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Soil Protection Activities and Soil Quality Monitoring in South Eastern Europe

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THEMATIC SCIENTIFIC CONFERENCE

"Soil Protection Activities and Soil Quality Monitoring in South Eastern Europe"

on June 18th and 19th, 2009, Sarajevo - Bosnia and Herzegovina

Organised by the:

Soil Science Society of Bosnia and Herzegovina

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In association with:

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Foreword

In the last decade soil and soil protection are becoming recognized as an important environmental topic. The number of recent soil thematic conferences reflects the concern of scientific community to stress the threats and impose the adequate soil protection and preservation measures. There is a common consensus among the soil scientists that soil truly is a vital natural resource. It is providing essential goods and services and is of life of terrestrial ecosystems. Sustainable soil use and soil protection is of vital importance for Mankind. Unfortunately, this fact is still not entirely recognised by the public, among politicians and the decision makers.

Western Balkans and the entire South Eastern Europe are characterized by the extreme diversity of geomorphologic conditions. Parent material and relief in combination with Alpine, Continental and Mediterranean climates are predominantly directing the pedogenesis and soil degradation processes. There is the wide diversity of soil types present in this area. The list of soil types could start from deep and fertile Chernosems of Vojvodina to the shallow Rendzinas and Rankers in the mountainous Bosnia, Gleysols of Croatia and to the salinized soils in Macedonia, to name just a few. Soils of the area are facing a number of possible threats which are are trans-boundary and so must also be the soil protection activities and actions.

Soil science and related knowledge has a rich history in the area. Many scientists and professors, who studied and explored the soils, passed their knowledge on to the younger generations. Regional conferences represent a chance for younger scientists to gather, inspire and interact with prospects of cross border scientific work. Collaboration and knowledge exchange is important for regional research as well as soil protection activities.

Soil science conferences should merely be milestones, a chance to present research focus, to review and verify research results. They offer the possibilities to discuss problems and plan joint research activities. Additionally conferences hold an important public impact. They raise the public awareness and draw the attention of politicians and decision makers.

The conference S*oil Protection Activities and Soil Quality Monitoring in South Eastern Europe* was organized in Sarajevo as a joint action by the Soil Science Society of Bosnia and Herzegovina and the Soil Science Society of Slovenia. The main objectives of conference were to review the soil protection and soil quality monitoring activities in SEE including research activities, project reports, good practice guides and various methodologies and monitoring strategies. The special emphasis was laid on the ecological and technical soil functions, remediation and re-cultivation measures, data collection and processing, soil protection policy, soil quality and soil resources management issues on the regional level. The conference was an opportunity to key regional soil science research institutions to present activities and achievements with further prospects of cross - border scientific collaboration.

This publication presents a selection of conference papers prepared by the authors from SEE countries and guest contributions from Austria, Slovenia and Syria.

On behalf of conference organizing committee and the editors

Borut Vrščaj and Hamid Čustović

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Producing an environmental indicator Progress in management of contaminated sites

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Abstract

Emission of hazardous substances from industry, as well as from municipal and industrial waste, may have impacts on the quality of soil and water, and especially groundwater. Management of contaminated sites assumes assessment of harmful effects that cause contamination and undertaking measures to comply with environmental standards required by the relevant legislation. Soil protection in Republic of Macedonia is regulated by several laws, including the Law on Environment, the Law on Nature Protection, the Law on Agricultural Land, etc., but there is no soil specific law, with clearly defined institutional responsibilities. Numerous activities causing soil contamination in Republic of Macedonia have been identified. This concerns especially industrial activities.

The progress in the management of contaminated sites has been designed to mitigate possible negative effects in case of suspected or confirmed environment degradation and there is a need to reduce potential threats to human health, biological diversity, water bodies, soil, habitats, foodstuffs, etc.

The management of contaminated sites starts with investigation that can further lead to rehabilitation or treatment of contaminated site, measures for its conservation and maintenance and revitalization of contaminated sites.

The indicator Progress in the management of contaminated sites shows progress in five main steps: site identification; preliminary investigation; main site investigation; implementation of remediation measures; measure completed.

In the Republic of Macedonia, 16 sites have been identified as areas of potential soil contamination, characterized as hotspots. Preliminary investigations have been carried out with 16 sites, while with two sites main investigations have been carried out and certain remediation measures implemented. Completion of measures has not been recorded with none of the identified hotspots. With regard to economic activities contributing to soil contamination expressed in percentage, the highest share belongs to mining with 43.75%, followed by metallurgy with 31.25%, organic chemical industry with 12.5% and refinery and leather manufacturing industry with 6.25%.

Key words: contaminated sites, preliminary investigation, main site investigation, economic activities contributing to soil contamination

1 Introduction

Emission of hazardous substances from industry, as well as from municipal and industrial waste, may have impacts on the quality of soil and water, and especially groundwater. Management of contaminated sites assumes assessment of harmful effects that cause contamination and undertaking measures to comply with environmental standards required by the relevant legislation. Unfortunately, no standards for the soil quality or defined targets for remediation of sites with exceeded standards have been put in place in Republic of Macedonia. On the other side, numerous activities causing soil contamination have been identified. This concerns especially industrial activities and waste disposal by municipalities and industrial facilities.

This indicator tracks the progress in the management of contaminated sites, as well as the level of financial resources (public and private) that should be allocated for remediation (Environmental indicators-Republic of Macedonia, 2008).

2 Evaluating an indicator

The term 'contaminated site' refers to a well-delimited area where the presence of soil contamination has been confirmed and the severity of possible impacts to ecosystems and human health are such that remediation is needed, specifically in relation to the current or planned use of the site. The remediation or clean-up of contaminated sites can result in a full elimination or in a reduction of these impacts.

