of ICP plots (16 x 16 km)
- Plots for 10 year monitoring interval
- Plots for 5 and 10 year monitoring interval

**Figure 2. Plots of ICP Forests Level I Network in the Republic of Croatia**



Tablica 1. Popis aktivnih ploha motrenja Razine I, ICP Forests mreže

| Ordinal No. | Plot No. (ICP) | Coordinates           |                        |          | Forest management branch | Economic unit          | Department | Section | Height above sea level (m) | Exposure (°) | Inclination (°) | Predominant type of trees and damage level                                |
|-------------|----------------|-----------------------|------------------------|----------|--------------------------|------------------------|------------|---------|----------------------------|--------------|-----------------|---------------------------------------------------------------------------|
|             |                | Geographical latitude | Geographical longitude | Y 5 zone |                          |                        |            |         |                            |              |                 |                                                                           |
| 1           | 1              | 133913,28             | 452655,14              | 5395061  | Buzet                    | Krišin                 | 110        | d       | 230                        | 45           | 13              | Aleppo pine                                                               |
| 2           | 3              | 133938,48             | 450914,70              | 5395065  | Buzet                    | Lim                    |            |         | 70                         | 0            | 0               | Turkey oak                                                                |
| 3           | 4              | 135126,79             | 451822,67              | 5018630  | Buzet                    | Kaidir                 |            |         | 125                        | 270          | 18              | Turkey oak, Pubescent oak                                                 |
| 4           | 7              | 135206,37             | 445253,92              | 4971429  | Buzet                    | Sijana                 |            |         | 30                         | 0            | 0               | Aleppo pine                                                               |
| 5           | 8              | 140321,47             | 452720,15              | 5035020  | Buzet                    | Kozarište              |            |         | 720                        | 150          | 15              | Black pine                                                                |
| 6           | 10             | 140445,08             | 451003,66              | 5003004  | Buzet                    | Sumber                 |            |         | 325                        | 0            | 0               | Black pine                                                                |
| 7           | 11             | 141604,51             | 452722,34              | 5034916  | Buzet                    | Opatija                |            |         | 80                         | 180          | 10              | Pubescent oak                                                             |
| 8           | 12             | 141606,45             | 451846,59              | 5018994  | Buzet                    | Opatija                |            |         | 430                        | 315          | 12              | Turkey oak                                                                |
| 9           | 13             | 142757,88             | 452759,44              | 5035939  | Delnice                  | Suho                   | 91         | b       | 1240                       | 120          | 25              | Common beech, significant damage on the plot amounts to 4.17 %            |
| 10          | 14             | 142816,61             | 444420,40              | 4955093  | Buzet                    | Vrana                  |            |         | 25                         | 90           | 2               | Evergreen oak                                                             |
| 11          | 15             | 144032,80             | 453454,69              | 5048671  | Delnice                  | Rudnik                 | 11         | d       | 690                        | 325          | 30              | Common beech                                                              |
| 12          | 16             | 144413,00             | 452555,00              | 5035000  | Delnice                  | Vršice                 | 49         |         | 840                        | 330          | 28              | Common beech, White fir, significant damage on the plot amounts to 58.3 % |
| 13          | 17             | 144042,68             | 451850,98              | 5018920  | Delnice                  | Brioško                | 74         |         | 710                        | 320          | 20              | Common beech, White fir, significant damage on the plot amounts to 75 %   |
| 14          | 18             | 144058,40             | 450123,66              | 4986591  | Senj                     | privatna šuma          |            |         | 180                        | 200          | 10              | Pubescent oak                                                             |
| 15          | 19             | 145249,74             | 452730,33              | 5034909  | Delnice                  | Čedanj                 | 3          | b       | 325                        | 340          | 10              | Durmast oak, Common beech                                                 |
| 16          | 20             | 145541,00             | 451644,00              | 5019000  | Delnice                  | Bjelolasica            | 5          |         | 1035                       | 295          | 7               | Common beech, White fir, significant damage on the plot amounts to 75 %   |
| 17          | 21             | 145259,15             | 451021,77              | 5003159  | Senj                     | Ričićko bilo           |            |         | 860                        | 280          | 10              | Common beech, significant damage on the plot amounts to 29.17%            |
| 18          | 22             | 150456,98             | 452626,41              | 5032933  | Delnice                  | Litorić                | 25         |         | 580                        | 100          | 10              | Common beech, White fir, significant damage on the plot amounts to 41.6 % |
| 19          | 23             | 150503,92             | 451856,17              | 5019034  | Delnice                  | Potočine               | 45         |         | 620                        | 155          | 7               | Common beech, White fir, significant damage on the plot amounts to 58.4 % |
| 20          | 24             | 150506,87             | 451018,03              | 5003041  | Ogulin                   | Čungar                 | 23         |         | 525                        | 225          | 15              | Common beech                                                              |
| 21          | 25             | 150501,20             | 450140,60              | 4987072  | Gospić                   | Javorov vrh-Stubica    | 58         |         | 720                        | 210          | 20              | Common beech                                                              |
| 22          | 26             | 150508,00             | 445207,70              | 4969389  | Gospić                   | Senjsko Bilo           | 19         | a       | 1130                       | 45           | 30              | Common beech                                                              |
| 23          | 27             | 150502,80             | 444421,60              | 4955005  | Gospić                   | Konjska Draga-Begovača |            |         | 1010                       | 230          | 40              | White fir, significant damage on the plot amounts to 79.17 %              |
| 24          | 28             | 150354,00             | 443311,00              | 4939000  | Gospić                   | Laktin vrh-Dabri       |            |         | 670                        | 315          | 30              | Common beech, significant damage on the plot amounts to 25 %              |
| 25          | 29             | 150451,30             | 441829,70              | 4907101  | Split                    | Vir, privatno          |            |         | 35                         | 170          | 3               | Aleppo pine                                                               |
| 26          | 31             | 151413,67             | 451857,37              | 5019096  | Ogulin                   | Bukovača               |            |         | 490                        | 225          | 10              | Common beech                                                              |
| 27          | 34             | 151656,20             | 444407,70              | 4954608  | Gospić                   | Kalčić vrh-Obiljaj     | 73         | a       | 570                        | 180          | 10              | European hornbeam                                                         |
| 28          | 36             | 151619,80             | 441852,20              | 4907828  | Split                    | Ražanac-Vrsi           |            |         | 35                         | 180          | 4               | Aleppo pine                                                               |
| 29          | 38             | 152948,71             | 454448,11              | 5067060  | Karlovac                 | Slapnica               | 33         | c       | 450                        | 135          | 20              | Common beech, Turkey oak                                                  |





| 30 | 42  | 152938,00 | 444912,00 | 4971000 | 5539000 | Gospić     | Štirovača                  |      | 480 | 270 | 10 | White fir                                                                         |
|----|-----|-----------|-----------|---------|---------|------------|----------------------------|------|-----|-----|----|-----------------------------------------------------------------------------------|
| 31 | 46  | 154955,00 | 460556,00 | 5115000 | 5555000 | Zagreb     | Krapina, Hum               |      | 280 | 240 | 15 | Common beech                                                                      |
| 32 | 47  | 154204,87 | 454441,19 | 5066966 | 5554944 | Karlovac   | K. O. Klinča Selo          |      | 455 | 250 | 30 | Common beech                                                                      |
| 33 | 48  | 154200,92 | 453605,42 | 5051043 | 5554998 | Karlovac   | Jastrebarski lugovi        | 70 b | 109 | 0   | 0  | English oak, Narrow-leaved ash, significant damage on the plot amounts to 29.17 % |
| 34 | 53  | 154048,00 | 444001,00 | 4955000 | 5555000 | Gospić     | Zapadni Resnik             | 26   | 790 | 90  | 15 | Common beech                                                                      |
| 35 | 57  | 160314,00 | 461352,00 | 5115000 | 5571000 | Zagreb     | Krapina, Radoboj           |      | 230 | 45  | 5  | Durmast oak, Common beech                                                         |
| 36 | 58  | 160213,00 | 460513,00 | 5099000 | 5571000 | Zagreb     | Krapina, Zabok             |      | 790 | 225 | 10 | Common beech                                                                      |
| 37 | 59  | 155440,30 | 455307,24 | 5082753 | 5571093 | Zagreb     | Sijeme Medvedgradske šume  | 46 a | 580 | 225 | 17 | European hornbeam                                                                 |
| 38 | 60  | 155421,50 | 453556,64 | 5050933 | 5571049 | Karlovac   | Gračec Lučelnica           | 27 b | 175 | 70  | 11 | Common beech                                                                      |
| 39 | 63  | 155158,00 | 443047,00 | 4923000 | 5571000 | Gospić     | Javornik-Kremen            | 21 a | 820 | 150 | 10 | Turkey Oak                                                                        |
| 40 | 69  | 161909,46 | 454451,96 | 5067907 | 5603021 | Zagreb     | Crnovčak                   | 23 a | 180 | 0   | 0  | Durmast Oak, Common beech                                                         |
| 41 | 70  | 160637,48 | 453552,30 | 5051000 | 5587000 | Sisak      | Peščenica-Cerje            | 7 d  | 125 | 260 | 8  | European hornbeam                                                                 |
| 42 | 71  | 160618,60 | 451850,83 | 5019462 | 5587025 | Sisak      | Pogledić-Biljeg            | 9 a  | 175 | 5   | 45 | Common beech                                                                      |
| 43 | 72  | 160607,12 | 450957,64 | 5003000 | 5587000 | Sisak      | Prolom-Kobiljak-Šašava     | 69 a | 375 | 60  | 35 | Common beech, significant damage on the plot amounts to 12.5 %                    |
| 44 | 75  | 160424,07 | 433503,37 | 4827223 | 5587056 | Split      | Blizna                     |      | 260 | 10  | 15 | Pubescent oak                                                                     |
| 45 | 77  | 162016,06 | 462737,50 | 5147136 | 5603126 | Koprivnica | Gornje Medimurje           | 18 f | 230 | 20  | 30 | Common beech                                                                      |
| 46 | 79  | 160739,39 | 455302,96 | 5082836 | 5587892 | Zagreb     | Duboki jarak               | 17 e | 130 | 0   | 0  | English oak, significant damage on the plot amounts to 66.6 %                     |
| 47 | 80  | 161813,47 | 450101,47 | 4986686 | 5603128 | Sisak      | Javornik                   | 91 a | 240 | 280 | 20 | Common beech                                                                      |
| 48 | 85  | 162609,85 | 434316,62 | 4842887 | 5616084 | Split      | Privatno                   |      | 530 | 225 | 5  | Turkey oak, Pubescent oak                                                         |
| 49 | 86  | 162624,48 | 433436,44 | 4826840 | 5616690 | Split      | Kozjak-Zagora              | 71 b | 420 | 80  | 5  | Black ash                                                                         |
| 50 | 87  | 163058,81 | 462727,08 | 5147062 | 5616846 | Koprivnica | Celine                     |      | 120 | 55  | 5  | English oak, Black alder                                                          |
| 51 | 88  | 163100,00 | 461013,49 | 5115152 | 5617474 | Koprivnica | Kalnik                     | 50 b | 425 | 20  | 30 | Durmast oak, Common beech                                                         |
| 52 | 89  | 163121,75 | 460135,82 | 5099179 | 5618256 | Koprivnica | Križevačke prigrorske šume | 10 a | 160 | 40  | 5  | English oak, European hornbeam                                                    |
| 53 | 90  | 163133,09 | 455254,87 | 5083101 | 5618808 | Bjelovar   | Bukovac                    | 6 a  | 140 | 0   | 0  | English oak                                                                       |
| 54 | 91  | 163508,08 | 433442,96 | 4827255 | 5628434 | Split      | Dugopolje                  |      | 370 | 60  | 15 | Pubescent oak                                                                     |
| 55 | 94  | 164331,35 | 461017,93 | 5115618 | 5633596 | Koprivnica | Dugačko Brdo               | 48 a | 210 | 5   | 37 | Common beech, European hornbeam                                                   |
| 56 | 95  | 164332,22 | 460145,60 | 5099802 | 5633958 | Bjelovar   | Bjelovarska Bilogora       | 18 a | 120 | 0   | 0  | English oak, significant damage on the plot amounts to 16.7 %                     |
| 57 | 96  | 164326,13 | 455317,50 | 5084113 | 5634167 | Bjelovar   | Bolčansko-zabljiački lug   | 29 b | 130 | 0   | 0  | English oak                                                                       |
| 58 | 97  | 164420,79 | 453548,45 | 5051754 | 5636050 | Zagreb     | Garjevica                  | 81 a | 330 | 145 | 65 | Durmast oak, Common beech                                                         |
| 59 | 98  | 164713,00 | 452805,00 | 5035721 | 5636618 | Zagreb     | Kutišinske nizinske šume   | 52 c | 60  | 0   | 0  | English oak, narrow-leaved ash                                                    |
| 60 | 99  | 164443,80 | 451829,67 | 5019704 | 5637246 | Sisak      | Posavske šume              | 70 a | 90  | 0   | 0  | English oak, narrow-leaved ash                                                    |
| 61 | 101 | 164547,00 | 433553,00 | 4827835 | 5644254 | Split      | Sinj                       |      | 520 | 0   | 0  | Pubescent oak, Oriental hornbeam                                                  |
| 62 | 102 | 164729,66 | 432617,22 | 4811987 | 5645408 | Split      | Kusići                     |      | 175 | 0   | 15 | Pubescent oak                                                                     |
| 63 | 103 | 165534,00 | 431800,00 | 4795851 | 5645406 | Split      | Brač                       |      | 340 | 135 | 10 | Evergreen oak                                                                     |



|    |     |           |           |         |         |               |                               |     |     |     |     |                                                                  |                                                                                     |
|----|-----|-----------|-----------|---------|---------|---------------|-------------------------------|-----|-----|-----|-----|------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 64 | 104 | 165432,00 | 430925,00 | 4799849 | 5645262 | Split         | Hvar                          | 2   | 175 | 0   | 5   | Aleppo pine                                                      |                                                                                     |
| 65 | 105 | 165627,29 | 460141,01 | 5100044 | 5650629 | Koprivnica    | Đurđevačka Bilogora           | 11  | a   | 180 | 20  | Common beech                                                     |                                                                                     |
| 66 | 106 | 165703,94 | 455323,16 | 5084694 | 5651793 | Bjelovar      | Bjelovarska Bilogora          | 155 | b   | 160 | 290 | Durmast oak                                                      |                                                                                     |
| 67 | 107 | 165629,49 | 454431,39 | 5068260 | 5651450 | Bjelovar      | Dugački gaj-Jasenova drljež   | 19  | b   | 130 | 0   | English oak                                                      |                                                                                     |
| 68 | 108 | 165333,28 | 453534,44 | 5051593 | 5648033 | Bjelovar      | Dišnica-Zobikovac-Petkovača   | 45  | b   | 120 | 45  | English oak                                                      |                                                                                     |
| 69 | 109 | 165819,00 | 451843,00 | 5020326 | 5653206 | Zagreb        | Trstika                       | 54  | a   | 75  | 0   | Narrow-leaved ash                                                |                                                                                     |
| 70 | 112 | 170836,98 | 455316,45 | 5084871 | 5666739 | Koprivnica    | Pitomačka Bilogora            | 16  | a   | 235 | 320 | Large-leaved linden                                              |                                                                                     |
| 71 | 114 | 170918,09 | 451006,14 | 5004933 | 5669774 | Nova Gradiška | Medustrugovi                  | 41  | a   | 80  | 0   | Common beech,<br>significant damage on the plot amounts to 8.3 % |                                                                                     |
| 72 | 115 | 170820,00 | 432548,00 | 4812995 | 5676817 | Split         | Imotski                       |     |     | 440 | 10  | 25                                                               | Black pine                                                                          |
| 73 | 116 | 170719,00 | 431713,00 | 4797000 | 5677393 | Split         | Vrgorac                       |     |     | 320 | 180 | 5                                                                | Black pine                                                                          |
| 74 | 118 | 172024,30 | 455312,59 | 5085180 | 5681992 | Bjelovar      | Suhopoljsko-virovičkičen šume | 25  | e   | 120 | 0   | 0                                                                | English oak                                                                         |
| 75 | 119 | 172103,25 | 454450,36 | 5069701 | 5683288 | Bjelovar      | Grubišnopoljska Bilogora      | 97  | d   | 190 | 270 | 10                                                               | European hornbeam                                                                   |
| 76 | 120 | 172116,07 | 453603,65 | 5053449 | 5684044 | Bjelovar      | Vrani Kamen                   | 88  | b   | 475 | 310 | 22                                                               | Common beech                                                                        |
| 77 | 122 | 172042,38 | 451849,01 | 5021490 | 5684247 | NovaGradiška  | Gradiška brda                 | 39  | f   | 380 | 190 | 5                                                                | Durmast oak                                                                         |
| 78 | 123 | 172133,02 | 451011,83 | 5005557 | 5685817 | NovaGradiška  | Ključevi                      | 22  | b   | 65  | 0   | 0                                                                | English oak                                                                         |
| 79 | 125 | 173327,95 | 454447,03 | 5070093 | 5699386 | Bjelovar      | Suhopoljska Bilogora          | 79  | c   | 180 | 315 | 12                                                               | Common beech, Durmast oak                                                           |
| 80 | 127 | 173336,52 | 452731,21 | 5038123 | 5700594 | Požega        | Poljanačke šume               | 17  | b   | 480 | 70  | 20                                                               | Durmast oak                                                                         |
| 81 | 128 | 173340,63 | 451853,27 | 5022138 | 5701193 | Požega        | Sjeverna Babja Gora           | 25  | e   | 320 | 140 | 3                                                                | Common beech                                                                        |
| 82 | 131 | 174553,62 | 452732,68 | 5038699 | 5716605 | Požega        | Južni Papuk                   | 142 | e   | 490 | 220 | 45                                                               | Common beech, Durmast oak                                                           |
| 83 | 132 | 174556,61 | 451855,83 | 5022747 | 5717219 | Požega        | Sjeverna Babja Gora           | 91  | e   | 320 | 130 | 10                                                               | Durmast oak                                                                         |
| 84 | 134 | 175757,06 | 454441,23 | 5071011 | 5731145 | Našice        | Čadavački lug-Jelas dol       |     |     | 85  | 0   | 0                                                                | English oak, European hornbeam                                                      |
| 85 | 136 | 175801,61 | 452739,35 | 5039470 | 5732412 | Našice        | Krmdija-gazijska              | 12  | a   | 290 | 135 | 5                                                                | Durmast oak                                                                         |
| 86 | 137 | 175805,26 | 451855,57 | 5023305 | 5733089 | Požega        | Sjeverni Dijl II              | 80  | d   | 175 | 120 | 2                                                                | Durmast oak, Turkey oak                                                             |
| 87 | 138 | 181029,04 | 453611,88 | 5055913 | 5748022 | Našice        | Lacić-Grožde                  | 4   | a   | 75  | 0   | 0                                                                | English oak, European hornbeam,<br>significant damage on the plot amounts to 12.5 % |
| 88 | 139 | 181027,49 | 452736,17 | 5039992 | 5748619 | Našice        | Krmdija našička               | 82  | c   | 200 | 320 | 9                                                                | Common beech                                                                        |
| 89 | 140 | 181059,00 | 451344,00 | 5007900 | 5749781 | Vinkovci      | Privatno                      |     |     | 80  | 0   | 0                                                                | English oak                                                                         |
| 90 | 142 | 182244,35 | 453554,22 | 5056020 | 5763978 | Ostijek       | Valpovačke nizinske šume      | 17  | a   | 70  | 0   | 0                                                                | English oak,<br>significant damage on the plot amounts to 39.13 %                   |
| 91 | 143 | 182425,00 | 452122,00 | 5024498 | 5765188 | Ostijek       | Đakovački lugovi i gajevi     | 99  | d   | 125 | 0   | 0                                                                | Black robinia, European hornbeam                                                    |
| 92 | 145 | 183424,71 | 451011,50 | 5009057 | 5781273 | Vinkovci      | Orljak                        | 23  | a   | 95  | 0   | 0                                                                | English oak                                                                         |
| 93 | 146 | 184700,75 | 451008,21 | 5009709 | 5797785 | Vinkovci      | Otočke šume                   | 2   | a   | 90  | 0   | 0                                                                | English oak,<br>significant damage on the plot amounts to 33.3 %                    |
| 94 | 147 | 185905,51 | 450123,42 | 4994272 | 5814410 | Vinkovci      | Vrbanjske šume                | 14  | b   | 80  | 0   | 0                                                                | English oak, narrow-leaved ash,<br>significant damage on the plot amounts to 25 %   |
| 95 | 148 | 185929,61 | 445245,31 | 4978305 | 5815727 | Vinkovci      | Trizlovi-Rastovo              | 49  | b   | 80  | 0   | 0                                                                | English oak                                                                         |

## 3.3. Soil sampling and soil description procedures for forestry soil monitoring

### 3.3.1. General data on plots for forestry soil monitoring

General data on the Level I Network plot, at which monitoring plot for forestry soil is located, will be entered in **I. Forms for general data on monitoring plots** during the first soil sampling, and if required, the data may be modified and/or supplemented in accordance with modification in the field.

#### I. Forms for general data on monitoring plots

| Plot number (ICP) | Country code (ICP) | Geographical latitude | Geographical longitude | Forest administration (park etc.) | Management unit | Compartment | Sub compartment |
|-------------------|--------------------|-----------------------|------------------------|-----------------------------------|-----------------|-------------|-----------------|
|                   |                    |                       |                        |                                   |                 |             |                 |
|                   |                    |                       |                        |                                   |                 |             |                 |
|                   |                    |                       |                        |                                   |                 |             |                 |
|                   |                    |                       |                        |                                   |                 |             |                 |
|                   |                    |                       |                        |                                   |                 |             |                 |
|                   |                    |                       |                        |                                   |                 |             |                 |

| Plot number (ICP) | Height above sea level (m) | Exposure (°) | Slope (°) | Rockiness (%) | Stoniness (%) | Phytocenological affiliation |
|-------------------|----------------------------|--------------|-----------|---------------|---------------|------------------------------|
|                   |                            |              |           |               |               |                              |
|                   |                            |              |           |               |               |                              |
|                   |                            |              |           |               |               |                              |
|                   |                            |              |           |               |               |                              |
|                   |                            |              |           |               |               |                              |
|                   |                            |              |           |               |               |                              |

| Plot number (ICP) | Soil (WRB) | Soil (HR) | Parent material (ICP Code book) | Water availability (ICP Code Book) | Humus form | Date of taking samples (ddmmyy) | Researcher / company (institution) | Other observations (works in the stand, application of pesticides etc.) |
|-------------------|------------|-----------|---------------------------------|------------------------------------|------------|---------------------------------|------------------------------------|-------------------------------------------------------------------------|
|                   |            |           |                                 |                                    |            |                                 |                                    |                                                                         |
|                   |            |           |                                 |                                    |            |                                 |                                    |                                                                         |
|                   |            |           |                                 |                                    |            |                                 |                                    |                                                                         |
|                   |            |           |                                 |                                    |            |                                 |                                    |                                                                         |
|                   |            |           |                                 |                                    |            |                                 |                                    |                                                                         |
|                   |            |           |                                 |                                    |            |                                 |                                    |                                                                         |
|                   |            |           |                                 |                                    |            |                                 |                                    |                                                                         |



The scheme of the monitoring plot (Figure 3) is sketched and enclosed along with I. Forms for general data on monitoring plots. The scheme includes a soil profile position, position of soil sampling points and the position of dominant trees.

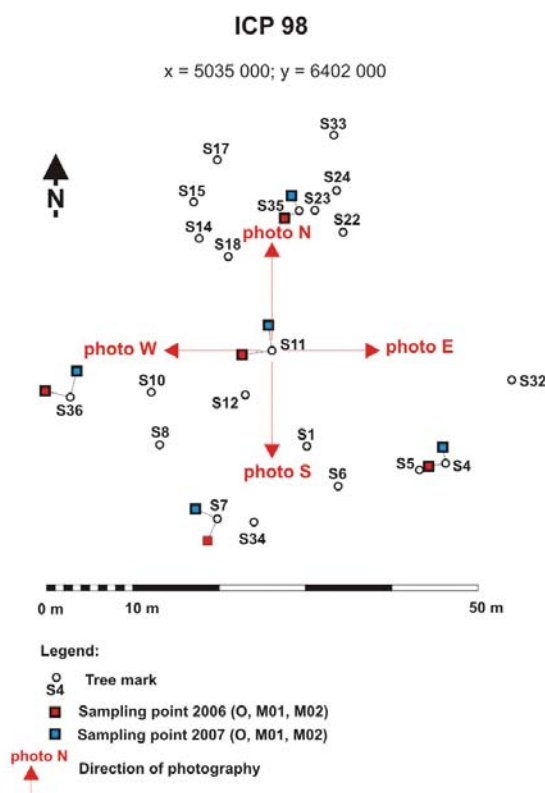


Figure 3. Example of scheme of monitoring plot from the Pilot Project

Furthermore, photographs are taken during each soil sampling and are deposited in the data base for each monitoring plot. At each ICP plot, 20 photographs are taken, which means 4 photographs in main directions of the world per each sampling point. Photographs are carefully marked and entered in the **II. Form for photographs of monitoring plot.**

**II. Form for photographs of monitoring plot**

| Marks of photographs at the monitoring plot                |                                                                                                                                                                                                              |            |            |            |            |
|------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|------------|------------|------------|
| Direction of shooting<br>(main directions of<br>the world) | Point/position at the plot (centre where the position of the plot is registered - "centre" + 4 groups of trees positioned from the centre in the direction of the main directions of the world – N, E, S, W) |            |            |            |            |
|                                                            | Centre                                                                                                                                                                                                       | N          | E          | S          | W          |
| N                                                          | ICPCN date                                                                                                                                                                                                   | ICPNN date | ICPEN date | ICPSN date | ICPWN date |
| E                                                          | ICPCE date                                                                                                                                                                                                   | ICPNE date | ICPEE date | ICPSE date | ICPWE date |
| S                                                          | ICPCS date                                                                                                                                                                                                   | ICPNS date | ICPES date | ICPSS date | ICPWS date |
| W                                                          | ICPCW date                                                                                                                                                                                                   | ICPNW date | ICPEW date | ICPSW date | ICPWW date |

### 3.3.2. Sampling of soil profile

The soil profile is opened on a one-time basis, to the depth of parent material, at the representative position at the location, taking into consideration that the tree roots are not significantly damaged.

Soil is classified pursuant to WRB classification (IUSS Working Group WRB. 2006. *World reference base for soil resources 2006*. World Soil Resources Reports No. 103. FAO, Rome).

Each profile obtains the mark of the plot according to ICP (for instance ICP1). A micro monolith is formed on the profile, and soil is sampled from genetic horizons for the analysis of chemical and physical properties of soil, pursuant to *ISO 10381-2 - Soil quality – Sampling – Part 2: Guidance on sampling techniques*.

Samples from the soil profile are taken in the same manner as it was described in Sampling of agricultural soil profiles:

1. **undisturbed condition** three samples from each horizon (from the highest to the lowest horizon), by impressing a cylinder of 100 cm<sup>3</sup> horizontally to the profile,
2. **disturbed condition** one sample from each horizon (from the highest to the lowest horizon).

Samples are further treated pursuant to *ISO 10381-3 Soil quality – Sampling – Part 3: Guidance on safety and ISO 10381-4 Soil quality – Sampling – Part 4: Guidance on the procedure for investigation of natural, near natural and cultivated sites*.

After the soil profile is processed, it has to be surfaced with soil. All data are entered in **III. Forms for soil profile** and deposited in the data base of ICP plots, with attached photographs of profile.

#### III. Forms for soil profile

| Profile mark: |      |               | Researcher:              |           |            | Date of elaboration: |               |      |            |      |
|---------------|------|---------------|--------------------------|-----------|------------|----------------------|---------------|------|------------|------|
| Horizons      |      |               | Horizon's lower boundary |           |            | Fragments of rocks   |               |      |            |      |
| No.           | Mark | Cylinder mark | Depth                    | Clearness | Topography | Occurrence (%)       | Diameter (mm) | Form | Weathering | Type |
| 1.            |      |               |                          |           |            |                      |               |      |            |      |
| 2.            |      |               |                          |           |            |                      |               |      |            |      |
| 3.            |      |               |                          |           |            |                      |               |      |            |      |
| 4.            |      |               |                          |           |            |                      |               |      |            |      |
| 5.            |      |               |                          |           |            |                      |               |      |            |      |

| No. | Texture of the fine earth fraction | Decomposition and humification of plant residues | Soil colour   |                 | Mottling       |           |        |          |          |
|-----|------------------------------------|--------------------------------------------------|---------------|-----------------|----------------|-----------|--------|----------|----------|
|     |                                    |                                                  | Dry condition | Humid condition | Occurrence (%) | Size (mm) | Colour | Contrast | Boundary |
| 1.  |                                    |                                                  |               |                 |                |           |        |          |          |
| 2.  |                                    |                                                  |               |                 |                |           |        |          |          |
| 3.  |                                    |                                                  |               |                 |                |           |        |          |          |
| 4.  |                                    |                                                  |               |                 |                |           |        |          |          |
| 5.  |                                    |                                                  |               |                 |                |           |        |          |          |



| No. | Redox-potential (rH) | Reducing conditions in the soil | Easily soluble salts (%) | pH value of the soil | Organic matter (%) | Carbonates  |      | Gypsum      |      |
|-----|----------------------|---------------------------------|--------------------------|----------------------|--------------------|-------------|------|-------------|------|
|     |                      |                                 |                          |                      |                    | Content (%) | Form | Content (%) | Form |
| 1.  |                      |                                 |                          |                      |                    |             |      |             |      |
| 2.  |                      |                                 |                          |                      |                    |             |      |             |      |
| 3.  |                      |                                 |                          |                      |                    |             |      |             |      |
| 4.  |                      |                                 |                          |                      |                    |             |      |             |      |
| 5.  |                      |                                 |                          |                      |                    |             |      |             |      |

| No. | Moisture status | Bulk density | Soil structure |      |                    | Soil consistence |            |            |            |
|-----|-----------------|--------------|----------------|------|--------------------|------------------|------------|------------|------------|
|     |                 |              | Degree         | Type | Size of aggregates | Dry soil         | Moist soil | Stickiness | Plasticity |
| 1.  |                 |              |                |      |                    |                  |            |            |            |
| 2.  |                 |              |                |      |                    |                  |            |            |            |
| 3.  |                 |              |                |      |                    |                  |            |            |            |
| 4.  |                 |              |                |      |                    |                  |            |            |            |
| 5.  |                 |              |                |      |                    |                  |            |            |            |

| No. | Porosity (%) | Pores |          |                              |                              | Roots    |                              |                              | Other biological properties |      |
|-----|--------------|-------|----------|------------------------------|------------------------------|----------|------------------------------|------------------------------|-----------------------------|------|
|     |              | Type  | Diameter | Number < 2mm/dm <sup>2</sup> | Number > 2mm/dm <sup>2</sup> | Diameter | Number < 2mm/dm <sup>2</sup> | Number > 2mm/dm <sup>2</sup> | Quantity                    | Type |
| 1.  |              |       |          |                              |                              |          |                              |                              |                             |      |
| 2.  |              |       |          |                              |                              |          |                              |                              |                             |      |
| 3.  |              |       |          |                              |                              |          |                              |                              |                             |      |
| 4.  |              |       |          |                              |                              |          |                              |                              |                             |      |
| 5.  |              |       |          |                              |                              |          |                              |                              |                             |      |

| No. | Coatings       |          |      |      |          | Cementation/Compaction |            |                        |                 |
|-----|----------------|----------|------|------|----------|------------------------|------------|------------------------|-----------------|
|     | Occurrence (%) | Contrast | Type | Form | Location | Degree                 | Continuity | Structure of the layer | Nature of layer |
| 1.  |                |          |      |      |          |                        |            |                        |                 |
| 2.  |                |          |      |      |          |                        |            |                        |                 |
| 3.  |                |          |      |      |          |                        |            |                        |                 |
| 4.  |                |          |      |      |          |                        |            |                        |                 |
| 5.  |                |          |      |      |          |                        |            |                        |                 |

| No. | Mineral concentrations |      |       |           |          |        |        |
|-----|------------------------|------|-------|-----------|----------|--------|--------|
|     | Occurrence (%)         | Kind | Shape | Size (mm) | Hardness | Nature | Colour |
| 1.  |                        |      |       |           |          |        |        |
| 2.  |                        |      |       |           |          |        |        |
| 3.  |                        |      |       |           |          |        |        |
| 4.  |                        |      |       |           |          |        |        |
| 5.  |                        |      |       |           |          |        |        |

| No. | Soil odour | Human transported material | Artefacts      |      |           |          |            |        |
|-----|------------|----------------------------|----------------|------|-----------|----------|------------|--------|
|     |            |                            | Occurrence (%) | Kind | Size (mm) | Hardness | Weathering | Colour |
| 1.  |            |                            |                |      |           |          |            |        |
| 2.  |            |                            |                |      |           |          |            |        |
| 3.  |            |                            |                |      |           |          |            |        |
| 4.  |            |                            |                |      |           |          |            |        |
| 5.  |            |                            |                |      |           |          |            |        |

### 3.3.3. Sampling of single samples and forming of composite samples

Sampling of single samples and forming of composite samples at monitoring plots refers to the following sampling:

- organic layer at the soil surface,
- mineral layer of the soil.

