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

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CROATIAN ENVIRONMENT AGENCY

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AGRONOMSKI FAKULTET ZAGREB MCMXIX

Croatian Environment Agency

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

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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.

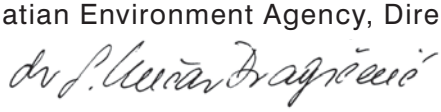
The Croatian Soil Monitoring Programme is the basis for the establishment of the Croatian Soil Monitoring System which shall ensure monitoring and comparability of soil condition data, as per reporting obligations on the condition of environment of the Republic of Croatia, as well as per internationally 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 storages, 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 polluters (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 sol 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 then 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 Manuel 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 Ekonerg - 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 developmet 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 (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.*

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 m2 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 m2 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.

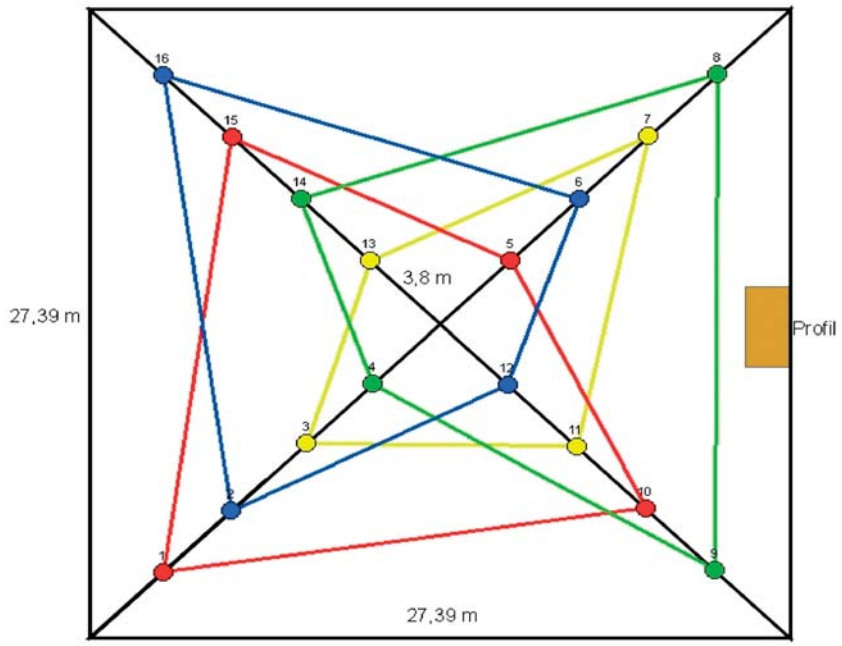
3.1.1. Description of agricultural soil monitoring station

A monitoring station is in the form of a square in the area of 750 m2 (27,39 x 27,39 m) and is located at agricultural parcel which size is not less than 5000 m2. 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°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 pedosystematic 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 1x1ş 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.

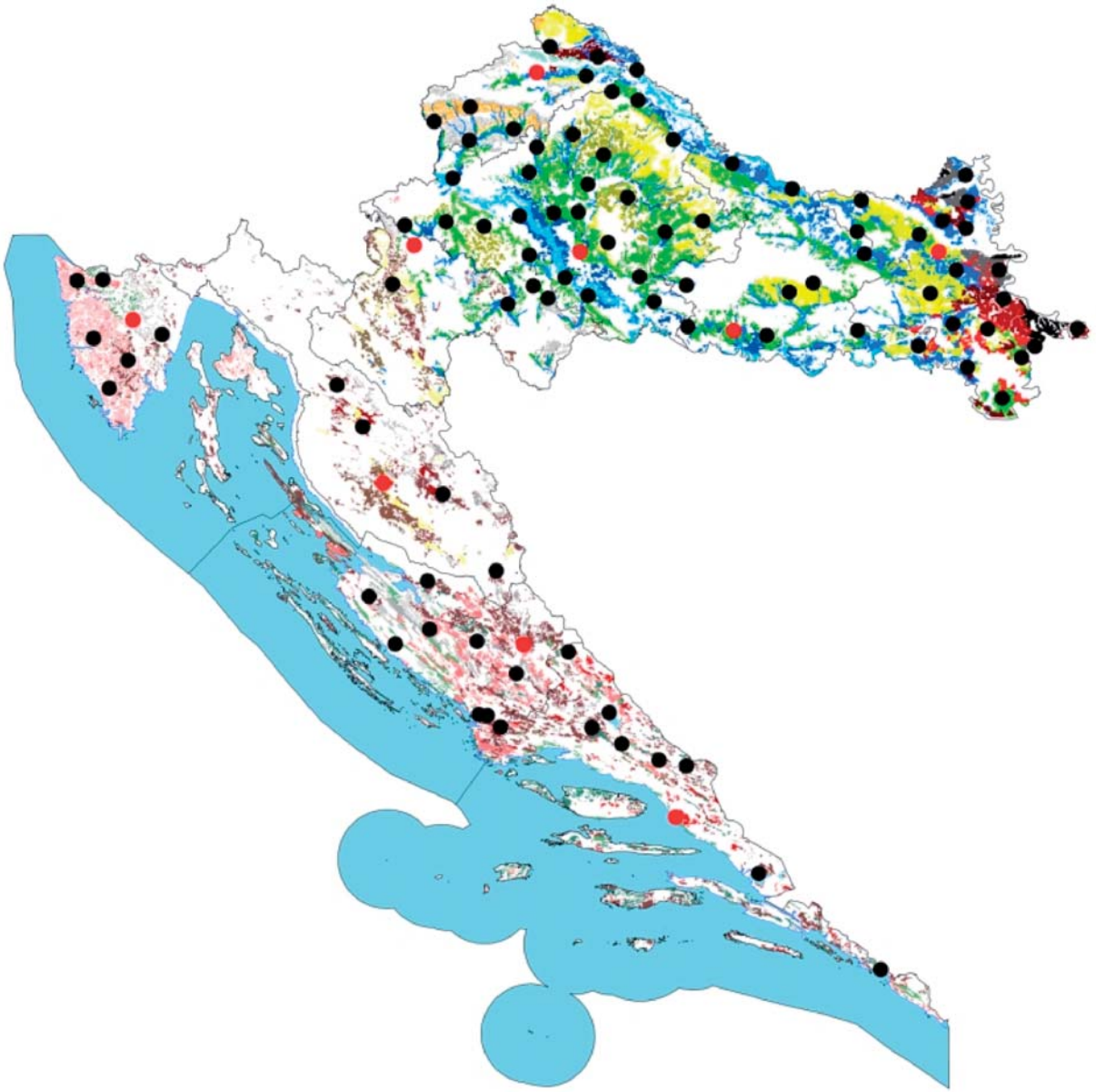
All locations for agricultural soil monitoring stations have been verified by field trips in August and September 2007. The verification determined whether locations are really representative for areas in which they are located and whether they are suitable for positioning of monitoring stations. By 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	Kutjevo	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 hydromeliorated	Level II
HR_P3_5	100	5024961	2506192	45,37820	16,57909	Sunja	complex of cultivated parcels	arable land	Eugley, partly hydromeliorated	Level II
HR_P3_6	115	5080426	2479699	45,87717	16,23839	Zagreb	complex of cultivated parcels	arable land	Eugley, partly hydromeliorated	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 hydromeliorated	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 hydromeliorated	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 hydromeliorated	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 hydromeliorated	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 hydromeliorated	Level II
HR_P4_7	237	5103260	2436980	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 hydromeliorated	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	Distric cambisol on loess and holocenic	Level I
HR_G2_1	495	4984801	2393219	45,00868	15,14494	Brinje	mostly agricultural land	arable land	Distric cambisol on loess and holocenic	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	Distric cambisol on loess and holocenic	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	Otric	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	Hydromeliorated	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 hydromeliorated	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	Hydromeliorated	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	Hydromeliorated	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	Prolosko 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																									
8.	**Relief**													**10.**	*12	**Nature of parent material**									
A	*4	Form of relief of the area																							
B	*5	Position of the station												**11.**	*12	**Geological age of soil**									
C	*7	Slope and exposition																							
D	*6	Shape of slope												**12.**	**Soil classification of the station**										
9.	*11	**Natural vegetation of the area**												A	Škorić et al, 1985.										
														B	WRB, 2006.										
13.	**Klima**				1	2	3	4	5	6	7	8	9	10	11	12									
A	Mean air temperature (annual average ≥20)																								
B	Mean precipitations (annual average ≥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																							
14.	**Mode of use**																								
A	*8	Mode of use																							
B	*9	Dominant cultures																							
C	Crops																								
D	Mode of cultivation																								
15.	**Inputs into soil**																								
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							
16.	**Rockiness**			**20.**	**Erosion**		
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	
17.	**Gravelness**			D	*19	Activity of erosion	
A	*15	Percentage of surface		**21.**	**Surface crust**		
B	*15	Diameter of fragments		A	*20	Thickness	
18.	**Surface salt efflorescence**			B	*20	Hardness	
A	*22	Percentage of surface		**22.**	**Surface cracks**		
B	*22	Thickness of layer		A	*21	Average width	
C		Type of salt		B	*21	Average depth	
19.	**Faded sand on the surface**			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, halomorhpic 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 NO3-) 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 cm3 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 tree 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
	*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 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^2	Number > 2mm/dm^2	Diameter	Number < 2mm/dm^2	Number > 2mm/dm^2	Quantity	Type
	*60	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	49. Human-transported material	50. Artefacts					
			Occurrence	Type	Size	Hardness	Weathering	Colour
	*45	*85	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	Name			
A	Date		B	Address			
B	Time		C	Place			
3.	**Data on the manager**		D	Contact person			
			E	Telephone			
A	Full name		**5.**	**Whether conditions**			
B	Institution		A *2	Current weather conditions			
C	Telephone		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							
8.	**Rockiness**			**12.**	**Erosion**		
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	
9.	**Gravelness**			D	*19	Activity of erosion	
A	*15	Percentage of surface		**13.**	**Surface crust**		
B	*15	Diameter of fragments		A	*20	Thickness	
10.	**Surface salt efflorescence**			B	*20	Hardness	
A	*22	Percentage of surface		**14.**	**Surface cracks**		
B	*22	Thickness of layer		A	*21	Average width	
C		Type of salt		B	*21	Average depth	
11.	**Faded sand on the surface**			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 conduced 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^{2+}, Mg^{2+}, Na^{+}, K^{+})	Amon-acetate method (pH=7)	HRN ISO 11260:2005 HRN ISO 13536:2005	L1, L2, T	1/6	Ecological depth
Total carbon	Bicromat method, Tjurin method Determination by Walkley-Black	HRN ISO 10694:2004 HRN ISO 14235:2004	L1, L2, T	1/3	Ecological depth
Total nitrogen	Modified method by Kjeldahl	HRN ISO 11261:2004 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, Method by Olsen, 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 Modified method by Lakanen-Ervio, DTPA, EDTA	HRN ISO 11047:2004 HRN ISO 11466:2004 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 HRN ISO 7888:2001 HRN ISO 10304-1:1998 HRN ISO 14911:2001	L1	1/3	Ecological depth
Persistent organic pollutants (PAH, PCB, triazine herbicides, organochlorine pesticides)	Ion chromatography	HRN ISO 11369:1997 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_2 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/ 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.)**
		ρv	ρč		Max Kv	Ret.Kv	Kz	Kv	Tv	Fav	Lv	micro	macro		
		g/cm^3		%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																
	Standard chemical properties										Capacity of exchangeable cations					
No.	pH of soil in			$CaCO_3$	Hydrolytic acidity	EC	N	C	S	H	KlK	Ca^{2+}	Mg^{2+}	Na^+	K^+	
	H_2O	KCl	$CaCl_2$	%	mmol/100g	mS/m	mg/kg				mmol/100 g					
1.																
2.																
3.																
4.																
5.																
6.																
7.																
Method/ ISO stand.																