The term 'potentially contaminated site' includes any site where soil contamination is suspected but not verified and investigations need to be carried out to verify whether relevant impacts exist.

The progress in the management of contaminated sites has been designed to mitigate possible negative effects in case of suspected or confirmed environment degradation and there is a need to reduce potential threats to human health, biological diversity, water bodies, soil, habitats, foodstuffs, etc.

The management of contaminated sites starts with investigation that can further lead to rehabilitation or treatment of contaminated site, measures for its conservation and maintenance and revitalization of contaminated sites (Environmental indicators-Republic of Macedonia, 2008).

The indicator shows progress in five main steps:

1) Site identification/ preliminary study (gathering and reviewing existing data on 'potentially contaminated site');

2) Preliminary investigation which include specification of a methodology to identify the potentially most environmental dangerous industrial contaminated site, including sample taking, physical analyses of soil and leaching test and chemical analysis of groundwater, soil , tailings from dump sites, slags sample from dump sites, gypsum from dump sites, fly ash);

3) Main site investigation;

4)Implementation of remediation measures (implementation of conclusions and recommendations for mitigation/remediation of the hotspots);

5) Measure completed.

In future, this indicator would also show the costs to the society for contaminated sites remediation, the main activities contributing to soil contamination and achievements in the management of contaminated sites (Environmental indicators-Republic of Macedonia, 2008).

2.1 Methodology used

Methodology for the indicator calculation was according to the methodology of European Environmental Agency, European Topic Centre for soil, which was used for the calculation of environmental indicator Progress in management of contaminated sites in other European countries.

Regarding methodological uncertainty, although there is a definition of contaminated site, because of the lack of limit values for the concentration of certain toxic substances and chemicals in the soil, it is difficult to determine the exact number of sites where soil contamination has been confirmed. The assessment of contaminated site depends to a great extent on the individual expert assessment.

Data for the indicator calculation was taken from the National Waste Management Plan of the Republic of Macedonia or Special study E-for industrial contaminated sites.

The shares of economic activities contributing to soil contamination are calculated e.g. [number of mines contributing to soil contamination]/[total number of sites or sites where soil contamination has been confirmed] x 100(Environmental indicators-Republic of Macedonia, 2008).

Regarding uncertainty of data set, all sites where certain industrial/economic activity is performed, have not been accounted as sites with determined contamination, although such activities generate chemical substances.

3 Policy relevance of the indicator

The implementation of the existing legislation, especially the Law on Environment which incorporates the Integrated Pollution Prevention and Control Directive, the Law on Nature Protection, the Law on Agricultural Land, the Law on Waste Management with transposed Landfill Directive, Law on Waters with transposed Water Framework Directive would result in specific activities that shall be undertaken to reduce soil contamination. However, major efforts are needed to settle the issue of historical contaminations.

Our country lacks legally prescribed standards on soil. Generally, the existing legislation is intended to prevent new contaminations. Implementation of the actual legislation would result in reduced soil contamination and improved control of contamination caused by natural and other developments.

Soil protection is regulated by several laws, including the Law on Environment, the Law on Nature Protection, the Law on Agricultural Land, etc., but there is no soil specific law, with clearly defined institutional responsibilities.

According to Article 2 of the Law on Environment, improvement of the state and quality of the environment includes the protection of soil. The same Law, in its Article 9, prescribes the polluter pays principle, while Article 13 introduces the principle of precaution which should assist in avoiding the local soil contamination in future. Article 36 envisages internal monitoring for legal and natural persons possessing emissions and making impacts by their activities on one or more environmental media.

The Law on Nature Protection, in its Article 11 concerning restriction in land use change and in correlation with Article 12 prohibition of nature use in a manner causing degradation of soil and its fertility loss.

4 The problem of industrial contaminated sites

4.1 General issues

The mining and metallurgy sector in Macedonia have a long history. Lead and Silver, for instance had been produced at several location of the Zletovo region during the Roman period. Most of the industrial capacities, however, have been built during the 1970s and 1980s. The core technologies applied were state-of-the-art for several years after the start-up period, but the auxiliary facilities and the management practices were far below the standards required for minimizing waste generation and proper waste management. As the waste on the landfills accumulated, its impact on the environment increased: heavy metals reported in groundwater at some industrial locations and organic compounds at others, while mines produce considerable amounts of mine and/or flotation tailings.

Lignite, copper ore, nickel ore and non- metal minerals are extracted by open pit mining in Macedonia, while lead and zinc ores are extracted by underground mining. Apart from the continuous impact on the environment several major accidents resulting in flooding a wide area around the landfills and contaminating the surface and ground water have already been experienced.

Macedonian companies faced severe problems during the transition period and some of them even prior to it. Several companies have stopped their activities with no chances to be restarted in the near future. Their landfills are also abandoned and little or no information can be obtained on the history of waste disposal and waste management. Due to indistinct ownership, allocation of the environmental liability is a very difficult task. In most cases the state is the only responsible party left (Special Study E, Industrial Contaminated Sites hotspots, 2005).

4.2 Environmental aspects

The main environmental risks of uncontrolled dumpsites of industrial hazardous waste are:

- Contamination with hazardous substances of freatic groundwater under and downstream of the dumpsite by percolating and runoff rainwater.
- Contamination of surrounding land by infiltration of runoff rainwater and/or deposit of airborne dispersion of hazardous substances.
- Contamination of nearby surface water through direct discharge of runoff water or contact/exchange with contaminated groundwater.