Sampling of single soil samples is conducted according to *ISO 10381-2: 2002 - Soil quality – Sampling – Part 2: Guidance on sampling techniques* and *ISO 10381-4: 2003 - Soil quality – Sampling – Part 4: Guidance on the procedure for investigation of natural, near natural and cultivated sites*.

#### Sampling of organic layer on the soil surface

At each sampling point, organic layer is first taken from the surface of the square form of 25x25 cm. Subhorizons O- and H- horizons (L, F and H) are sampled separately. Exceptionally, if H-subhorizon is thinner than 1 cm, then F- and H- subhorizons are sampled as OFH, i.e. as HFH. When taking samples, care is to be taken that the organic matter is not contaminated by mineral particles. If this happens, samples are to be taken on a new point. If F- and H-subhorizons may be singled out separately only on some points of the plot, a unique composite sample (OFH or HFH) is to be formed. Homogenised composite samples are stored into bags with the mark of ICP plot, mark of the subhorizon and the date of sampling, for instance 1, OL, 24.06.2010.

Samples O or H- subhorizons are weighted in the field immediately after sampling.



Figure 4. Sampling of organic layer on the soil surface



## Sampling of mineral layer of the soil

Samples of mineral soil are taken by a probe of inner diameter  $\geq 8$  cm, from two depths (0-10 cm and 10-20 cm) at the same points at which organic horizon was sampled.

All 5 subsamples are to be of the same volume, except when the limiting depth of soil varies. In case that the skeletal structure of the soil makes it impossible to take samples by probe, it may be done by an adequate spade.

Five samples (gathered at all 5 points) are homogenised in a composite sample, so that two composite samples of mineral soil are obtained at each monitoring plot. These samples from mineral layers obtain the mark in the form of the letter "M" (mineral) and 01 (0-10 cm), i.e. 12 (10-20 cm).

Samples are stored in bags with a mark of the plot, mark of the layer and the date of sampling, for instance 1, M01, 24.06.2010. A composite sample for determination of the current humidity (in the laboratory) is taken in a special receptacle.

During the first sampling in soil monitoring at 3 points at least, it is necessary to take samples from the middle of mineral layer with a cylinder of 100 cm<sup>3</sup>.

After the first sampling, it is necessary to level the soil on the plot with the surplus of soil from the same sampling point.



Figure 5. Sampling of mineral layer of soil

### 3.3.4. Preparation of samples for analysis and storage of samples

Soil samples are prepared for laboratory analyses pursuant to *HRN ISO 11464: 2004 – Soil quality – Pretreatment of samples for physical-chemical analyses*.

Conservation and transport of soil samples must prevent chemical modifications in samples. Should this happen, it is necessary to explain the reason for long or inappropriate transport in the attached report.

Samples are conserved at the samples archives for at least 10 years.

### 3.3.5. Time dynamics of sampling

Pursuant to the *Rulebook on the mode of data collection, network of points, keeping the register, conditions for using data on damage of forest ecosystems* (OG 129/06), monitoring of the soil condition at the Level I Network is to take place every ten years (Article 8).

With the above mentioned time dynamics, first comparable data of monitoring forest soils will be available ten years after the establishment of forest ecosystems monitoring, while the first trends of the forestry soil condition will be available in twenty years.

The Project “Development of the Croatian Soil Monitoring Programme with the Pilot Project” recommends intensive monitoring of soils at 30 selected plots of Level I Network, each five years after the regular soil monitoring is conducted pursuant to the Rulebook. As the beginning of forest ecosystems monitoring and forestry soil monitoring pursuant to the Rulebook is expected in 2010, intensive monitoring at 30 plots would begin in 2015, and would then be repeated in 2025, i.e. 5 years after the second treatment of all plots in accordance to time dynamics which will be conducted by the National Coordination Centre.

Considering that soil parameters have not been monitored in the past implementation of ICP Forests Programme at the Level I Network, proposed intensive forestry soil monitoring with the time dynamics of five years will enable gathering of valuable data on the condition of forestry soil in the Republic of Croatia.



## 3.4. List of parameters for physical and chemical soil analysis

Parameters for physical and chemical soil analysis are listed in tables 2 and 3. Microbiological analysis of forestry soil are usually not conducted. Analyses methods that are mostly used in Croatia and recommended ISO standards are specified for each soil parameter.

The tables contains also time dynamics of soil parameters monitoring and sampling depths of soil profile and composite soil samples. Physical soil parameters (except of dry matter content) are analyzed on a one-time basis during first sampling on specific monitoring plot, since no changes are expected in forestry soils.

Chemical soil parameters are also analyzed on a one-time basis from single soil samples of soil profile, while they are analysed every five years from composite samples.

**Table 2. Physical parameters**

| Parameter                 | Methods used in the Republic of Croatia | ISO standard       | Time dynamics | Measuring depth |                   |
|---------------------------|-----------------------------------------|--------------------|---------------|-----------------|-------------------|
|                           |                                         |                    |               | Profile         | Composite samples |
| Granulometric composition | International A and B method            | HRN ISO 11277:2004 | 1/1           | All horizons    | 0-10 cm, 10-20 cm |
| Bulk density              | Kopecki rings                           | HRN ISO 11272:2004 | 1/1           | All horizons    | 0-10 cm, 10-20 cm |
| Skeletal structure        | Field assessment                        | HRN ISO 11272:2004 | 1/1           | All horizons    | 0-10 cm, 10-20 cm |
| Dry matter content        | Gravimetric method                      | HRN ISO 11465:2004 | 1/5           |                 | 0-subhorizon      |

**Table 3. Chemical parameters**

| Parameter                                                                                                       | Methods used in the Republic of Croatia                  | ISO standard       | Profile – first sampling | Composite samples |                                              |
|-----------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|--------------------|--------------------------|-------------------|----------------------------------------------|
|                                                                                                                 |                                                          |                    | Measuring depth          | Time dynamics     | Measuring depth                              |
| Soil acidity (pH value)                                                                                         | Electrometric determination                              | HRN ISO 10390:2005 | All horizons             | 1/5               | 0-subhorizon, OF+OH or OH, 0-10 cm, 10-20 cm |
| Carbonate content (CaCO <sub>3</sub> )                                                                          | Scheibler calcimeter – volumetric determination          | HRN ISO 10693:2004 | All horizons             | 1/5               | 0-10 cm, 10-20 cm                            |
| Total nitrogen                                                                                                  | Modified method by Kjeldahl, Elemental analyses          | HRN ISO 11261:2004 | All horizons             | 1/5               | 0-subhorizon, OF+OH or OH, 0-10 cm, 10-20 cm |
| Total carbon                                                                                                    | Method by Tjurin (bichromate method), Elemental analyses | HRN ISO 10694:2004 | All horizons             | 1/5               | 0-10 cm, 10-20 cm                            |
| Total metal content and potentially toxic elements: P, Ca, K, Mg, Mn, Cu, Pb, Cd, Zn, Al, Fe, Cr, Ni, S, Hg, Na | Aqua regia, Determination by AAS                         | HRN ISO 11466:2004 | All horizons             | 1/5               | 0-subhorizon, OF+OH or OH, 0-10 cm, 10-20 cm |
| Exchangeable cations: (CEC + Ca <sup>2+</sup> , Mg <sup>2+</sup> , Na <sup>+</sup> , K <sup>+</sup> )           | Barium chloride solution, Amon-acetate method (pH=7)     | HRN ISO 11260:2005 | All horizons             | 1/5               | 0-subhorizon, OF+OH or OH, 0-10 cm, 10-20 cm |
| Exchangeable acidity                                                                                            | Barium chloride solution                                 | HRN ISO 14254:2004 | All horizons             | 1/5               | 0-subhorizon, OF+OH or OH, 0-10 cm, 10-20 cm |
| Exchangeable H <sup>+</sup>                                                                                     | Barium chloride solution and titration to pH 7,8         |                    | All horizons             | 1/5               | 0-10 cm, 10-20 cm                            |

Results of laboratory analyses are entered in standardised forms developed in accordance to ICP Forests Programme, for soil monitoring at Level I Network, which represent the basis for organising the data base.

Results of soil samples analyses from the profile are entered in: **IV. Analyses Form - soil profile**, and results of composite samples analysis from the monitoring plot are entered in: **V. Analyses Form - monitoring plot**.

#### IV. Analyses Form – Soil Profile

| Profile mark: |              |                               | Laboratory:             |                                | Analyst:     |                |            |               | Date of analyses: |                                  |  |
|---------------|--------------|-------------------------------|-------------------------|--------------------------------|--------------|----------------|------------|---------------|-------------------|----------------------------------|--|
| No.           | Horizon mark | Horizon's lower boundary (cm) | Rock fragments (vol. %) | Particle size distribution (%) |              |                |            | Texture class | Soil density      | Carbonates (g kg <sup>-1</sup> ) |  |
|               |              |                               |                         | 2-0,2 mm                       | 0,2-0,063 mm | 0,063-0,002 mm | < 0,002 mm |               |                   |                                  |  |
| 1.            |              |                               |                         |                                |              |                |            |               |                   |                                  |  |
| 2.            |              |                               |                         |                                |              |                |            |               |                   |                                  |  |
| 3.            |              |                               |                         |                                |              |                |            |               |                   |                                  |  |
| 4.            |              |                               |                         |                                |              |                |            |               |                   |                                  |  |
| 5.            |              |                               |                         |                                |              |                |            |               |                   |                                  |  |
| 6.            |              |                               |                         |                                |              |                |            |               |                   |                                  |  |
| 7.            |              |                               |                         |                                |              |                |            |               |                   |                                  |  |

| No. | pH       |                      | Total nitrogen        | Organic carbon | Content in aqua regia extracted (mg kg <sup>-1</sup> ) |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |
|-----|----------|----------------------|-----------------------|----------------|--------------------------------------------------------|----|---|----|----|----|----|----|----|----|----|----|----|---|----|----|--|
|     | In water | In CaCl <sub>2</sub> | (g kg <sup>-1</sup> ) |                | P                                                      | Ca | K | Mg | Mn | Cu | Pb | Cd | Zn | Al | Fe | Cr | Ni | S | Hg | Na |  |
| 1.  |          |                      |                       |                |                                                        |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |
| 2.  |          |                      |                       |                |                                                        |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |
| 3.  |          |                      |                       |                |                                                        |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |
| 4.  |          |                      |                       |                |                                                        |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |
| 5.  |          |                      |                       |                |                                                        |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |
| 6.  |          |                      |                       |                |                                                        |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |
| 7.  |          |                      |                       |                |                                                        |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |

| No. | Exchange-able acidity | Exchange-able Al | Exchange-able Ca | Exchange-able Fe | Exchange-able K | Exchange-able Mg | Exchange-able Mn | Exchange-able Na | Exchange-able H |
|-----|-----------------------|------------------|------------------|------------------|-----------------|------------------|------------------|------------------|-----------------|
|     | cmol kg <sup>-1</sup> |                  |                  |                  |                 |                  |                  |                  |                 |
| 1.  |                       |                  |                  |                  |                 |                  |                  |                  |                 |
| 2.  |                       |                  |                  |                  |                 |                  |                  |                  |                 |
| 3.  |                       |                  |                  |                  |                 |                  |                  |                  |                 |
| 4.  |                       |                  |                  |                  |                 |                  |                  |                  |                 |
| 5.  |                       |                  |                  |                  |                 |                  |                  |                  |                 |
| 6.  |                       |                  |                  |                  |                 |                  |                  |                  |                 |
| 7.  |                       |                  |                  |                  |                 |                  |                  |                  |                 |



### V. Analysis Form – Monitoring Plot

| ICP plot mark: |              | Laboratory:                      |                         | Analyst:                       |              |                |            | Date of analyses: |             |                                  |  |
|----------------|--------------|----------------------------------|-------------------------|--------------------------------|--------------|----------------|------------|-------------------|-------------|----------------------------------|--|
| No.            | Horizon mark | Dry matter (kg m <sup>-2</sup> ) | Rock fragments (vol. %) | Particle size distribution (%) |              |                |            | Texture class     | Soil densit | Carbonates (g kg <sup>-1</sup> ) |  |
|                |              |                                  |                         | 2 - 0,2 mm                     | 0,2-0,063 mm | 0,063-0,002 mm | < 0,002 mm |                   |             |                                  |  |
| 1.             | OL ili HL    |                                  |                         |                                |              |                |            |                   |             |                                  |  |
| 2.             | OF ili HF    |                                  |                         |                                |              |                |            |                   |             |                                  |  |
| 3.             | OFH ili HFH  |                                  |                         |                                |              |                |            |                   |             |                                  |  |
| 4.             | M01          |                                  |                         |                                |              |                |            |                   |             |                                  |  |
| 5.             | M12          |                                  |                         |                                |              |                |            |                   |             |                                  |  |

| No. | Horizon mark | pH       |                      | Total nitrogen        | Organic carbon | Content in aqua regia extracted (mg kg <sup>-1</sup> ) |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |
|-----|--------------|----------|----------------------|-----------------------|----------------|--------------------------------------------------------|----|---|----|----|----|----|----|----|----|----|----|----|---|----|----|--|
|     |              | In water | In CaCl <sub>2</sub> | (g kg <sup>-1</sup> ) |                | P                                                      | Ca | K | Mg | Mn | Cu | Pb | Cd | Zn | Al | Fe | Cr | Ni | S | Hg | Na |  |
| 1.  | OL ili HL    |          |                      |                       |                |                                                        |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |
| 2.  | OF ili HF    |          |                      |                       |                |                                                        |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |
| 3.  | OFH ili HFH  |          |                      |                       |                |                                                        |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |
| 4.  | M01          |          |                      |                       |                |                                                        |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |
| 5.  | M12          |          |                      |                       |                |                                                        |    |   |    |    |    |    |    |    |    |    |    |    |   |    |    |  |

| No. | Oznaka sloja | Exchange-able acidity | Exchange-able Al | Exchange-able Ca | Exchange-able Fe | Exchange-able K | Exchange-able Mg | Exchange-able Mn | Exchange-able Na | Exchange-able H |
|-----|--------------|-----------------------|------------------|------------------|------------------|-----------------|------------------|------------------|------------------|-----------------|
|     |              | cmol kg <sup>-1</sup> |                  |                  |                  |                 |                  |                  |                  |                 |
| 1.  | OL ili HL    |                       |                  |                  |                  |                 |                  |                  |                  |                 |
| 2.  | OF ili HF    |                       |                  |                  |                  |                 |                  |                  |                  |                 |
| 3.  | OFH ili HFH  |                       |                  |                  |                  |                 |                  |                  |                  |                 |
| 4.  | M01          |                       |                  |                  |                  |                 |                  |                  |                  |                 |
| 5.  | M12          |                       |                  |                  |                  |                 |                  |                  |                  |                 |

## 3.5. Institutional framework and obligations for implementation of the Forestry Soil Monitoring System

### 3.5.1. Proposal of a Referent Centre and authorized institutions for System implementation

When recognising the potential institutions that are to conduct the duties of the Referent Centre for implementation of the Programme in the part related to forestry soil monitoring, primarily was considered the current legislation.

In late 2006 the Rulebook on the mode of data collection, network of points, keeping the register, conditions for using data on damage of forest ecosystems (OG 129/06) was issued. This Rulebook prescribes :

- Article 3:  
*„(1) The **Forest Research Institute Jastrebarsko** is assigned as the National Coordination Centre for the evaluation of the influence of atmospheric damage and other factors to forest ecosystems (hereafter: National Centre).”*
- Article 5:  
*„(1) For the needs of monitoring and reporting on the damage of forest ecosystems to local and international bodies and institutions, the National Centre shall organise and keep a unique Register on the damage of forest ecosystems in electronic form, as well as archives of samples of environment.  
(2) The Register of damage of forest ecosystems shall be kept for Level 1 (hereafter: Register of Level 1) and Level 2 (hereafter: Register of Level 2).  
(3) Register of Level 1 is composed of: Register of Damage of Branches, **Register of the condition of forest soil**, Register of the condition of nutrition of forest trees and other registers that are organised and kept pursuant to the Programme of measures for gathering data on the damage of forest ecosystems from Article 20 of this Rulebook (hereafter: Programme of measures for data gathering).  
(4) Register of the Level 2 is composed of: Register of damage of branches, Register of the condition of forest soil, Register of the condition of nutrition of forest trees, Register of vegetation, Register of increment and other registers organised and kept pursuant to the Programme of measures for gathering data.  
(5) Register of damage of forest ecosystems will be formed in the way so that it may be possible to obtain data from on the damage of forest ecosystems according to various indicators.  
(6) Archives of samples from the environment are composed of samples of soil and plant material from plots from the Level 1 and Level 2.”*
- Article 14:  
*„The National Centre gathers, processes and reports on the data for the Register of the condition of forest soil and the Register on the condition of nutrition of forest trees at plots of the Level 1 every ten years.”*
- Article 18:  
*„The National Centre forwards the annual report on the damage of forest ecosystems of the Republic of Croatia to the Ministry and legal persons from Article 11, paragraph 1 of these Regulations until 1 May of the current year for the previous year, and to other state authorities and legal persons when these data are necessary in order to perform legally specified affairs and tasks from their competence, as well as to other persons who express a legal interest, with the consent of the Ministry.”*





Tasks and activities of the National Centre (Forest Research Institute, Jastrebarsko) specified by the Rulebook almost completely correspond to the tasks that are to be performed by the **Referent Centre for forestry soil monitoring**. Considering the existence of this legal regulation, and taking into consideration the guidelines from Article 5, paragraph 2 of the Regulation on Environment Information System (OG 68/08), it is proposed to establish the Forest Research Institute Jastrebarsko as the Referent Centre for forestry soil monitoring. Once appointed, the Forest Research Institute Jastrebarsko shall be obliged to extend its activities defined by the Rulebook, by introducing intensive forestry soil monitoring at 30 selected plots of the Level I Network, with the objective of gathering forestry soil condition data pursuant to the Programme.

In addition, pursuant to Article 9 of the Regulation on Environment Information System (OG 68/08), the Referent Centre for forestry soil monitoring is to ensure the processing, control and entry of data to the Environment Information System databases. Specifically in the case of forestry soil, data shall be entered directly, by Internet interface, to the Database on Croatian soils, within Croatian Soil Information System (CROSIS), in Croatian Environment Agency.

### 3.5.2. Data flow and access to data

The National Centre (Referent Centre for forestry soil monitoring) delivers the data on the forestry soil condition gathered through regular monitoring pursuant to the Rulebook and data gathered by intensive monitoring at 30 selected plots of the Level I Network, to the Croatian Environment Agency in electronic form, by direct entry through Internet interface to the Croatian Soil Information System (to the Database on Croatian soils) which is the integral part of the Environment Information System.

Pursuant to Article 18 of the Rulebook, the National Centre (Referent Centre for forestry soil monitoring) is to submit to the Croatian Environment Agency a written report on the forestry soil condition, by 1 May of the current year for the previous year in which the soil monitoring was conducted pursuant to the Rulebook or in which was conducted intensive monitoring at 30 selected plots of the Level I Network.

The Referent Centre for forestry soil monitoring is to be obliged to coordinate its annual work plan to Croatian Environment Agency annual work plan for years in which the forestry soil monitoring will be conducted.

The Referent Centre for forestry soil monitoring is responsible for the accuracy and quality of submitted data.

The availability of forestry soil monitoring data to other potential users is specified by the Regulation on Environment Information System (OG 68/08).

## 3.6. Structure and sources of financing the intensive forestry soil monitoring at 30 plots

### 3.6.1. Specification of costs for intensive forestry soil monitoring

Table 4 displays the assessment and specification of costs of intensive forestry soil monitoring at 30 selected plots of the Level 1 Network, elaborated pursuant to data gathered during the implementation of the Project “Development of the Croatian Soil Monitoring Programme with a Pilot Project.”

Costs of sample preparation, physical and chemical analysis are in conformity with official price lists of the Forest Research Institute, the Institute for Soil, the Faculty of Agriculture – Department of General Agronomy and the Institute for Public Health of the City of Zagreb.

**Table 4. Costs for intensive monitoring of forestry soil – one-time basis sampling costs for 30 plots**

| Type of costs                         | Description                                                                                                            | Quantity | Price (HRK) | Total price (HRK) |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------|----------|-------------|-------------------|
| <b>1.1. Travel costs</b>              | 1.1.1. Mileage                                                                                                         | 500      | 2,00        | 1.000,00          |
|                                       | 1.1.2. Daily allowances                                                                                                | 2        | 170,00      | 340,00            |
| <b>1.2. Field and office work</b>     | 1.2.1. Field work                                                                                                      | 24       | 53,70       | 1.288,80          |
|                                       | 1.2.2. Office work                                                                                                     | 24       | 53,70       | 1.288,80          |
|                                       | 1.2.3. Sampling                                                                                                        | 25       | 20,00       | 500,00            |
| <b>1.3. Material costs</b>            | 1.3.1. Expendable supplies                                                                                             | 1        | 500,00      | 500,00            |
| <b>1.4. Preparation of samples</b>    | 1.4.1. Drying, crushing and stocking                                                                                   | 5        | 40,00       | 200,00            |
| <b>1.5. Physical analyses</b>         | 1.5.1. Water capacity in O- horizon                                                                                    | 3        | 50,00       | 150,00            |
| <b>1.6. Chemical analysis of soil</b> | 1.6.1. Determination of pH in H <sub>2</sub> O and CaCl                                                                | 5        | 28,00       | 140,00            |
|                                       | 1.6.2. Carbonate content                                                                                               | 2        | 25,00       | 50,00             |
|                                       | 1.6.3. C,H,N,S analyses                                                                                                | 4        | 270,00      | 1.080,00          |
|                                       | 1.6.4. Aqua regia: 16 elements according to the list                                                                   | 4        | 1.000,00    | 4.000,00          |
|                                       | 1.6.5. Exchangeable cations: CEC (Ca <sup>2+</sup> , Mg <sup>2+</sup> , Na <sup>+</sup> , K <sup>+</sup> , Al, Fe, Mn) | 4        | 1.000,00    | 4.000,00          |
|                                       | 1.6.6. Exchangeable acidity and exchangeable hydrogen                                                                  | 4        | 600,00      | 2.400,00          |
| <b>Cost per plot</b>                  |                                                                                                                        |          |             | <b>16.937,60</b>  |
| <b>Cost for 30 plots</b>              |                                                                                                                        |          |             | <b>508.128,00</b> |



### 3.6.2. Sources of financing the Forestry Soil Monitoring System

Financial funds for the implementation of the additional, i.e. intensive forestry soil monitoring programme, the National Centre is to plan within the Programme of measures for data gathering on the damage of forest ecosystems of the Rulebook (OG 129//06), and in accordance with foreseen time dynamics (5 years after regular soil monitoring).

As stated, specified financial funds (table 4) for costs of intensive forestry soil monitoring must be provided every tenth year.

The model for ensuring financial funds for implementation of forestry soil monitoring is specified by the *Rulebook on the mode of data collection, network of points, keeping the register, conditions for using data on damage of forest ecosystems (OG 129/06), Article 20:*

- „(1) National Centre is to elaborate and propose to the Ministry, for adoption, a Programme of measures for data gathering on the damage of forest ecosystems, by 1 June of the current year, for the next year.*
  
- (2) Programme from paragraph 1 of this Article is to contain data on the extent, type and mode of gathering data, as well as financial funds for its implementation.”*



### III. Croatian Contaminated Soil Monitoring Programme

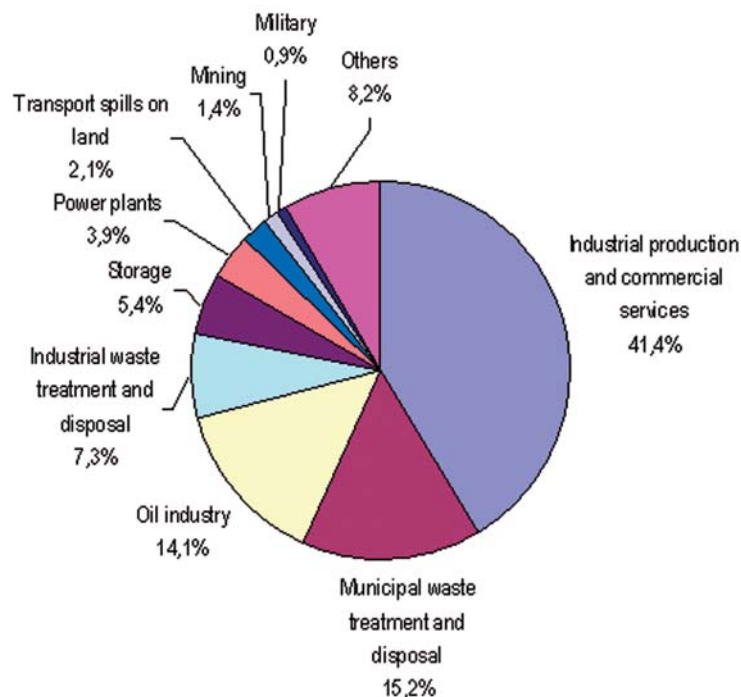
#### 1. Introduction

Contamination of soil is the input of substances, biological organisms or energy into the soil resulting in the modification of the soil quality and which impacts the normal use of the soil or the health of people and other organisms. Problems related to contaminated soil are closely related to the development of modern society.

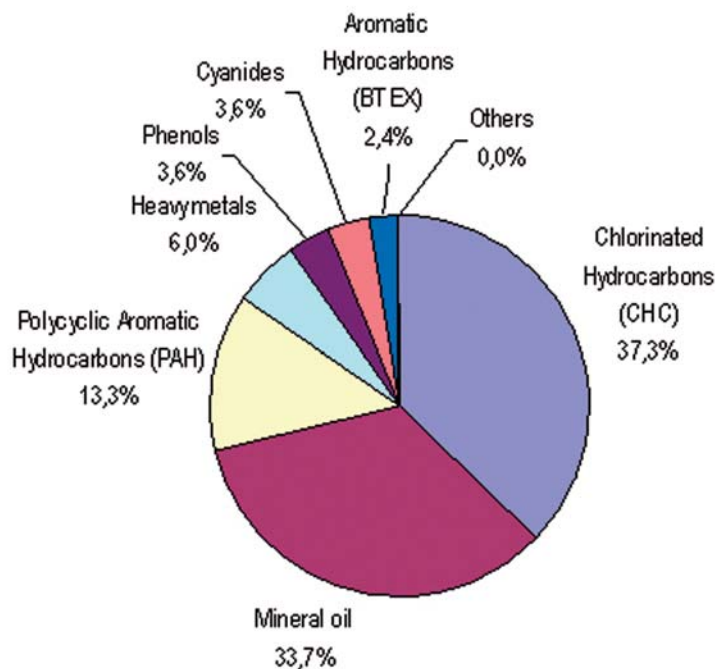
Soil pollutants are heavy metals, hydrocarbons, toxic organic compounds, other industrial chemicals, waste rich in nutrients, radionuclides and pathogenic organisms. The input of pollutants to the soil may result in damage or loss of several functions of the soil and may thus create negative consequences for the health of people, all types of ecosystems and other natural resources. In order to evaluate the effect of pollutants to the soil, it is necessary to monitor their concentration, as well as to continually monitor their functioning in the environment and mechanisms which affect ecosystems.

The cause of contamination may be industrial production, treatment and disposal of industrial waste, disposal of urban waste, oil industry, electric power plants, inflow to the soil during transportation, mining, military activity and other. According to the data of the European Environment Agency (EEA EIONET 2007), activities causing soil contamination are presented in the graph 1, while the graph 2, according to the same source, shows pollutants which affect soils in Europe. Based on the past research at the territory of the Republic of Croatia, the same activities and causative agents of soil contamination may be assumed.





**Graph 1. Review of activities causing soil contamination in Europe**  
 Source: : EIONET priority data flows on contaminates locations, EEA 2007



**Graph 2. Review of pollutants affecting soils in Europe**  
 Source: EIONET priority data flows on contaminates sites, EEA 2007



The general approach for discussion on soil contamination differentiates protection based on the cause of contamination with the view to prevent any further soil contamination, and procedures with already contaminated soils: remediation and recovery.

Spatial diversity of the soil, as well as diversity of soil contamination is very high, therefore, the sampling strategy at particular location is to be connected to the variety of potential contamination of environment. Thus, those who make decision related to the recovery of potentially contaminated locations would have the exact data on the size and form of contamination.

In Croatia, there is no systematic collection and processing of information on the soil quality, and it has been determined that it is necessary to establish the System for monitoring of potentially contaminated locations (Environment Protection Act, Chapter: Principles of Environment Protection, Articles: 7 - 18).