Accessible nutrients in the soil										
No.	P_2O_5	K_2O	NO_3-N	NO_3-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/ ISO stand.										

Total 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/ 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/ ISO stand.																	

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

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

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

Chemical composition of drainage water																
Lysimetar:		**Laboratory:**						**Analyst:**						**Date of analysis:**		
No.	**pH**	**EC**	**Cations**						**Anions**							
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Li^{+}	NH_4^{+}	F^{-}	Cl^{-}	NO_3^{-}	NO_2^{-}	Br^{-}	SO_4^{2-}	$H_2PO_4^{-}$	$H_2PO_4^{2-}$
		mS/m	mg/L						mg/L							
1.																
2.																
Method/ ISO stand.																

FORM FOR ANALYSIS OF AGRICULTURAL SOIL MONITORING STATION– P3 III Microbiological parameters			
Laboratory:		**Analyst:**	**Date of analysis:**
No.	Cellulolytic activity	Activity of dehydrogenase	CO_2 production
	Mg glu/g tla	Mmol/100g	ugTPF/g tla
1.			
2.			
3.			
4.			
5.			
Method/ 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
Chemical analysis of soil	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
Microbiological soil analysis	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_2 production	320,00	6	1.920,00	6	1.920,00	6	1.920,00
Total costs of Level 2 station (without lysimeters)				49.958,80		32.567,60		33.837,60
Total costs of Level 1 station (including lysimeters)				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 planed 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 Leve1 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
Total costs for the establishment of stations						**5.037.203,00**
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
Total costs for monitoring 3 years after the establishment of stations						**2.956.995,00**
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
Total costs for monitoring 6 years after the establishment of stations						**3.071.295,00**
TOTAL COSTS for the 9 year monitoring cycle			**9 / 81**			**11.065.493,00**

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.

[1] „…3. establishment of the Information System for contaminated agricultural land."

[2] „…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)[1].

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).

[1]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 it 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.