The main possible impacts of above listed risks are:

- Contaminated well water intended for drinking water, livestock feed, and irrigation water thus threatening the health of humans and animals.
- Contaminated surface water causing damage to aquatic life and limiting the use as feedstock for drinking water preparation.
- Bioaccumulation of toxic substances in the food chain, and in the natural flora and fauna.
- Deterioration of the quality and decrease of the value of agricultural land and urban development land.

4.3 Evaluation of the Hazard Potential

The hazard potential of contaminated sites is mainly defined by the following parameters:

- Hazard and toxic characteristics of the disposed waste
- Leacheability of the waste
- Height or thickness of the waste dump
- Level of the freatic groundwater
- Permeability of the sub-soil
- Presence of nearby surface water
- Erosion of the top layer of the dumpsite causing airborne dispersion

These critical parameters have been quantified and used in the methodology of prioritisation of the contaminated sites (Special Study E, Industrial Contaminated Sites hotspots, 2005).

5 Results and discussion

In the Republic of Macedonia, 16 sites have been identified as areas of potential soil contamination, characterized as hotspots. Site identification on the base of reviewing existing data was performed and preliminary investigations have been carried out with 16 sites, while in two sites main investigations have been carried out and certain remediation measures implemented. Main site investigation in Zletovo mine area include detail analysis of the soil, tailings, surface water, groundwater, river bottom sediments and crops contamination by harmful heavy metals (As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Zn, Mn) in the area of 107 km^2 in Zletovica basin (The Study on capacity development for soil contamination management related to mining in the Republic of Macedonia, December 2007).

In Silmak ferro-silicium smelter and as well as near dumpsite wich is define as site that has high environmental risks, main site investigation have been performed, including soil, groundwater, surfacewater contamination investigation. The contamination of soil, groundwater, surface water with Cr^{6+} has been confirmd and the remediation measures has been implemented. Drainage sistem and water tretment plant have been constructed where Cr^{6+} is converted in nontoxic form Cr^{3+}. Half of the area of dumpsite has been covered with unpermeable PVC membrane, coverd with uncontaminated soil and planted with grass (Protection of soil, groundwater and surface water from polution of chromium in area of Jegunovce, 2006).

Completion of measures has not been recorded with none of the identified hot-spots. As a result of priority ranking of industrial contaminated sites-hotspots in Republic of Macedonia we are able to define that 3 out of 16 contaminated sites possess high environmental risks, 7 out of 16 sites possess medium environmental risks and 6 sites have low environmental risks (Special Study E, Industrial Contaminated Sites-hotspots, 2005). With regard to economic activities contributing to soil contamination expressed in percentage, the highest share belongs to mining with 43.75%, followed by metallurgy with 31.25%, organic chemical industry with 12.5% and refinery and leather manufacturing industry with 6.25% (Environmental indicators-Republic of Macedonia, 2008). The aggregate number of potential contaminated sites is 16, with following characteristics: 5 non-ferro metal mines, 2 power stations with lignite mines, 4 metallurgical industries, 2 chemical industries, 1 petroleum refinery and 2 other industries (Table 1) (Special Study E, Industrial Contaminated Sites-hotspots, 2005)

Table 1: Identified industrial contaminated sites-hotspots

Nr.	Site ('hotspot')	Municipality	Status of operation	Environmental Liability
1.	OHIS Chemical Industry	Skopje	Abandoned, partly operational	Macedonia /OHIS
2.	Silmak Ferro/Silicium Smelter (former HEK Jugochrom)	Jegunovce	Dumpsite closed	Arbitrary
3.	MHK Zletovo Lead/zinc Smelter	Veles	Closed (2 yrs)	Due diligence
4.	Lojane Chromium/antimony Mine	Lojane	Abandoned (30 yrs)	Macedonia
5.	Toranica Lead/zinc Mine	Kriva Palanka	Closed (>5 yrs)	Macedonia
6.	Zletovo Lead/zinc Mine	Probistip	Operational	Macedonia
7.	Sasa Lead/zinc Mine	Makedonska Kamenica	Operational	Macedonia
8.	Bucim Copper Mine	Radovis	Operational	Arbitrary
9.	REK Bitola (lignite mine/power plant)	Bitola	Operational	REK Bitola
10.	REK Oslomej (lignite mine/power plant)	Kicevo	Operational	REK Oslomej
11.	Makstil Steelworks	Skopje	Operational	Makstil
12.	OKTA (petroleum refinery)	Skopje	Operational	OKTA
13.	Tane Caleski (metal products)	Kicevo	Closed (5 yrs)	Macedonia
14.	MHK Zletovo Fertilizer Plant	Veles	Closed (5 yrs)	Macedonia
15.	Godel Tannery	Skopje	Closed (5 yrs)	Macedonia
16.	Feni Industry (ferro-nickel alloys)	Kavadarci	Operational	Feni industry

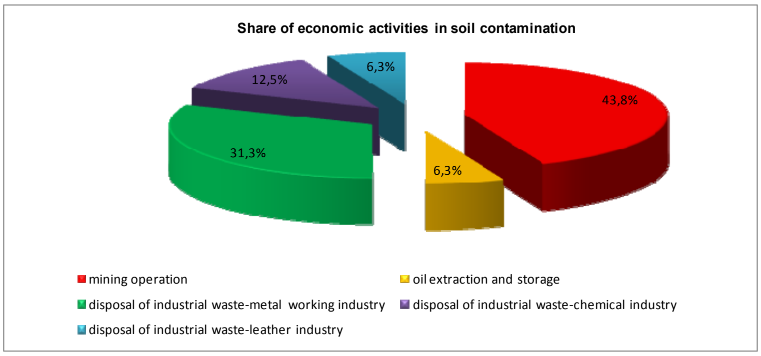

Figure 1: *Share of economic activities in soil contamination*

Figure 1 present the share of economic activities in soil contamination as percentage of sites where the activity is present compared to the total number of processed sites.