In the Contaminated Soil Monitoring Programme, as part of the Croatian Soil Monitoring Programme, potentially contaminated locations have been defined at which it is necessary to determine the condition of soil (inventarisation) and according to results, to establish monitoring points. The Programme contains a proposal of an institutional framework for implementation of the potentially contaminated and contaminated soil monitoring System, as well as assessment of costs. It also contains a detailed description of procedures for research of soil and attached standardised forms for the input and archiving of data about location, sampling and soil analyses. The structure of the form for monitoring of potentially contaminated and contaminated soil enables a simple and compatible input of data to the Croatian Soil Information System - CROSIS.





## 2. Overview of contaminated soil monitoring in the Republic of Croatia and the existing regulations

The concept of soil contamination, pollutants, and thresholds for particular types of soil according to the particle size distribution have been defined in the Republic of Croatia for the first time in the Ordinance on agricultural land protection of contamination on harmful substances (OG, 15/92). Environmental Protection Act (OG 110/07) introduced the Polluter Pays Principle. However, apart from this principle, there is no other legal regulation directly referring to potentially contaminated and contaminated locations.

In accordance with the above mentioned practice under which the polluter pays, some economic entities (INA, HEP) occasionally conduct monitoring of the condition of soil at sites they use. The most representative monitoring of the condition of soil has been conducted for 15 years now in the surroundings of the Central Gas Station Molve where, at the same sites soil is sampled in Spring and Autumn each year, and chemical parameters of soil are monitored. That kind of monitoring starts from integral approach which includes inventarisation of potentially contaminated site, elaboration of risk assessment study for people and the environment, and remediation or a project proposal for monitoring of site. During the last decade, in some scientific projects, soil monitoring was conducted at the local level (for instance, the Contamination of soil and soil monitoring at the Zagreb County (Romić et al, 1999-2004)); but until today, there has been no systematic monitoring of potentially contaminated and contaminated soils at the entire territory of Croatia.

It can only be assumed how many similar studies or surveys for monitoring of the soil condition at potentially contaminated and contaminated locations throughout Croatia have been carried out, since data are archived at different places (usually with the clients) and in different forms. The next problem is the implementation of different parameters and laboratory analyses, the sampling mode and the number of samples which is often not sufficient to representatively present the condition of soil. Therefore, the comparison of results of local projects and studies in most cases is not possible.

The Pilot Project for monitoring of contaminated soil has been conducted by employees of the Faculty of Agriculture University of Zagreb in the period between September 2006 and February 2008.

Pursuant to data from existing researches, and by analysing of representative areas, a site potentially contaminated by hydrocarbons of petrol origin has been selected for the implementation of the Pilot Project for monitoring of contaminated soil. Pilot site was located within the working area of the collection station (Os-5) in the area of Osekovo-Stružec, the municipality of Popovača, County of Sisak and Moslavina. This location has been selected because the majority of boreholes and the largest part of oil/gas network is located in the Pannonian part of Croatia where also agricultural production prevails.

A basic problem in the field of monitoring of soil condition and gathering of soil data at potentially contaminated and contaminated sites is the lack of legal regulations, and especially the lack of specified thresholds for pollutants concentrations in the soil considering the land use.

The state of contaminated soil monitoring in the Republic of Croatia may most clearly be seen from the SWOT analysis (Table 1).

**Table 1. SWOT analysis for the implementation of contaminated soil monitoring**

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>S – Strengths</b>     | <ul style="list-style-type: none"> <li>➤ including the results of the existing scientific and expert projects in the planning of monitoring of contaminated soils</li> <li>➤ several well equipped scientific institutions and agencies</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>W – Weaknesses</b>    | <ul style="list-style-type: none"> <li>➤ lack of legal solutions</li> <li>➤ uneven treatment of air, water and soil</li> <li>➤ lack of interest of the wider community for problems of soil contamination</li> <li>➤ lack of financial funds, absence of incentive instruments at the state level, economic entities and the local community for the prevention of soil contamination</li> <li>➤ absence of consistent implementation of certain laws</li> <li>➤ very weak transparency of data gathered to date</li> </ul>                                                                                                                                                                                                                                                                                                                                                                      |
| <b>O – Opportunities</b> | <ul style="list-style-type: none"> <li>➤ to organise a unique gathering of the existing data on soil contamination</li> <li>➤ to specify indicators for monitoring soil contamination</li> <li>➤ to keep a high ecological rating of the Republic of Croatia</li> <li>➤ to establish an integral system for soil monitoring</li> <li>➤ to begin integrating measures for the prevention of soil contamination into legislation (Regulation on the assessment of the impact of interventions to environment, Study of environment impact, Regulations on the protection of agricultural land, Ordinance on management of mud from devices for purification of waste waters when mud is being used in agriculture, and Ordinance on good agricultural practice on the use of fertilizers)</li> <li>➤ to adopt the Soil Protection Strategy and the Sustainable land management Strategy</li> </ul> |
| <b>T – Threats</b>       | <ul style="list-style-type: none"> <li>➤ lack of legislation on non-agricultural land</li> <li>➤ lack of relevant legal acts and regulations</li> <li>➤ lack of unique institution and reference centres for the implementation of soil monitoring</li> <li>➤ unevenness of homogeneous data</li> <li>➤ not well established sources and flow of data</li> <li>➤ non-existence of the system for monitoring soil and the condition and modification (degradation) of soil/land</li> <li>➤ unreliability of the existing data</li> </ul>                                                                                                                                                                                                                                                                                                                                                          |

In Croatia, there is no legal regulations which directly refer to monitoring of the soil condition and gathering of data on potentially contaminated and contaminated soils. Some existing legal acts and accompanying regulations indirectly mention the problems of potentially contaminated and contaminated soils:

- Waste Act (OG 178/04, 111/06, 60/08), in which, among other, it is stated that *“goals for waste management are waste disposal in a regulated manner and recovery of environment contaminated by waste”* (Article 5);...  
*“if the soil is contaminated by illegally stored, deposited or abandoned waste, an inspector will require recovery of contaminated site by an authorized person”* (Article 34).
- Mining Act (OG 190/03), according to which *“... commercial company and craftsman are obliged, during conducting and after the termination of exploitation works,...., to recover a devastated land. Legal and individual persons which illegally conduct research or exploitation of mineral raw material must recover land devastated by illegal works...”* (Article 53).
- Mineral Resources Management Strategy of the Republic Croatia (Draft, Ministry of Economy, Labour and Entrepreneurship, March, 2008.) gives guidelines for achieving sustainable and ecologically acceptable mineral resources exploitation, according to which it is necessary:
  - *Recovery and re-cultivation of site after mineral resources exploitation, with emphasis on land, surface water and groundwater.*
  - *Collection and disposal of technological waste generated in exploration and exploitation process, according to environment protection principles.*



- *Development of systematic environmental monitoring (ecological monitoring) with developing organizational, informational and institutional infrastructure in accordance with international norms and standards.*
  - *Continuous reporting to general public on results of systematic environment monitoring.*
  - *Development of collective responsibility towards environmental protection.*
  - *Strategic planning of mineral resources exploitation on sustainable development principles on local, regional and national level considering environment protection factors and global ecological standards implementation.*
  - *Creation of legal regulations for sustainable and ecologically acceptable exploitation of mineral resources with implementation of international obligations of the Republic of Croatia.*
  - *Encouragement of scientific researches and technological development for the purpose of realization of Mineral resources management Strategy of the Republic of Croatia goals.*
- Act on Confirmation of the United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa (UNCCD), (OG-IT 11/00). This Act has been adopted as the basic international agreement on soil protection. The Convention was adopted in Paris in 1994, and entered into force on 26th of December 1996. In Republic of Croatia the Convention entered into force on 4th of January 2001.
  - Act on Stockholm Convention on persistent organic pollutants (OG - IT 11/06) confirms the Stockholm Convention on Persistent Organic Pollutants signed by the Republic of Croatia on 23 May 2001. *“The goal of this Convention is to protect human health and environment from persistent organic pollutants”* (Article 1). The Convention specifies measures for the reduction or removal of emissions from intentional production and use, measures for the reduction or removal of emission from non-intended production, and measures for the reduction or removal of emission from stock and waste.
  - Regulation on limit values for pollutant emissions from stationary sources into the air (OG 21/07). *“In case where there is a reasonable doubt that there has been excessive emission of pollutants into air from a certain stationary source, special measurements are being conducted that may be specified by an environment protection inspector”* (Article 16).
  - Ordinance on waste management (OG 23/07), according to which, procedures which include waste disposal, among other, include *“waste disposal into or to the soil (such as landfills etc.), treatment of waste on or in the soil (such as biological degradation of liquid or muddy waste in the soil etc.), deep impression of waste (such as waste disposal into boreholes, used salt deposits, natural faults ), waste disposal to surface pools (such as disposal of liquid or muddy waste into pits, pools, lagoons etc.), waste incineration on the land, permanent waste disposal (such as storage in coal mines etc.)”* (Article 4).
  - Environmental Protection Act (OG 110/07) in which the obligation to prevent contamination of environment is clearly stated, through the “Polluter Pays Principle” which reads as follows: *“The polluter bears the costs for monitoring the condition of environment and the application of specified measures, as well as costs for conducting prevention measures for environment contamination, regardless of whether these costs have been created as a result of specified liability for environment contamination, i.e. by emissions into the environment or as a compensation specified by certain financial instruments, i.e. as an obligation specified by a regulation on the reduction of environment contamination”* (Article 15).

- Ordinance on environmental pollutants register (OG 35/08), according to which obligators of data delivery to a competent authority, are to forward data on: *“emission of pollutants into air, water and/or sea and soil, transfer outside the place of creation of pollutants in waste waters intended for further treatment, production and/or transfer outside of place of creation: - hazardous waste in the total quantity larger than 50 kilos per year and non-toxic waste in the total amount larger than 2000 kg per year, for recycling or disposal, except for the production of waste which is being referred to procedures of disposal by treatment of waste on or in the soil, i.e. by deep loading of waste into soil”* (Article 7).
- Regulation on environmental impact assessment (OG 64/08) specifies *“interventions for which environmental impact assessment is maintained, interventions which are subject to evaluation on necessity for environmental impact assessment, mode of environmental impact assessment procedure, mode of operations and a mandatory summary of committee opinion, mode of participation of authorized persons, mode of procedure implementation of evaluation on environmental impact assessment, mode of procedure implementation of certificate issuing on content of study according to intervention holder’s request, mode of publicity informing and public and interested public participation in procedures prescribed by this regulation, criteria and methods of individual inquiries on the basis of which is decided about needs for environmental impact assessment.”* (Article 1). According to this regulation mandatory content of study contains: *“Description of environmental impact of intervention during building and/or usage, which particularly includes: impact on people, animals and plants, soil, water, air, climate factors, material goods which include cultural and archaeological legacy and landscape and interaction between them and in relation to intervention.”* (Annex IV).
- Ordinance on the register of use permits establishing integrated environmental requirements and of decisions on integrated environmental requirements for existing installations (OG 113/08). *“The register is central source of information, in Republic of Croatia, about use permits establishing integrated environmental requirements and on decisions on integrated environmental requirements for existing installations.”* (Article 2). *“Data are entered in the Register according to Form contained in the Ordinance, for each firm and facility on a separate page of the register, numbered, chronologically ordered according to date of submitted documentation to the Agency, by means that for each facility of the firm, on each location data are separately registered. Register is maintained by use of software application which enables network input, processing and presentation of data stored in the Register.”* (Article 4).
- Ordinance on the register of installations in which dangerous substances have been identified and on the register of reported major accidents (OG 113/08), which *“prescribes content and mode of maintenance of the register of installations in which dangerous substances have been identified by means of ordinance which regulates prevention of major accidents which include dangerous substances, content and mode of maintenance of the register of reported major accidents and method and terms of data delivery to the register.”* (Article 1). *“Data on identified dangerous substances in installations obliged persons deliver by using Notification form on identified dangerous substances in installations which is prescribed in Annex II of Regulation on the prevention of major accidents involving dangerous substances. Data on major accidents are entered into Register using Forms for reporting major accidents in installations and, according to law, obliged person is required to deliver the data to the Agency.”* (Article 16).
- Regulation on the procedure for establishing integrated environmental requirements (OG 114/08), which *“specifies activities which may cause emissions contaminating the soil, air, water and the sea and with this regard, an incomplete list of main indicative substances,*

<sup>1</sup>The Regulation enters into force on 31 March 2009.





*governs the mode of submitting a request for determining and the mode of determining consolidated conditions for environment protection for new plants in which activities are being conducted which may cause emissions contaminating the soil, air, water and the sea, with mandatory contents of technical and technological solution for an installation, mandatory contents of the solution which specifies consolidated conditions for environment protection for new installations, the mode and obligation for implementing a trail work of the installation considering the specified measures and consolidated conditions for environment protection, the mode for delivery of data on monitoring emissions into the soil, air, water and the sea, and other environment components, conditions when new consolidated conditions for the environment protection are to be obtained, i.e. decision on amendments of established consolidated conditions for environment protection and the mode of procedure of competent authorities in cases when emission from an installation might cause transborder impact on health of people and environment of other states, as well as other measures and conditions pursuant to internationally recognised norms and regulations, and determination of costs and the mode of covering costs in procedures of determining consolidated conditions for environment protection “ (Article 1).*

- Regulation on the prevention of major accidents involving dangerous substances (OG 114/08 ), *“This Regulation specifies the list of hazardous substances which are present in installations or may be created in installations during a large incident; the mode of determining the quantities of hazardous substances and the permitted quantity, as well as criteria according to which these substances are classified as hazardous” (Article 1).*
- Ordinance on the methods and conditions for the landfill of waste, categories and operational requirements for waste landfills on the mode of waste disposal, categories and working conditions of landfills (117/07) which goals are *“to minimize harmful impact on environment in whole duration period of landfill, particularly contamination of surface and groundwater, soil and air, including effect of greenhouse gas and minimizing risks on human health which may be caused by waste disposal and duration of landfill.” (Article 1).*
- Regulation on the manner of establishing environmental damage (OG 139/08), according to which in case of damage of land, the recovery implies removal of each significant risk from harmful impact on life and health of people. Among other, the Regulation specifies guidelines for the selection of measures for removal and measures for the prevention of damage and impairment on land: *“Necessary measures shall be taken with the view to ensuring, as a minimum, that corresponding pollutants are removed, monitored, restricted or reduced, as well as contaminated/damaged land, taking into consideration of its current use or approved future use at the moment of damage, so as not to continue to present a significant risk from harmful impact on human health. The existence of such risks shall be evaluated by procedures for risk assessment, taking into consideration properties and the function of the soil, the type and concentration of pollutants, preparations, organisms or microorganisms, the risk related to them and the possibility of their spreading. The use is to determine, based on regulations specifying the use of land or, if they exist, based on other relevant regulations which were in force at the moment the damage occurred. In case of modification of the purpose of use of land, all necessary measures are to be taken with the view to preventing all harmful cases to human health. If there are no special regulations on the use of land or other relevant regulations, the nature of the area at which damage occurred shall specify the use of that area, taking into consideration its expected, i.e. planned development. The option to be taken into consideration is the natural renewed establishment i.e. the option in which there would be no direct human interventions in the process of renewed establishment” (Annex II).*

<sup>2</sup>The Regulation enters into force on 31 March 2009.

In the field of environment protection, the Croatian economy faces a large challenge of adjustment to the European Union requests, i.e. to standardise our laws and directives with various directives in force in the European Union. The most serious task in the field of regulation of relations of industry and environment is the adjustment to the Directive EC 61/96 Integrated Pollution Prevention and Control – IPPC. This Directive primarily obliges to the use of preventive procedures, i.e. the prevention of the production of waste, as well as the application of environmentally friendly methods for control and treatment of waste, namely that waste that can not be avoided. The goal is to stimulate prevention measures for the prevention of production of waste at the source primarily by cleaner production and the application of Best Available Techniques (BAT). Countries which have recently joined the European Union (such as Slovenia and Slovakia), are allowed a transitional period for the application of the request of IPPC Directive, but only for the existing plants, while requests of IPPC Directive are in force for new plants. The majority of candidate countries for membership in the European Union has already begun with preparations for its implementation.

By notification on the succession from 8 October 1991, the Republic of Croatia became part to the Convention on Long-Range Transboundary Air Pollution from 1979 and Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), ([www.unece.org/env/lrtap](http://www.unece.org/env/lrtap)).

Besides these agreements, the Republic of Croatia ratified Protocol to the 1979 Convention on long-range transboundary air Pollution on further reduction of sulphur emissions (OG-IT 17/98 and 3/99), Protocol on Heavy Metals (OG-IT 5/07), Protocol on Persistent Organic Pollutants (OG-IT 5/07), Protocol on control of emissions of nitrogen oxides or their transboundary fluxes (OG-IT 10/07), Protocol on control of emissions of volatile organic compounds or their transboundary fluxes (OG-IT 10/07), Protocol to the 1979 Convention on long-range transboundary air Pollution to abate acidification, eutrophication and ground-level ozone (OG-IT 4/08).

At the European Union level, the European Pollutant Release and Transfer Register (EPRTR) (Regulation EC 166/2006) has been established. EPRTR is a completely integrated data system which is to include emissions from large industrial sources, as well as emission from diffuse sources such as roads, air transport, transport by boat, agriculture. The first year to report to the EPRTR is 2007 for which Member States shall forward data by June 2009, and the European Commission shall publish them in Autumn 2009. Synchronization to EPTR Directive in Croatia has been made through Ordinance on environmental pollutants register (OG 35/08).

Monitoring of local sources of contamination and their selection, according to conclusions of the Working Group for contaminated soils (Van-Camp. L., Bujarrabal, B., Gentile, A-R., Jones, R.J.A., Montanarella, L., Olazabal, C. and Selvaradjou, S-K. (2004) Reports of the Technical Working Groups Established under the Thematic Strategy for Soil Protection. EUR 21319 EN/4, 872 pp. Office for Official Publications of the European Communities, Luxembourg.) are to be made according to the following recommendations:

1. Establishment of the European Point Source Assessment System – EPSAS at defined locations where it is necessary to conduct continual monitoring. The Monitoring System shall include activities which shall be on the jointly agreed (EU) list of potential polluters. Activities shall be distinguished to those which are subject to European legislation and those which are in the competence of certain states. The System is to be based on already existing monitoring networks.
2. At the European level, EPSAS shall include those plants which have been obliged, to date, to issue reports on the condition of environment according to specified standards.





These are industrial plants which are subject to IPPC Directive, included by SEVESO II Directive, and industries included by the new BAT reference document (BREF) of the IPPC Directive, and landfills which are subject to the Landfill Directive. (BREF documents are being made for more that 30 industrial sectors.)

At the level of states, monitoring is being conducted based on agreed list of potential activities which cause soil contamination. It is recommended to the Member States of the European Union to conduct monitoring of facilities which are not currently included by the European Union legislation (such as military facilities, exploitation of mineral raw materials and other).

## 3. Contaminated Soil Monitoring Programme

### 3.1. Definition and description of locations considering potential sources and types of soil contamination

Soil contamination according to its origin may be:

- **natural** (floods, banks, strong rain, strong winds, natural radioactive emission, deposits of volcanic eruption and other), and
- **anthropogenic** (waste waters, city mud, liquid organic fertilisers, mineral fertilizers, pesticides, industrial emissions, anthropogenic radioactive emission and other).

Sources of contamination:

- **Local or point sources of contamination** are clearly limited. Soil contamination caused by local (or point) sources is mostly connected to mining, industrial plants, landfills and other plants during their activities, but also after their closing. These plants present a risk for both the soil and the water.
- **Line sources of contamination** are mostly related to roads and railways. Depending on the traffic, and notably in places where cars or trains stay for a longer period of time (traffic lights in city traffic, places for payment of toll, entries and exits from tunnels, ferry berths, railway stations), larger contamination emissions are expected. Spreading of contamination emission from line sources primarily depends on natural vegetation growing by the roads. If the roads are surrounded by natural vegetation (forest) or protection fences for wind, potential emission is lower immediately by the road. If there are no barriers, its increased spreading to the environment i.e. air occurs from which the contamination emission falls on the ground.
- **Diffuse sources of contamination** are mostly connected to atmospheric deposition, some agricultural activities and urban industrial areas, and in some part to roads and railways. Atmospheric deposition is related to gaseous emission in industry, traffic and agriculture.

Within this Programme diffuse contamination sources have been included through agricultural soil monitoring and forestry soil monitoring according to International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests, which has been established under UN and European Commission Convention on Long-Range Transboundary Air Pollution (CLRTAP).

#### 3.1.1. Indicators of potential contamination, potential sources of contamination and pollutants

Factors which influence the soil contamination may be defined by natural or anthropogenic indicators.

1. Natural indicators include:

- climatologic conditions (temperature, precipitations, evapotranspiration, and wind rose),
- soil (type of soil, parent rock, particle size distribution and structure),
- vegetation (type, density, annual or perennial, deciduous or evergreen),
- topographic (relief, slope, inclination, height above sea level).



2. Anthropogenic indicators include:

- agricultural and forest mode of using soil,
- industrial mode of using soil,
- permanent conversion (city surfaces, roads),
- other modes of using soil (mining, landfills)

Preliminary risk assessment for contamination of environment from contaminated soil may be presented in the following way:

1. The risk related to contamination of underground waters:

- use of surface and underground waters,
- type, toxicity, mobility, solubility and degradability of pollutants,
- overstepping of limiting value,
- sum of pollutants in saturated and unsaturated area,
- amount of pollutants in the soil,
- surface and volume of contaminated soil,
- surface and volume of contaminated underground waters,
- area of potential contamination (agricultural or forest soil, industrial area, area of special care/national parks, parks of nature etc./).

2. Risk for surface waters:

- use of surface waters,
- type, toxicity, mobility, solubility and degradability of pollutants,
- quantity of contamination in surface waters,
- distance from surface waters,
- overstepping of maximally allowed value of contamination in surface waters,
- level of protection of surface waters (drinking water, water for bathing or for another use).

3. Risk related to inhaling and toxicity of pollutants for humans:

- distance of the site from the closest settlement,
- vulnerability and sensitivity of the area,
- type and quantity of contamination,
- toxicity of inhaling,
- solubility of pollutants,
- potency (thickness) of pollutants,
- degree of overstepping limiting value.

The potential sources of soil contamination and types of possible emissions from contaminated locations are listed in Table 2 which is a guide for identification of possible sources of soil contamination, and pollutants which may be expected in increased quantity when conducting analyses.

**Table 2. Potential sources of contamination and pollutants**

| Potential sources of contamination                                         | Pollutants |    |    |    |    |    |    |   |     |     |         |                                                          |
|----------------------------------------------------------------------------|------------|----|----|----|----|----|----|---|-----|-----|---------|----------------------------------------------------------|
|                                                                            | Pb         | Cd | Cr | Cu | Ni | Hg | Zn | F | PAH | PCB | Dioxins | Other                                                    |
| <b>1. Vicinity of possible sources of contamination</b>                    |            |    |    |    |    |    |    |   |     |     |         |                                                          |
| <b>1.1. Traffic infrastructure</b>                                         |            |    |    |    |    |    |    |   |     |     |         |                                                          |
| Roads                                                                      | x          | x  |    |    |    |    | x  |   | x   |     |         |                                                          |
| Airports                                                                   | x          | x  |    | x  |    |    | x  |   | x   |     |         |                                                          |
| Railway facilities                                                         |            |    |    | x  |    |    |    |   |     |     |         |                                                          |
| Ventilation systems in tunnels                                             | x          | x  |    |    |    |    | x  |   | x   |     |         | Sulphur                                                  |
| <b>1.2. Energy</b>                                                         |            |    |    |    |    |    |    |   |     |     |         |                                                          |
| Thermal power plants                                                       | x          | x  | x  |    |    |    | x  |   | x   |     | x       |                                                          |
| Working space of gas plant and coal depots                                 | x          | x  |    |    |    |    | x  |   | x   |     |         |                                                          |
| <b>1.3. Landfills</b>                                                      |            |    |    |    |    |    |    |   |     |     |         |                                                          |
| Landfills of inert and dangerous waste                                     | x          | x  | x  | x  | x  | x  | x  | x | x   | x   | x       |                                                          |
| Plant for waste incineration (older technology)                            | x          | x  | x  | x  | x  | x  | x  | x | x   | x   | x       |                                                          |
| for disposal or recycling of animal corpses or animal waste                | x          | x  | x  | x  | x  | x  | x  | x | x   | x   | x       |                                                          |
| Plants for treatment of communal waste waters                              | x          | x  | x  | x  | x  | x  | x  | x | x   | x   | x       |                                                          |
| <b>1.4. Military plants</b>                                                | x          |    |    | x  |    | x  | x  |   |     |     |         | Antimony                                                 |
| <b>1.5. Industrial facilities</b>                                          |            |    |    |    |    |    |    |   |     |     |         |                                                          |
| Production of mineral fertilizers                                          | x          | x  |    | x  |    |    | x  |   |     |     |         | Sulphur                                                  |
| Mineral foundry                                                            | x          | x  |    | x  |    |    | x  |   |     |     | x       |                                                          |
| Oil and gas boreholes                                                      | x          | x  | x  | x  |    | x  | x  |   |     |     |         | Barium                                                   |
| Oil and gas pipelines                                                      | x          | x  | x  | x  |    |    | x  |   |     |     |         |                                                          |
| Oil and gas refineries, foundries                                          | x          | x  | x  | x  |    |    | x  |   |     |     |         |                                                          |
| Zink foundry                                                               |            | x  |    |    |    |    | x  |   |     |     |         |                                                          |
| Metal industry                                                             | x          | x  | x  | x  | x  |    | x  |   |     |     |         |                                                          |
| Glass production, including glass fibre                                    | x          | x  |    |    |    | x  | x  | x |     |     |         |                                                          |
| Production of ceramics, tiles and bricks etc.                              | x          | x  |    |    |    | x  | x  | x |     |     |         |                                                          |
| Production of asbestos and asbestos products                               |            |    |    |    |    |    |    |   |     |     |         | Asbestos fibre                                           |
| Cement factories                                                           | x          |    |    |    |    | x  |    | x |     |     | x       | Thallium                                                 |
| Textile industry                                                           |            |    | x  | x  |    |    |    |   |     |     |         |                                                          |
| Plastic processing                                                         |            | x  |    |    |    |    |    |   | x   | x   |         |                                                          |
| Printing houses                                                            | x          | x  | x  | x  |    |    | x  |   |     |     |         |                                                          |
| Facilities with application of organic solvents                            |            |    | x  | x  |    |    |    |   |     |     |         |                                                          |
| Construction, painting or removal of paint from ships                      |            |    | x  | x  |    |    |    |   |     |     |         |                                                          |
| Saw-mills                                                                  |            |    | x  | x  |    |    |    |   |     | x   |         |                                                          |
| Places for leather processing                                              |            |    | x  |    |    | x  |    | x | x   |     |         |                                                          |
| Paint and varnish factories                                                | x          | x  | x  | x  |    | x  | x  |   | x   | x   |         |                                                          |
| Production of agents for plant protection                                  |            |    |    |    |    |    |    |   |     |     |         |                                                          |
| Production of explosives and pyrotechnic products                          |            |    |    |    |    |    |    |   |     |     |         |                                                          |
| <b>1.6. Metal buildings, bridges and other facilities</b>                  | x          | x  | x  |    |    |    | x  |   | x   | x   |         | Iron                                                     |
| <b>2. Soils in agricultural production</b>                                 |            |    |    |    |    |    |    |   |     |     |         |                                                          |
| Soils at which mud from devices for purification of waste waters are used  | x          | x  | x  | x  | x  | x  | x  |   | x   | x   | x       |                                                          |
| Domestic gardens                                                           | x          | x  |    | x  |    | x  | x  |   |     |     |         |                                                          |
| Vineyard soils                                                             | x          | x  |    | x  |    |    |    |   |     |     |         |                                                          |
| Intensive agricultural soils                                               | x          |    |    | x  |    |    |    |   |     | x   |         | Insecticides based on hydrocarbons<br>Atrazine, Simazine |
| Soils with intensive use of organic liquid fertilizers (manure and slurry) |            |    |    | x  |    |    | x  |   |     |     |         |                                                          |
| <b>3. Mining activities</b>                                                |            |    |    |    |    |    |    |   |     |     |         |                                                          |
| Underground mining and similar activities                                  | x          | x  | x  | x  | x  | x  | x  |   | x   | x   |         |                                                          |
| Surface pits and quarries                                                  | x          | x  | x  | x  | x  | x  | x  |   | x   | x   |         |                                                          |

Source: Manual – Sampling and sample pre-treatment for soil pollutant monitoring. Published by Swiss Agency for the Environment, Forests and Landscape SAEFL, Berne, Switzerland, 2003.



### 3.1.2. Limiting values for emission of hazardous substances to the soil

The evaluation of the degree of contamination is primarily based on the impact of contamination on human health and/or environment. The problem is limiting value, that is, the difference in the content of pollutants in relation to basic - source - background values since the final valuation of the level of contamination includes a combined assessment of current conditions, comparison with reference values, the quantity of contamination in a time unit and the volume of contaminated material. The above mentioned differs from one state to another, and in states where the consciousness on preservation of environment is higher (or where there are larger problems), certain regions have separate stricter criteria for using soils for various uses.

Limiting values for heavy metals are to be accessed particularly carefully since physiological role and influence of heavy metals on humans, plants and animals are still not sufficiently known. Some heavy metals belong to the group of biogenic microelements necessary for life, some in a certain degree of content in the soil have a stimulating function, some are phytoecologically lethal or show synergetic activity; one group is without any physiological significance, and one part is toxic and leads to anomalies in living organisms.

Further, heavy metals included in the food chain above tolerant content cause acute or chronic diseases or death. There are even significant differences in the activity of the one and the same element in plant or animal worlds. Due to this, certain elements may change the place to which they “belong” today.

The balance of the emission of soil contamination by potential pollutants is shown in figure 1.