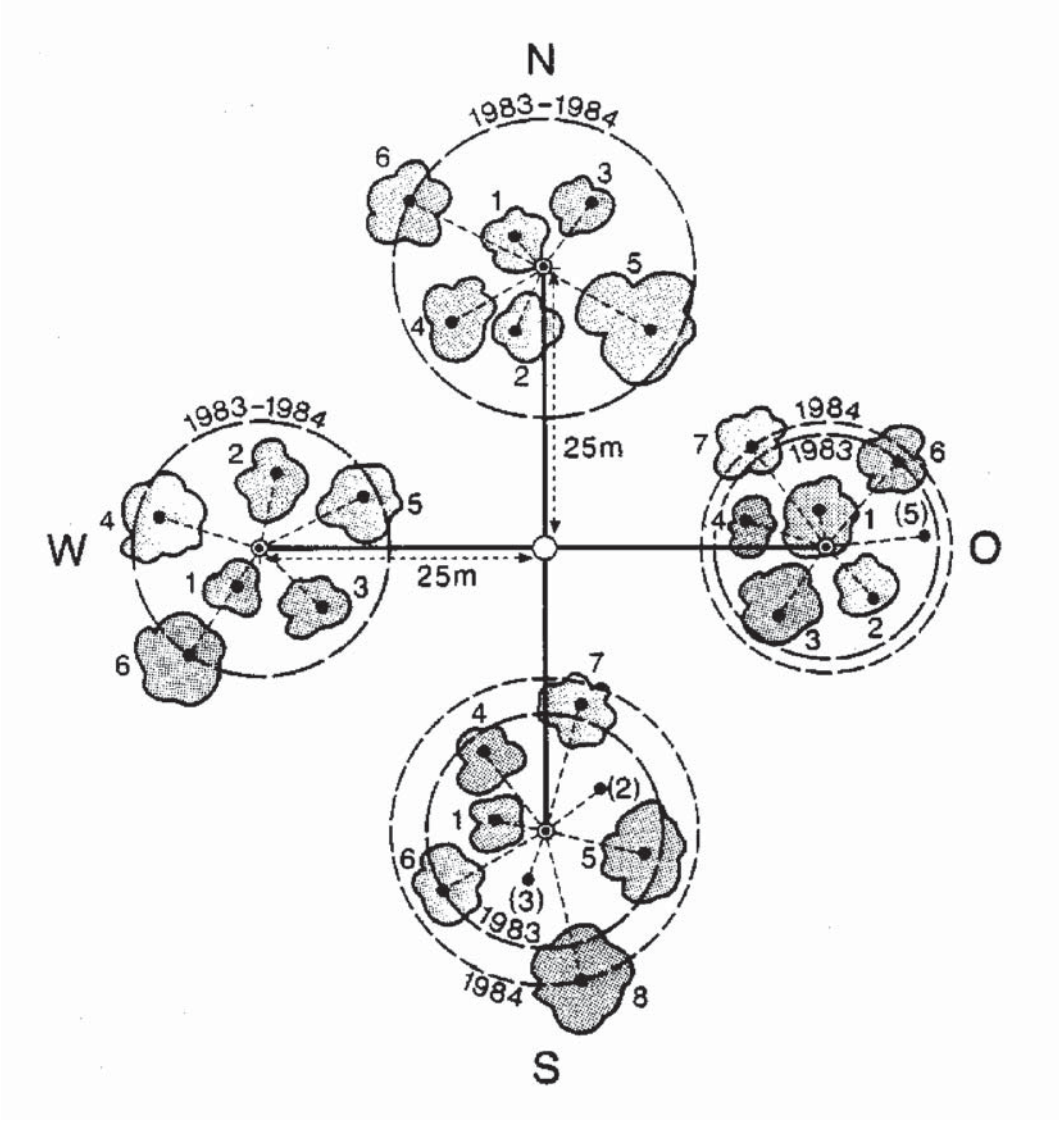


Figure 1. Ideal Scheme of monitoring plot with four groups of trees

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 then 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.

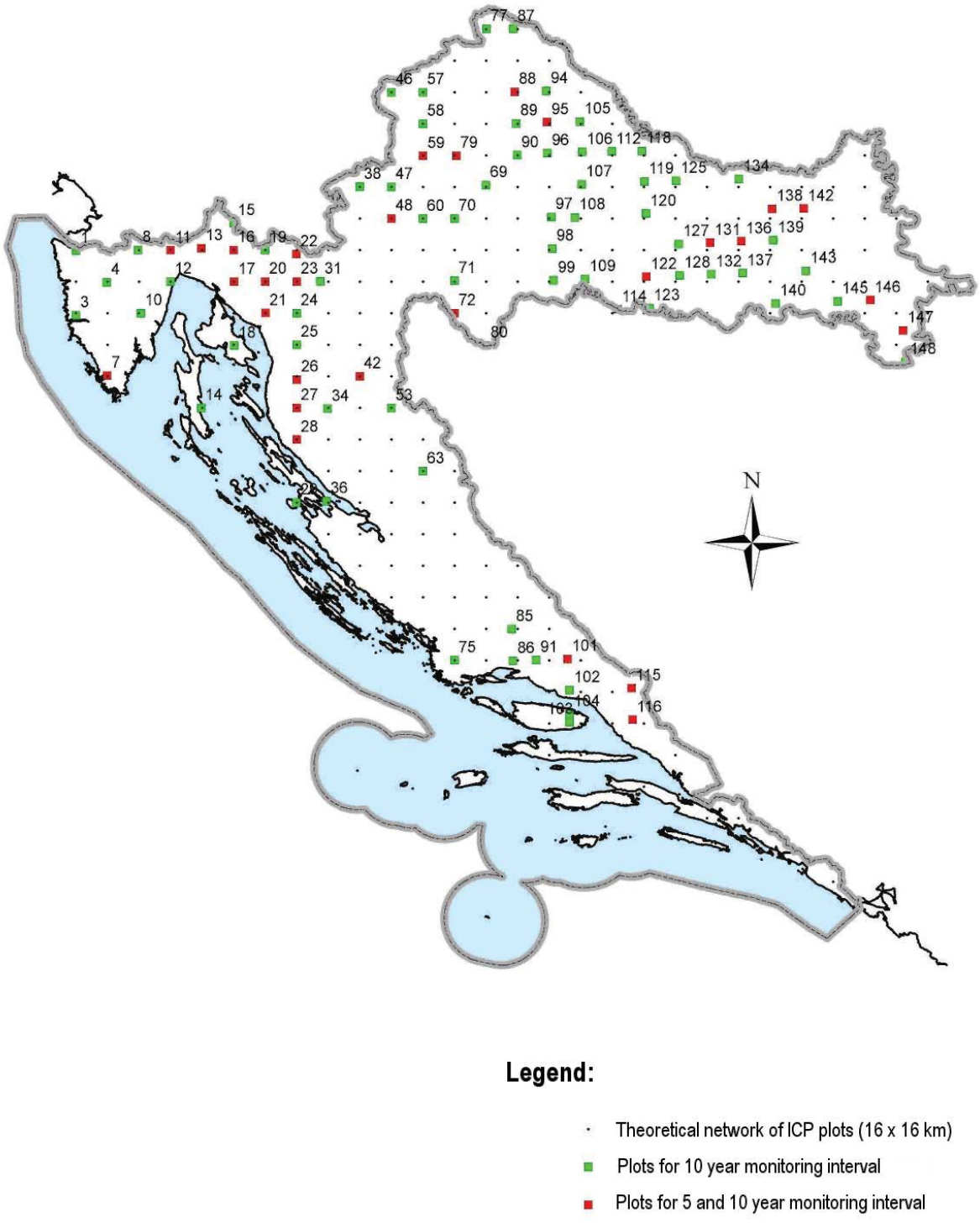


Figure 2. Plots of ICP Forests Level I Network in the Republic of Croatia

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	X 5 zone	Y 5 zone								
1	1	133913,28	452655,14	5034696	5395061	Buzet	Kršin	110	d	230	45	13	Aleppo pine
2	3	133938,48	450914,70	5001953	5395065	Buzet	Lim			70	0	0	Turkey oak
3	4	135126,79	451822,67	5018630	5410774	Buzet	Kaldir			125	270	18	Turkey oak, Pubescent oak
4	7	135206,37	445253,92	4971429	5410977	Buzet	Sijana			30	0	0	Aleppo pine
5	8	140321,47	452720,15	5035020	5426536	Buzet	Kozarište			720	150	15	Black pine
6	10	140445,08	451003,66	5003004	5427988	Buzet	Sumber			325	0	0	Black pine
7	11	141604,51	452722,34	5034916	5443114	Buzet	Opatija			80	180	10	Pubescent oak
8	12	141606,45	451846,59	5018994	5443012	Buzet	Opatija			430	315	12	Turkey oak
9	13	142757,88	452759,44	5035939	5458620	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	5458500	Buzet	Vrana			25	90	2	Evergreen oak
11	15	144032,80	453454,69	5048671	5475070	Delnice	Rudnik	11	d	690	325	30	Common beech
12	16	144413,00	452555,00	5035000	5475000	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	5475165	Delnice	Brloško	74		710	320	20	Common beech, White fir, significant damage on the plot amounts to 75 %
14	18	144058,40	450123,66	4986591	5475382	Senj	privatna šuma			180	200	10	Pubescent oak
15	19	145249,74	452730,33	5034909	5491024	Delnice	Čedanj	3	b	325	340	10	Durmast oak, Common beech
16	20	145541,00	451644,00	5019000	5491000	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	5491183	Senj	Ričićko bilo			860	280	10	Common beech, significant damage on the plot amounts to 29.17%
18	22	150456,98	452626,41	5032933	5506825	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	5506991	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	5507072	Ogulin	Čungar	23		525	225	15	Common beech
21	25	150501,20	450140,60	4987072	5506958	Gospić	Javorov vrh-Stubica	58		720	210	20	Common beech
22	26	150508,00	445207,70	4969389	5507124	Gospić	Senjsko Bilo	19	a	1130	45	30	Common beech
23	27	150502,80	444421,60	4955005	5507025	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	5507000	Gospić	Laktin vrh-Dabri			670	315	30	Common beech, significant damage on the plot amounts to 25 %
25	29	150451,30	441829,70	4907101	5506828	Split	Vir, privatno			35	170	3	Aleppo pine
26	31	151413,67	451857,37	5019096	5518964	Ogulin	Bukovača			490	225	10	Common beech
27	34	151656,20	444407,70	4954608	5522722	Gospić	Kalčić vrh-Obljaj	73	a	570	180	10	European hornbeam
28	36	151619,80	441852,20	4907828	5522084	Split	Ražanac-Vrsi			35	180	4	Aleppo pine
29	38	152948,71	454448,11	5067060	5539031	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	Sljeme 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	Pešćenica-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 Međimurje	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 prigorske 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-žabljački 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	Kutinske 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	5	Common beech
66	106	165703,94	455323,16	5084694	5651793	Bjelovar	Bjelovarska Bilogora	155	b	160	290	6	Durmast oak
67	107	165629,49	454431,39	5068260	5651450	Bjelovar	Dugački gaj-Jasenova drljež	19	b	130	0	0	English oak
68	108	165333,28	453534,44	5051593	5648033	Bjelovar	Dišnica-Zobikovac-Petkovača	45	b	120	45	5	English oak
69	109	165819,00	451843,00	5020326	5653206	Zagreb	Trstika	54	a	75	0	0	Narrow-leaved ash
70	112	170836,98	455316,45	5084871	5666739	Koprivnica	Pitomačka Bilogora	16	a	235	320	13	Large-leaved linden
71	114	170918,09	451006,14	5004933	5669774	Nova Gradiška	Međustrugovi	41	a	80	0	0	Common beech, 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-virovitičken 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 sume	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	Krndija-gazijska	12	a	290	135	5	Durmast oak
86	137	175805,26	451855,57	5023305	5733089	Požega	Sjeverni Dilj 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, significant damage on the plot amounts to 12.5 %
88	139	181027,49	452736,17	5039992	5748619	Našice	Krndija 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	Osijek	Valpovačke nizinske šume	17	a	70	0	0	English oak, significant damage on the plot amounts to 39.13 %
91	143	182425,00	452122,00	5024498	5765188	Osijek	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, 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, 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	Compa-rtment	Sub compart-ment