Table 2: Five main steps in the progress in contaminated sites management

Five main steps in the progress in contaminated sites management	Identified sites
Site identification/preliminary study	16
Preliminary investigation	16
Main site investigation	2
Implementation of remediation measures	1
Measure completed	0

Table 2 present the number of sites managed to a certain step out of the five main steps of the indicator.

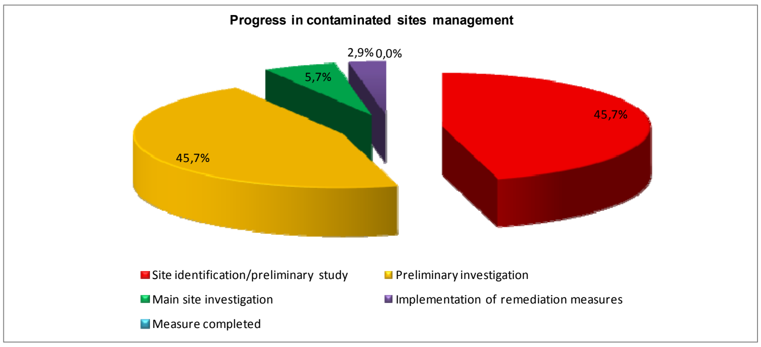

Figure 2: *Progress in contaminated sites management*

Figure 2 present the number of sites for which each of five steps within contaminated sites management has been completed as a percentage of the total number of sites to be processed.

According to the National Waste Management Plan of the Republic of Macedonia, calculations have led to the conclusion that around 77 million EUR or 38 EUR per capita will be needed for the implementation of remediation measures to all contaminated sites (Special Study E, Industrial Contaminated Sites hotspots, 2005).

6 Summary / Conclusions

Producing an environmental indicator Progress in management of contaminated sites, and updating it, give us ability to answer several questions regarding the share of economic activities contributing to soil contamination in Republic of Macedonia, and about the progress that has been made in local soil contamination management and control. In order to show the state regarding management of contaminated sites and answer the above questions, it is necessary to carry out additional investigations of contaminated sites, as well inspection of the activities of industrial companies producing contaminants as by-products. Further we have to implement the National waste management plan, development of local programmes and plans for different solid waste types management, remediation of tailings, stabilization and recultivation of industrial landfills. Also we will be able to estimate the costs for soil contamination remediation and contribution from the public budget and contribution from private budget.

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Soil diversity as a factor of development of endemic flora and vegetation on the Dinaric karst

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Abstract

The soil is one of the key factors in the determination biodiverstiy. Soil of diversity is a good indicator of the diversity of abiotic and biotic factors in specified ecosystem. Soil significantly affects the processes of creating new species (speciation) and plant communities (syngenesis). In addition, the soil together with the geological surface is an important factor in the process of endemogenesis or creating of endemic species. This is especially true on the terrestrial species of plants and communities.

The aim of this research is to determine the patterns and rules of floristic richnees and degree of endemism vascular flora and vegetation in the horizontal and vertical profile of Dinaric karst, Bosnia and Herzegovina, with special emphasis on the catchment area of the Neretva river. In each vegetation belt going from the sea to the highest mountains in selected areas has been elaborated the endemic flora and vegetation and soil types. The national nomenclature of soils with a correlation with the nomenclature of WRC have been applyed.

The highest degree endemism of plants is determined by the undeveloped soils in the (A)- C profile vegetation in rock crevices, and screes. More than 80% of species in these soils are endemic and relic character. Level of endemism decreases with the increase soil (pedological) profile. Also, endemism decreases with increase nutrients in the soil, and with productivity of biocoenoses.

To preserve the endemic flora and vegetation in the Dinaric karst, Bosnia and Herzegovina necessary preserve the existing natural karst soil, carried out their conservation and to access the establishing of soil information system (SIS). One of the essential steps in the process of sustainable conservation of karst soils and unique karst flora and vegetation and the establishment of protected areas, and the „red book of soils“.

Key words: karst, soil diversity, biodiversity, endemism, soil conservation, red book of soils, Soil information system

1 Introduction

Biodiversity in accordance Convention of Biological diversity (CBD) includes the totality of the world lives on planet Earth. Biodiversity is organized on genetic, species and ecological level. Diversity means a diversity of species living world at the level of organic species of plants, animals and fungi. Ecological diversity means the diversity of ecosystems biocoenoses and landscapes in a particular dimension of time and space (UNEP, 1992). The question is whether the concept of biodiversity includes the living world in earlier geological periods?

There are a number of key factors that determine biodiversity (structure, richness, endemism and relict ness and threats) on the local, regional and global scale. One of the very important factors determines biodiversity is soil. This applies especially to the diversity of plants in terrestrial ecosystem. In addition, soil is one of the key factors in the processes of florogenesis (creating flora of the area) and syngenesis (development of communities and ecosystems). On the other hand pedogenesis or generating of soil is closely connected with the structure of the world lives in a given area, and with other factors - geological surface, climate and relief. At some places some of these factors are dominant, which results in the establishment and development of specific forms of flora and fauna and soil. Karst is a unique natural phenomenon which supports the development of special processes of soil and plant cover, and geological and hydrological diversity (Cvijić, 1893; Bonacci, 1987, White, 1988; Redžić, 1997, 2007a).