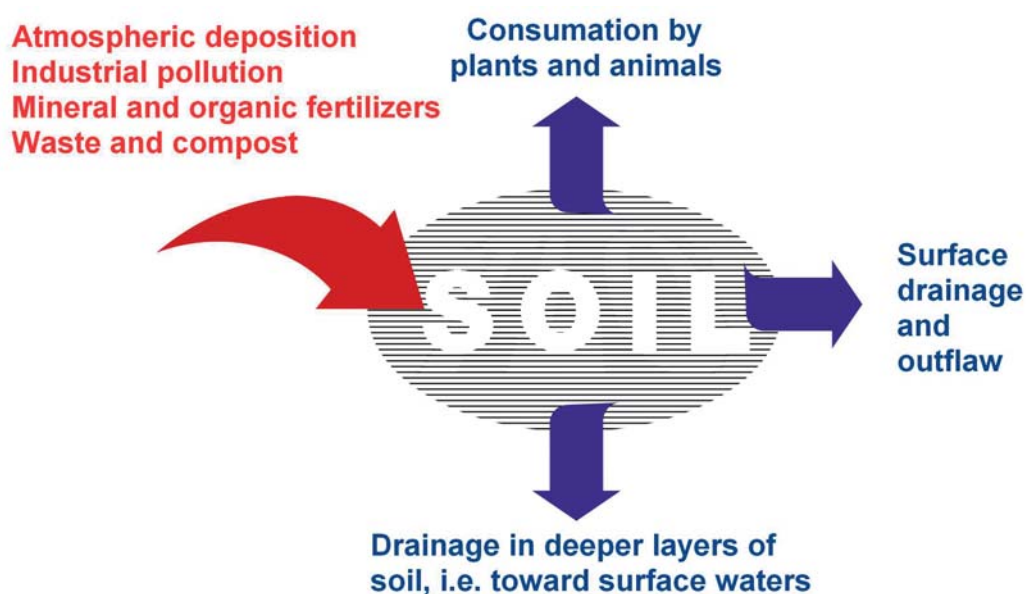


Figure 1. Balance of the emission of soil contamination by potential (red – income; blue – expenses)

Unlike the Republic of Croatia in which, apart from the Ordinance on agricultural land protection of contamination on harmful substances (OG, 15/92) there is no regulation specifying limiting values, the European Union countries began to elaborate limiting values related to various modes of using land:

- Children playgrounds i.e. spaces in which children stay for longer periods have separate limiting values, while sand grounds in kindergartens, playgrounds and parks have much stronger criteria.
- Living areas, parks and rest areas.
- Surface used for industrial and commercial purposes.
- A classification of agricultural land has been made to those used for cultivation of vegetable crops, and agricultural land used as a permanent green surface for pasture of cattle.

Based on the above mentioned regulations on various modes of using land used in Germany, Switzerland, Slovenia, Italy and Slovakia, a proposal has been made of limiting values of pollutants according to various modes of use of land in the Republic of Croatia. Since mostly the same types of soil have been determined in the mentioned countries, as well as similar geological base, the mode of using land, and especially similar sources of potential contamination of land as in the Republic of Croatia, a basis for the above mentioned limiting values are standards used in the mentioned countries.

The proposal of limiting values of pollutants in the soil according to various modes of using soil in the Republic of Croatia is presented in Table 3.





**Table 3. Limiting values of pollutants in the soil according to various modes of soil usage**

| Mode of using soil →                                                                 | Soils for agricultural production | Children playgrounds | Living areas | Parks and recreation areas | Areas for industrial and commercial purposes |
|--------------------------------------------------------------------------------------|-----------------------------------|----------------------|--------------|----------------------------|----------------------------------------------|
| Type of contamination in soil<br>↓                                                   | (mg/kg of dry soil)               |                      |              |                            |                                              |
| <b>1. Metals extracted in aqua regia:</b>                                            |                                   |                      |              |                            |                                              |
| Cadmium and its compounds (Cd)                                                       | 2                                 | 5                    | 10           | 30                         | 50                                           |
| Copper and its compounds (Cu)                                                        | 60                                | 60                   | 100          | 300                        | 500                                          |
| Nickel and its compounds (Ni)                                                        | 50                                | 50                   | 70           | 200                        | 500                                          |
| Lead and its compounds (Pb)                                                          | 100                               | 100                  | 100          | 500                        | 1.000                                        |
| Zink and its compounds (Zn)                                                          | 200                               | 200                  | 300          | 700                        | 1.200                                        |
| Chrome, total (Cr)                                                                   | 100                               | 100                  | 200          | 500                        | 750                                          |
| Mercury and its compounds (Hg)                                                       | 2                                 | 5                    | 10           | 30                         | 50                                           |
| Cobalt and its compounds (Co)                                                        | 50                                | 50                   | 75           | 250                        | 500                                          |
| Molybdenum and its compounds (Mo)                                                    | 10                                | 10                   | 40           | 250                        | 500                                          |
| Arsenic and its compounds (As)                                                       | 20                                | 20                   | 30           | 50                         | 100                                          |
| Barium and its compounds (Ba)                                                        | 100                               | 100                  | 200          | 300                        | 500                                          |
| Vanadium and its compounds (V)                                                       | 50                                | 50                   | 100          | 200                        | 400                                          |
| Thallium and its compounds (Tl)                                                      | 1                                 | 1                    | 2            | 5                          | 20                                           |
| <b>2. Other inorganic compounds</b>                                                  |                                   |                      |              |                            |                                              |
| Total fluorides                                                                      | 300                               | 450                  | 825          | 1.200                      | 1.500                                        |
| <b>3. Specified and total concentration of polycyclic aromatic hydrocarbons– PAH</b> |                                   |                      |              |                            |                                              |
| Naphthalene                                                                          | 0,1                               | 0,1                  | 0,25         | 0,25                       | 1,0                                          |
| Acenaphtalene                                                                        | 0,1                               | 0,1                  | 0,25         | 0,25                       | 1,0                                          |
| Fluorene                                                                             | 0,1                               | 0,1                  | 0,3          | 0,25                       | 1,0                                          |
| Phenantrene                                                                          | 0,2                               | 0,2                  | 0,6          | 1,5                        | 4,5                                          |
| Anthracene                                                                           | 0,1                               | 0,1                  | 0,3          | 0,25                       | 1,0                                          |
| Fluoranthene                                                                         | 0,2                               | 0,2                  | 0,5          | 1,5                        | 3,0                                          |
| Benzo(a)anthracene                                                                   | 0,2                               | 0,2                  | 0,7          | 2                          | 5,0                                          |
| Benzo(a)pyrene                                                                       | 0,2                               | 0,2                  | 0,6          | 1,5                        | 3,0                                          |
| Benzo(b)fluoranthene                                                                 | 0,2                               | 0,2                  | 0,6          | 1,5                        | 3,0                                          |
| Benzo(k)fluoranthene                                                                 | 0,2                               | 0,2                  | 0,6          | 1,5                        | 3,0                                          |
| Benzo(g,h,i)perylene                                                                 | 0,2                               | 0,2                  | 0,6          | 1,5                        | 3,0                                          |
| Kryzene                                                                              | 0,2                               | 0,2                  | 0,6          | 3                          | 7,5                                          |
| Dibenzo(a,h)anthracene                                                               | 0,1                               | 0,1                  | 0,3          | 0,5                        | 1,5                                          |
| Indeno(1,2,3,-c,d)pyrene                                                             | 0,2                               | 0,2                  | 0,7          | 1,5                        | 5,0                                          |
| Pyrene                                                                               | 0,2                               | 0,2                  | 0,6          | 3                          | 7,5                                          |
| Sum of PAH's                                                                         | 2                                 | 2                    | 7,5          | 20                         | 50                                           |
| <b>4a. Total concentration of polychlorinated biphenyls – PCB</b>                    |                                   |                      |              |                            |                                              |
| PCB = PCB28 + PCB52 + PCB101 + PCB118 + PCB138 + PCB153 + PCB180                     | 0,2                               | 0,2                  | 0,6          | 1                          | 2                                            |
| <b>4b. Insecticides on the base of chlorinated hydrocarbons</b>                      |                                   |                      |              |                            |                                              |
| DDT/DDD/DDE (total concentration = DDT+DDD+DDE)                                      | 0,1                               | 0,1                  | 2            | 4                          | 10                                           |
| Drins (total concentration= aldrins + dieldrins + endrins)                           | 0,1                               | 0,1                  | 2            | 4                          | 10                                           |
| HCH compounds ( total concentration = alpha-HCH + beta-HCH + gama-HCH + delta-HCH)   | 0,1                               | 0,1                  | 2            | 4                          | 10                                           |
| <b>4c. Other phytopharmaceutical agents</b>                                          |                                   |                      |              |                            |                                              |
| Atrazine                                                                             | 0,01                              | 0,01                 | 3            | 6                          | 8                                            |
| Simazine                                                                             | 0,01                              | 0,01                 | 3            | 6                          | 8                                            |

## 3.2. Selection of locations for monitoring points at potentially contaminated and contaminated soil

### 3.2.1. Inventarisation of potentially contaminated locations

During 2005/2006, the Croatian Environment Agency developed the Database on potentially contaminated and contaminated localities - GEOL, georeferenced (GIS) database and information on potentially and recognised contaminated sites, potentially and confirmed pollutants on locations and the status of recovery implemented at contaminated sites.

Pursuant to EU guidelines, the Soil Thematic Strategy COM (2006)231) and the Proposal for a Soil Framework Directive COM(2006) 232) from 2006, GEOL database was supplemented in 2007 within the implementation of the Project, and was harmonised with recommendations of the Directive on European Pollutant Release and Transfer Register (Regulation EC 166/2006 – EPRTR - European Pollutant Release and Transfer Register).

Pursuant to the above mentioned supplements from 2007, GEOL database contains data on potential point sources of contamination; 2264 of potentially contaminated locations owned by 1080 legal entities.

The Soil Monitoring Programme foresees the establishment of a System for monitoring of potentially contaminated soil at 247 locations at the territory of the Republic of Croatia (Figure 2, list of sites is stated in Annex 1), sorted out considering the type of activity which is being conducted at the location, production capacities, a high potential of contamination and the type of pollutants that these activities may generate.

Inventarisation is to be conducted at all 247 potentially contaminated locations, i.e. the recording of the condition, in order to establish the following:

- contaminated sites at which, considering the limiting values from Table 2, there is real contamination which is to be recovered, and to establish soil monitoring at the location,
- potentially contaminated sites at which increased values of concentration of certain pollutants have not been determined (although the potentially contaminating activity is conducted at the site) or they are determined, but they do not overstep limiting values from Table 2, but it is necessary to monitor them considering potentially contaminating activity which is being conducted at the above mentioned site.



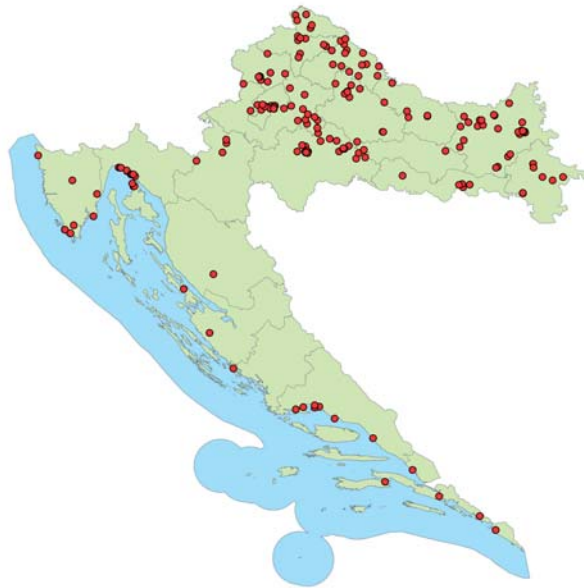
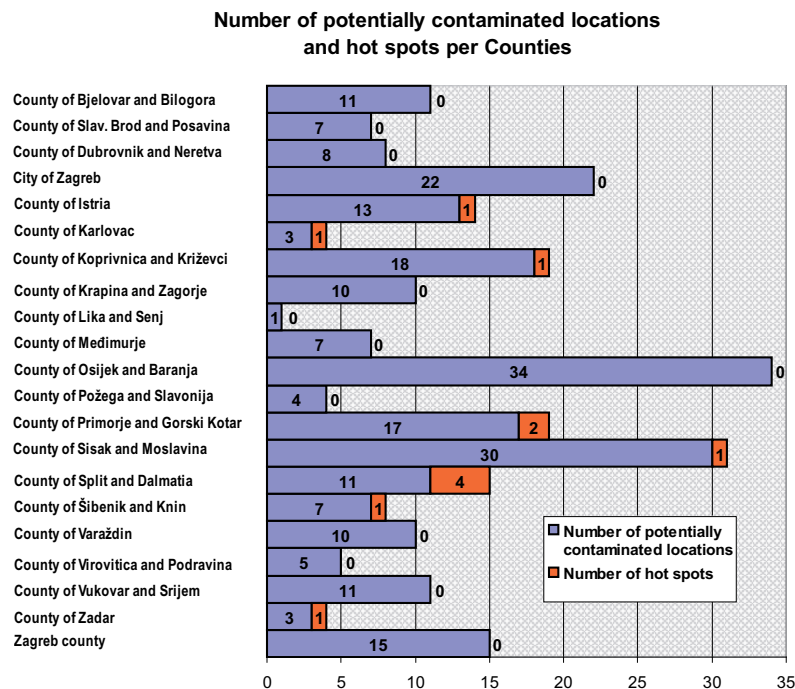


Figure 2. GEOL base - 247 potentially contaminated sites

Graph 3. shows the distribution of 247 potentially contaminated locations and 12 confirmed contaminated sites (hot spots) per Counties of the Republic of Croatia. It may be seen from the graph that the County with the largest number of potentially contaminated sites is the County of Osijek and Baranja (34), followed by the County of Sisak and Moslavina with 30 sites and the City of Zagreb with 22 potentially contaminated sites. At the territory of the County of Lika and Senj, there is one potentially contaminated site, while the Counties of Zadar and Karlovac have 3 potentially contaminated sites each. The largest number of confirmed contaminated sites (hot spots) is noted at the territory of the County of Split and Dalmatia.



Graph 3. Number of potentially contaminated location and hot spots per Counties of the Republic of Croatia

The above mentioned contaminated sites are mostly landfills of dangerous waste of former industrial plants and they should, in accordance with the results of the current situation of the soil contamination, be recovered in the shortest period and included in the Soil Monitoring System. At some locations (Obrovac Alumina Plant, Coke Plant in Bakar, Kašteli and Salonit Vranjic), the recovery procedures of contaminated soil are already being conducted and soil monitoring has already been established (HEP Plomin).

By the Environment Protection and Energy Efficiency Fund's Work Programme for the period from 2005 to 2008 (Class: 024-04/05-01/002, Reg. No.: 563-01-05-1, 17 May 2005), for the recovery of landfills of dangerous waste, investments are planned in the Fund in the amount of 162 million HRK (Table 4). Since the costs for disposal of dangerous waste at the mentioned locations are considerably larger than planned, it is probable that for this purpose, additional funds will be secured by the Work Programme of the Fund for the period from 2009 to 2012.

**Table 4. Review of selected funds and the recovery status of landfills of dangerous waste**

| No.           | Landfills of dangerous waste (contaminated sites) | Funds selected for the recovery for the period of 2005 - 2008 | Status                           |
|---------------|---------------------------------------------------|---------------------------------------------------------------|----------------------------------|
| 1.            | Ex- Obrovac Alumina Plant                         | 27 million HRK                                                | Recovery underway                |
| 2.            | Ex-Koksara u Bakru                                | 18 million HRK                                                | Recovery underway                |
| 3.            | TMG Kutina, phosphogypsum dump                    | 16 million HRK                                                | Funds for recovery approved      |
| 4.            | HŽ Cargo, Botovo                                  | 8 million HRK                                                 | Funds for recovery approved      |
| 5.            | Landfills Lemić Brdo                              | 22 million HRK                                                | Funds for recovery approved      |
| 6.            | Factory of electrodes and ferroalloy Šibenik      |                                                               | Recovery contracted in July 2008 |
| 7.            | HEP - Plomin                                      | 10 million HRK                                                | Recovery underway                |
| 8.            | Landfills of slag in Kaštela                      | 21 million HRK                                                | Recovery underway                |
| 9.            | Mravinačka kava, Salonit and Vranjic              | 22 million HRK                                                | Recovery underway                |
| 10.           | Ex-Borovo, Vukovar                                | 2,9 million HRK                                               | Funds for recovery approved      |
| 11.           | Landfills Sovjak, Rijeka                          | 18 million HRK                                                | Funds for recovery approved      |
| 12.           | TVIK - Knin                                       |                                                               | Not recovered                    |
| <b>Total:</b> |                                                   | <b>162 million HRK</b>                                        |                                  |

Source: Programme of Work of the Environment Protection and Energy Efficiency Fund for the period of 2005-2008 (Class: 024-04/05-01/002, Reg. No.: 563-01-05-1, 17 May 2005)



### 3.3. Soil sampling and soil description procedure for monitoring of potentially contaminated and contaminated soil

It is important to distinguish two types of soil sampling at contaminated sites:

1. Possible incidents which occur during various industrial activities. When it comes to incidents during regular work of industrial plants, cracking of various pipelines, overturning of tanks transporting dangerous substances and the like, sampling is made in accordance with the current situation in the field. In such situations, sampling will mostly be conducted according to the rules for point sources of contamination.
2. Soil monitoring at potentially contaminated and contaminated locations. Based on the source of contamination, soil sampling is being conducted for point or line monitoring of contaminated sites.

#### 3.3.1. Selection of soil monitoring point at the potentially contaminated location

Industrial (such as atmosphere deposition, disposal of waste or city waste mud) and agricultural activities (such as organic matter, fertilizers and pesticides) are considered as anthropogenic sources of contamination. However, it is often difficult to determine whether increased content of research parameter comes from pedogeochemical (evolutionary-genetical) or anthropogenic sources.

For the selection of points for monitoring of potentially contaminated locations, we recommend two field methods for the evaluation of the origin of potential sources of contamination:

1. **Method of “vertical comparison”** is used when the concentration of researched contamination in the upper horizon (layer) of soil was statistically higher than the one in the lower soil horizons, so that the contamination may be considered, with largest probability, as anthropogenic.
2. **Method of “horizontal comparison”** is used when the soil near to potential source of contamination contains more contamination than distanced soil located in the direction of the wind rose at similar locations (the same particle size distribution, soil which is not cultivated - pastures and meadows), so it is considered that the source of increased contamination is anthropogenic activity.

Both methods presume that there has been no shifting of the upper layer of soil in the vicinity of researched area, such as by reshaping of landscape or some other forms of construction. Based on past long-term research, and based on the results of the Pilot Project for monitoring of potentially contaminated soil, it was concluded that the combination of these two methods gives the best result.

The monitoring point of potentially contaminated and contaminated locations is selected on a plot where there is no construction, plant or relief barriers, which means that the spreading of the emission of contamination is equally possible in all directions.

For these reasons, during line contamination (roads and railway routes), sampling plot is to be set at the place where there are no protective fences for wind at either side of the road. In the opposite case, measured results may indicate very inaccurate conclusions.

When sampling of potentially contaminated soil, the nature and the spreading of contamination are to be taken into consideration. Sampling must be justified and documented. Surveyed area may be divided to corresponding sections, depending on the type of hazardous substances, the strength of threat, type of soil, shape of terrain, quality of soil, vegetation and other.

In order to determine the condition of soil and to justify the establishment of monitoring at a certain location, first it is necessary to conduct preliminary research. The **Sampling Plan** is a preparatory form for soil sampling at potentially contaminated and contaminated locations which enables a review of field conditions.

| Sampling Plan                                                                                                | YES                      | NO                       |
|--------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------|
| <b>1. Sampling method</b>                                                                                    |                          |                          |
| Does the sampling method (distribution and number of samples) meets the requests?<br>Note:                   | <input type="checkbox"/> | <input type="checkbox"/> |
| Is it possible to obtain a representative view of contamination using the selected sampling method?<br>Note: | <input type="checkbox"/> | <input type="checkbox"/> |
| Are other sampling methods considered?<br>Note:                                                              | <input type="checkbox"/> | <input type="checkbox"/> |
| Is there a procedure for determining replacement locations?<br>Note:                                         | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>2. Sample types</b>                                                                                       |                          |                          |
| Have necessary types of samples been determined?<br>Note:                                                    | <input type="checkbox"/> | <input type="checkbox"/> |
| Has a procedure for obtaining composite samples been determined?<br>Note:                                    | <input type="checkbox"/> | <input type="checkbox"/> |
| Does the sampling procedure enables taking of representative samples?<br>Note:                               | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>3. Sampling depth</b>                                                                                     |                          |                          |
| Have sampling depths been determined?<br>Note:                                                               | <input type="checkbox"/> | <input type="checkbox"/> |
| Can the purpose of research be achieved if selected sampling depths are used?<br>Note:                       | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>3.1. Sampling of subsurface soil layer</b>                                                                |                          |                          |
| Have sampling depths of subsurface layer/soil horizon been determined?<br>Note:                              | <input type="checkbox"/> | <input type="checkbox"/> |
| Is sampling at fixed depths or horizons of soil appropriate?<br>Note:                                        | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>4. Quantity of samples</b>                                                                                |                          |                          |
| Has a necessary quantity of samples been determined pursuant to planned analyses?<br>Note:                   | <input type="checkbox"/> | <input type="checkbox"/> |
| Have reserves of samples and storage of samples been taken into consideration?<br>Note:                      | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>5. Agreement with owners of locations at which soil monitoring is conducted</b>                           |                          |                          |
| Have owners and/or users-holders been informed that monitoring is being conducted?<br>Note:                  | <input type="checkbox"/> | <input type="checkbox"/> |
| Are there any cables and pipes and have all necessary approvals been obtained?<br>Note:                      | <input type="checkbox"/> | <input type="checkbox"/> |
| Is the staff adequately qualified and sufficiently trained?<br>Note:                                         | <input type="checkbox"/> | <input type="checkbox"/> |
| Is the planned time of monitoring adequate?<br>Note:                                                         | <input type="checkbox"/> | <input type="checkbox"/> |
| Has the risk from contamination been taken into consideration considering the order of sampling?<br>Note:    | <input type="checkbox"/> | <input type="checkbox"/> |
| Can a necessary quantity of samples be taken considering the planned number of single samples?<br>Note:      | <input type="checkbox"/> | <input type="checkbox"/> |
| Does the samples storage and transport satisfy standards requests?<br>Note:                                  | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>6. Preconditions for sampling</b>                                                                         |                          |                          |
| Does the temporary warehouse corresponds to requests (containers, temperature, duration)?<br>Note:           | <input type="checkbox"/> | <input type="checkbox"/> |
| Will the samples be dried in the shortest possible time?<br>Note:                                            | <input type="checkbox"/> | <input type="checkbox"/> |
| Is there a danger from soil contamination during grinding and sieving?<br>Note:                              | <input type="checkbox"/> | <input type="checkbox"/> |
| Is the procedure of division of samples adequate for the creation of representative sub-sample?<br>Note:     | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>7. Storage of soil samples</b>                                                                            |                          |                          |
| Is there a plan for storage?<br>Note:                                                                        | <input type="checkbox"/> | <input type="checkbox"/> |
| Have conditions for long-term storage been satisfied?<br>Note:                                               | <input type="checkbox"/> | <input type="checkbox"/> |





### 3.3.2. General data on stations for monitoring of potentially contaminated and contaminated soil

During the establishment of a soil monitoring station, data are gathered on potentially contaminated location which are entered in the pertaining Forms for descriptions of monitoring station on potentially contaminated and contaminated soil - O1;

- I. General data on the monitoring station,
- II. Factors of creation and evolution of soil,
- III. Surface properties of soil.

Forms are archived, in printed form, in the filing folder of the monitoring station.

| FORM FOR DESCRIPTION OF STATIONS FOR MONITORING OF POTENTIALLY CONTAMINATED AND CONTAMINATED SOIL - O1 |                                           |          |          |          |          |                                   |          |  |
|--------------------------------------------------------------------------------------------------------|-------------------------------------------|----------|----------|----------|----------|-----------------------------------|----------|--|
| I. General data on the monitoring station                                                              |                                           |          |          |          |          |                                   |          |  |
| 1.                                                                                                     | Station identification number             |          |          |          |          |                                   |          |  |
| 2.                                                                                                     | Time of survey of the station             |          |          |          | 5.       | Data on the owner of the parcel   |          |  |
| A                                                                                                      | Date                                      |          |          |          | A        | Name                              |          |  |
| B                                                                                                      | Time                                      |          |          |          | B        | Address                           |          |  |
| 3.                                                                                                     | Data on the Manager of survey             |          |          |          | C        | Place                             |          |  |
| A                                                                                                      | Full name                                 |          |          |          | D        | Contact person                    |          |  |
| B                                                                                                      | Institution                               |          |          |          | E        | Telephone                         |          |  |
| C                                                                                                      | Telephone                                 |          |          |          | 6.       | Administrative data on the parcel |          |  |
| 4.                                                                                                     | Data on the location of the station       |          |          |          | A        | County                            |          |  |
| A                                                                                                      | Closest populated settlement              |          |          |          | B        | Political municipality            |          |  |
| B                                                                                                      | Distance from the closest settlement      |          |          |          | C        | Cadastral municipality            |          |  |
| C                                                                                                      | Direction of movement from the settlement |          |          |          | D        | Cadastral plot                    |          |  |
| 7.                                                                                                     | Geographical data on the station          | NE angle | NW angle | SW angle | SE angle | Marker 1                          | Marker 2 |  |
| A                                                                                                      | Plane coordinates (Gauss Krüger)          | X        |          |          |          |                                   |          |  |
|                                                                                                        |                                           | Y        |          |          |          |                                   |          |  |
| B                                                                                                      | Geographical coordinates (WGS 84)         | N        |          |          |          |                                   |          |  |
|                                                                                                        |                                           | E        |          |          |          |                                   |          |  |
| C                                                                                                      | Mark of list HOK-a M=1:5.000              |          |          |          |          |                                   |          |  |
| D                                                                                                      | Height above sea level                    |          |          |          |          |                                   |          |  |

**FORM FOR DESCRIPTION OF STATIONS FOR MONITORING OF POTENTIALLY CONTAMINATED  
AND CONTAMINATED SOIL - 01**

**II. Factors for the creation and evolution of soil**

|            |                                                    |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
|------------|----------------------------------------------------|---------------------------------------|---|------------|-------------------------------------------|---|---|---|---|---|---|----|----|----|--|--|
| <b>8.</b>  | <b>Relief</b>                                      |                                       |   | <b>10.</b> | <b>*12 Nature of parent material</b>      |   |   |   |   |   |   |    |    |    |  |  |
| A          | *4                                                 | Form of relief of the area            |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| B          | *5                                                 | Position of the station               |   | <b>11.</b> | <b>*12 Geological age of the soil</b>     |   |   |   |   |   |   |    |    |    |  |  |
| C          | *7                                                 | Slope and exposition                  |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| D          | *6                                                 | Shape of slope                        |   | <b>12.</b> | <b>Soil classification of the station</b> |   |   |   |   |   |   |    |    |    |  |  |
| <b>9.</b>  | *11                                                | <b>Natural vegetation of the area</b> | A |            | Škorić et al, 1985                        |   |   |   |   |   |   |    |    |    |  |  |
|            |                                                    |                                       | B |            | WRB, 2006                                 |   |   |   |   |   |   |    |    |    |  |  |
| <b>13.</b> | <b>Climate</b>                                     |                                       | 1 | 2          | 3                                         | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |  |  |
| A          | Average air temperature                            |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| B          | Average precipitations                             |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| C          | Average annual air temperature                     |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| D          | Sum of precipitations                              |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| E          | Length of vegetation period                        |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| F          | *2                                                 | Current weather conditions            |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| G          | *2                                                 | Past weather conditions               |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| H          | *3                                                 | Water regime of the soil              |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| I          | *3                                                 | Temperature regime of the soil        |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| <b>14.</b> | <b>Wind rose</b>                                   |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| A          | Exposed/sheltered                                  |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| B          | Description                                        |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| <b>15.</b> | <b>Mode of using</b>                               |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| A          | *8                                                 | Mode of using                         |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| B          | Duration of current use (from-until; no. of years) |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| C          | Former use                                         |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| D          | Duration of former use (from-until; no. of years)  |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| <b>17.</b> | <b>Local sources of contamination - list</b>       |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |
| <b>18.</b> | <b>Additional information</b>                      |                                       |   |            |                                           |   |   |   |   |   |   |    |    |    |  |  |

\* Enter the marks from Tables of the above mentioned numbers - Guidelines for soil description, FAO, 2006.



| FORM FOR DESCRIPTION OF STATIONS FOR MONITORING OF POTENTIALLY CONTAMINATED AND CONTAMINATED SOIL - 01     |                                   |                        |  |            |                       |                         |  |
|------------------------------------------------------------------------------------------------------------|-----------------------------------|------------------------|--|------------|-----------------------|-------------------------|--|
| III. Surface soil properties                                                                               |                                   |                        |  |            |                       |                         |  |
| <b>16.</b>                                                                                                 | <b>Rockiness</b>                  |                        |  | <b>20.</b> | <b>Erosion</b>        |                         |  |
| A                                                                                                          | *14                               | Percentage of surface  |  | A          | *16                   | Nature of erosion       |  |
| B                                                                                                          | *14                               | Distance between rocks |  | B          | *17                   | Percentage of surface   |  |
| C                                                                                                          |                                   | Size of rocks          |  | C          | *18                   | Degree of erosion       |  |
| D                                                                                                          |                                   | Hardness of rocks      |  | D          | *19                   | Activity of erosion     |  |
| <b>17.</b>                                                                                                 | <b>Gravelness</b>                 |                        |  | <b>21.</b> | <b>Surface crust</b>  |                         |  |
| A                                                                                                          | *15                               | Percentage of surface  |  | A          | *20                   | Thickness               |  |
| B                                                                                                          | *15                               | Diameter of fragments  |  | B          | *20                   | Hardness                |  |
| <b>18.</b>                                                                                                 | <b>Surface salt efflorescence</b> |                        |  | <b>22.</b> | <b>Surface cracks</b> |                         |  |
| A                                                                                                          | *22                               | Percentage of surface  |  | A          | *21                   | Average width           |  |
| B                                                                                                          | *22                               | Thickness of layer     |  | B          | *21                   | Average depth           |  |
| C                                                                                                          |                                   | Type of salt           |  | C          | *21                   | Average mutual distance |  |
| <b>19.</b>                                                                                                 | <b>Faded sand on the surface</b>  |                        |  |            |                       |                         |  |
| A                                                                                                          | *23                               | Percentage of surface  |  |            |                       |                         |  |
| * Enter the marks from Tables of the above mentioned numbers - Guidelines for soil description, FAO, 2006. |                                   |                        |  |            |                       |                         |  |

### 3.3.3. Sampling of soil profile

Soil profile is elaborated on a one time basis, during the establishment of the station. The profile is opened down to the depth of the parent material, and even deeper if necessary, if the parent material is mealy, depending on potential contamination. The face of the profile is prepared for the description, measure tape is set from the surface to the bottom of the profile, and the profile and the landscape of the station are photographed.

The manager of field works classifies the soil as precisely as possible based on morphological properties. The final classification of the soil is determined based on analytical data obtained from the laboratory. The procedure of soil classification is equal to the classification during monitoring of agricultural soils.

Sampling of soil profile is conducted pursuant to ISO 10381-2:2005 - *Soil quality - Sampling - Part 2: Guidance on sampling techniques*, and ISO 10381-5: 2003 - *Soil quality - Sampling - Part 5: Guidance on the procedure for the investigation of urban and industrial sites with regard to soil contamination*.

Soil samples are taken from all horizons of soil profile in disturbed and undisturbed condition for the necessary analyses, in the same way as in agricultural soils.

All data on soil profile are entered into **Forms for description of stations for monitoring of potentially contaminated and contaminated soil - 01; IV. Soil profile description, and V. Photographic documentation** and are archived in the filing folder of the station.