Plot number (ICP)	Height above sea level (m)	Exposure (°)	Slope (°)	Rockiness (%)	Stoniness (%)	Phitocenological 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.

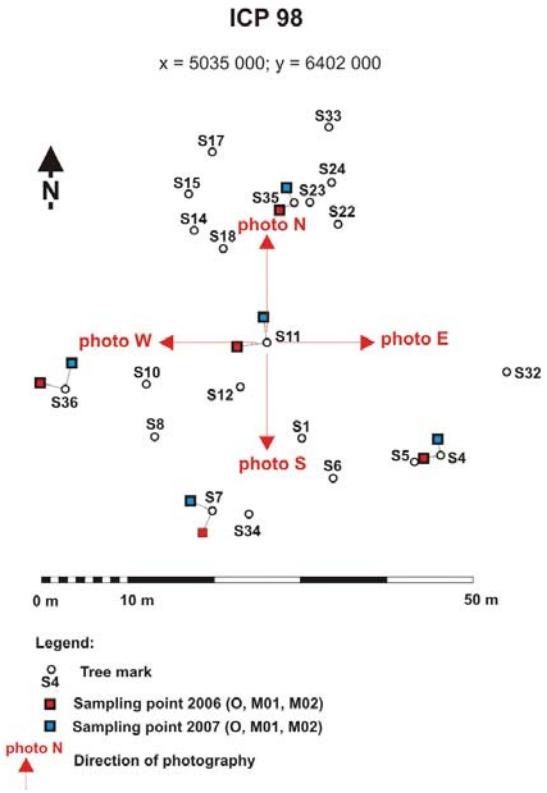


Figure 3. Example of scheme of monitoring plot from the Pilot Project

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 (main directions of 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^3 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 consistance			
			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^2	Number > 2mm/dm^2	Diameter	Number < 2mm/dm^2	Number > 2mm/dm^2	Quantity	Type
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 > or = 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^3.

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 ($CaCO_3$)	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 potentialy 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^{2+}, Mg^{2+}, Na^{+}, K^{+})	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^{+}	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 $^{-1}$)
				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 $^{-1}$)														
	In water	In $CaCl_2$	(g kg -1)		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^{-1}								
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^{-2})	Rock fragments (vol. %)	Particle size distribution (%)				Texture class	Soil densit	Carbonates (g kg^{-1})
				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^{-1})														
		In water	In $CaCl_2$	(g kg^{-1})		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^{-1}								
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 iInfluence 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)
1.1. Travel costs	1.1.1. Mileage	500	2,00	1.000,00
	1.1.2. Daily allowances	2	170,00	340,00
1.2. Field and office work	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
1.3. Material costs	1.3.1. Expendable supplies	1	500,00	500,00
1.4. Preparation of samples	1.4.1. Drying, crushing and stocking	5	40,00	200,00
1.5. Physical analyses	1.5.1. Water capacity in O- horizon	3	50,00	150,00
1.6. Chemical analysis of soil	1.6.1. Determination of pH in H2O 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 (Ca2+, Mg2+, Na+, K+, Al, Fe, Mn)	4	1.000,00	4.000,00
	1.6.6. Exchangeable acidity and exchangeable hydrogen	4	600,00	2.400,00
Cost per plot				**16.937,60**
Cost for 30 plots				**508.128,00**

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."

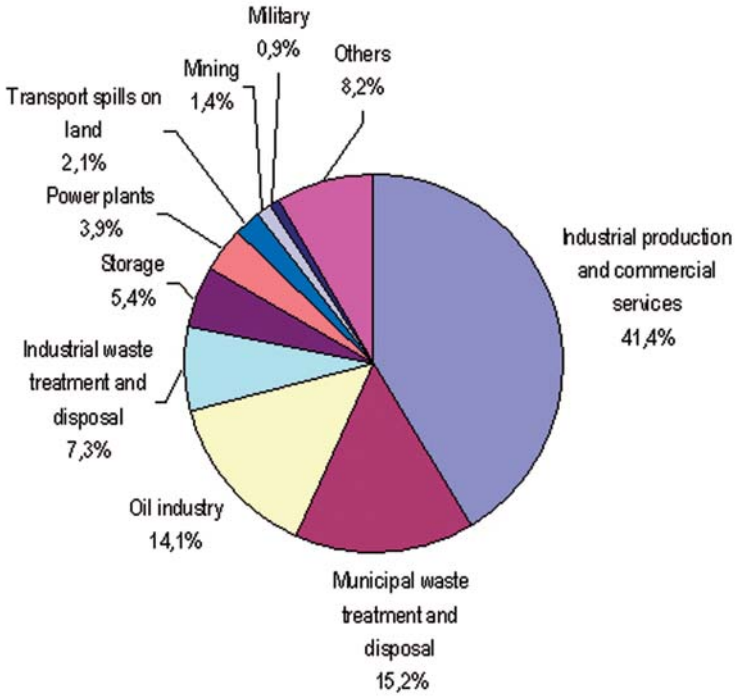
III. Croatian Contaminated Soil Monitoring Programme

1. Introduction

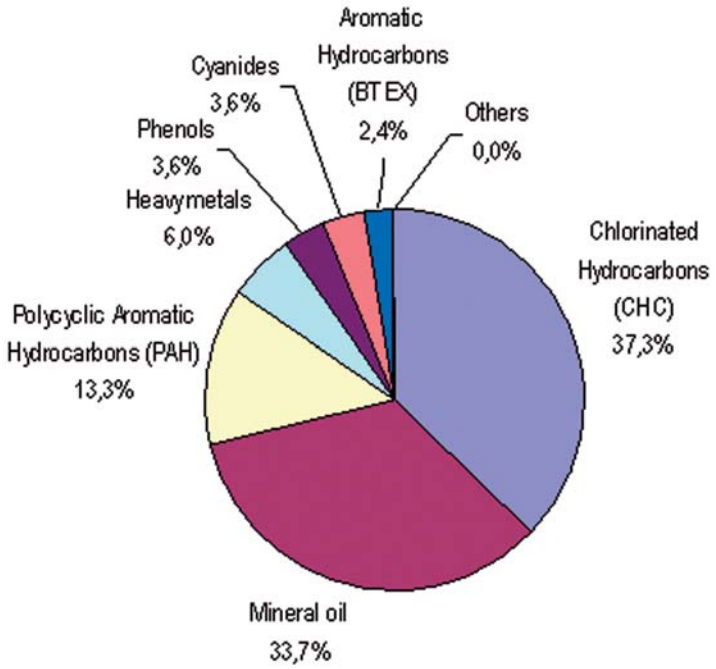
Contamination of soil is the input of substances, biological organisms or energy into the soil resulting in the modification of the soil quality and which impacts the normal use of the soil or the health of people and other organisms. Problems related to contaminated soil are closely related to the development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