It is in different periods of geological history, and especially after the recent glaciations caused the development of a wide range of unique soils and plant cover (Katzer, 1909; Cvijić, 1989). Process of karstogenesis is very specific and takes place in terms of carbonate geological substrate and hydrological conditions. Should be added and unique patterns in the development of climate on Dinarides (AK, 1967). The strong interaction of karstogenic factors in the Dinaric Mts. initiated the development of a wide range of soil, different developmental stages and types (Horvat et al., 1974; Škorić, 1985, 1986, 1991; Škorić et al., 1985; Antić et al. 1986; ISZRBIH, 2000; Resulović & Ćustović, 2002).

On this dynamic karst soils formed the unique flora and vegetation, which in many ways different from the flora and vegetation of the rest of Europe and the world (Beck, 1909, 1916, Beck et al., 1967; Ritter-Studnička, 1956, 1959). Karst is one of the key factors in the determination of unique geomorphologic and hydrological diversity of the Dinarides (Lučić, 2003; Lepirica, 2005). In addition, the karst is one of the strongest factors in the processes of endemogenesis, which resulted in the creation of hundreds of endemic species of plants and plant communities (Lakušić, 1970; Horvat et al. 1974; Fukarek, 1979; Bjelčić & Šilić, 1971). Only in Bosnia-Herzegovina is known for more than 600 species of endemic plants, of which about 75% of the karst (Bjelčić, 1987; Šilić, 2000, 2002; Redžić et al., 2007; Redžić et al., 2009). Carbonate background different geological age, relief and hydrological conditions are significantly contributed to the unique processes of karstogenesis the Dinaric area which has caused a high diversity of natural habitats (Čičić & Panić, 1977, 1979; Čičić et al., 1984; Bognar, 1987; Lučić, 2003, 2007; Marjanac 2008; Trinajstić, 2008).

Karst in a broader sense includes waste rock or cliff, in a narrower sense, the specific relief from a separate, mostly underground, blood circulation in soluble rocks (limestone, dolomite, tuff). Karst limestone occurs dissolving water, which in itself is CO_2, where $CaCO_3$ is converted into water soluble $Ca(CO_3)_2$. Corrosion cracks in the limestone and expand mutually connected in a network of underground holes and channels, which reach great depths, even below sea level (Katzer, 1916, 1926; Cvijić, 1989; White, 1988).

Spacious depression along major cracks in the karst are bays. The largest are epressions with flat bottoms or karst poljes. Karts poljes mostly arise where the limestone rocks and not permeable for water and present center of recent biodiverstiy (Cvijić, 1989; Riter-Studnička, 1956, 1959; Redžić, 2007b; Redžić, 2008a).

The aim of this work is to determine the link between the diversity of soils and vegetation diversity, and to demonstrate to what extent development and soil type affect the floristic richness and endemism flora and vegetation on the example of karst Dinaric mountains, with special emphasis on karst catchment area of the Neretva river.

2 Materials and methods

In the past few years occurred in intensive floristic and syntaxonomical research on horizontal and vertical profile of Dinaric karst, with special emphasis on the Bosnian-Herzegovina's Dinarides. Special attention was devoted to determination of the patterns of distribution of plant life and floristic richness, and tries to determine the key factors in the floristic and vegetation richness, level of endemism and relictness. In addition, they used other available data that treated this issue of the Dinaric karst area (Horvatić, 1963; Fukarek, 1979; Redžić, 1999, 2003, 2004; Redžić et al., 2000; Trinajstić, 2008). Exact investigations are conducted the following profiles (Figure 1).

Figure 1: *Geographical position of investigated karst area in Western Balkans.*

(i) the level of the sea (Neum - Klek) - Žaba mountain-Čabulja-Čvrsnica – Vrana; (ii) the level of the sea (Neum-Klek) - Žegulja-Buna-Velež-Prenj-Konjic-Zlatar Bjelašnica; (iii) sea level -Kamešnica-Dinara-Šator-Osječenica-Klekovača; (iv) Martin Brod-Unac-Drvarsko field-Grahovsko field-Ždralovac-Livno's polje-Cincar-Kupres Duvno's polje-Posušje's polje-Grude's-Ljubuško polje-Mostarsko Blato; (v) the level of the sea (Neum - Klek) - Popovo polje-Dabarsko-Fatnica's polje-Nevesinje's polje-Gacko polje; (vi) the profile of the mountain Orjen. However, special attention was paid to the relative diversity of vegetation and soils in the catchments area of the Neretva River.

Area of research in complex of high mountains of Herzegovina is determined by coordinates 17º i 19º E i 43º i 44º N. Observed area is high upland frame of mountains of Prenj, Čvrsnica and Čabulja. It is positioned in north Herzegovina, in area of middle and upper Neretva (Figure 1).

In each vegetation belt, on all selected profiles, samples were taken vegetation (phytocoenological relevé) according to Braun-Blanquet (1964), we estimate the number of and covering all registered plants to $100m^2$ and $200m^2$ and $500m^2$ in depending on the type of vegetation. In this way the estimate was made the number of species and later estimates of endemism and relictness by Flora Europea (Tutin et al., 1964-1980), and according to the Flora of Bosnia and Herzegovina (Beck et al., 1967; Šilić, 2000, 2003). Nomenclature of plant communities was performed in accordance with the *International Code of Phytosociological Nomenclature* (Webber et al., 2000), and syntaxonomy communities cited in this work by Lakušić et al., (1978), Jovanović et al., (1980), Rodwell et al., (2002), Redžić et al., (2007) and Redžić et al., (2009).