**FORM FOR DESCRIPTION OF STATIONS FOR MONITORING OF POTENTIALLY CONTAMINATED  
AND CONTAMINATED SOIL - 01  
IV. Soil profile description**

| No. | 23. Horizons |                  | 24. Lower border of horizon |           |            | 25. Rock's fragments |          |       |            |       |
|-----|--------------|------------------|-----------------------------|-----------|------------|----------------------|----------|-------|------------|-------|
|     | Mark         | Mark of cylinder | Depth                       | Clearness | Topography | Percentage           | Diameter | Form  | Weathering | Type  |
|     | A **         | B ***            | A                           | B *24     | C *24      | A *26                | B *27    | C *28 | D *29      | E *30 |
| 1.  |              |                  |                             |           |            |                      |          |       |            |       |
| 2.  |              |                  |                             |           |            |                      |          |       |            |       |
| 3.  |              |                  |                             |           |            |                      |          |       |            |       |
| 4.  |              |                  |                             |           |            |                      |          |       |            |       |
| 5.  |              |                  |                             |           |            |                      |          |       |            |       |
| 6.  |              |                  |                             |           |            |                      |          |       |            |       |
| 7.  |              |                  |                             |           |            |                      |          |       |            |       |

\* Enter the marks from Tables of the above mentioned numbers - Guidelines for soil description, FAO, 2006.

\*\* Mark according to Škorić et al., 1985.

\*\*\* Factory mark of the cylinder for sampling of soil in undisturbed condition.

| No. | 26. Texture of the fine earth fraction | 27. Degradation and humification of plant residues | 28. Soil colour                       |                 | 29. Mottles |       |        |          |        |  |
|-----|----------------------------------------|----------------------------------------------------|---------------------------------------|-----------------|-------------|-------|--------|----------|--------|--|
|     |                                        |                                                    | Dry condition                         | Humid condition | Percentage  | Size  | Colour | Contrast | Border |  |
|     | *25                                    | *31                                                | Marks from Munsell Soil Colour Charts |                 | A *32       | B *33 | C **** | D *34    | E *35  |  |
| 1.  |                                        |                                                    |                                       |                 |             |       |        |          |        |  |
| 2.  |                                        |                                                    |                                       |                 |             |       |        |          |        |  |
| 3.  |                                        |                                                    |                                       |                 |             |       |        |          |        |  |
| 4.  |                                        |                                                    |                                       |                 |             |       |        |          |        |  |
| 5.  |                                        |                                                    |                                       |                 |             |       |        |          |        |  |
| 6.  |                                        |                                                    |                                       |                 |             |       |        |          |        |  |
| 7.  |                                        |                                                    |                                       |                 |             |       |        |          |        |  |

\* Enter the marks from Tables of the above mentioned numbers - Guidelines for soil description, FAO, 2006.

\*\*\*\* Unique colour descriptions according to Munsell Soil Colour Charts

| No. | 30. Redox-potential (rH) | 31. Reducing conditions in the soil | 32. Easily soluble salts | 33. pH value of the soil | 34. Organic matter | 35. Carbonates |       | 36. Gypsum |       |
|-----|--------------------------|-------------------------------------|--------------------------|--------------------------|--------------------|----------------|-------|------------|-------|
|     |                          |                                     |                          |                          |                    | Content        | Form  | Content    | Form  |
|     | *36                      | *37                                 | *42                      |                          | *46                | A *38          | B *39 | A *40      | B *41 |
| 1.  |                          |                                     |                          |                          |                    |                |       |            |       |
| 2.  |                          |                                     |                          |                          |                    |                |       |            |       |
| 3.  |                          |                                     |                          |                          |                    |                |       |            |       |
| 4.  |                          |                                     |                          |                          |                    |                |       |            |       |
| 5.  |                          |                                     |                          |                          |                    |                |       |            |       |
| 6.  |                          |                                     |                          |                          |                    |                |       |            |       |
| 7.  |                          |                                     |                          |                          |                    |                |       |            |       |

\* Enter the marks from Tables of the above mentioned numbers - Guidelines for soil description, FAO, 2006.



| No. | 37. Moisture status of the soil | 38. Bulk density | 39. Soil structure |       |                    |               | 40. Soil consistency |            |            |       |
|-----|---------------------------------|------------------|--------------------|-------|--------------------|---------------|----------------------|------------|------------|-------|
|     |                                 |                  | Degree             | Type  | Size of aggregates | Dry condition | Humid condition      | Stickiness | Plasticity |       |
|     | *57                             |                  | *58                | A *47 | B *49              | C *50         | A *53                | B *54      | C *55      | D *56 |
| 1.  |                                 |                  |                    |       |                    |               |                      |            |            |       |
| 2.  |                                 |                  |                    |       |                    |               |                      |            |            |       |
| 3.  |                                 |                  |                    |       |                    |               |                      |            |            |       |
| 4.  |                                 |                  |                    |       |                    |               |                      |            |            |       |
| 5.  |                                 |                  |                    |       |                    |               |                      |            |            |       |
| 6.  |                                 |                  |                    |       |                    |               |                      |            |            |       |
| 7.  |                                 |                  |                    |       |                    |               |                      |            |            |       |

\* Enter the marks from Tables of the above mentioned numbers - Guidelines for soil description, FAO, 2006.

| No. | 41. Porosity | 42. Pores |          |                              |                              | 43. Roots |                              |                              | 44. Other biological properties |       |
|-----|--------------|-----------|----------|------------------------------|------------------------------|-----------|------------------------------|------------------------------|---------------------------------|-------|
|     |              | Type      | Diameter | Number < 2mm/dm <sup>2</sup> | Number > 2mm/dm <sup>2</sup> | Diameter  | Number < 2mm/dm <sup>2</sup> | Number > 2mm/dm <sup>2</sup> | Quantity                        | Type  |
|     |              | *60       | A *61    | B *62                        | C *63                        | D *63     | A *79                        | B *80                        | C *80                           | A *81 |
| 1.  |              |           |          |                              |                              |           |                              |                              |                                 |       |
| 2.  |              |           |          |                              |                              |           |                              |                              |                                 |       |
| 3.  |              |           |          |                              |                              |           |                              |                              |                                 |       |
| 4.  |              |           |          |                              |                              |           |                              |                              |                                 |       |
| 5.  |              |           |          |                              |                              |           |                              |                              |                                 |       |
| 6.  |              |           |          |                              |                              |           |                              |                              |                                 |       |
| 7.  |              |           |          |                              |                              |           |                              |                              |                                 |       |

\* Enter the marks from Tables of the above mentioned numbers - Guidelines for soil description, FAO, 2006.

| No. | 45. Coatings |          |       |       |          | 46. Cementation/Compaction |            |                 |                     |
|-----|--------------|----------|-------|-------|----------|----------------------------|------------|-----------------|---------------------|
|     | Percentage   | Contrast | Type  | Form  | Location | Degree                     | Continuity | Layer structure | Nature of the layer |
|     | A *64        | B *65    | C *66 | D *67 | E *68    | A *72                      | B *69      | C *70           | D *71               |
| 1.  |              |          |       |       |          |                            |            |                 |                     |
| 2.  |              |          |       |       |          |                            |            |                 |                     |
| 3.  |              |          |       |       |          |                            |            |                 |                     |
| 4.  |              |          |       |       |          |                            |            |                 |                     |
| 5.  |              |          |       |       |          |                            |            |                 |                     |
| 6.  |              |          |       |       |          |                            |            |                 |                     |
| 7.  |              |          |       |       |          |                            |            |                 |                     |

\* Enter the marks from Tables of the above mentioned numbers - Guidelines for soil description, FAO, 2006.

| No. | 47. Concentrations of minerals |       |       |       |          |        |        |
|-----|--------------------------------|-------|-------|-------|----------|--------|--------|
|     | Percentage                     | Type  | Form  | Size  | Hardness | Nature | Colour |
|     | A. *73                         | B *74 | C *75 | D *75 | E *76    | F *77  | G *78  |
| 1.  |                                |       |       |       |          |        |        |
| 2.  |                                |       |       |       |          |        |        |
| 3.  |                                |       |       |       |          |        |        |
| 4.  |                                |       |       |       |          |        |        |
| 5.  |                                |       |       |       |          |        |        |
| 6.  |                                |       |       |       |          |        |        |
| 7.  |                                |       |       |       |          |        |        |
| 8.  |                                |       |       |       |          |        |        |

\* Enter the marks from Tables of the above mentioned numbers - Guidelines for soil description, FAO, 2006.

| No. | 48. Soil odour<br>*45 | 49. Human-transported material<br>*85 | 50. Artefacts |       |       |          |            |        |
|-----|-----------------------|---------------------------------------|---------------|-------|-------|----------|------------|--------|
|     |                       |                                       | Percentage    | Type  | Size  | Hardness | Weathering | Colour |
|     |                       |                                       | A *26         | B *83 | C *27 | D *76    | E *29      | F *78  |
| 1.  |                       |                                       |               |       |       |          |            |        |
| 2.  |                       |                                       |               |       |       |          |            |        |
| 3.  |                       |                                       |               |       |       |          |            |        |
| 4.  |                       |                                       |               |       |       |          |            |        |
| 5.  |                       |                                       |               |       |       |          |            |        |
| 6.  |                       |                                       |               |       |       |          |            |        |
| 7.  |                       |                                       |               |       |       |          |            |        |
| 8.  |                       |                                       |               |       |       |          |            |        |

\* - Guidelines for soil description, FAO, 2006.

| FORM FOR DESCRIPTION OF STATIONS FOR MONITORING OF POTENTIALLY CONTAMINATED AND CONTAMINATED SOIL - 01 |                           |     |                              |
|--------------------------------------------------------------------------------------------------------|---------------------------|-----|------------------------------|
| V. Photographic documentation                                                                          |                           |     |                              |
| 51.                                                                                                    | Photograph of the profile | 52. | Photographs of the landscape |
|                                                                                                        |                           |     |                              |
|                                                                                                        |                           |     |                              |





### 3.3.4. Sampling of single samples and forming of composite samples

Sampling of single and forming of composite soil samples is being conducted pursuant to standards; ISO 10381-2:2005 - *Soil quality - Sampling - Part 2: Guidance on sampling techniques* and ISO 10381-5: 2003 - *Soil quality - Sampling - Part 5: Guidance on the procedure for the investigation of urban and industrial sites with regard to soil contamination*.

Due to complexity of research at potentially contaminated and contaminated sites and often large heterogeneity at a small space in these researches, it is not recommended to take single samples, but results obtained based on composite samples are always preferred. Composite soil samples are united from 15 to 25 single samples and whose number depend on the evaluation of the Manager of field works (Figure 3).

Sampling for an composite sample is most often conducted in the form of a circle (Figure 3), in the middle of which a soil profile is opened in order to determine the number of horizons, i.e. the depth from which single samples for the composite sample are taken. Sampling may be conducted on two diagonals, in the form of letter S or according to other solids. It is important to emphasise that the sampling for the composite sample implies that the field is homogenous, i.e. that there are no differences in exposition, inclination, height above sea level, soil usage and other.

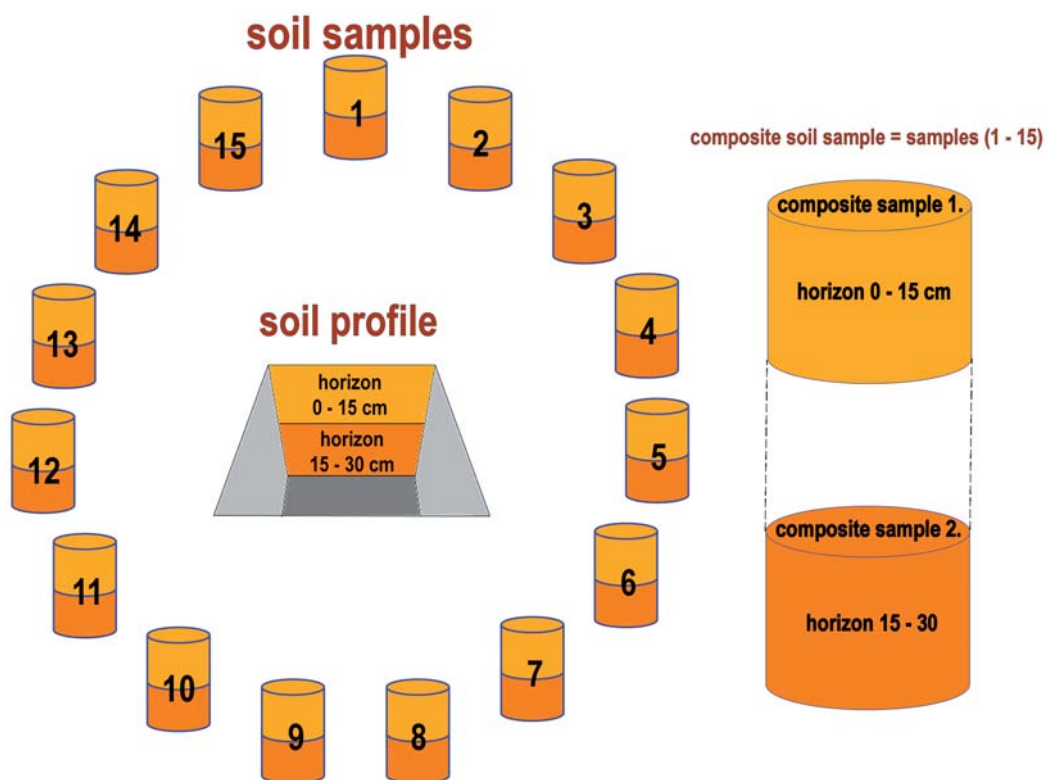


Figure 3. Sampling of composite samples

The quantity of taken soil for composite sample primarily depends on the number of planned laboratory analyses of soil. The total weight of an composite sample should not be less than 1 kilogramme of soil of the current humidity, but no larger than 2 kilograms of soil with the current humidity.

Samples are stored into bags marked by number of the station, number of sample, depth of sampling and the type of laboratory analyses for which the sample was intended. During each repeated sampling, it is necessary to fill in the **Forms for sampling of stations for monitoring of potentially contaminated and contaminated soil - O2; I. General data on the monitoring station**, and to file it in the filing folder of the station together with previously filled forms.

| FORM FOR SAMPLING OF STATIONS FOR MONITORING OF POTENTIALLY CONTAMINATED AND CONTAMINATED SOIL – O2 |                                                   |  |    |                                   |
|-----------------------------------------------------------------------------------------------------|---------------------------------------------------|--|----|-----------------------------------|
| I. General data on the monitoring station                                                           |                                                   |  |    |                                   |
| 1.                                                                                                  | Station identification number                     |  |    |                                   |
| 2.                                                                                                  | Time of survey of the station                     |  | 5. | Data on the owner of the parcel   |
| A                                                                                                   | Date                                              |  | A  | Name                              |
| B                                                                                                   | Time                                              |  | B  | Address                           |
| 3.                                                                                                  | Data on the Manager of survey                     |  | C  | Place                             |
| A                                                                                                   | Full name                                         |  | D  | Contact person                    |
| B                                                                                                   | Institution                                       |  | E  | Telephone                         |
| C                                                                                                   | Telephone                                         |  | 6. | Administrative data on the parcel |
| 4.                                                                                                  | Data on the location of the station               |  | A  | County                            |
| A                                                                                                   | Closest populated settlement                      |  | B  | Political municipality            |
| B                                                                                                   | Distance from the closest settlement              |  | C  | Cadastral municipality            |
| C                                                                                                   | Direction of movement from the settlement         |  | D  | Cadastral plot                    |
| 7.                                                                                                  | Wind rose                                         |  |    |                                   |
| A                                                                                                   | Exposed/sheltered                                 |  |    |                                   |
| B                                                                                                   | Description                                       |  |    |                                   |
| 8.                                                                                                  | Mode of use                                       |  |    |                                   |
| A                                                                                                   | Mode of use                                       |  |    |                                   |
| B                                                                                                   | Duration of current use (from - to; no. of years) |  |    |                                   |
| C                                                                                                   | Former use                                        |  |    |                                   |
| D                                                                                                   | Duration of former use (from - to; no. of years)  |  |    |                                   |
| 9.                                                                                                  | Local sources of contamination - list             |  |    |                                   |
| 10.                                                                                                 | Additional information                            |  |    |                                   |

### 3.3.4.1. Sampling of point sources of contamination

Due to specificity and often large heterogeneity of soil at potentially contaminated and contaminated locations of point sources, for each composite sample, a soil profile is opened with the view to determine the number of horizons and sampling depth of single samples. If established that it is necessary to take soil samples from two or more horizons, then the single sampling will be conducted from more depths and samples will be united into several composite samples.



Figure 4 presents a soil profile in which contamination has been determined in the second horizon, and therefore, it is necessary to take soil samples from two depths:

1. composite sample – from 0 to 15 cm,
2. composite sample - from 15 to 30 cm.



**Figure 4. Soil profile at a contaminated location**

Regardless of the form of point source of contamination, soil samples are always taken in a parallel, i.e. the identical number of composite samples is taken from a potentially contaminated area, as well as from the surrounding area (“clean soil”) which borders with the contaminated area.

Around the source of contamination, full circles are drawn pursuant to the size of contaminated location in diameter of 100 meters up to 7.5 kilometres, depending on the diameter of the circle of the potential source of contamination. In accordance with the increase of the surface of the potential source of contamination (Table 4), the number of soil samples increases, as well as the distance from the source of contamination. In the main directions of the world, a network of sampling is set at the surrounding soil, but taking into consideration the dominant direction of wind blowing.

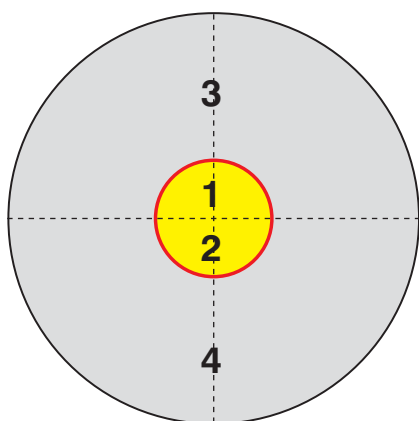


**Table 4. Sampling of potentially contaminated and contaminated locations considering their size**

| Size of potentially contaminated location |                     | Sampling                                             |                                                                |                                                                                     |
|-------------------------------------------|---------------------|------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------------|
| ha                                        | m <sup>2</sup>      | Clean soil at the distance from contamination (to m) | Number of profiles (potentially contaminated soil + pure soil) | Number of composite samples by horizon (potentially contaminated soil + clean soil) |
| 1                                         | 10.000              |                                                      |                                                                |                                                                                     |
| 1-3                                       | 10.000-30.000       | 250                                                  | 2 + 2                                                          | 2 + 2                                                                               |
| 3-5                                       | 30.000-50.000       | 500                                                  | 3 + 3                                                          | 3 + 3                                                                               |
| 5-10                                      | 50.000-100.000      | 750                                                  | 4 + 4                                                          | 4 + 4                                                                               |
| 10-50                                     | 100.000-500.000     | 1.500                                                | 6 + 6                                                          | 6 + 6                                                                               |
| 50-100                                    | 500.000-1.000.000   | 3.000                                                | 8 + 8                                                          | 8 + 8                                                                               |
| 100-200                                   | 1.000.000-2.000.000 | 5.000                                                | 10 + 10                                                        | 10 + 10                                                                             |
| ≥200                                      | ≥2.000.000          | 7.500                                                | 15 + 15                                                        | 15 + 15                                                                             |

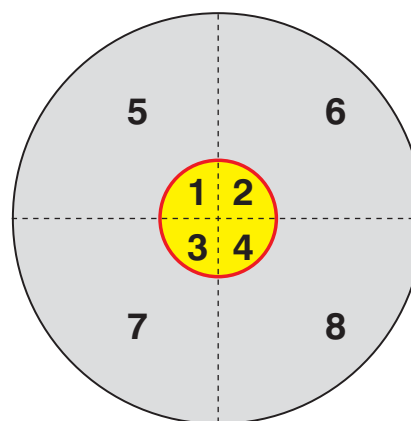
If the source of potential contamination is the size of up to 3 hectares (figure 5), two soil profiles (the total of 4) shall be opened in the middle of potential source of contamination and two in the surrounding, clean soil which has not been affected by potential contaminating activity. If the analysis of soil profiles has determined that samples of only one horizon (one depth) will be taken, then, the total of four composite samples are taken; two at potentially contaminated area, and two in the border area which was not affected by a potentially contaminating activity.

Further, in case when a potential source of contamination is the size of 5 to 10 hectares (Figure 6), four soil profiles are opened in the middle of potential source of contamination, and four composite samples are taken, also with the assumption that by the analysis of a soil profile, it was established that sampling of only one horizon is needed. The same procedure is repeated in the border area which has not been affected by potentially contaminated activity.



- Potentially contaminated location of size 1-3 ha
- 1,2 Soil profiles / composite soil samples from contaminated soil
- 3,4 Soil profiles / composite soil samples from clean soil

**Figure 5. Sampling of potentially contaminated location of size 1-3 ha**



- Potentially contaminated location of size 5-10 ha
- 1,2,3,4 Soil profiles / composite soil samples from contaminated soil
- 5,6,7,8 Soil profiles / composite soil samples from clean soil

**Figure 6. Sampling of potentially contaminated location of size 5-10 ha**



### 3.3.4.2. Sampling of line sources of contamination

When sampling of line sources of contamination (roads, railways, roads, waterways and the like), composite samples are taken at 5, 10, 20, 50, 100 m or more depending on the type and intensity of traffic and the character of pollutant and included surface according to the attached scheme (Figures 7 and 8).

The soil sampling network at line sources of contamination must be set in the area where there are no protective wind fences or other natural barriers which prevents equal spreading of potential emission of contamination from line source on all sides. Sampling of line sources of contamination should be conducted at meadows or pastures which have not been shifted from the road, nor agro-technically processed. The soil sampling of line sources of contamination should be conducted at site of higher transport concentration, such as sites of frequent traffic (as entrances into the cities, road junctions, railway junctions, etc)

The density of sampling of line sources of contamination (roads and railways) must be adjusted to geomorphologic characteristics of surveyed terrain. If the route passes through uniformed and plain terrain, then the density of sampling will be less (one sampling point per 500 or 1000 km). if the relief is more dynamic (highland, karsts area) then the sampling of the length of line source of contamination will be more dense (one sampling point per 50 or 100 km).

In case of roads, the sampling network is set at the distance of 100 metres from road, in such a way that on both sides of the road samples are taken from the surface layer of the soil in the parcel. At the distance of 10 meters from dividing channel which divides the road from arable surface, the first couple of composite samples is taken (composite samples 1 and 2), the second couple of samples is taken at the distance from 25 to 50 meters (composite samples 3 and 4), while the third couple is taken at the distance of 50 to 100 meters (composite samples 5 and 6). The control samples are taken from the parcel at the distance larger than 100 metres (composite samples 7 and 8). It is considered that at this distance, the influence of the road to the soil is lost. Only one soil profile is opened during line sampling.

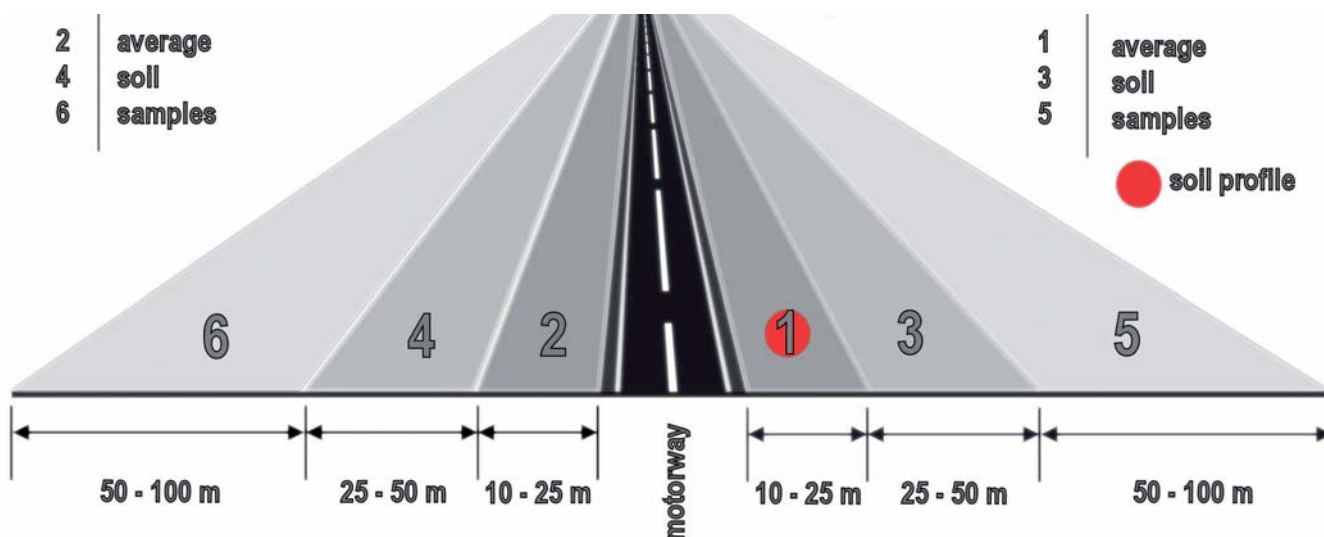


Figure 7. Soil sampling scheme at line (roads) sources of contamination

Identical sampling is conducted at railways, but only in this case, the distance of sampling is 40 metres from the tracks, since it is considered that the influence of tracks is lost at the largest distance.

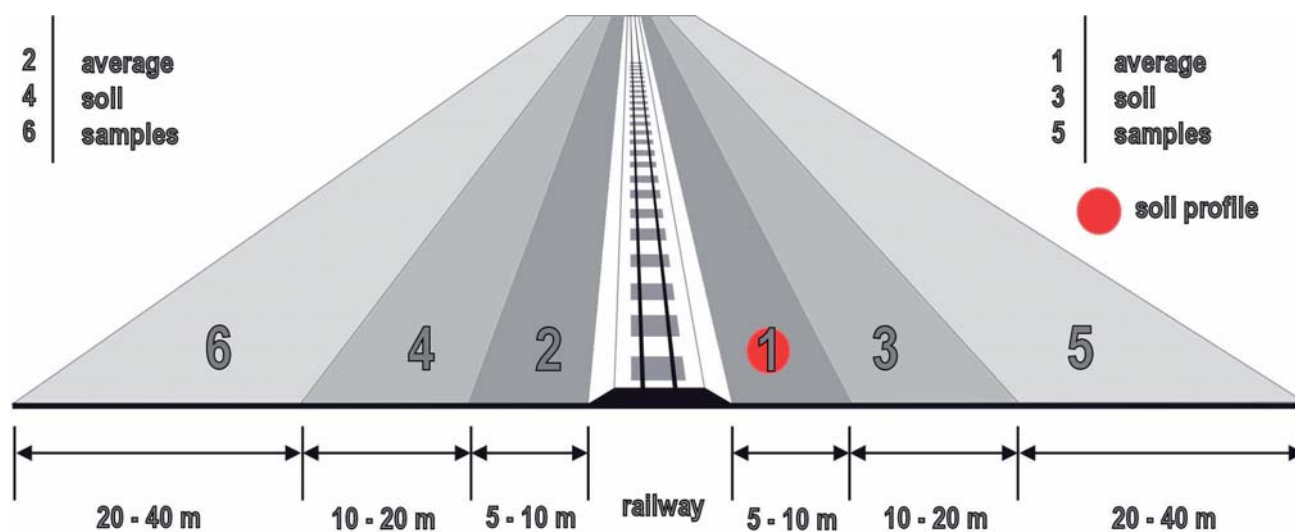


Figure 8. Soil sampling scheme at line (railways) sources of contamination

### 3.3.5. Preparation of soil samples for analysis and storage

Preparation of soil samples for the analyses is being conducted pursuant to standard HRN ISO 11464:2004 - *Soil quality - Pre-treatment of samples for physical-chemical analyses*.

All samples are stored and conserved in a storage room for keeping samples in the period of six years after sampling, pursuant to the standard ISO/DIS 18512:2006 - *Soil quality – Guidance on long and short term storage of soil samples*.

### 3.3.6. Time dynamics of sampling

It is considered that the time dynamics for sampling of potentially contaminated and contaminated sites from 5 to 10 years is enough for determining the changes in the concentrations of heavy metals and organic compounds (Van-Camp et al., 2004) while the changes in the concentrations of nitrogen and phosphorus are much faster. Taking into consideration types of potential contamination and potentially contaminating activities at 247 selected locations, the soil monitoring every five years is recommended.





### 3.4. List of parameters for physical, chemical and biological soil analyses

Tables 5, 6 and 7 contains a list of parameters for physical, chemical and microbiological analyses of soil. For each parameter, methods of analyses which are most frequently conducted in Croatia and recommended ISO standards are listed. Continual analyses of parameters according to the named methods and ISO standards shall ensure comparable results and enable a harmonised monitoring of the soil condition.

Tables contain a time dynamics for monitoring certain soil parameters. Since no changes are expected in physical soil properties in potentially contaminated and contaminated soil at which there are no agro-technical interventions, physical parameters are analysed on a one-time basis, during the first sampling, while chemical and microbiological parameters are to be analysed every five years.