S – Strengths	➢ including the results of the existing scientific and expert projects in the planning of monitoring of contaminated soils ➢ several well equipped scientific institutions and agencies
W – Weaknesses	➢ lack of legal solutions ➢ uneven treatment of air, water and soil ➢ lack of interest of the wider community for problems of soil contamination ➢ lack of financial funds, absence of incentive instruments at the state level, economic entities and the local community for the prevention of soil contamination ➢ absence of consistent implementation of certain laws ➢ very weak transparency of data gathered to date
O – Opportunities	➢ to organise a unique gathering of the existing data on soil contamination ➢ to specify indicators for monitoring soil contamination ➢ to keep a high ecological rating of the Republic of Croatia ➢ to establish an integral system for soil monitoring ➢ 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) ➢ to adopt the Soil Protection Strategy and the Sustainable land management Strategy
T – Threats	➢ lack of legislation on non-agricultural land ➢ lack of relevant legal acts and regulations ➢ lack of unique institution and reference centres for the implementation of soil monitoring ➢ unevenness of homogeneous data ➢ not well established sources and flow of data ➢ non-existence of the system for monitoring soil and the condition and modification (degradation) of soil/land ➢ unreliability of the existing data

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 of 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,*

[1]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).

[2]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).

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 transbundary 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 IPCC Directive, included by SEVESO II Directive, and industries included by the new BAT reference document (BREF) of the IPCC 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
1. Vicinity of possible sources of contamination												
1.1. Traffic infrastructure												
Roads	x	x					x		x			
Airports	x	x		x			x		x			
Railway facilities				x								
Ventilation systems in tunnels	x	x					x		x			Sulphur
1.2. Energy												
Thermal power plants	x	x	x				x		x		x	
Working space of gas plant and coal depots	x	x					x		x			
1.3. Landfills												
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	
1.4. Military plants	x			x		x	x					Antimony
1.5. Industrial facilities												
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												
1.6. Metal buildings, bridges and other facilities	x	x	x				x		x	x		Iron
2. Soils in agricultural production												
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 Atrazine, Simazine	
Soils with intensive use of organic liquid fertilizers (manure and slurry)				x			x					
3. Mining activities												
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.

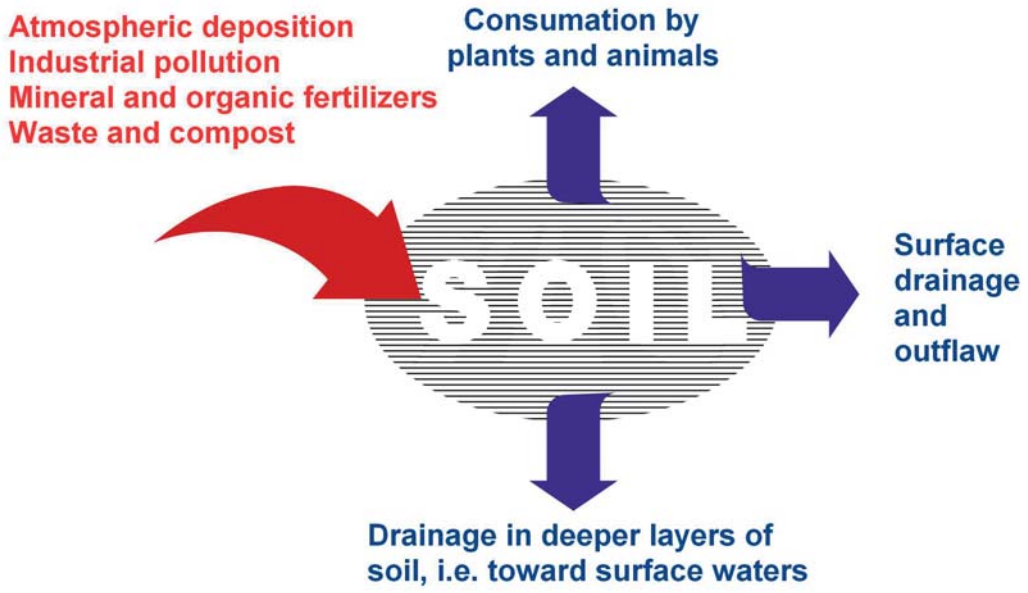


Figure 1. Balance of the emission of soil contamination by potential (red – income; blue – expenses)

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 → / Type of contamination in soil ↓	Soils for agricultural production	Children playgrounds	Living areas	Parks and recreation areas	Areas for industrial and commercial purposes
	(mg/kg of dry soil)				
1. Metals extracted in aqua regia:					
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
2. Other inorganic compounds					
Total fluorides	300	450	825	1.200	1.500
3. Specified and total concentration of polycyclic aromatic hydrocarbons– PAH					
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
4a. Total concentration of polychlorinated biphenyls – PCB					
PCB = PCB28 + PCB52 + PCB101 + PCB118 + PCB138 + PCB153 + PCB180	0,2	0,2	0,6	1	2
4b. Insecticides on the base of chlorinated hydrocarbons					
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
4c. Other phytopharmaceutical agents					
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.

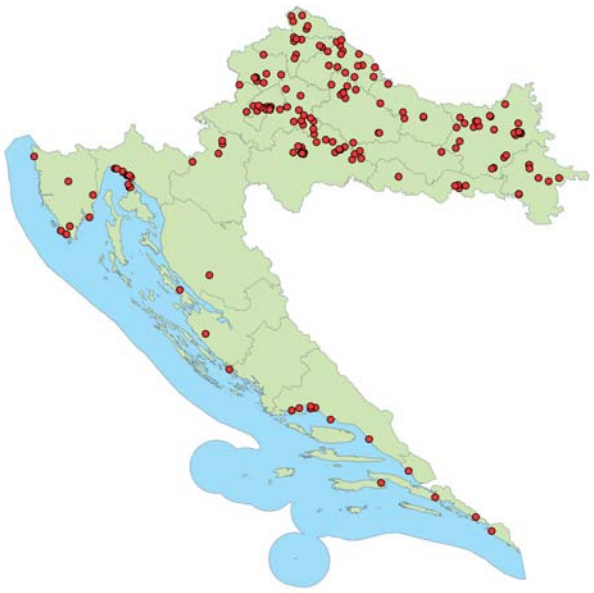
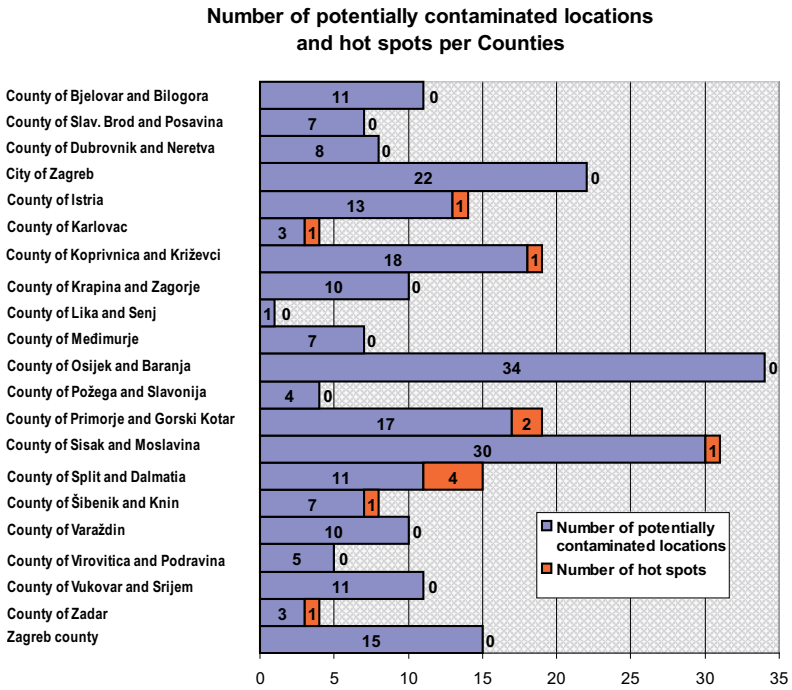