At each position was performed and the evaluation of sites according to the coordinates in the GPS, altitude, exposure and slope, the geological substrate and soil type. Assessment of type of land was performed on the basis of pedogenetic horizons digging of pedological profile, pH humusne-accumulative horizon, and with the use of literature sources (Jakšić, 1972a, 1972b; Škorić et al., 1985; Ćirić, 1987; Resulović & Ćustović, 2002). Soil nomenclature was taken by former national classification and nomenclature (Škorić et al., 1985) with komparation certain types of soils according to the World Reference Base for Soil (IUSS, 2006).

3 Results and discussion

In the development of soil on karst pedogenetic dominant factors are: background geology, climate (especially temperature and hydrological regime) and biodiversity (Figure 2). In the constant process of spending of carbonate karst rocks occurs mineral component of soil, a constant decomposition of organic matter creates an organic component of soil. All this occurs in conditions of high amounts of precipitation (more than 1500 mm / year) and different types of climate (Gračanin, 1950; AK, 1967; Milosavljević, 1973). As a result of this interaction runs soil genesis process, and create of karst soils.

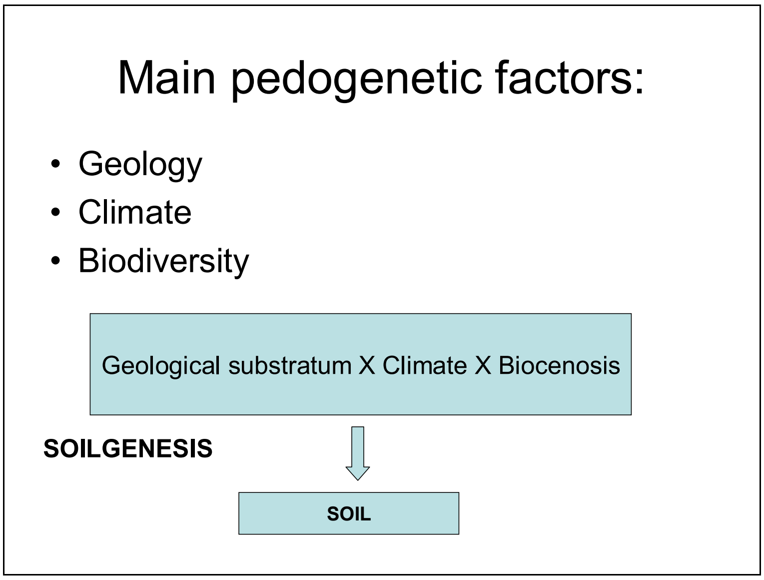

Figure 2*: Main pedogenetic factors in the karts soil genesis*

On the other hand the development biodiversity is very conditional by soil evolution. Soil is a key factor in determination process of the formation of species (speciation), the development of different categories phylogenetic categories (phylogenesis), the development of flora designated areas (florogenesis), community development and ecosystem (syngenesis). Processes of biodiversity genesis and soil genesis are unbreakable (Figure 3).

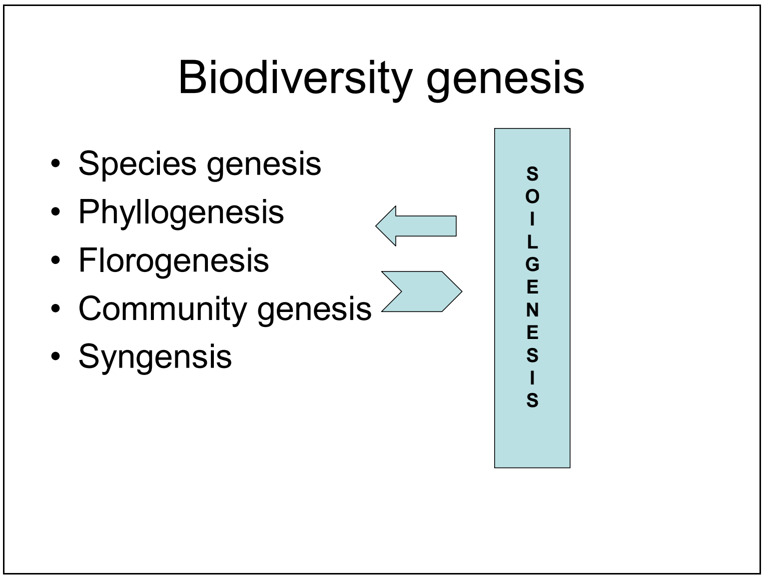

Figure 3: *This is the text of the picture.*

The carbonate rocks that are exposed to action of high temperatures and strong precipitation and strong winds, with little participation of organic matter from the most simple terrestrial organisms (bacteria, cianobacteria and some fungi) occurs first calcareous soil lithosol. Humusne-accumulative horizon of this soil is very shallow (the tenth millimeter to 1-2mm). Despite what is shallow, lithosol has great significance in the processes of vegetation succession. Lithosol is soil on which the developed and the first initial stages of development terrestrial vegetation and biological communities in general. Settled it lithophilic lichens that build community *Lichentea* class (Figure 4).