**Table 5. Physical parameters**

| Parameters                                         | Methods used in the Republic of Croatia | Recommended ISO standards                                      | Time dynamics |
|----------------------------------------------------|-----------------------------------------|----------------------------------------------------------------|---------------|
| Particle size distribution                         | International A and B method            | HRN ISO 11277:2004                                             |               |
| Bulk density                                       | Cylinders by Kopecki                    | HRN ISO 11272:2004                                             | 1/1           |
| Maximum water capacity, pF 0                       | Cylinders by Kopeck – gravimetric       | HRN ISO 11274:2004<br>HRN ISO 11272:2004<br>HRN ISO 11461:2001 | 1/1           |
| Water capacity, pF 2,5                             | Pressure plate extractor                | HRN ISO 11274:2004                                             | 1/1           |
| Wilting point, pF 4,2                              | Pressure membrane                       | HRN ISO 11274:2004                                             | 1/1           |
| Physiologically active and easily accessible water | Pressure plate extractor                | HRN ISO 11274:2004                                             | 1/1           |
| Density and porosity                               | Pyknometar, calculation                 | HRN ISO 11508:2004<br>HRN ISO 11272:2004                       | 1/1           |
| Air capacity                                       | Calculation                             | HRN ISO 11508:2004<br>HRN ISO 11272:2004<br>HRN ISO 11461:2001 | 1/1           |
| Soil permeability for water                        | Serial determination – laboratory       | HRN ISO 17313:2004                                             | 1/1           |
| Soil compaction                                    | Penetrometar                            | Penetrometar                                                   | 1/1           |

**Table 6. Chemical parameters**

| Parameters                                                                                                                                                                                                                              | Methods used in the Republic of Croatia                                                                                                                                                                                                                      | Recommended ISO standards                                                                                                                                           | Time dynamics |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Soil acidity (pH value)                                                                                                                                                                                                                 | Electrochemical                                                                                                                                                                                                                                              | HRN ISO 10390:2005                                                                                                                                                  | 1/5           |
| Carbonate content (CaCO <sub>3</sub> )                                                                                                                                                                                                  | Scheibler calcimeter – volumetric<br>Elementary analysis                                                                                                                                                                                                     | HRN ISO 10693:2004<br>HRN ISO 10694:2004                                                                                                                            | 1/5           |
| Exchangeable acidity                                                                                                                                                                                                                    | Extraction with 1 M NaAc<br>Extraction with 1 M KCl                                                                                                                                                                                                          | HRN ISO 14254:2004                                                                                                                                                  | 1/5           |
| Cation exchange capacity (CEC, exchangeable Ca <sup>2+</sup> , Mg <sup>2+</sup> , Na <sup>+</sup> , K <sup>+</sup> )                                                                                                                    | Barium-chloride solution, Method by Kappen,<br>Extraction with hexa-amino-cobalt-trichloride                                                                                                                                                                 | HRN ISO 11260:2005<br>HRN ISO 13536:2005<br>ISO 23470:2007                                                                                                          | 1/5           |
| Organic and total carbon                                                                                                                                                                                                                | Method by Tjurin (Bikromat method)<br>Determination by Walkley-Black<br>Elementary analysis                                                                                                                                                                  | HRN ISO 10694:2004<br>HRN ISO 14235:2004                                                                                                                            | 1/5           |
| Total nitrogen                                                                                                                                                                                                                          | Modified method by Kjeldahl,<br>Elementary analysis (dry combustion)                                                                                                                                                                                         | HRN ISO 11261:2004<br>HRN ISO 13878:2004                                                                                                                            | 1/5           |
| Total sulphur                                                                                                                                                                                                                           | Elementary analysis (dry combustion)                                                                                                                                                                                                                         | HRN ISO 15178:2005                                                                                                                                                  | 1/5           |
| Accessible elements in the soil (P, K, Ca, Mg, NO <sub>3</sub> , Fe, Cu, Zn, S, Mn)                                                                                                                                                     | AL method - extraction with ammonium-lactate acetic acid (P and K)<br>Extraction of trace elements by fount solution DTPA<br>Extraction of trace elements with NH <sub>4</sub> NO <sub>3</sub><br>Determination to AAS, ICP-OES, ICP-MS, spectrophotometrics | HRN ISO 14870: 2005<br>ISO 19730:2008<br>HRN ISO 11263:2004                                                                                                         | 1/5           |
| Total metals and potentially toxic elements: Fe, Al, As, B, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Se, Sr, Zn, Tl                                                                                                                          | Extraction in aqua regia<br>Analysis with fluorohydrogen acid and perchlorate acid<br>Analysis with alkaline fusion<br>Determination to AAS, ICP-OES, ICP-MS                                                                                                 | HRN ISO 11466:2004<br>HRN ISO 14869-1:2004<br>HRN ISO 14869-2:2004<br>HRN ISO 11047:2004<br>ISO 22036:2008<br>ISO 16772:2004<br>ISO 20279:2005                      | 1/5           |
| Anions and cations: NO <sub>3</sub> <sup>-</sup> , NO <sub>2</sub> <sup>-</sup> , NH <sub>4</sub> <sup>+</sup> , SO <sub>4</sub> <sup>2-</sup> , CN <sup>-</sup> , ...                                                                  | 1:10 water extract<br>Extraction with KCl<br>Extraction with CaCl <sub>2</sub><br>Determination by ion chromatography (IC), continuous flow analyzer (CFA), spectrophotometrics                                                                              | ONORM L 1092-93<br>ISO 14256-1:2005<br>ISO 14256-2:2003<br>HRN ISO 10304-1:1998<br>HRN ISO 14911:2001<br>HRN ISO 11048:2004<br>HRN ISO 11262:2005<br>ISO 17380:2004 | 1/5           |
| Electrical conductivity (EC)                                                                                                                                                                                                            | Electrometric                                                                                                                                                                                                                                                | HRN ISO 11265:2004                                                                                                                                                  | 1/5           |
| Persistent organic pollutants: Polycyclic aromatic hydrocarbons (PAH), herbicides, organochlorinated pesticides, polychlorinated biphenyls (PCB), chlorphenols, volatile aromatic hydrocarbons (BTX), volatile halogenated hydrocarbons | Liquid (HPLC) and gas (GC) chromatography                                                                                                                                                                                                                    | ISO 18287:2006<br>HRN ISO 13877:2004<br>ISO 15009:2002<br>ISO 10382:2002<br>ISO 14154:2005<br>ISO 11264:2005<br>DIN 38414-24:2000                                   | 1/5           |
| Total oils                                                                                                                                                                                                                              | GC (gas chromatography)                                                                                                                                                                                                                                      | ISO 16703:2004                                                                                                                                                      | 1/5           |
| Mineral oils                                                                                                                                                                                                                            | Extraction with coal tetrachloride and 1,1,2 trichloro-trifluoroethan<br>IR Spectrometry<br>GC (gas chromatography)                                                                                                                                          | HRN ISO/TR 11046:2005<br>ISO 16703:2004                                                                                                                             | 1/5           |
| Chemical composition of drainage water at the depth of up to 2 m (pH, EC, anions, cations)                                                                                                                                              | Electrometric,<br>Ion chromatography                                                                                                                                                                                                                         | HRN ISO 10523:1998<br>HRN ISO 7888:2001<br>HRN ISO 10304-1:1998<br>HRN ISO 14911:2001                                                                               | 1/5           |



**Table 7. Microbiological parameters**

| Parameters                 | Methods used in the Republic of Croatia                                                       | Recommended ISO standards | Time dynamics |
|----------------------------|-----------------------------------------------------------------------------------------------|---------------------------|---------------|
| Cellulolytic activity      | Celluloses test                                                                               | ISO 23753-1-2:2005        | 1/5           |
| Activity of dehydrogenase  | Method with triphenyl-tetrazolium chloride(TTC) Method with iodine-tetrazolium chloride (INT) | ISO 23753-1-2:2005        | 1/5           |
| CO <sub>2</sub> production | <b>Substrate-induced respiration method</b>                                                   | HRN ISO 14240-1:2004      | 1/5           |

Results of laboratory analysis are entered in the **Forms for analysis of stations for monitoring of potentially contaminated and contaminated soil – O3:**

- I. Physical parameters,**
- II. Chemical parameters,**
- III. Microbiological parameters.**

Forms for analyses are filed in the filing folder together with all the previous filled forms for monitoring of the station.

| FORM FOR ANALYSIS OF STATION FOR MONITORING POTENTIALLY CONTAMINATED AND CONTAMINATED SOIL – O3 |                                       |                         |                     |                                       |                        |                           |                           |               |                                                  |                        |                           |                           |                  |
|-------------------------------------------------------------------------------------------------|---------------------------------------|-------------------------|---------------------|---------------------------------------|------------------------|---------------------------|---------------------------|---------------|--------------------------------------------------|------------------------|---------------------------|---------------------------|------------------|
| I. Physical parameters                                                                          |                                       |                         |                     |                                       |                        |                           |                           |               |                                                  |                        |                           |                           |                  |
| Station identification number:                                                                  |                                       |                         |                     | Laboratory:                           |                        |                           | Analyst:                  |               |                                                  | Date of analysis:      |                           |                           |                  |
| No.                                                                                             | Mark of horizon/<br>composite samples | Lower border of horizon | Content of skeleton | Particle size distribution (in water) |                        |                           |                           |               | Particle size distribution (in Na-pyrophosphate) |                        |                           |                           |                  |
|                                                                                                 |                                       |                         |                     | Large sand (2,0-0,2 mm)               | Small sand (0,2-0,063) | Large powder (0,063-0,02) | Small powder (0,02-0,002) | Clay (<0,002) | Large sand (2,0-0,2)                             | Small sand (0,2-0,063) | Large powder (0,063-0,02) | Small powder (0,02-0,002) | Clay (<0,002 mm) |
| 1.                                                                                              |                                       |                         |                     |                                       |                        |                           |                           |               |                                                  |                        |                           |                           |                  |
| 2.                                                                                              |                                       |                         |                     |                                       |                        |                           |                           |               |                                                  |                        |                           |                           |                  |
| 3.                                                                                              |                                       |                         |                     |                                       |                        |                           |                           |               |                                                  |                        |                           |                           |                  |
| 4.                                                                                              |                                       |                         |                     |                                       |                        |                           |                           |               |                                                  |                        |                           |                           |                  |
| 5.                                                                                              |                                       |                         |                     |                                       |                        |                           |                           |               |                                                  |                        |                           |                           |                  |
| 6.                                                                                              |                                       |                         |                     |                                       |                        |                           |                           |               |                                                  |                        |                           |                           |                  |
| 7.                                                                                              |                                       |                         |                     |                                       |                        |                           |                           |               |                                                  |                        |                           |                           |                  |

| No. | Textural mark | Bulk              |                | Total porosity | Soil capacity |        |    | Water constants |    |     |    | Stability of structural aggregates |       | Porosity (labor.) | Compaction (dig. penetr.) | Redox poten. |
|-----|---------------|-------------------|----------------|----------------|---------------|--------|----|-----------------|----|-----|----|------------------------------------|-------|-------------------|---------------------------|--------------|
|     |               | ρ <sub>v</sub>    | ρ <sub>c</sub> |                | Max Kv        | Ret.Kv | Kz | Kv              | Tv | Fav | Lv | mikro                              | makro |                   |                           |              |
|     |               | g/cm <sup>3</sup> |                | %vol           | %vol          |        |    | % mas           |    |     |    | %                                  |       | m/dan             | MPa                       |              |
| 1.  |               |                   |                |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |              |
| 2.  |               |                   |                |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |              |
| 3.  |               |                   |                |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |              |
| 4.  |               |                   |                |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |              |
| 5.  |               |                   |                |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |              |
| 6.  |               |                   |                |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |              |
| 7.  |               |                   |                |                |               |        |    |                 |    |     |    |                                    |       |                   |                           |              |

**FORM FOR ANALYSIS OF STATION FOR MONITORING POTENTIALLY CONTAMINATED AND CONTAMINATED SOIL – 03**  
**II. Chemical parameters**

**General parameters**

| No.                      | pH of soil in    |     |                   | Exchangeable acidity<br>mmol/100g | EC<br>mS/m | CaCO <sub>3</sub><br>% | Humus<br>% | KIK | Ca <sup>2+</sup> | Mg <sup>2+</sup> | Na <sup>+</sup> | K <sup>+</sup> | TC | TOC | N | S | H | P |
|--------------------------|------------------|-----|-------------------|-----------------------------------|------------|------------------------|------------|-----|------------------|------------------|-----------------|----------------|----|-----|---|---|---|---|
|                          | H <sub>2</sub> O | KCl | CaCl <sub>2</sub> |                                   |            |                        |            |     |                  |                  |                 |                |    |     |   |   |   |   |
| 1.                       |                  |     |                   |                                   |            |                        |            |     |                  |                  |                 |                |    |     |   |   |   |   |
| 2.                       |                  |     |                   |                                   |            |                        |            |     |                  |                  |                 |                |    |     |   |   |   |   |
| 3.                       |                  |     |                   |                                   |            |                        |            |     |                  |                  |                 |                |    |     |   |   |   |   |
| 4.                       |                  |     |                   |                                   |            |                        |            |     |                  |                  |                 |                |    |     |   |   |   |   |
| 5.                       |                  |     |                   |                                   |            |                        |            |     |                  |                  |                 |                |    |     |   |   |   |   |
| 6.                       |                  |     |                   |                                   |            |                        |            |     |                  |                  |                 |                |    |     |   |   |   |   |
| 7.                       |                  |     |                   |                                   |            |                        |            |     |                  |                  |                 |                |    |     |   |   |   |   |
| Method/<br>ISO<br>stand. |                  |     |                   |                                   |            |                        |            |     |                  |                  |                 |                |    |     |   |   |   |   |

**Accessible elements in the soil**

| No.                      | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O | NO <sub>3</sub> <sup>-</sup> | NO <sub>2</sub> <sup>-</sup> | NH <sub>4</sub> <sup>+</sup> | SO <sub>4</sub> <sup>3-</sup> | Fe | Cu | Zn | S | Mn |
|--------------------------|-------------------------------|------------------|------------------------------|------------------------------|------------------------------|-------------------------------|----|----|----|---|----|
|                          | mg/100 g                      |                  | mg/100 g                     | kg/ha                        | mg/kg                        |                               |    |    |    |   |    |
| 1.                       |                               |                  |                              |                              |                              |                               |    |    |    |   |    |
| 2.                       |                               |                  |                              |                              |                              |                               |    |    |    |   |    |
| 3.                       |                               |                  |                              |                              |                              |                               |    |    |    |   |    |
| 4.                       |                               |                  |                              |                              |                              |                               |    |    |    |   |    |
| 5.                       |                               |                  |                              |                              |                              |                               |    |    |    |   |    |
| 6.                       |                               |                  |                              |                              |                              |                               |    |    |    |   |    |
| 7.                       |                               |                  |                              |                              |                              |                               |    |    |    |   |    |
| Method/<br>ISO<br>stand. |                               |                  |                              |                              |                              |                               |    |    |    |   |    |

**Specific parameters - inorganic**

**Total metals / metalloids**

| No.                      | Fe    | Al | As | B | Cd | Co | Cr | Cu | Hg | Mn | Mo | Ni | Pb | Se | Sn | Sr | Zn | Sb | Ba | V | Tl | Be | Ti | Ag |  |
|--------------------------|-------|----|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|----|----|----|----|--|
|                          | mg/kg |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 1.                       |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 2.                       |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 3.                       |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 4.                       |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 5.                       |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 6.                       |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 7.                       |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| Method/<br>ISO<br>stand. |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |



| Specific parameters - inorganic |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
|---------------------------------|-------|----|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|----|----|----|----|--|
| Accessible metals / metalloids  |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| No.                             | Fe    | Al | As | B | Cd | Co | Cr | Cu | Hg | Mn | Mo | Ni | Pb | Se | Sn | Sr | Zn | Sb | Ba | V | Tl | Be | Ti | Ag |  |
|                                 | mg/kg |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 1.                              |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 2.                              |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 3.                              |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 4.                              |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 5.                              |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 6.                              |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| 7.                              |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |
| Method/<br>ISO<br>stand.        |       |    |    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |   |    |    |    |    |  |

| Specific parameters - inorganic |                             |                 |                 |                |                      |                       |                  |                  |                |          |
|---------------------------------|-----------------------------|-----------------|-----------------|----------------|----------------------|-----------------------|------------------|------------------|----------------|----------|
| Broj                            | Ions                        |                 |                 |                |                      |                       |                  |                  | Other elements |          |
|                                 | S <sub>2</sub> <sup>-</sup> | Br <sup>-</sup> | Cl <sup>-</sup> | F <sup>-</sup> | Free CN <sup>-</sup> | Total CN <sup>-</sup> | SCN <sup>-</sup> | Cr <sub>6+</sub> | Total F        | Total Br |
|                                 | mg/kg                       |                 |                 |                |                      |                       |                  |                  | mg/kg          |          |
| 1.                              |                             |                 |                 |                |                      |                       |                  |                  |                |          |
| 2.                              |                             |                 |                 |                |                      |                       |                  |                  |                |          |
| 3.                              |                             |                 |                 |                |                      |                       |                  |                  |                |          |
| 4.                              |                             |                 |                 |                |                      |                       |                  |                  |                |          |
| 5.                              |                             |                 |                 |                |                      |                       |                  |                  |                |          |
| 6.                              |                             |                 |                 |                |                      |                       |                  |                  |                |          |
| 7.                              |                             |                 |                 |                |                      |                       |                  |                  |                |          |
| Method/<br>ISO<br>stand.        |                             |                 |                 |                |                      |                       |                  |                  |                |          |

| Specific parameters – organic (1) |                                 |        |        |         |         |         |         |         |         |
|-----------------------------------|---------------------------------|--------|--------|---------|---------|---------|---------|---------|---------|
| No.                               | Polychlorinated biphenyls (PCB) |        |        |         |         |         |         |         |         |
|                                   | Total PCB                       | PCB 28 | PCB 52 | PCB 101 | PCB 102 | PCB 118 | PCB 138 | PCB 153 | PCB 180 |
|                                   | mg/kg                           | mg/kg  |        |         |         |         |         |         |         |
| 1.                                |                                 |        |        |         |         |         |         |         |         |
| 2.                                |                                 |        |        |         |         |         |         |         |         |
| 3.                                |                                 |        |        |         |         |         |         |         |         |
| 4.                                |                                 |        |        |         |         |         |         |         |         |
| 5.                                |                                 |        |        |         |         |         |         |         |         |
| 6.                                |                                 |        |        |         |         |         |         |         |         |
| 7.                                |                                 |        |        |         |         |         |         |         |         |
| Method/<br>ISO stand              |                                 |        |        |         |         |         |         |         |         |

| Specific parameters – organic (2)      |           |            |                   |                 |          |                  |                 |                  |        |     |         |     |     |     |      |       |      |
|----------------------------------------|-----------|------------|-------------------|-----------------|----------|------------------|-----------------|------------------|--------|-----|---------|-----|-----|-----|------|-------|------|
| Polycyclic aromatic hydrocarbons (PAH) |           |            |                   |                 |          |                  |                 |                  |        |     |         |     |     |     |      |       |      |
| No.                                    | Total PAH | Naphtalene | Acen-<br>aflilene | Acen-<br>aftene | Fluorene | Phen-<br>antrene | Anthra-<br>cene | Fluor-<br>antene | Pyrene | BaA | Krysene | BbF | BkF | BaP | DahA | BghiP | IcdP |
|                                        | mg/kg     | mg/kg      |                   |                 |          |                  |                 |                  |        |     |         |     |     |     |      |       |      |
| 1.                                     |           |            |                   |                 |          |                  |                 |                  |        |     |         |     |     |     |      |       |      |
| 2.                                     |           |            |                   |                 |          |                  |                 |                  |        |     |         |     |     |     |      |       |      |
| 3.                                     |           |            |                   |                 |          |                  |                 |                  |        |     |         |     |     |     |      |       |      |
| 4.                                     |           |            |                   |                 |          |                  |                 |                  |        |     |         |     |     |     |      |       |      |
| 5.                                     |           |            |                   |                 |          |                  |                 |                  |        |     |         |     |     |     |      |       |      |
| 6.                                     |           |            |                   |                 |          |                  |                 |                  |        |     |         |     |     |     |      |       |      |
| 7.                                     |           |            |                   |                 |          |                  |                 |                  |        |     |         |     |     |     |      |       |      |
| Method/<br>ISO stand                   |           |            |                   |                 |          |                  |                 |                  |        |     |         |     |     |     |      |       |      |

| Specific parameters – organic (3)                                                          |                                                                    |                                                             |                                                             |
|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------|
| Organochlorinated pesticides (OCP)<br>(Parameter/ Result (ng/kg)/<br>Method / ISO standard | Herbicides<br>(Parameter/ Result (ng/kg)/<br>Method / ISO standard | VAH<br>(Parameter/ Result (ng/kg)/<br>Method / ISO standard | VHH<br>(Parameter/ Result (ng/kg)/<br>Method / ISO standard |
|                                                                                            |                                                                    |                                                             |                                                             |
|                                                                                            |                                                                    |                                                             |                                                             |
|                                                                                            |                                                                    |                                                             |                                                             |
|                                                                                            |                                                                    |                                                             |                                                             |
|                                                                                            |                                                                    |                                                             |                                                             |

| Specific parameters - organic (4)                             |                                                                     |                                                                               |                                                               |                                                                |
|---------------------------------------------------------------|---------------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------------------------|----------------------------------------------------------------|
| PCDD/PCDF<br>(Parameter/ Result (ng/<br>kg)/ Method / ISO st. | Aliphatic ether<br>(Parameter/ Result (mg/<br>kg)/ Method / ISO st. | Chlorine phenol and<br>phenol (Parameter/ Result<br>(mg/kg)/ Method / ISO st. | Total oils<br>(Parameter/ Result (g/<br>kg)/ Method / ISO st. | Mineral oils<br>(Parameter/ Result (g/kg)/<br>Method / ISO st. |
|                                                               |                                                                     |                                                                               |                                                               |                                                                |
|                                                               |                                                                     |                                                                               |                                                               |                                                                |
|                                                               |                                                                     |                                                                               |                                                               |                                                                |
|                                                               |                                                                     |                                                                               |                                                               |                                                                |
|                                                               |                                                                     |                                                                               |                                                               |                                                                |





| Specific parameters - organic (5) - Hydrocarbons                                                 |                                                      |                                                                               |
|--------------------------------------------------------------------------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------|
| Aliphatic (cyclic/acyclic /saturated /non-saturated)<br>(Parameter/ Result (mg/kg)/ Method / ISO | Aromatic<br>(Parameter/ Result (mg/kg)/ Method / ISO | Total petroleum hydrocarbons (TPH)<br>(Parameter/ Result (g/kg)/ Method / ISO |
|                                                                                                  |                                                      |                                                                               |
|                                                                                                  |                                                      |                                                                               |
|                                                                                                  |                                                      |                                                                               |
|                                                                                                  |                                                      |                                                                               |
|                                                                                                  |                                                      |                                                                               |

| Specific parameters – organic (6)                                         |                                                                         |                                                       | Specific parameters – organometallic compounds                        |                                                                      |
|---------------------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------|-----------------------------------------------------------------------|----------------------------------------------------------------------|
| Organophosphorous insect.<br>(Parameter/ Result (ng/kg)/ Method / ISO st. | Insecticides Carbamates<br>(Parameter/ Result (ng/kg)/ Method / ISO st. | Other<br>(Parameter/ Result (mg/kg)/ Method / ISO st. | Organo-lead compounds<br>(Parameter/ Result (ng/kg)/ Method / ISO st. | Organo-tin compounds<br>(Parameter/ Result (ng/kg)/ Method / ISO st. |
|                                                                           |                                                                         |                                                       |                                                                       |                                                                      |
|                                                                           |                                                                         |                                                       |                                                                       |                                                                      |
|                                                                           |                                                                         |                                                       |                                                                       |                                                                      |
|                                                                           |                                                                         |                                                       |                                                                       |                                                                      |
|                                                                           |                                                                         |                                                       |                                                                       |                                                                      |

| Specific parameters – other parameters                        |                                                               |                                                          |                                                            |
|---------------------------------------------------------------|---------------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------|
| Radionuclides<br>(Parameter/ Result (Bq/kg)/ Method / ISO st. | Pathogenic organisms<br>(Parameter/ Result / Method / ISO st. | Asbestos<br>(Parameter/ Result (mg/kg)/ Method / ISO st. | Explosives<br>(Parameter/ Result (mg/kg)/ Method / ISO st. |
|                                                               |                                                               |                                                          |                                                            |
|                                                               |                                                               |                                                          |                                                            |
|                                                               |                                                               |                                                          |                                                            |
|                                                               |                                                               |                                                          |                                                            |
|                                                               |                                                               |                                                          |                                                            |

| FORM FOR ANALYSIS OF STATION FOR MONITORING POTENTIALLY CONTAMINATED AND CONTAMINATED SOIL – 03<br>III Microbiological parameters |                       |                           |                            |
|-----------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------------------|----------------------------|
| No.                                                                                                                               | Cellulolytic activity | Activity of dehydrogenase | CO <sub>2</sub> production |
|                                                                                                                                   | Mg glu/g of soil      | Mmol/100g                 | ugTPF/g of soil            |
| 1.                                                                                                                                |                       |                           |                            |
| 2.                                                                                                                                |                       |                           |                            |
| 3.                                                                                                                                |                       |                           |                            |
| 4.                                                                                                                                |                       |                           |                            |
| 5.                                                                                                                                |                       |                           |                            |
| 6.                                                                                                                                |                       |                           |                            |
| 7.                                                                                                                                |                       |                           |                            |
| Method/<br>ISO stand.                                                                                                             |                       |                           |                            |

## 3.5. Institutional framework and obligations for implementation of the Contaminated Soil Monitoring System

### 3.5.1. Proposal of a Referent Centre and authorised institutions for System implementation

The appointment of the Referent Centre for monitoring of potentially contaminated and contaminated soil is defined by Article 123 of Environmental Protection Act (OG 110/07).

The services of the Referent Centre for monitoring of potentially contaminated and contaminated soil are to include field works and laboratory analyses of specified parameters, and the delivery of processed data to the Croatian Environment Agency. Quality soil monitoring at various types of contaminated sites requires participation of expert persons from various scientific areas for the elaboration of analysis and interpretation of results on the condition of soil contamination. According to data gathered during the implementation of the project “Development of the Croatian Soil Monitoring Programme with a Pilot Project”, there is no institution in the Republic of Croatia which satisfies all conditions for performing the tasks of the Referent Centre for monitoring of potentially contaminated and contaminated soil.

It has already been mentioned that the Croatian Environment Agency has elaborated a Database on Croatian soils within Environment Information System. During 2009, it is planned to upgrade the Database to enable acquisition of data on monitoring of potentially contaminated and contaminated soil through Internet interface.

Therefore, the Croatian Environment Agency may take the role of the Referent Centre in terms of gathering data and reporting on the condition of potentially contaminated and contaminated soils. However, implementation of the Soil Monitoring System at potentially contaminated and contaminated sites (field work, laboratory analysis and data processing), may conduct only authorised legal persons who satisfy expert and technical conditions. Pursuant to Article 39, paragraph 3 of the Environmental Protection Act (OG 110/07) for performing the above mentioned tasks, authorised persons must obtain the permission of the Ministry for Environment Protection, Physical Planning and Construction.

The Regulation on Soil Monitoring in Croatia is to prescribe obligation of monitoring locations at which a contamination risk exists, considering the type of activity that is conducted at the location, production capacities, high potential for contamination and the type of pollutants that these activities may generate. Soil monitoring at potentially contaminated and contaminated locations in the way recommended by this Programme can be conducted only by legal persons which are authorised by the Ministry for Environment Protection, Physical Planning and Construction.

Cost of authorized persons for soil monitoring, data processing, reporting and data delivery to the Referent Centre have to defray legal persons who are owners and/or users of locations, according to “Polluter pays Principle” (Article 15 of the Environmental Protection Act), every five years pursuant to recommended time dynamics.

The Annex 1 presents a list of 247 locations at the territory of the Republic of Croatia sorted out from the GEOL database (CEA, revision and update of the GEOL database, according to available data, was made in 2007), pursuant to recommendations of the Directive on



the European Pollutant Release and Transfer Register (Regulation EC 166/2006), and considering:

- the type of activity that is being conducted at the location,
- production capacities,
- high potential for contamination and
- the type of pollutants that these activities may generate.

The annexed list of locations represents a basis for the establishment of the potentially contaminated and contaminated Soil Monitoring System. The Regulation on Soil Monitoring is to foresee a review and update of the list of potentially contaminated locations, i.e. legal entities “polluters”, pursuant to the Registers and lists generated from existing and future legal acts, such as:

- Ordinance on the environmental polluters register (OG 35/08),
- Regulation on environmental impact assessment of projects (OG 64/08),
- Ordinance on the register of use permits establishing integrated environmental requirements and of decisions on integrated environmental requirements for existing installations (OG 113/08)
- Ordinance on the register of installations in which dangerous substances have been identified and on the register of reported major accidents (OG 113/08)

### 3.5.2. Data flow and access to data

Authorised persons for monitoring of potentially contaminated and contaminated soil are to ensure processing, control and entry of data to the Database on Croatian soils at the Croatian Environment Agency.

The dissemination of soil monitoring data to other potential users is specified by the Regulation on the Environmental Information System (OG 68/08).

## 3.6. Financial structure of potentially contaminated and contaminated soil monitoring

### 3.6.1. Specification of costs for stations establishment and monitoring every 5 years

Unlike forestry and agricultural soils, the costs of soil monitoring at potentially contaminated and contaminated sites depend on several factors:

- type of contamination, i.e. potentially contaminating activity conducted at the location that define parameters which are to be monitored (Table 3),
- size of potentially contaminated site, based on which the number of composite samples is determined (Table 4),
- soil properties, i.e. the number of horizons from which the soil is sampled which also determine the number of composite samples that are to provide representative results.

Table 8. specifies the costs for monitoring of potentially contaminated location of the size from 1 to 3 hectares at which composite samples are taken from two horizons. Pursuant to the Directive on the European Pollutant Release and Transfer Register (Regulation EC 166/2006), parameters which are to be monitored are defined for main groups of potentially contaminating activities. Prices of analysis are presented pursuant to the official price lists of the Institute for Soil, Department for General Agronomy of the Faculty of Agriculture University of Zagreb, the Department of Mineralogy, Petrology and Mineral Resources of the Faculty of Mining, Geology and Petroleum Engineering University of Zagreb, and the Institute for Public Health of the City of Zagreb.

Since physical soil parameters are analysed on a one-time basis, costs are divided pursuant to time dynamics to:

1. Costs of first monitoring - inventarisation per location ( $x + y$ )
2. Costs for monitoring per location every 5 years ( $y$ )

Personnel costs (field and office work, travel costs) and material costs are not included in the specification considering that they depend on several factors (such as: distance and the size of location), and considering that price lists of services of institutions are not standardised.

From selected basic 247 potentially contaminated locations (Annex 1), the Table 9. presents the number of locations according to main groups of potentially contaminating activities, and the assessment of the total costs for the establishment and monitoring of potentially contaminated soil considering the type of potential contamination. Certain legal entities have registered several activities at the same location, therefore, these costs are specified and evaluated according to the primary activity.

It is necessary to emphasize one more time that the specified costs are informative, stated on the basis of potentially contaminated location of the average size of 1 to 3 hectares at which composite samples are taken from two horizons. At the locations of smaller size at which samples are taken from only one horizon, costs of monitoring shall be considerably less. Just the same, at potentially contaminated location of larger surface, with the increase of the number of necessary composite samples, the costs of monitoring shall be increased as well.