Figure 2. GEOL base - 247 potentially contaminated sites

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
	Total:	**162 million HRK**	

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
1. Sampling method		
Does the sampling method (distribution and number of samples) meets the requests? Note:	□	□
Is it possible to obtain a representative view of contamination using the selected sampling method? Note:	□	□
Are other sampling methods considered? Note:	□	□
Is there a procedure for determining replacement locations? Note:	□	□
2. Sample types		
Have necessary types of samples been determined? Note:	□	□
Has a procedure for obtaining composite samples been determined? Note:	□	□
Does the sampling procedure enables taking of representative samples? Note:	□	□
3. Sampling depth		
Have sampling depths been determined? Note:	□	□
Can the purpose of research be achieved if selected sampling depths are used? Note:	□	□
3.1. Sampling of subsurface soil layer		
Have sampling depths of subsurface layer/soil horizon been determined? Note:	□	□
Is sampling at fixed depths or horizons of soil appropriate? Note:	□	□
4. Quantity of samples		
Has a necessary quantity of samples been determined pursuant to planned analyses? Note:	□	□
Have reserves of samples and storage of samples been taken into consideration? Note:	□	□
5. Agreement with owners of locations at which soil monitoring is conducted		
Have owners and/or users-holders been informed that monitoring is being conducted? Note:	□	□
Are there any cables and pipes and have all necessary approvals been obtained? Note:	□	□
Is the staff adequately qualified and sufficiently trained? Note:	□	□
Is the planned time of monitoring adequate? Note:	□	□
Has the risk from contamination been taken into consideration considering the order of sampling? Note:	□	□
Can a necessary quantity of samples be taken considering the planned number of single samples? Note:	□	□
Does the samples storage and transport satisfy standards requests? Note:	□	□
6. Preconditions for sampling		
Does the temporary warehouse corresponds to requests (containers, temperature, duration)? Note:	□	□
Will the samples be dried in the shortest possible time? Note:	□	□
Is there a danger from soil contamination during grinding and sieving? Note:	□	□
Is the procedure of division of samples adequate for the creation of representative sub-sample? Note:	□	□
7. Storage of soil samples		
Is there a plan for storage? Note:	□	□
Have conditions for long-term storage been satisfied? Note:	□	□

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 - O1 II. Factors for the creation and evolution of soil														
8.	**Relief**													
A	*4	Form of relief of the area												
B	*5	Position of the station												
C	*7	Slope and exposition												
D	*6	Shape of slope												
9.	*11	**Natural vegetation of the area**												
10.	*12	**Nature of parent material**												
11.	*12	**Geological age of the soil**												
12.	**Soil classification of the station**													
A	Škorić et al, 1985													
B	WRB, 2006													
13.	**Climate**		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												
14.	**Wind rose**													
A	Exposed/sheltered													
B	Description													
15.	**Mode of using**													
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)													
17.	**Local sources of contamination - list**													
18.	**Additional information**													
* 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 - O1 III. Surface soil properties							
16.	**Rockiness**			**20.**	**Erosion**		
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	
17.	**Gravelness**			**21.**	**Surface crust**		
A	*15	Percentage of surface		A	*20	Thickness	
B	*15	Diameter of fragments		B	*20	Hardness	
18.	**Surface salt efflorescence**			**22.**	**Surface cracks**		
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	
19.	**Faded sand on the surface**						
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 - O1; 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^2	Number > 2mm/dm^2	Diameter	Number < 2mm/dm^2	Number > 2mm/dm^2	Quantity	Type
	*60	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 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	49. Human-transported material	50. Artefacts					
			Percentage	Type	Size	Hardness	Weathering	Colour
	*45	*85	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.

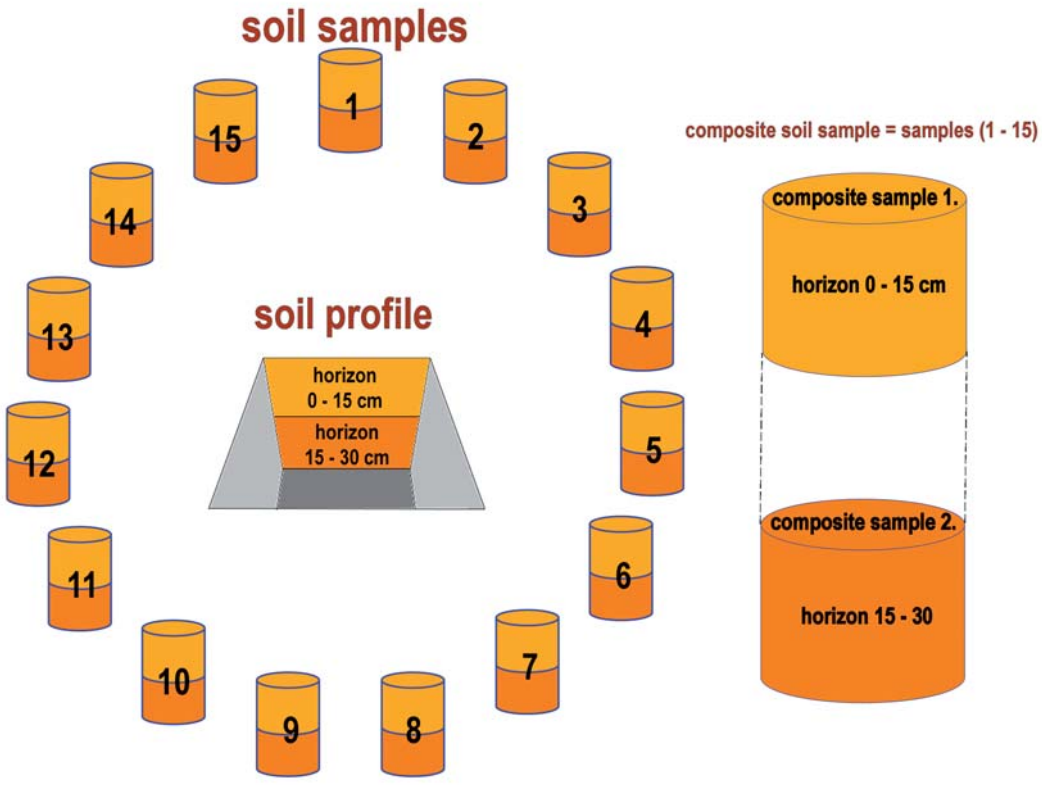


Figure 3. Sampling of composite samples

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.

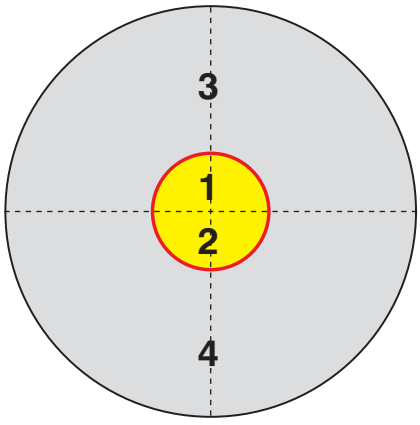
Around the source of contamination, full circles are drawn pursuant to the size of contaminated location in diameter of 100 meters up to 7.5 kilometres, depending on the diameter of the circle of the potential source of contamination. In accordance with the increase of the surface of the potential source 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^2	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.

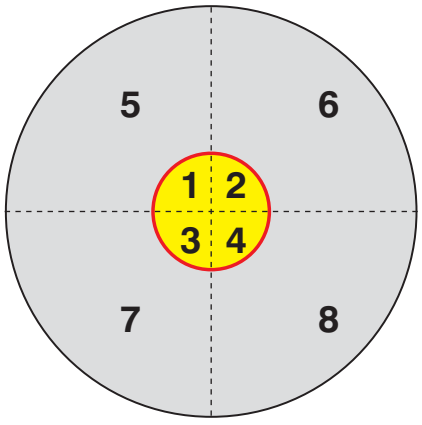


Potentially contaminated location of size 1-3 ha

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 polluter 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.