By accumulation of organic matter lithosol becomes deeper (about 5mm) and comes to the colonization lithophilic or epilithic moss that building community classes *Ctenidietea mollusci*. In later stages of succession, due to action of wind and precipitation, and changing thermal conditions, comes to breaking the rocks. There are cracks in the continuing processes of soil development. In this way generate the regosol. Becoming of regosol create the conditions for the colonization vascular plants whose roots are deeply penetrates the crack rocks. Regosols the vegetation habitats in crevices of rocks class *Asplenietea trichomanis* (Figure 4). As the ecological profile of regosol a very deep (sometimes several meters) in these habitats are common endemic-relict dendrohazmophitic community (community Illyrian Black pine *Pinion illyricae*, White bark Pine communities *Pinion heldreichi*, community shrubbery sibiraea and spirea *Spiraeo-Sibireion croaticae*). Crushing of carbonate rocks, often in terms of their slope (over 45°) mechanical composition is mixed with the remains of organic matter, resulting in sirozem who is constantly locomotive series slope. In these habitats survive only hazmophitic plants with a very developed root system that can withstand constant upheaval, "soil". Sirozems on karst habitats are scree vegetation of class *Thlaspietea rotondifolii* and *Drypeetea spinosae*.

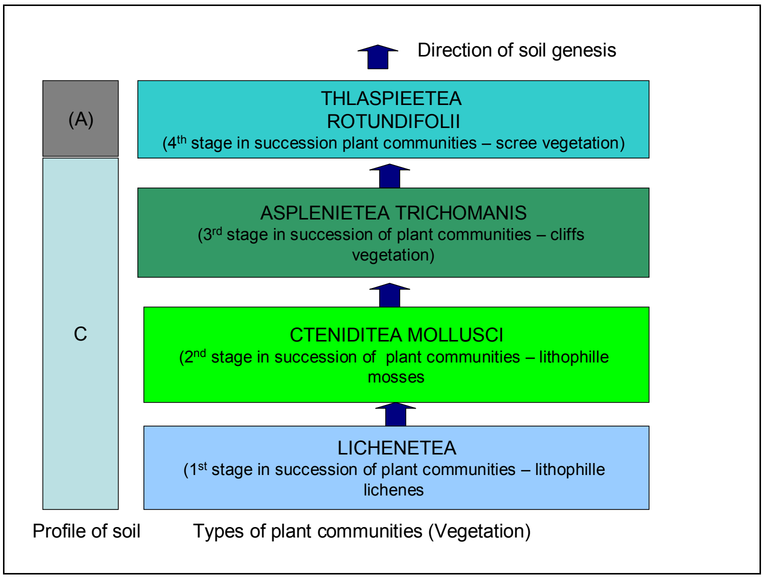

Figure 4*: At the shallow soils are the highest level of endemic plants diversity*

Undeveloped soils (A)-C profile, although a very shallow and variable with a very high diversity type, subtype, and the variety of forms. Diversity of soils and highly expressed dynamics eco-climatic certain conditions are very different types of vegetation, which is extremely high number of endemic species and relic plants. Endemic species are included in the construction of communities that are also endemic and relic character. In the endemic development centre Prenj-Čvrsnica-Čabulja in western Herzegovina, a very diverse karst undeveloped soils, which are habitats for many communities in the crevices of rocks. It is in endemic development center which is dominated by undeveloped karst soils were found and the maximum number of endemic and relic species in crevices of rocks and scree. According to these and earlier studies (Bjelčić & Šilić, 1970; Redžić et al., 2007; Redžić et al. 2009) on shallow regosol and sirozems found even 29 plant communities that belong in the context of 9 and five lines.

These communites syntaxonomiclly are differentiate at the following units: Class *Asplenietea trichomanis,* Order *Potentilletalia caulescentis* and Alliance: *Potentillion caulescentis with* community *Potentilletum caulescentis;* Alliance *Micromerion croaticae* with associations: *Potentilletum clusianae, Asplenietum fissi, Asperulo hercegovinae-Potentilletum appeninae, Arenaria gracilis-Campanuletum hercegovinae, Primula-Edraianthetum serpyllifoliae, Primula-Campanuletum hercegovinae, Asplenio fissi-Potentilletum apenninanae, Edraiantho serpyllifolii-Potentilletum clusianae,* then alliance *Moehringion muscosae* with communities *Moehringio-Corydaletum* and *Cardamino-Campanuletum cochlearifolia. Order Moltkietalia petreae with the alliance Edraianthion* and communities: *Potentilla speciosa-Moltkea petraea, Centaurea triumfetti-Moltkaeetum petraeae,* Alliance *Centaurea-Campanulion* with communities: *Inulo-Moltkaeetum petraeae, Asplenio-Cotyledonetum horizontalis, Cephalario leucanthae-Inuletum verbascifoliae, Achnanthero-Moltkaeetum petraeae, Micromeria thymifoliae-Inuletum verbascifoliae* and *Edraiantho-Seslerietum interruptae.*

Order *Amphoricarpetalia* and alliance *Amphoricarpion autariati* with communitis: *Heliospermo retzdorfiani-Oreoherzogietum illyricae* and *Micromerio croaticae-Potentilletum persicinae;* Alliance *Amphoricarpion neumayeri* with communities: *Amphoricarpi-Pinetum leucodermis, Moltkeaeo-Pinetum heldreichii, Arenario gracili-Moltkaeetum petraeae* and *Asperulo hercegovinae-Potentilletum persicinae.* The order *Anomodonto-Polypodietalia* with alliance *Polypodion serrati* and order *Potentilletalia speciosae* with alliance *Moltkeo-*

Potentillion speciosae and communities: *Edraiantho-Potentilletum speciosae* and *Molkaeo-Potentilletum speciosae.*

These ecosystems are very affine to ecosystems of shaded and wet karst rocks of Mediterranean and sub-Mediterranean strap of class *Adiantetea*, order *Adiantetalia* and group *Adiantion capilli-veneris*, which is developed in fragments on recesses in canyon of river Neretva that is under influence of Mediterranean climate.