**Table 8. Specification of costs at potentially contaminated locations of various activities, of average size up to 3 ha, sampling from two horizons**

| Parameters                                                                                                                                            | Unit price for analysis (HRK) | 8 composite samples |                  | Potentially contaminating activities (list in table 9.) |                  |                  |                  |                                |                  |                  |                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|---------------------|------------------|---------------------------------------------------------|------------------|------------------|------------------|--------------------------------|------------------|------------------|------------------|
|                                                                                                                                                       |                               | Quant               | Price (HRK)      | 1. 9. (f) 9. (g)                                        | 2.               | 3.               | 4. 9. (h)        | 5. 9. (a) 9. (b) 9. (c) 9. (e) | 6.               | 7.               | 8.               |
| <b>Physical analysis of soil</b>                                                                                                                      |                               |                     |                  |                                                         |                  |                  |                  |                                |                  |                  |                  |
| Particle size distribution                                                                                                                            | 200,00                        | 8                   | 1.600,00         | x                                                       | x                | x                | x                | x                              | x                | x                | x                |
| Bulk density of soil                                                                                                                                  | 80,00                         | 8                   | 640,00           | x                                                       | x                | x                | x                | x                              | x                | x                | x                |
| Maximum capacity for water                                                                                                                            | 25,00                         | 8                   | 200,00           | x                                                       | x                | x                | x                | x                              | x                | x                | x                |
| Capacity for water                                                                                                                                    | 35,00                         | 8                   | 280,00           | x                                                       | x                | x                | x                | x                              | x                | x                | x                |
| Wilting point                                                                                                                                         | 25,00                         | 8                   | 200,00           | x                                                       | x                | x                | x                | x                              | x                | x                | x                |
| Physiologically active and easily accessible water                                                                                                    | 50,00                         | 8                   | 400,00           | x                                                       | x                | x                | x                | x                              | x                | x                | x                |
| Hardness of hard particles and total porosity                                                                                                         | 90,00                         | 8                   | 720,00           | x                                                       | x                | x                | x                | x                              | x                | x                | x                |
| Capacity for water                                                                                                                                    | 0,00                          | 8                   | 0,00             | x                                                       | x                | x                | x                | x                              | x                | x                | x                |
| Soil permeability for water                                                                                                                           | 50,00                         | 8                   | 400,00           | x                                                       | x                | x                | x                | x                              | x                | x                | x                |
| Soil compaction                                                                                                                                       | 35,00                         | 8                   | 280,00           | x                                                       | x                | x                | x                | x                              | x                | x                | x                |
| <b>Chemical analysis of soil</b>                                                                                                                      |                               |                     |                  |                                                         |                  |                  |                  |                                |                  |                  |                  |
| Soil acidity (pH)                                                                                                                                     | 36,00                         | 8                   | 288,00           | y                                                       | y                | y                | y                | y                              | y                | y                | y                |
| Carbonate content                                                                                                                                     | 30,00                         | 8                   | 180,00           |                                                         |                  | y                |                  | y                              | y                | y                | y                |
| Hydrolytic acidity                                                                                                                                    | 30,00                         | 8                   | 180,00           |                                                         |                  |                  |                  | y                              | y                | y                | y                |
| Cation exchange capacity                                                                                                                              | 100,00                        | 8                   | 800,00           | y                                                       | y                | y                | y                | y                              | y                | y                | y                |
| Organic matter and C,H,N,S analyses                                                                                                                   | 270,00                        | 8                   | 2.160,00         | y                                                       | y                | y                | y                | y                              | y                | y                | y                |
| Accessible elements in the soil                                                                                                                       | 66,00                         | 8                   | 528,00           |                                                         | y                | y                | y                | y                              | y                | y                | y                |
| Total metals and potentially toxic elements                                                                                                           | 760,00                        | 8                   | 6.080,00         | y                                                       | y                | y                | y                | y                              |                  | y                | y                |
| Electrical conductivity                                                                                                                               | 18,00                         | 8                   | 144,00           |                                                         |                  | y                |                  | y                              | y                |                  |                  |
| Persistent organic pollutants                                                                                                                         | 1.400,00                      | 8                   | 11.200,00        |                                                         | y                |                  | y                |                                |                  |                  |                  |
| Total and mineral oils                                                                                                                                | 420,00                        | 8                   | 3.360,00         | y                                                       |                  |                  |                  |                                |                  |                  |                  |
| Chemical composition of drainage water                                                                                                                | 200,00                        | 4                   | 800,00           | y                                                       | y                | y                | y                | y                              | y                | y                | y                |
| <b>Microbiological analysis of soil</b>                                                                                                               |                               |                     |                  |                                                         |                  |                  |                  |                                |                  |                  |                  |
| Cellulolytic activity                                                                                                                                 | 320,00                        | 6                   | 1.920,00         |                                                         |                  |                  |                  |                                | y                | y                | y                |
| Activity of dehydrogenase                                                                                                                             | 320,00                        | 6                   | 1.920,00         |                                                         |                  |                  |                  |                                | y                | y                | y                |
| CO <sub>2</sub> production                                                                                                                            | 320,00                        | 6                   | 1.920,00         |                                                         |                  |                  |                  |                                | y                | y                | y                |
| <b>1. Costs of first monitoring - inventarisation per location (x + y)</b>                                                                            |                               |                     | <b>36.200,00</b> | <b>18.208,00</b>                                        | <b>26.576,00</b> | <b>15.700,00</b> | <b>26.576,00</b> | <b>15.880,00</b>               | <b>15.560,00</b> | <b>21.496,00</b> | <b>21.496,00</b> |
| <b>2. Costs of monitoring per location every 5 years (y)</b>                                                                                          |                               |                     | <b>31.480,00</b> | <b>13.488,00</b>                                        | <b>21.856,00</b> | <b>10.980,00</b> | <b>21.856,00</b> | <b>11.160,00</b>               | <b>10.840,00</b> | <b>16.776,00</b> | <b>16.776,00</b> |
| Time dynamics: x – single parameters (analysed during first sampling – inventarisation), y – monitoring (parameters which are analysed every 5 years) |                               |                     |                  |                                                         |                  |                  |                  |                                |                  |                  |                  |

**Table 9. Assessment of soil monitoring costs at 247 potentially contaminated locations according to activities and in total**

| Potentially contaminating activities                                                                                                                                                                                                                                  | Number of locations | Costs of first monitoring – inventarisation (HRK) |                     | Costs of permanent monitoring (HRK) |                     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|---------------------------------------------------|---------------------|-------------------------------------|---------------------|
|                                                                                                                                                                                                                                                                       | (A)                 | Per location (B)                                  | Total (A x B)       | Per location (C)                    | Total (A x C)       |
| 1. Energy sector                                                                                                                                                                                                                                                      | 32                  | 18.208,00                                         | 582.656,00          | 13.488,00                           | 431.616,00          |
| 2. Production and processing of metal                                                                                                                                                                                                                                 | 19                  | 26.576,00                                         | 504.944,00          | 21.856,00                           | 415.264,00          |
| 3. Mineral industry                                                                                                                                                                                                                                                   | 9                   | 15.700,00                                         | 141.300,00          | 10.980,00                           | 98.820,00           |
| 4. Chemical industry                                                                                                                                                                                                                                                  | 37                  | 26.576,00                                         | 983.312,00          | 21.856,00                           | 808.672,00          |
| 5. Waste and wastewater management                                                                                                                                                                                                                                    | 7                   | 15.880,00                                         | 111.160,00          | 11.160,00                           | 78.120,00           |
| 6. Paper and wood production and processing                                                                                                                                                                                                                           | 3                   | 15.560,00                                         | 46.680,00           | 10.840,00                           | 32.520,00           |
| 7. Intensive livestock production and aquaculture                                                                                                                                                                                                                     | 21                  | 21.496,00                                         | 451.416,00          | 16.776,00                           | 352.296,00          |
| 8. Animal and vegetable products from food and beverage sector                                                                                                                                                                                                        | 10                  | 21.496,00                                         | 214.960,00          | 16.776,00                           | 167.760,00          |
| 9. Other activities                                                                                                                                                                                                                                                   |                     |                                                   |                     |                                     |                     |
| 9. (a) Plants for the pre-treatment (operations such as washing, bleaching, mercerisation) or dyeing of fibres or textiles with the capacity of processing 10 tons a day                                                                                              | 5                   | 15.880,00                                         | 79.400,00           | 11.160,00                           | 55.800,00           |
| 9. (b) Plants for tanning hides and skin with the capacity of processing 12 tons of finished product a day                                                                                                                                                            | 3                   | 15.880,00                                         | 47.640,00           | 11.160,00                           | 33.480,00           |
| 9. (c) Installations for surface treatment of substances, objects or products using organic solvents, in particular for dressing, printing, coating, degreasing, waterproofing, sizing, painting, cleaning or impregnating with the capacity of consumption of 150 kg | 3                   | 15.880,00                                         | 47.640,00           | 11.160,00                           | 33.480,00           |
| 9. (e) Installations for the building of, and painting or removal of paint from ships with the capacity for ships 100 m long                                                                                                                                          | 11                  | 15.880,00                                         | 174.680,00          | 11.160,00                           | 122.760,00          |
| 9. (f) Places for stocking petrol and petrol derivatives                                                                                                                                                                                                              | 82                  | 18.208,00                                         | 1.493.056,00        | 13.488,00                           | 1.106.016,00        |
| 9. (g) Places for stocking hazardous substances (apart from petrol and petrol derivatives)                                                                                                                                                                            | 1                   | 18.208,00                                         | 18.208,00           | 13.488,00                           | 13.488,00           |
| 9. (h) Places for stocking fertilisers                                                                                                                                                                                                                                | 4                   | 26.576,00                                         | 106.304,00          | 21.856,00                           | 87.424,00           |
| Total costs of inventarisation and monitoring (HRK)                                                                                                                                                                                                                   |                     |                                                   | <b>5.003.356,00</b> |                                     | <b>3.837.516,00</b> |





### 3.6.2. Sources of financing the Contaminated Soil Monitoring System

The Environmental Protection Act (OG 110/07), in the „Polluter Pays Principle “ (Article 15) clearly specifies obligations of a legal entity - polluter:

- 1. The polluter bears the costs incurred by contamination of environment.*
- 2. Costs stated in paragraph 1 of this Article includes costs incurred in relation to contamination of environment including costs of damage assessment, evaluation of necessary measures and costs of removing damage in the environment.*
- 3. The polluter defray the costs of monitoring the condition of environment and the application of specified measures, as well as costs for taking measures for the prevention of environment contamination, regardless of whether these costs have incurred as a result of established liability for contamination of environment, i.e. by emission into environment or as a compensation established by relevant financial instruments, i.e. as an obligation established by a regulation on the decrease of environment contamination.*

The Regulation on Soil Monitoring in Croatia is to oblige legal entities which conduct potentially contaminating activity to establish monitoring of soil condition at the location where the activity is being conducted. As stated in the previous chapter (3.5. Institutional framework and obligations for implementation of the Contaminated Soil Monitoring System), and pursuant to Article 15 of the Environment Protection Act (OG 110/07), legal entities are to defray the costs for monitoring of potentially contaminated and contaminated soil that are to be conducted by authorised persons, including costs of data processing, reporting and data delivery to the Croatian Environment Agency.

Thereby it should be taken into consideration that time dynamics of soil monitoring at potentially contaminated and contaminated sites, recommended by this Programme, is five years.

Annex 1. List of potentially contaminated locations  
recommended for establishment of soil monitoring  
(source: GEOL database, CEA, 2007)

| Main Activity and other activities                                      | No. | Registration No | Name of legal entity                                                             | County                            | Former soil researches (year) |
|-------------------------------------------------------------------------|-----|-----------------|----------------------------------------------------------------------------------|-----------------------------------|-------------------------------|
| 1. Energy sector (a)<br>Mineral oil and gas refineries                  | 1   | 3586243         | INA-INDUSTRIJA NAFTE d.d.                                                        | County of Osijek-Baranja          |                               |
|                                                                         | 2   | 3586243         | INA-INDUSTRIJA NAFTE d.d.                                                        | County of Osijek-Baranja          |                               |
|                                                                         | 3   | 3586243         | INA-INDUSTRIJA NAFTE d.d.                                                        | County of Osijek-Baranja          |                               |
|                                                                         | 4   | 3586243         | INA-INDUSTRIJA NAFTE d.d.                                                        | County of Primorje-Gorski Kotar   | 2008.                         |
|                                                                         | 5   | 3586243         | INA-INDUSTRIJA NAFTE d.d.                                                        | County of Primorje-Gorski Kotar   | 2008.                         |
|                                                                         | 6   | 3586243         | INA-INDUSTRIJA NAFTE d.d.                                                        | County of Sisak-Moslavina         | 2007.                         |
|                                                                         | 7   | 3586243         | INA-INDUSTRIJA NAFTE d.d.                                                        | County of Vukovar-Srijem          | 2007.                         |
|                                                                         | 8   | 3586243         | INA-INDUSTRIJA NAFTE d.d.                                                        | County of Zagreb                  |                               |
|                                                                         | 9   | 1615912         | MAZIVA ZAGREB d.o.o. for production and trade of lubricants and related products | City of Zagreb                    |                               |
|                                                                         | 10  | 1582615         | HEP - PLIN d.o.o. for gas distribution and supply                                | County of Osijek-Baranja          |                               |
| 1. Energy sector (b)<br>Installations for gasification and liquefaction | 11  | 3334171         | JADRANSKI NAFTAOVOD d.d.                                                         | County of Slavonski Brod-Posavina |                               |
|                                                                         | 12  | 3334171         | JADRANSKI NAFTAOVOD d.d.                                                         | County of Koprivnica-Križevci     |                               |
|                                                                         | 13  | 3334171         | JADRANSKI NAFTAOVOD d.d.                                                         | County of Primorje-Gorski Kotar   |                               |
|                                                                         | 14  | 3334171         | JADRANSKI NAFTAOVOD d.d.                                                         | County of Primorje-Gorski Kotar   |                               |
|                                                                         | 15  | 3334171         | JADRANSKI NAFTAOVOD d.d.                                                         | County of Sisak-Moslavina         |                               |
|                                                                         | 16  | 1311999         | KISIKANA, d.o.o. for production of industrial gases                              | County of Sisak-Moslavina         |                               |
|                                                                         | 17  | 175676          | LINDE PLIN d.o.o. for production, trade, import-export of technical gases        | County of Karlovac                |                               |
|                                                                         | 18  | 3275647         | MESSER CROATIA PLIN d.o.o. for production and trade of technical gases           | County of Požega-Slavonia         |                               |
|                                                                         | 19  | 3275647         | MESSER CROATIA PLIN d.o.o. for production and trade of technical gases           | County of Split-Dalmatia          |                               |
|                                                                         | 20  | 1537571         | PLINACRO d.o.o. for transport and trade of natural gas                           | City of Zagreb                    |                               |
| 1. Energy sector (b)<br>Installations for gasification and liquefaction | 21  | 1537571         | PLINACRO d.o.o. for transport and trade of natural gas                           | County of Koprivnica-Križevci     |                               |
|                                                                         | 22  | 1537571         | PLINACRO d.o.o. for transport and trade of natural gas                           | County of Krapina-Zagorje         |                               |
|                                                                         | 23  | 1537571         | PLINACRO d.o.o. for transport and trade of natural gas                           | County of Osijek-Baranja          |                               |
|                                                                         | 24  | 1537571         | PLINACRO d.o.o. for transport and trade of natural gas                           | County of Sisak-Moslavina         |                               |
| 1. Energy sector (c)                                                    | 25  | 1643983         | HEP - Proizvodnja d.o.o. for production of electrical and thermal energy         | City of Zagreb                    |                               |
|                                                                         | 26  | 1643983         | HEP - Proizvodnja d.o.o. for production of electrical and thermal energy         | City of Zagreb                    |                               |
|                                                                         | 27  | 1643983         | HEP - Proizvodnja d.o.o. for production of electrical and thermal energy         | County of Istra                   |                               |



|                                                                                                                                                                                                                                                                                                            |    |         |                                                                                  |                                 |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|---------|----------------------------------------------------------------------------------|---------------------------------|--|
| Thermal power stations and other combustion installations with a heat input of 50 megawatts (MW)                                                                                                                                                                                                           | 28 | 1643983 | HEP - Proizvodnja d.o.o. for production of electrical and thermal energy         | County of Krapina-Zagorje       |  |
|                                                                                                                                                                                                                                                                                                            | 29 | 1643983 | HEP - Proizvodnja d.o.o. for production of electrical and thermal energy         | County of Osijek-Baranja        |  |
|                                                                                                                                                                                                                                                                                                            | 30 | 1643983 | HEP - Proizvodnja d.o.o. for production of electrical and thermal energy         | County of Primorje-Gorski Kotar |  |
|                                                                                                                                                                                                                                                                                                            | 31 | 1643983 | HEP - Proizvodnja d.o.o. for production of electrical and thermal energy         | County of Sisak-Moslavina       |  |
|                                                                                                                                                                                                                                                                                                            | 32 | 1582623 | HEP - TOPLINARSTVO d.o.o. for production and distribution of thermal energy      | City of Zagreb                  |  |
| 2. Production and processing of metals (b) Installations for the production of pig iron or steel (primary or secondary melting) including continuous casting, with a capacity of 2,5 tonnes per hour                                                                                                       | 33 | 1809997 | FELIS PRODUKTI d.o.o. for production, internal and external trade and services   | County of Sisak-Moslavina       |  |
|                                                                                                                                                                                                                                                                                                            | 34 | 1695053 | MECHEL Željezara d.o.o. for trade and services – in bankruptcy                   | County of Sisak-Moslavina       |  |
|                                                                                                                                                                                                                                                                                                            | 35 | 1866516 | VALJAONICA CIJEVI SISAK d.o.o. for production and services                       | County of Sisak-Moslavina       |  |
|                                                                                                                                                                                                                                                                                                            | 36 | 1866516 | VALJAONICA CIJEVI SISAK d.o.o. for production and services                       | County of Sisak-Moslavina       |  |
|                                                                                                                                                                                                                                                                                                            | 37 | 3321886 | ŽELJEZARA SISAK d.d. for ferrous metallurgy and metal processing – in bankruptcy | County of Sisak-Moslavina       |  |
|                                                                                                                                                                                                                                                                                                            | 38 | 3417891 | ŽELJEZARA SPLIT company for steel production and processing d.d.                 | County of Split-Dalmatia        |  |
| 2. Production and processing of metals (d) Ferrous metal foundries with a production capacity of 20 tonnes per day                                                                                                                                                                                         | 39 | 1502115 | DALIT - CT d.o.o. for production of castings                                     | County of Bjelovar-Bilogora     |  |
|                                                                                                                                                                                                                                                                                                            | 40 | 3038076 | LJEVAONICA BJELOVAR d.o.o. for production of gray and nodular casts              | County of Bjelovar-Bilogora     |  |
|                                                                                                                                                                                                                                                                                                            | 41 | 3632636 | METALSKA INDUSTRIJA VARAŽDIN d.d.                                                | County of Varaždin              |  |
|                                                                                                                                                                                                                                                                                                            | 42 | 3025373 | OLT – Osijek ironworks and machine factory d.d.                                  | County of Osijek-Baranja        |  |
|                                                                                                                                                                                                                                                                                                            | 43 | 3628396 | Plamen - International d.o.o. ironworks and factory of household devices         | County of Požega-Slavonia       |  |
| 2. Production and processing of metals (e)(ii) Installations for the smelting, including the alloying, of non-ferrous metals, including recovered production (refining, foundry casting, etc.), with a melting capacity of 4 tonnes per day for lead and cadmium or 20 tonnes per day for all other metals | 44 | 1577956 | ALMOS d.o.o. for production of aluminium casts                                   | County of Sisak-Moslavina       |  |
|                                                                                                                                                                                                                                                                                                            | 45 | 1197550 | CIMOS LJEVAONICA ROČ d.o.o. production of aluminium casts                        | County of Istra                 |  |
|                                                                                                                                                                                                                                                                                                            | 46 | 1654985 | DALEKOVOD-CINČAONICA d.o.o. for zinc coating                                     | County of Zagreb                |  |
|                                                                                                                                                                                                                                                                                                            | 47 | 1696289 | IVANAL aluminium industry d.o.o.                                                 | County of Šibenik-Knin          |  |
|                                                                                                                                                                                                                                                                                                            | 48 | 1686623 | LIPOVICA d.o.o.                                                                  | County of Sisak-Moslavina       |  |
|                                                                                                                                                                                                                                                                                                            | 49 | 1812955 | TLM - TPP d.o.o. factory of pressed products                                     | County of Šibenik-Knin          |  |
|                                                                                                                                                                                                                                                                                                            | 50 | 3464415 | TLM d.d. light metals industry                                                   | County of Šibenik-Knin          |  |
|                                                                                                                                                                                                                                                                                                            | 51 | 1748807 | TLM-TVP d.o.o. factory of rolled products                                        | County of Šibenik-Knin          |  |
| 3. Mineral industry (b)(vii) Opencast mining and quarrying: Construction sand and gravel,                                                                                                                                                                                                                  | 52 | 3275531 | Dalekovod, d.d. for engineering, production and construction                     | City of Zagreb                  |  |

|                                                                                                                                                          |    |         |                                                                                               |                                 |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------|----|---------|-----------------------------------------------------------------------------------------------|---------------------------------|--|
| 9. Other activities (f)<br>Places for storage of oil and oil derivatives                                                                                 | 52 | 3275531 | Dalekovod, d.d. for engineering, production and construction                                  | City of Zagreb                  |  |
| 3. Mineral industry<br>(b)(vi) Opencast mining and quarrying: Gypsum,<br>(b)(xvi) Opencast mining and quarrying: Silicate resources                      | 53 | 3107329 | SAMOBORKA d.d. construction materials industry                                                | County of Zagreb                |  |
|                                                                                                                                                          | 54 | 3747344 | HOLCIM mineral aggregates d.o.o.                                                              | County of Varaždin              |  |
| 3. Mineral industry<br>(b)(xv) Opencast mining and quarrying: Sea salt,                                                                                  | 55 | 3053016 | SOLANA PAG, d.d. for production, processing and enrichment of sea salt                        | County of Zadar                 |  |
|                                                                                                                                                          | 56 | 3302113 | SOLANA STON d.d. for production of sea salt, plastic processing tourism and catering services | County of Dubrovnik and Neretva |  |
| 3. Mineral industry<br>(c)(i) Installations for the production of cement clinker in rotary kilns with a production capacity of 500 tonnes per day        | 57 | 3668568 | DALMACIJACEMENT d.d. for production and trade of cement and other construction materials      | County of Split-Dalmatia        |  |
|                                                                                                                                                          | 58 | 3074854 | HOLCIM d.o.o. for cement production                                                           | County of Istra                 |  |
|                                                                                                                                                          | 59 | 3209784 | ISTRA CEMENT d.o.o. for production of special cement                                          | County of Istra                 |  |
|                                                                                                                                                          | 60 | 3123731 | NAŠICECEMENT d.d.                                                                             | County of Osijek-Baranja        |  |
| 4. Chemical industry<br>(a) Production of basic organic chemicals                                                                                        | 61 | 1326805 | HERBOS DIJAGNOSTIKA d.o.o. for production and trade of diagnostic reagents                    | County of Sisak-Moslavina       |  |
|                                                                                                                                                          | 62 | 3331539 | ISKRA d.d. chemical industry                                                                  | County of Zagreb                |  |
|                                                                                                                                                          | 63 | 3020924 | METEOR d.d. for production of chemical products                                               | County of Osijek-Baranja        |  |
| 4. Chemical industry<br>(a)(viii) Production of basic organic chemicals: basic plastic materials (polymers, synthetic fibres and cellulose-based fibres) | 64 | 3037690 | BIFIX d.o.o. for production and trade of chemical products                                    | County of Istra                 |  |
|                                                                                                                                                          | 65 | 3221199 | CHROMOS – resins industry d.d., production of artificial resins and chemicals                 | City of Zagreb                  |  |
|                                                                                                                                                          | 66 | 1695274 | DINA-Petrokemija d.d. production, terminals and services                                      | County of Primorje-Gorski Kotar |  |
|                                                                                                                                                          | 67 | 1695274 | DINA-Petrokemija d.d. production, terminals and services                                      | County of Primorje-Gorski Kotar |  |
|                                                                                                                                                          | 68 | 3692507 | DIOKI d.d. organic petrochemistry                                                             | City of Zagreb                  |  |
| 4. Chemical industry<br>(a)(ix) Production of basic organic chemicals: synthetic rubbers                                                                 | 69 | 3809579 | GUMA d.o.o. for internal and external trade, production and services                          | County of Krapina-Zagorje       |  |
|                                                                                                                                                          | 70 | 1754467 | GUMA PROFIL d.o.o.                                                                            | County of Krapina-Zagorje       |  |
|                                                                                                                                                          | 71 | 3272893 | GUMARA-ČAVIĆ d.d. production of special rubber products                                       | City of Zagreb                  |  |
|                                                                                                                                                          | 72 | 3386791 | TERMIKA d.o.o. Industry for technical, acoustic and fire isolations                           | County of Varaždin              |  |
| 4. Chemical industry<br>(a)(x) Production of basic organic chemicals: Dyes and pigments                                                                  | 73 | 3036294 | HEMPEL d.o.o. Chemical processing industry                                                    | County of Istra                 |  |
|                                                                                                                                                          | 74 | 3765687 | A-PROMA d.o.o. Industry of dyes and pigments, glues, industrial and decorative flooring       | City of Zagreb                  |  |
|                                                                                                                                                          | 75 | 3302148 | ASTRA-DUBRAVKA d.d. for production, trade and services                                        | County of Dubrovnik and Neretva |  |



|                                                                                                                                                   |     |         |                                                                                                      |                                   |  |
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|                                                                                                                                                   | 76  | 3164934 | CHROMOS d.d. Graphical dyes industry                                                                 | County of Zagreb                  |  |
|                                                                                                                                                   | 77  | 3073777 | CHROMOS-SVJETLOST d.o.o. Dyes and pigments industry                                                  | County of Slavonski Brod-Posavina |  |
|                                                                                                                                                   | 78  | 287326  | KEMOZON d.o.o. for production and services                                                           | City of Zagreb                    |  |
|                                                                                                                                                   | 79  | 3457826 | MEGATTI d.o.o. for chemical production, trade and export and import                                  | City of Zagreb                    |  |
|                                                                                                                                                   | 80  | 3695131 | PRIPOL d.o.o. production and trade of chemical products                                              | City of Zagreb                    |  |
|                                                                                                                                                   | 81  | 1086162 | SITOLOR MEDIUS d.o.o. for production, trade and export and import                                    | County of Slavonski Brod-Posavina |  |
| 4. Chemical industry (c) Production of phosphorous-, nitrogen- or potassium-based fertilisers (simple or compound fertilisers)                    | 82  | 3674223 | PETROKEMIJA d.d. fertilizers industry                                                                | County of Sisak-Moslavina         |  |
|                                                                                                                                                   | 83  | 3674223 | PETROKEMIJA d.d. fertilizers industry                                                                | County of Sisak-Moslavina         |  |
|                                                                                                                                                   | 84  | 3674223 | PETROKEMIJA d.d. fertilizers industry                                                                | County of Sisak-Moslavina         |  |
|                                                                                                                                                   | 85  | 3674223 | PETROKEMIJA d.d. fertilizers industry                                                                | County of Sisak-Moslavina         |  |
|                                                                                                                                                   | 86  | 3674223 | PETROKEMIJA d.d. fertilizers industry                                                                | County of Sisak-Moslavina         |  |
| 4. Chemical industry (d) production of basic plant health products and of biocides                                                                | 87  | 3221172 | CHROMOS AGRO d.d production of plant health products                                                 | County of Sisak-Moslavina         |  |
|                                                                                                                                                   | 88  | 3318150 | HERBOS d.d. for production of chemicals and chemical products                                        | County of Sisak-Moslavina         |  |
| 4. Chemical industry (e) Production of basic pharmaceutical products                                                                              | 89  | 3805140 | BELUPO d.d. drugs and cosmetics                                                                      | County of Koprivnica-Križevci     |  |
|                                                                                                                                                   | 90  | 3805140 | BELUPO d.d. drugs and cosmetics                                                                      | County of Varaždin                |  |
|                                                                                                                                                   | 91  | 3072843 | FARMAL d.d. pharmaceuticals                                                                          | County of Varaždin                |  |
|                                                                                                                                                   | 92  | 3715957 | JADRAN - GALENSKI LABORATORIJ d.d. for production and trade of pharmaceuticals and cosmetic products | County of Primorje-Gorski Kotar   |  |
|                                                                                                                                                   | 93  | 3214222 | LABUD d.o.o. washing agents, cosmetics and chemicals industry                                        | City of Zagreb                    |  |
|                                                                                                                                                   | 94  | 3214052 | PLIVA d.d. pharmaceuticals                                                                           | City of Zagreb                    |  |
|                                                                                                                                                   | 95  | 3012476 | SAPONIA d.d. chemical, food and pharmaceutical industry                                              | County of Osijek-Baranja          |  |
|                                                                                                                                                   | 96  | 1526782 | VETERINA d.o.o. production of veterinary products                                                    | City of Zagreb                    |  |
| 4. Chemical industry (f) Production of explosives and pyrotechnic products                                                                        | 97  | 3782816 | CROEX factory of explosives d.d.                                                                     | County of Split-Dalmatia          |  |
| 5. Waste and wastewater management (d) (i) Landfills; of municipal waste (receiving 10 tonnes per day or with a total capacity of 25 000 tonnes.) | 98  | 1115073 | JUNAKOVCI d.o.o. for municipal activities                                                            | County of Osijek-Baranja          |  |
|                                                                                                                                                   | 99  | 1115073 | JUNAKOVCI d.o.o. for municipal activities                                                            | County of Osijek-Baranja          |  |
|                                                                                                                                                   | 100 | 578746  | KOMBEL d.o.o. for municipal activities                                                               | County of Osijek-Baranja          |  |
|                                                                                                                                                   | 101 | 1793969 | KOMUNALNO-BILJE d.o.o. for municipal activities                                                      | County of Osijek-Baranja          |  |
|                                                                                                                                                   | 102 | 3209822 | PULA HERCULANEA d.o.o. for municipal activities                                                      | County of Istra                   |  |
|                                                                                                                                                   | 103 | 3013421 | UNIKOM d.o.o. for municipal management                                                               | County of Osijek-Baranja          |  |
|                                                                                                                                                   | 104 | 3021220 | UNIVERZAL d.o.o. for municipal activities                                                            | County of Osijek-Baranja          |  |