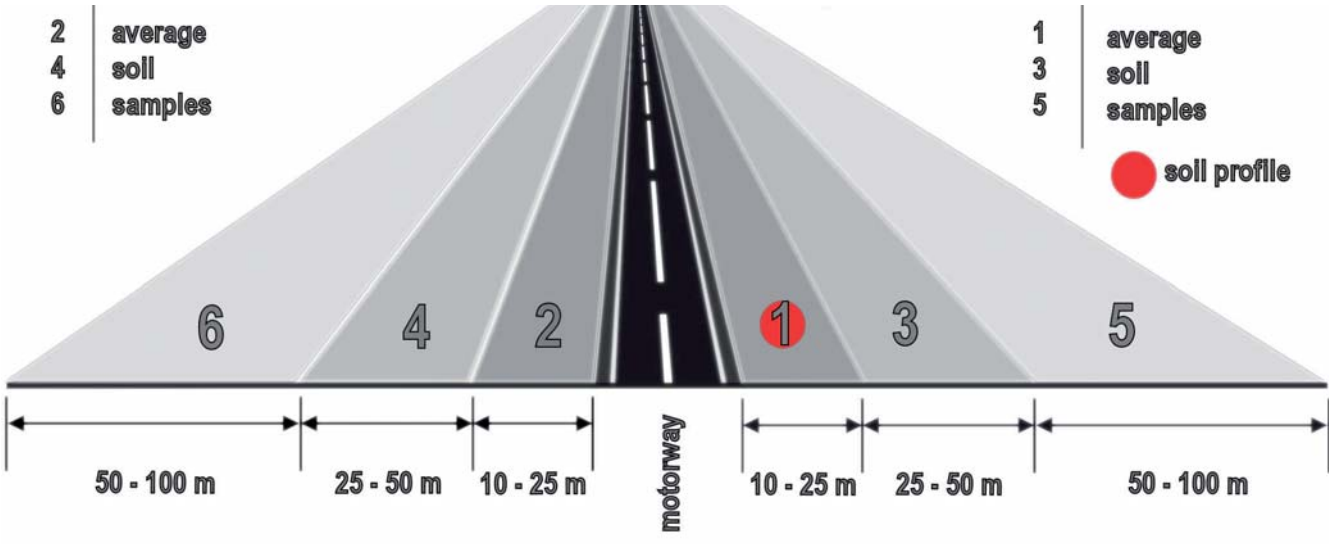


Figure 7. Soil sampling scheme at line (roads) sources of contamination

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.

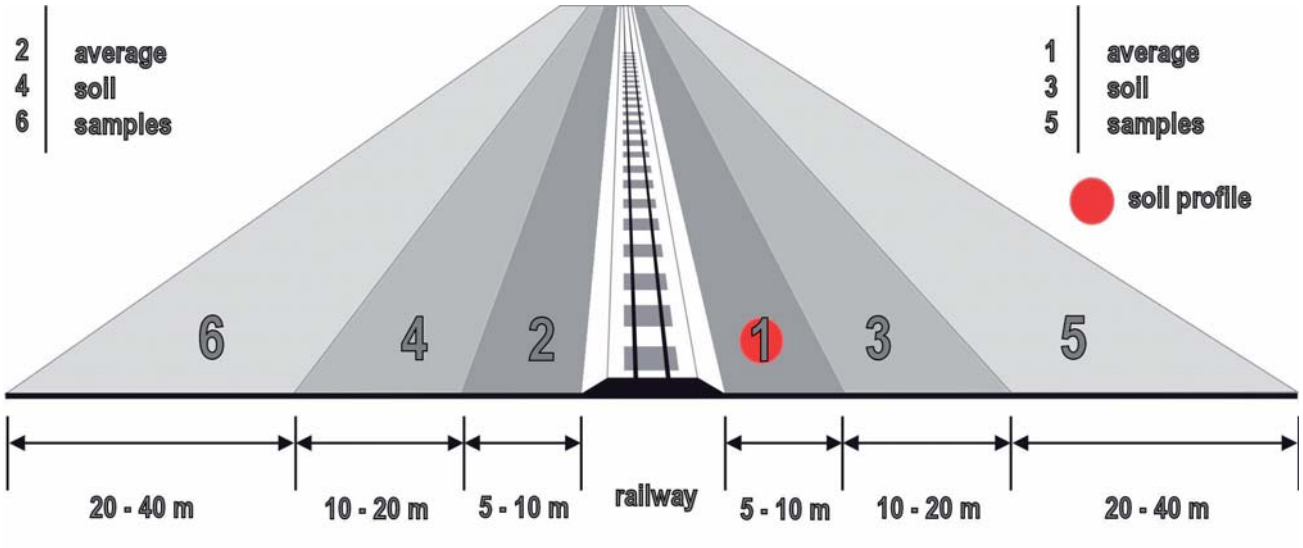


Figure 8. Soil sampling scheme at line (railways) sources of contamination

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 HRN ISO 11272:2004 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 HRN ISO 11272:2004	1/1
Air capacity	Calculation	HRN ISO 11508:2004 HRN ISO 11272:2004 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 ($CaCO_3$)	Scheibler calcimeter – volumetric Elementary analysis	HRN ISO 10693:2004 HRN ISO 10694:2004	1/5
Exchangeable acidity	Extraction with 1 M NaAc Extraction with 1 M KCl	HRN ISO 14254:2004	1/5
Cation exchange capacity (CEC, exchangeable Ca^{2+}, Mg^{2+}, Na^{+}, K^{+})	Barium-chloride solution, Method by Kappen, Extraction with hexa-amino-cobalt-trichloride	HRN ISO 11260:2005 HRN ISO 13536:2005 ISO 23470:2007	1/5
Organic and total carbon	Method by Tjurin (Bikromat method) Determination by Walkley-Black Elementary analysis	HRN ISO 10694:2004 HRN ISO 14235:2004	1/5
Total nitrogen	Modified method by Kjeldahl, Elementary analysis (dry combustion)	HRN ISO 11261:2004 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_3, Fe, Cu, Zn, S, Mn)	AL method - extraction with ammonium-lactate acetic acid (P and K) Extraction of trace elements by fount solution DTPA Extraction of trace elements with NH_4NO_3 Determination to AAS, ICP-OES, ICP-MS, spectrophotometrics	HRN ISO 14870: 2005 ISO 19730:2008 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 Analysis with fluorohydrogen acid and perchlorate acid Analysis with alkaline fusion Determination to AAS, ICP-OES, ICP-MS	HRN ISO 11466:2004 HRN ISO 14869-1:2004 HRN ISO 14869-2:2004 HRN ISO 11047:2004 ISO 22036:2008 ISO 16772:2004 ISO 20279:2005	1/5
Anions and cations: NO_3^-, NO_2^-, NH_4^+, SO_4^{2-}, CN^-, …	1:10 water extract Extraction with KCl Extraction with CaCl2 Determination by ion chromatography (IC), continuous flow analyzer (CFA), spectrophotometrics	ONORM L 1092-93 ISO 14256-1:2005 ISO 14256-2:2003 HRN ISO 10304-1:1998 HRN ISO 14911:2001 HRN ISO 11048:2004 HRN ISO 11262:2005 ISO 17380:2004	1/5
Electrical conductivity (EC)	Electrometric	HRN ISO 11265:2004	1/5
Persistent organic polluters: 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 HRN ISO 13877:2004 ISO 15009:2002 ISO 10382:2002 ISO 14154:2005 ISO 11264:2005 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 IR Spectrometry GC (gas chromatography)	HRN ISO/TR 11046:2005 ISO 16703:2004	1/5
Chemical composition of drainage water at the depth of up to 2 m (pH, EC, anions, cations)	Electrometric, Ion chromatography	HRN ISO 10523:1998 HRN ISO 7888:2001 HRN ISO 10304-1:1998 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_2 production	**Substrate-induced respiration method**	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 – 03 I. Physical parameters													
Station identification number:			**Laboratory:**					**Analyst:**				**Date of analysis:**	
No.	**Mark of horizon/ 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.**
		ρv	ρč		Max Kv	Ret.Kv	Kz	Kv	Tv	Fav	Lv	mikro	makro			
		g/cm3		%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	EC	$CaCO_3$	Humus	KIK	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	TC	TOC	N	S	H	P	
	H_2O	KCl	$CaCl_2$	mmol/100g	mS/m	%	%	mmol/100 g					mg/kg						
1.																			
2.																			
3.																			
4.																			
5.																			
6.																			
7.																			
Method/ ISO stand.																			