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| 6. Paper and wood production and processing (a)<br>Industrial plants for the production of pulp from timber or similar fibrous materials                                                                                               | 105 | 3051226 | BELIŠĆE d.d. for production of paper, machines, primal and final wood processing and dry distillation of wood | County of Osijek-Baranja          |  |
| 6. Paper and wood production and processing (b)<br>Industrial plants for the production of paper and board and other primary wood products (such as chipboard, fibreboard and plywood) with a production capacity of 20 tonnes per day | 106 | 1320556 | PAN d.o.o. TVORNICA PAPIRA ZAGREB – paper industry                                                            | City of Zagreb                    |  |
|                                                                                                                                                                                                                                        | 107 | 1602543 | VALOVITI PAPIR - DUNAPACK d.o.o. for production and trade of corrugated paper                                 | County of Krapina-Zagorje         |  |
| 7. Intensive livestock production and aquaculture (a)(i)<br>Installations for the intensive rearing of poultry and pigs with 40 000 places for poultry                                                                                 | 108 | 3226778 | AGROKOKA - PULA d.o.o. for production and trade of poultry products                                           | County of Istra                   |  |
|                                                                                                                                                                                                                                        | 109 | 3341739 | GALA d.o.o. for consumption eggs production                                                                   | County of Bjelovar-Bilogora       |  |
|                                                                                                                                                                                                                                        | 110 | 1335260 | GALIVET d.o.o. for production and trade                                                                       | County of Međimurje               |  |
|                                                                                                                                                                                                                                        | 111 | 3026264 | KOKA d.d. pultry food industry                                                                                | County of Varaždin                |  |
|                                                                                                                                                                                                                                        | 112 | 3039315 | PERFA, d.o.o. for consumption eggs production                                                                 | County of Krapina-Zagorje         |  |
|                                                                                                                                                                                                                                        | 113 | 767514  | PIKO d.o.o. for poultry rearing                                                                               | County of Zagreb                  |  |
|                                                                                                                                                                                                                                        | 114 | 1636618 | PUREX d.o.o. poultry rearing                                                                                  | County of Split-Dalmatia          |  |
|                                                                                                                                                                                                                                        | 115 | 3044998 | PURIS d.d. agricultural, food, trade and catering industry                                                    | County of Istra                   |  |
|                                                                                                                                                                                                                                        | 116 | 1397745 | VALIONICA d.o.o. for production, trade and services                                                           | County of Slavonski Brod-Posavina |  |
|                                                                                                                                                                                                                                        | 117 | 1721569 | VALIONICA PERADI GUSAKOVEC d.o.o. for production and trade                                                    | County of Krapina-Zagorje         |  |
| 7. Intenzivno stočarstvo i akvakultura (a)<br>(ii) Postrojenja za intenzivni uzgoj peradi ili svinja s 2000 mjesta za svinje (preko 30 kg)                                                                                             | 119 | 3231631 | DUBRAVICA d.d. for pigs rearing                                                                               | County of Zagreb                  |  |
|                                                                                                                                                                                                                                        | 120 | 1926624 | FARMA JELAS d.o.o. for livestock farming and trade                                                            | County of Sisak-Moslavina         |  |
|                                                                                                                                                                                                                                        | 121 | 926078  | FARMA LIPINE d.o.o. for agricultural production and trade                                                     | County of Osijek-Baranja          |  |
|                                                                                                                                                                                                                                        | 122 | 3100022 | FARMA SENKOVAC d.d. for livestock farming, animal feeding stuffs and meat processing                          | County of Virovitica-Podravina    |  |
| 8. Animal and vegetable products from the food and beverage sector                                                                                                                                                                     | 123 | 1602241 | Gavrilović - Agriculture, d.o.o.                                                                              | County of Sisak-Moslavina         |  |
|                                                                                                                                                                                                                                        | 124 | 945374  | PIK VRBOVEC d.o.o. – pigs rearing farm, for livestock farming and agricultural services                       | County of Zagreb                  |  |
|                                                                                                                                                                                                                                        | 125 | 3074161 | POLJOPRIVREDNA ZADRUGA ĐURĐEVAC                                                                               | County of Koprivnica-Križevci     |  |
|                                                                                                                                                                                                                                        | 126 | 3074196 | POLJOPRIVREDNA ZADRUGA VIRJE                                                                                  | County of Koprivnica-Križevci     |  |
|                                                                                                                                                                                                                                        | 127 | 1388053 | STOČAR d.o.o. for agriculture, livestock, trade and services                                                  | County of Varaždin                |  |





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| (b) Treatment and processing intended for the production of food and beverage products                                                                                                                                                                                                                                 | 128 | 1763865 | SVINJOGOJSKA FARMA LIPOVAČA - PRKOS d.o.o. for meat production and processing                                      | County of Osijek-Baranja          |  |
|                                                                                                                                                                                                                                                                                                                        | 129 | 1627554 | SVINJOGOJSKA FARMA ROVIŠĆE d.o.o. for production and services                                                      | County of Bjelovar-Bilogora       |  |
| 8. Animal and vegetable products from the food and beverage sector (b) (ii) Treatment and processing intended for the production of food and beverage products: vegetable raw materials with a finished product production capacity of 300 tonnes per day                                                              | 130 | 3033872 | IPK TVORNICA ŠEĆERA OSIJEK d.o.o.                                                                                  | County of Osijek-Baranja          |  |
|                                                                                                                                                                                                                                                                                                                        | 131 | 1863533 | KANDIT PREMIJER d.o.o. for production, trade and services                                                          | County of Osijek-Baranja          |  |
|                                                                                                                                                                                                                                                                                                                        | 132 | 3307484 | SLADORANA d.d.                                                                                                     | County of Vukovar-Srijem          |  |
|                                                                                                                                                                                                                                                                                                                        | 133 | 3307484 | SLADORANA d.d.                                                                                                     | County of Vukovar-Srijem          |  |
|                                                                                                                                                                                                                                                                                                                        | 134 | 3307484 | SLADORANA d.d.                                                                                                     | County of Vukovar-Srijem          |  |
|                                                                                                                                                                                                                                                                                                                        | 135 | 3307484 | SLADORANA d.d.                                                                                                     | County of Vukovar-Srijem          |  |
|                                                                                                                                                                                                                                                                                                                        | 136 | 3307484 | SLADORANA d.d.                                                                                                     | County of Vukovar-Srijem          |  |
| 9. Other activities (a) Plants for the pre-treatment (operations such as washing, bleaching, mercerisation) or dyeing of fibres or textiles                                                                                                                                                                            | 138 | 1494210 | BENETTON CROATIA d.o.o.                                                                                            | County of Osijek-Baranja          |  |
|                                                                                                                                                                                                                                                                                                                        | 139 | 3108252 | ČATEKS, d.d. for production of textiles, artificial leather, household linen and products for sport and recreation | County of Međimurje               |  |
|                                                                                                                                                                                                                                                                                                                        | 140 | 3065634 | PAMUČNA INDUSTRIJA DUGA RESA d.d. for production of textiles, in bankruptcy                                        | County of Karlovac                |  |
|                                                                                                                                                                                                                                                                                                                        | 141 | 3016277 | Regeneracija d.d. un-woven textiles and carpets                                                                    | County of Krapina-Zagorje         |  |
|                                                                                                                                                                                                                                                                                                                        | 142 | 3747034 | VARTEKS d.d. varaždin textile industry                                                                             | County of Varaždin                |  |
| 9. Other activities (b) Plants for the tanning of hides and skins with a treatment capacity of 12 tonnes of finished product per day                                                                                                                                                                                   | 143 | 1526901 | BOXMARK LEATHER d.o.o. for leather production and trade                                                            | County of Varaždin                |  |
|                                                                                                                                                                                                                                                                                                                        | 144 | 3020118 | INKOP d.d. leather and footwear industry                                                                           | County of Krapina-Zagorje         |  |
|                                                                                                                                                                                                                                                                                                                        | 145 | 3000133 | PSUNJ, LEATHER FACTORY, d.d.                                                                                       | County of Slavonski Brod-Posavina |  |
| 9. Other activities (c) Installations for the surface treatment of substances, objects or products using organic solvents, in particular for dressing, printing, coating, degreasing, waterproofing, sizing, painting, cleaning or impregnating, with a consumption capacity of 150 kg per hour or 200 tonnes per year | 146 | 3440494 | AD PLASTIK d.d. for production of vehicle parts and equipment and plastic products                                 | County of Split-Dalmatia          |  |
|                                                                                                                                                                                                                                                                                                                        | 147 | 3440494 | AD PLASTIK d.d. for production of vehicle parts and equipment and plastic products                                 | County of Split-Dalmatia          |  |
|                                                                                                                                                                                                                                                                                                                        | 148 | 3440494 | AD PLASTIK d.d. for production of vehicle parts and equipment and plastic products                                 | County of Split-Dalmatia          |  |
| 9. Other activities (e) Installations for the building of, and painting or removal                                                                                                                                                                                                                                     | 149 | 3861635 | BRODOGRADILIŠTE I MARINA d.o.o.                                                                                    | County of Šibenik-Knin            |  |
|                                                                                                                                                                                                                                                                                                                        | 150 | 3333957 | BRODOGRADILIŠTE KRALJEVICA d.d. for ship building and repairing                                                    | County of Primorje-Gorski Kotar   |  |
|                                                                                                                                                                                                                                                                                                                        | 151 | 2139162 | BRODOGRADILIŠTE ŠIBENIK d.o.o. for ship building and equip                                                         | County of Šibenik-Knin            |  |

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| of paint prom ships,<br>with a capacity for<br>ships 100 m long                                                                                                                                                                                                                                                                                                                                                                             | 152 | 3333710 | BRODOGRADILIŠTE VIKTOR LENAC d.d.<br>in bankruptcy                                            | County of Primorje-Gorski Kotar   |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 153 | 3333710 | BRODOGRADILIŠTE VIKTOR LENAC d.d.<br>in bankruptcy                                            | County of Primorje-Gorski Kotar   |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 154 | 3333710 | BRODOGRADILIŠTE VIKTOR LENAC d.d.<br>in bankruptcy                                            | County of Primorje-Gorski Kotar   |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 155 | 3333710 | BRODOGRADILIŠTE VIKTOR LENAC d.d.<br>in bankruptcy                                            | County of Primorje-Gorski Kotar   |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 156 | 3333477 | Brodograđevna industrija 3. MAJ d.d.                                                          | County of Primorje-Gorski Kotar   |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 157 | 3761223 | BRODOSPLIT-BRODOGRADILIŠTE d.o.o.                                                             | County of Split-Dalmatia          |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 158 | 3041913 | BRODOTROGIR d.d.                                                                              | County of Split-Dalmatia          |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 159 | 1523104 | LEDA d.o.o. for ship building, trade and<br>tourism                                           | County of Dubrovnik and Neretva   |                |
| 8. Animal and<br>vegetable products<br>from the food and<br>beverage sector (b)<br>(i) Treatment and<br>processing intended<br>for the production of<br>food and beverage<br>products: animal<br>raw materials (other<br>than milk) with a<br>finished product<br>production capacity<br>of 75 tonnes per day<br>9. Other activities<br>(f) Places for<br>storage of oil and<br>oil derivatives (h)<br>Places for storage of<br>fertilisers | 160 | 3108503 | AGROMEĐIMURJE d.d. Čakovec                                                                    | County of Međimurje               |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 161 | 3307042 | BELJE d.d. for activities in agriculture,<br>processing industry and trade of goods,<br>Darda | County of Osijek-Baranja          |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 162 | 3307042 | BELJE d.d. for activities in agriculture,<br>processing industry and trade of goods,<br>Darda | County of Osijek-Baranja          |                |
| 9. Other activities<br>(f) Places for<br>storage of oil and oil<br>derivatives                                                                                                                                                                                                                                                                                                                                                              | 163 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Bjelovar-Bilogora       |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 164 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Bjelovar-Bilogora       |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 165 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Bjelovar-Bilogora       | 2006.          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 166 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Bjelovar-Bilogora       | 2006.          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 167 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Bjelovar-Bilogora       | 1998;<br>2006. |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 168 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Bjelovar-Bilogora       | 1999;<br>2004. |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 169 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Bjelovar-Bilogora       | 2006.          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 170 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Slavonski Brod-Posavina |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 171 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Dubrovnik and Neretva   |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 172 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Dubrovnik and Neretva   |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 173 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Dubrovnik and Neretva   |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 174 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | City of Zagreb                    |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 175 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | City of Zagreb                    |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 176 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | City of Zagreb                    |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 177 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Istra                   |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 178 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Istra                   |                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                             | 179 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Istra                   |                |



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|                                                                             | 180     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Istra               |       |
|                                                                             | 181     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Karlovac            |       |
|                                                                             | 182     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 183     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 184     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 185     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 186     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
| 9. Other activities (f)<br>Places for storage of<br>oil and oil derivatives | 187     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 188     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 189     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 190     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 191     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 192     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 193     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 194     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 195     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Lika-Senj           |       |
|                                                                             | 185     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 186     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 187     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 188     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
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|                                                                             | 190     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
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|                                                                             | 192     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 193     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 194     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Koprivnica-Križevci |       |
|                                                                             | 195     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Lika-Senj           |       |
|                                                                             | 196     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Međimurje           |       |
|                                                                             | 197     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Međimurje           | 2007. |
|                                                                             | 198     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Međimurje           |       |
| 199                                                                         | 3586243 | INA-INDUSTRIJA NAFTE d.d. | County of Međimurje       |                               |       |
| 200                                                                         | 3586243 | INA-INDUSTRIJA NAFTE d.d. | County of Osijek-Baranja  | 1999;<br>2000.                |       |
| 201                                                                         | 3586243 | INA-INDUSTRIJA NAFTE d.d. | County of Osijek-Baranja  | 2000;<br>2007.                |       |
| 202                                                                         | 3586243 | INA-INDUSTRIJA NAFTE d.d. | County of Osijek-Baranja  |                               |       |
| 203                                                                         | 3586243 | INA-INDUSTRIJA NAFTE d.d. | County of Osijek-Baranja  | 2000;<br>2007.                |       |
| 204                                                                         | 3586243 | INA-INDUSTRIJA NAFTE d.d. | County of Osijek-Baranja  |                               |       |
| 205                                                                         | 3586243 | INA-INDUSTRIJA NAFTE d.d. | County of Osijek-Baranja  | 1999;<br>2000;<br>2007.       |       |
| 9. Other activities (f)<br>Places for storage of<br>oil and oil derivatives | 206     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Osijek-Baranja      | 1999. |
|                                                                             | 207     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Osijek-Baranja      |       |
|                                                                             | 208     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Osijek-Baranja      |       |
|                                                                             | 209     | 3586243                   | INA-INDUSTRIJA NAFTE d.d. | County of Požega-Slavonia     | 2005. |

|                                                                                                                         |     |         |                                                                                               |                                 |                         |
|-------------------------------------------------------------------------------------------------------------------------|-----|---------|-----------------------------------------------------------------------------------------------|---------------------------------|-------------------------|
|                                                                                                                         | 210 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Primorje-Gorski Kotar | 2008.                   |
|                                                                                                                         | 211 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Primorje-Gorski Kotar | 2008.                   |
|                                                                                                                         | 212 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Primorje-Gorski Kotar |                         |
|                                                                                                                         | 213 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Sisak-Moslavina       | 1998;<br>2001;<br>2006. |
|                                                                                                                         | 214 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Sisak-Moslavina       | 2007.                   |
|                                                                                                                         | 215 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Sisak-Moslavina       | 2005.                   |
|                                                                                                                         | 216 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Sisak-Moslavina       | 2001.                   |
|                                                                                                                         | 217 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Sisak-Moslavina       | 2005.                   |
|                                                                                                                         | 218 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Sisak-Moslavina       | 2001;<br>2002;<br>2005. |
|                                                                                                                         | 219 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Sisak-Moslavina       | 2005;<br>2007.          |
|                                                                                                                         | 220 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Sisak-Moslavina       | 2002;<br>2005;<br>2007. |
|                                                                                                                         | 222 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Split-Dalmatia        |                         |
|                                                                                                                         | 223 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Šibenik-Knin          |                         |
|                                                                                                                         | 224 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Varaždin              |                         |
|                                                                                                                         | 225 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Virovitica-Podravina  | 1996.                   |
|                                                                                                                         | 226 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Virovitica-Podravina  |                         |
|                                                                                                                         | 227 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Virovitica-Podravina  | 1992;<br>1995;<br>1998. |
|                                                                                                                         | 228 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Vukovar-Srijem        | 2007.                   |
|                                                                                                                         | 229 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Vukovar-Srijem        | 2007.                   |
|                                                                                                                         | 230 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Vukovar-Srijem        |                         |
|                                                                                                                         | 231 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Vukovar-Srijem        |                         |
|                                                                                                                         | 232 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Zadar                 |                         |
|                                                                                                                         | 233 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Zadar                 |                         |
| 9. Other activities (f)<br>Places for storage of<br>oil and oil derivatives                                             | 234 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Zagreb                | 2002; 2007              |
|                                                                                                                         | 235 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Zagreb                |                         |
|                                                                                                                         | 236 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Zagreb                |                         |
|                                                                                                                         | 237 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Zagreb                |                         |
|                                                                                                                         | 238 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Zagreb                | 2002.                   |
|                                                                                                                         | 239 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Zagreb                | 2007.                   |
|                                                                                                                         | 240 | 3586243 | INA-INDUSTRIJA NAFTE d.d.                                                                     | County of Zagreb                | 1998;<br>2006.          |
| 9. Other activities (f)<br>Places for storage of<br>oil and oil derivatives<br>(h) Places for<br>storage of fertilizers | 241 | 3326411 | Kutjevo d.d. for production and trade of<br>agriculture and food products                     | County of Požega-Slavonia       |                         |
| 9. Other activities (f)                                                                                                 | 242 | 3870693 | NAFTNI TERMINALI FEDERACIJE d.o.o. for<br>storage, forwarding, external and internal<br>trade | County of Dubrovnik and Neretva |                         |



|                                                                                                             |     |         |                                                                                         |                                 |  |
|-------------------------------------------------------------------------------------------------------------|-----|---------|-----------------------------------------------------------------------------------------|---------------------------------|--|
| Places for storage of oil and oil derivatives                                                               | 243 | 3870693 | NAFTNI TERMINALI FEDERACIJE d.o.o. for storage, forwarding, external and internal trade | County of Dubrovnik and Neretva |  |
| 9. Other activities (f) Places for storage of oil and oil derivatives (h) Places for storage of fertilizers | 244 | 3315193 | PIK - VINKOVCI d.d. for agriculture production, food industry and trade                 | County of Vukovar-Srijem        |  |
| 9. Other activities (f) Places for storage of oil and oil derivatives                                       | 245 | 1417967 | TIFON, d.o.o. for trade and services                                                    | County of Krapina-Zagorje       |  |
|                                                                                                             | 246 | 3877302 | ŽITO d.o.o. for trade and services                                                      | County of Osijek-Baranja        |  |
| 9. Other activities (g) Places for storage of hazardous substances (besides oil and oil derivatives)        | 247 | 3701654 | "COCA-COLA SOUTHEAST EUROPE" d.o.o. for trade and services                              | City of Zagreb                  |  |

## Conclusion

The Croatian Soil Monitoring Programme and simultaneously developed Croatian Soil Information System are based on experiences of EU countries and recommendations of the Thematic Strategy for Soil Protection (COM(2006)231) and accompanying materials of Technical Working Groups and Advisory Forum. Thereby, compatibility with the future European Soil Information System - EUSIS has been ensured.

Special attention was given to adjustment of this Programme with the existing legal acts of the Croatian legislation, where it has been noticed that many regulations and laws are not fully implemented for many reasons. The most frequent reasons are the lack of financial resources, insufficient institutional capacities, undefined deadlines for execution of certain tasks, undefined data flow, undefined or not implemented sanctions for jobs that are not executed.

With the objective to minimise the soil monitoring costs and to maximally utilize the existing institutional capacities and legal regulations, the Croatian Soil Monitoring Programme has been divided to three parts, in accordance with the soil usage: to agricultural soils, forestry soils and potentially contaminated and contaminated locations. For each soil category, physical, chemical and microbiological parameters have been defined which are to enable the gathering of necessary information on the changes of the condition and characteristics of soil. Field works, laboratory analysis and data processing have been harmonised through recommended ISO standards of which the largest part has already been adopted in Croatia (HRN ISO). The time dynamics has been adjusted to possible changes of the values of monitored parameters considering the soil usage.

The Croatian Agricultural Soil Monitoring Programme directed special attention to positioning of soil monitoring stations at locations which, according to the usage and management conditions, are representative for each agricultural sub-region to ensure the adequate monitoring of the soil condition and of agricultural land management. The estimated costs for agricultural soil monitoring during the period of 9 years amount to total of 11 million HRK, of which 1.6 million HRK per year was required for the first three years for the establishment of stations, and then about one million HRK per year for monitoring. However, it is necessary to consider that during the nine years cycle, each monitoring station will be elaborated three times in three year intervals which shall enable the calculation of soil condition indicators and trends evaluation. The institutional framework for the implementation of the System has been already established by the Regulation on the establishment of the Institute for Soil (OG 100/01) and the Agricultural Land Act (OG 66/01, 87/02, 90/05, draft June 2008), while all other aspects of agricultural soil monitoring have been defined by this Programme. Gathered data shall enable the planning of strategies for sustainable development of agriculture and the preservation of rich natural resources of Croatia, and shall multiple justify invested financial resources.

The Croatian Forestry Soil Monitoring Programme defines, in details, monitoring of forestry soil as already specified by the Regulation on the mode of data collection, network of points, keeping the register and conditions for using data on damage of forest ecosystems (OG 129/2006), and emphasises the need of additional, intensive monitoring of forestry soil at 30 selected plots of the existing Level I ICP Forests Network, with the objective to gather data on the condition of forestry soils in shorter period of time, to ensure a faster monitoring and gathering of data on the condition of forestry soil and duly observing of possible threats. Estimated financial resources in the amount of 508,128.00 HRK, for additional costs of intensive forestry soil monitoring are to be ensured every ten years.





The Croatian Contaminated Soil Monitoring Programme defines monitoring of potentially contaminated sites at the territory of the Republic of Croatia selected on the basis of available data considering the type of activity conducted at the location, production capacities, high potential of contamination and the type of pollutants that the present activities may generate. The main problem in the field of monitoring of the soil condition and data gathering on potentially contaminated and contaminated sites is the non-existence of legal regulations, and notably the lack of specified limiting values for the concentration of pollutants in soil considering the mode of using land. Pursuant to the “Polluter Pays Principle” (Article 15) of the Environment Protection Act (OG 110/07), the Contaminated Soils Monitoring Programme emphasises the need to obligate legal entities who conduct potentially contaminating activity to monitor the condition of soil with the time dynamics of 5 years at the location at which the activity is taking place. The costs of monitoring potentially contaminated and contaminated soil depend on several factors: the type of contamination, the type of potential contaminating activity which is conducted at the location based on which monitoring parameters are determined, the size of potentially contaminated location based on which the number of average samples is determined, the soil properties and the number of horizons from which the soil is sampled that determines the number of average samples needed for representative results. At locations of smaller size, the costs of monitoring will be lower and vice versa. It needs to be taken into consideration that certain, larger economic entities (INA, HEP) periodically monitor the soil condition at locations they use. However, due to various sampling methods and application of various parameters and laboratory analyses, such data are not comparable.

By adopting the Regulation on Soil Monitoring of which this Programme is to be the integral part, all preconditions will be achieved for the beginning of soil monitoring in Croatia. In 2009, the Agency, in cooperation with the Ministry of Environment, Physical Planning and Construction, shall elaborate the Regulation and refer it in procedure, so the beginning of the soil monitoring activities is to be expected soon, whereby ensuring necessary data for planning and implementation of the policy of sustainable management of soil in the Republic of Croatia.

# References

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- and working conditions of landfills (OG 117/07).
- Ordinance on environmental pollutants register (OG 35/08).
- Ordinance on the register of installations in which dangerous substances have been identified and on the register of reported major accidents (OG 113/08)
- Ordinance on the register of use permits establishing integrated environmental requirements and of decisions on integrated environmental requirements for existing installations (OG 113/08)

### **EU regulations and guidelines**

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| HRN ISO 7888:2001       | Water quality - Determination of electrical conductivity.                                                                                                                                                         |
| HRN EN ISO 10304-1:1998 | Water quality - Determination of dissolved fluoride, chloride, nitrite, orthophosphate, bromide, nitrate and sulfate ions, using liquid chromatography of ions - Part 1: Method for water with low contamination. |
| HRN ISO 10390:2005      | Soil quality - Determination of pH.                                                                                                                                                                               |
| HRN ISO 10523:1998      | Water quality - Determination of pH.                                                                                                                                                                              |
| HRN ISO 10693:2004      | Soil quality - Determination of carbonate content - Volumetric method.                                                                                                                                            |
| HRN ISO 10694:2004      | Soil quality - Determination of organic and total carbon after dry combustion (elementary analysis).                                                                                                              |
| HRN ISO/TR 11046:2005   | Soil quality - Determination of mineral oil content.                                                                                                                                                              |
| HRN ISO 11047:2004      | Soil quality - Determination of cadmium, chromium, cobalt, copper, lead, manganese, nickel and zinc - Flame and electrothermal atomic absorption spectrometric methods.                                           |
| HRN ISO 11048:2004      | Soil quality - Determination of water-soluble and acid-soluble sulfate.                                                                                                                                           |
| HRN ISO 11260:2004      | Soil quality – Determination of effective cation exchange capacity and base saturation level using barium chloride solution.                                                                                      |
| HRN ISO 11261:2004      | Soil quality - Determination of total nitrogen - Modified Kjeldahl method.                                                                                                                                        |
| HRN ISO 11262:2005      | Soil quality - Determination of cyanide.                                                                                                                                                                          |
| HRN ISO 11263:2004      | Soil quality - Determination of phosphorus -- Spectrometric determination of phosphorus soluble in sodium hydrogen carbonate solution.                                                                            |
| HRN ISO 11265:2004      | Soil quality - Determination of the specific electrical conductivity.                                                                                                                                             |
| HRN ISO 11272:2004      | Soil quality - Determination of dry bulk density.                                                                                                                                                                 |
| HRN ISO 11274:2004      | Soil quality - Determination of the water retention characteristic - Laboratory methods.                                                                                                                          |
| HRN ISO 11277:2004      | Soil quality - Determination of particle size distribution in mineral soil material - Method by sieving and sedimentation.                                                                                        |
| HRN ISO 11369:2002      | Water quality - Determination of selected plant treatment agents - Method using high performance liquid chromatography with UV detection after solid-liquid extraction.                                           |
| HRN ISO 11461:2001      | Soil quality - Determination of soil water content as a volume fraction using coring sleeves - Gravimetric method.                                                                                                |
| HRN ISO 11464:2004      | Soil quality - Pretreatment of samples for physico-chemical analyses.                                                                                                                                             |
| HRN ISO 11465:2004      | Soil quality - Determination of dry matter and water content on a mass basis - Gravimetric method                                                                                                                 |
| HRN ISO 11466:2004      | Soil quality - Extraction of trace elements soluble in aqua regia.                                                                                                                                                |
| HRN ISO 11508:2004      | Soil quality - Determination of particle density.                                                                                                                                                                 |
| HRN ISO 13536:2005      | Soil quality - Determination of the potential cation exchange capacity and exchangeable cations using barium chloride solution buffered at pH=8.1                                                                 |
| HRN ISO 13877:2004      | Soil quality - Determination of polynuclear aromatic hydrocarbons - Method using high-performance liquid chromatography.                                                                                          |
| HRN ISO 13878:2004      | Soil quality - Determination of total nitrogen content by dry combustion ("elemental analysis").                                                                                                                  |
| HRN ISO 14235:2004      | Soil quality - Determination of organic carbon by sulfochromic oxidation.                                                                                                                                         |
| HRN ISO 14240-1:2004    | Soil quality - Determination of soil microbial biomass -- Part 1: Substrate-induced respiration method.                                                                                                           |
| HRN ISO 14254:2004      | Soil quality – Determination of exchangeable acidity in barium chloride extracts.                                                                                                                                 |
| HRN ISO 14255:2004      | Soil quality - Determination of nitrate nitrogen, ammonium nitrogen and total soluble nitrogen in air-dry soils using calcium chloride solution as extractant.                                                    |
| HRN ISO 14869-1:2004    | Soil quality - Dissolution for the determination of total element content - Part 1: Dissolution with hydrofluoric and perchloric acids.                                                                           |
| HRN ISO 14869-2:2004    | Soil quality - Dissolution for the determination of total element content - Part 2: Dissolution by alkaline fusion.                                                                                               |
| HRN ISO 14870:2005      | Soil quality - Extraction of trace elements by buffered DTPA solution.                                                                                                                                            |

|                       |                                                                                                                                                                                                                                                                                            |
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| HRN EN ISO 14911:2001 | Water quality - Determination of dissolved Li <sup>+</sup> , Na <sup>+</sup> , NH <sub>4</sub> <sup>+</sup> , K <sup>+</sup> , Mn <sup>2+</sup> , Ca <sup>2+</sup> , Mg <sup>2+</sup> , Sr <sup>2+</sup> and Ba <sup>2+</sup> using ion chromatography - Method for water and waste water. |
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| ISO 10381-4:2003      | Soil quality - Sampling - Part 4: Guidance on the procedure for investigation of natural, near-natural and cultivated sites.                                                                                                                                                               |
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| ISO 10381-6:1993      | Soil quality - Sampling - Part 6: Guidance on the collection, handling and storage of soil for the assessment of aerobic microbial processes in the laboratory.                                                                                                                            |
| ISO 10381-7:2005      | Soil quality - Sampling - Part 7: Guidance on sampling of soil gas.                                                                                                                                                                                                                        |
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| ISO 14154:2005        | Soil quality - Determination of some selected chlorophenols - Gas-chromatographic method with electron-capture detection.                                                                                                                                                                  |
| ISO 15009:2002        | Soil quality - Gas chromatographic determination of the content of volatile aromatic hydrocarbons, naphthalene and volatile halogenated hydrocarbons - Purge-and-trap method with thermal desorption.                                                                                      |
| ISO 16703:2004        | Soil quality - Determination of content of hydrocarbon in the range C10 to C40 by gas chromatography.                                                                                                                                                                                      |
| ISO 16772:2004        | Soil quality - Determination of mercury in aqua regia soil extracts with cold-vapour atomic spectrometry or cold-vapour atomic fluorescence spectrometry.                                                                                                                                  |
| ISO 17380:2004        | Soil quality - Determination of total cyanide and easily released cyanide - Continuous-flow analysis method.                                                                                                                                                                               |
| ISO 18287:2006        | Soil quality - Determination of polycyclic aromatic hydrocarbons (PAH) - Gas chromatographic method with mass spectrometric detection (GC-MS).                                                                                                                                             |
| ISO 20279:2005        | Soil quality - Extraction of thallium and determination by electrothermal atomic absorption spectrometry.                                                                                                                                                                                  |
| ISO 23753-1:2005      | Soil quality - Determination of dehydrogenase activity in soils - Part 1: Method using triphenyltetrazolium chloride (TTC).                                                                                                                                                                |
| ISO 23753-2:2005      | Soil quality - Determination of dehydrogenase activity in soils - Part 2: Method using iodotetrazolium chloride (INT).                                                                                                                                                                     |
| ISO/TS 14256-1:2003   | Soil quality - Determination of nitrate, nitrite and ammonium in field-moist soils by extraction with potassium chloride solution - Part 1: Manual method.                                                                                                                                 |
| ISO 14256-2:2005      | Soil quality - Determination of nitrate, nitrite and ammonium in field-moist soils by extraction with potassium chloride solution - Part 2: Automated method with segmented flow analysis.                                                                                                 |
| ISO 19730:2008        | Soil quality – Extraction of trace elements using ammonium nitrate solution.                                                                                                                                                                                                               |
| ISO 22036:2008        | Soil quality – Determination of trace elements in extracts of soil by inductively coupled plasma – atomic emission spectrometry (ICP-AES).                                                                                                                                                 |
| ISO 23470:2007        | Soil quality - Determination of effective cation exchange capacity (CEC) and exchangeable cations using a hexamminecobalt trichloride solution.                                                                                                                                            |
| EPA METHOD 550        | Determination of polycyclic aromatic hydrocarbons in drinking water by liquid-liquid extraction and HPLC with coupled ultraviolet and fluorescence detection.                                                                                                                              |
| ONORM L 1092-93       | 1:10 water-extract of soil.                                                                                                                                                                                                                                                                |
| DIN 38414-24:2000     | German standard methods for the examination of water, waste water and sludge - Sludge and sediments (group S) - Part 24: Determination of polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofuranes (PCDFs) (S 24).                                                        |