Accessible elements in the soil											
No.	P_2O_5	K_2O	NO_{3-}	NO_{2-}	NH_4^{+}	SO_4^{3-}	Fe	Cu	Zn	S	Mn
	mg/100 g		mg/100 g	kg/ha	mg/kg						
1.											
2.											
3.											
4.											
5.											
6.											
7.											
Method/ ISO 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/ ISO 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/ ISO stand.																								

Specific parameters - inorganic										
Ions									**Other elements**	
Broj	S_2-	Br^-	Cl^-	F^-	Free CN^-	Total CN^-	SCN^-	Cr_{6+}	Total F	Total Br
	mg/kg								mg/kg	
1.										
2.										
3.										
4.										
5.										
6.										
7.										
Method/ ISO stand.										

Specific parameters – organic (1)									
Polychlorinated biphenyls (PCB)									
No.	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/ ISO stand									

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

Specific parameters – organic (3)			
Organochlorinated pesticides (OCP) (Parameter/ Result (ng/kg)/ Method / ISO standard	**Herbicides** (Parameter/ Result (ng/kg)/ Method / ISO standard	**VAH** (Parameter/ Result (ng/kg)/ Method / ISO standard	**VHH** (Parameter/ Result (ng/kg)/ Method / ISO standard

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

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

Specific parameters – organic (6)			Specific parameters – organometallic compounds	
Organophosporous insect. (Parameter/ Result (ng/kg)/ Method / ISO st.	**Insecticides Carbamates** (Parameter/ Result (ng/kg)/ Method / ISO st.	**Other** (Parameter/ Result (mg/kg)/ Method / ISO st	**Organo-lead compounds** (Parameter/ Result (ng/kg)/ Method / ISO st.	**Organo-tin compounds** (Parameter/ Result (ng/kg)/ Method / ISO st.

Specific parameters – other parameters			
Radionuclides (Parameter/ Result (Bq/kg)/ Method / ISO st.	**Pathogenic organisms** (Parameter/ Result / Method / ISO st.	**Asbestos** (Parameter/ Result (mg/kg)/ Method / ISO st.	**Explosives** (Parameter/ Result (mg/kg)/ Method / ISO st.

FORM FOR ANALYSIS OF STATION FOR MONITORING POTENTIALLY CONTAMINATED AND CONTAMINATED SOIL – 03 III Microbiological parameters			
No.	**Cellulolytic activity**	**Activity of dehydrogenase**	**CO_2 production**
	Mg glu/g of soil	Mmol/100g	ugTPF/g of soil
1.			
2.			
3.			
4.			
5.			
6.			
7.			
Method/ 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.
Physical analysis of soil											
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
Chemical analysis of soil											
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
Microbiological analysis of soil											
Cellulolytic activity	320,00	6	1.920,00						y	y	y
Activity of dehydrogenase	320,00	6	1.920,00						y	y	y
CO_2 production	320,00	6	1.920,00						y	y	y
1. Costs of first monitoring - inventarisation per location (x + y)			**36.200,00**	**18.208,00**	**26.576,00**	**15.700,00**	**26.576,00**	**15.880,00**	**15.560,00**	**21.496,00**	**21.496,00**
2. Costs of monitoring per location every 5 years (y)			**31.480,00**	**13.488,00**	**21.856,00**	**10.980,00**	**21.856,00**	**11.160,00**	**10.840,00**	**16.776,00**	**16.776,00**
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)			**5.003.356,00**		**3.837.516,00**

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) 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) Installations for gasification and liquefaction	11	3334171	JADRANSKI NAFTOVOD d.d.	County of Slavonski Brod-Posavina	
	12	3334171	JADRANSKI NAFTOVOD d.d.	County of Koprivnica-Križevci	
	13	3334171	JADRANSKI NAFTOVOD d.d.	County of Primorje-Gorski Kotar	
	14	3334171	JADRANSKI NAFTOVOD d.d.	County of Primorje-Gorski Kotar	
	15	3334171	JADRANSKI NAFTOVOD 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) 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) Places for storage of oil and oil derivatives	52	3275531	Dalekovod, d.d. for engineering, production and construction	City of Zagreb	
3. Mineral industry (b)(vi) Opencast mining and quarrying: Gypsum, (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 (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 (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 (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 (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 (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 (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	

	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 pharmaceutics 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. pharmaceutics	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	

6. Paper and wood production and processing (a) 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) 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) 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	
	118	1736400	VINDON d.o.o. for production and trade	County of Slavonski Brod-Posavina	
7. Intenzivno stočarstvo i akvakultura (a) (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	

(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-weaved 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	

of paint prom ships, with a capacity for ships 100 m long	152	3333710	BRODOGRADILIŠTE VIKTOR LENAC d.d. in bankruptcy	County of Primorje-Gorski Kotar	
	153	3333710	BRODOGRADILIŠTE VIKTOR LENAC d.d. in bankruptcy	County of Primorje-Gorski Kotar	
	154	3333710	BRODOGRADILIŠTE VIKTOR LENAC d.d. in bankruptcy	County of Primorje-Gorski Kotar	
	155	3333710	BRODOGRADILIŠTE VIKTOR LENAC d.d. 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 tourism	County of Dubrovnik and Neretva	
8. Animal and vegetable products from the food and beverage sector (b) (i) Treatment and processing intended for the production of food and beverage products: animal raw materials (other than milk) with a finished product production capacity of 75 tonnes per day 9. Other activities (f) Places for storage of oil and oil derivatives (h) Places for storage of fertilisers	160	3108503	AGROMEĐIMURJE d.d. Čakovec	County of Međimurje	
	161	3307042	BELJE d.d. for activities in agriculture, processing industry and trade of goods, Darda	County of Osijek-Baranja	
	162	3307042	BELJE d.d. for activities in agriculture, processing industry and trade of goods, Darda	County of Osijek-Baranja	
9. Other activities (f) Places for storage of oil and oil 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; 2006.
	168	3586243	INA-INDUSTRIJA NAFTE d.d.	County of Bjelovar-Bilogora	1999; 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	

	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) Places for storage of 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	
	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	
	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; 2000.
	201	3586243	INA-INDUSTRIJA NAFTE d.d.	County of Osijek-Baranja	2000; 2007.
	202	3586243	INA-INDUSTRIJA NAFTE d.d.	County of Osijek-Baranja	
	203	3586243	INA-INDUSTRIJA NAFTE d.d.	County of Osijek-Baranja	2000; 2007.
	204	3586243	INA-INDUSTRIJA NAFTE d.d.	County of Osijek-Baranja	
	205	3586243	INA-INDUSTRIJA NAFTE d.d.	County of Osijek-Baranja	1999; 2000; 2007.
9. Other activities (f) Places for storage of 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; 2001; 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; 2002; 2005.
	219	3586243	INA-INDUSTRIJA NAFTE d.d.	County of Sisak-Moslavina	2005; 2007.
	220	3586243	INA-INDUSTRIJA NAFTE d.d.	County of Sisak-Moslavina	2002; 2005; 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; 1995; 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) Places for storage of 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; 2006.
9. Other activities (f) Places for storage of oil and oil derivatives (h) Places for storage of fertilizers	241	3326411	Kutjevo d.d. for production and trade of agriculture and food products	County of Požega-Slavonia	
9. Other activities (f)	242	3870693	NAFTNI TERMINALI FEDERACIJE d.o.o. for storage, forwarding, external and internal 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.

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