A similar situation and the diversity of vegetation with different variations of sirozems and colluvium soils such as scree who have a special form of geological diversity from the present level of the sea to the highest mountain peaks.

Same as ecosystems in breach of rocks, rock creeps or lathes are azonal in character. They are developed in bases of mountain massive, and all the way to peeks of Prenj, Čvrsnica and Čabulja. They are especially impressive in sub-mountain strap of the whole endemic center where they form magnificent communities of unique floristic content, appearance, origin and role in system of creation of new types of vegetation, or in system of syngenesis. Due to extreme and unique of climate forms, geological surface, lack of organic substances and other factors of biotope, specific forms of speciation have developed that are characterized by unique endemic genesis. That resulted in development of endemics, relicts and plants with narrow geographical spreading. 30 associations, 7 alliances, included in 4 orders that belong to wider spread class are determined in this vegetation. Sintaxonomical, this class is differentiated into following communities: Class *Thlaspieetea rotundifolii*, order *Thlaspietalia rotundifolii* (*=Arabidetalia flavescentis*), alliance *Corydalion ochroleucae* with community *Micromerio thymifoliae-Corydaletum ochroleucae;* Alliance *Saxifragion prenjae* with communities: *Saxifrago-Papaveretum kerneri, Violo biflorae- Saxifragetum prenjae, Aubrietum croatiace, Bunio-Saxifragetum prenjae, Seslerio robustae-Scutellarietum alpinae, Cystopteri-Aquilegietum dinaricae, Saxifrago prenjae-Adenostyletum alliariacae, Doronico-Adenostyletum alliariae, Papavero kerneri-Doronicetum,* and alliance *Bunion alpini* with communities *Bunio-Iberetum carnosae* and *Euphorbio-Valerianetum berstiscei.* Order *Drypeetalia spinosae,* alliance *Peltarion alliaceae* with communities: *Drypeetum jacquinianae, Geranio-Artemisietum fumarioidis, Teucrio arduini-Peucadanetum, Micromerio thymifoliae-Geranietum macrorrhizi, Euphorbio-Saturejetum montanae, Corydalo-Epilobietum rosmarinifoliae* and alliance *Silenion marginatae* with communities: *Drypidi-Silenetum marginatae, Geranio-Heracleetum balcanicum, Drypeetum linneanae, Drypidi-Heracleetum orsinii, Dryopteridetum villarsi, Seslerio robustae-Petasitetum kablikiani, Senecio visianiani-Heracleetum orsinii.*

Rock creeps along with breach of rocks provide this area with unique forms of total biological diversity. Following endemic species found refuge in this area: *Saxifraga prenja, Papaver kerneri, Heracleum orsinii, Teucrium arduini, Bunium alpinum* and other species (Redžić et al. 2009). Similar laws in the correlation of diversity of soils and vegetation found in other areas of Dinaric Alps (Redžić, 2007c, 2007d; Redžić et al., 2008). It is thanks to diversity shallow soils, eco-climatic conditions, karst substrate specificity as well as hydric regime in the catchment area of Neretva river meets the highest level of diversity and endemism of vascular flora and vegetation in the broader geographic area.

In any orographic and climatic zone in vertical profile of karst area of Bosnia-Herzegovina occur if the specific processes of pedogenesis. This resulted in creating of different classes and types automorphic soils. Diversity of soils is the high degree of diversity of plant cover vegetation through attested recovery unit level connections (Table 1). In dependency of orographic terrain, exposure and slope belts in all, there are undeveloped soil (A)-C profiles in the developing vegetation on hard carbonate rocks, in crevices of rocks and scree and colluvium. In the Mediterranean belt pedogenesis flowing to terra rossa, which were developed climatogenous community evergreen oak forests *Quercion ilicis*. Only in the karst depressions terra rossa and brown Mediterranean calcareous soil goes into luvisol on to develop the forest laurel *Laurion nobili*.

In the sub-Medieterranean belt pedogenesis also flows from lithosol over humusne-accumulative soils A-C profile, and through cambisol A-(B)-C profile to dryer varieties of luvisol on flat terrain. Climatogenous vegetation in this belt are trees and shrubs of the alliance *Ostryo-Carpinion orientalis* with great number of communities. It is in sub-Mediterranean belt and numerous refugee of tertiary flora and vegetation (the canyon of the Neretva river and its tributaries) in which the developmental centers endemic flora and vegetation.

Table 1: Relationship of soil diversity and vegetation diversity at the vertical profile of Dinaric karst area in Bosnia and Herzegovina

Orographic/Climatic belt	***Soil profile***	***Type of soil***	***Plant community/Vegetation***
MEDITERRANEAN (0-200 M)	(A)-C	(Halo)Lithosol	*Crithmo-Statition*
	(A)-C	Lithosol	*Lichenetea & Ctenidietea mollusci*
	(A)-C	Regosol	*Edraianthion tenuifolii* *Centaureo-Campanulion*
	(A)-C	Sirozem	*Peltarion alliaceae* *Cymbopogo-Brachypodion ramosi*
	(A)-C	Colluvium	*Peltarion alliaceae* *Cymbopogo-Brachypodin ramosi*
	A-C	Calcomelanosol	*Paliurion aculeati* *Cisto-Ericion* *Cymbopogo-Brachypodion ramose*
	A-C	Rendzine	*Cisto-Ericion* *Cymbopogo-Brachypodion ramosi*
	A-(B)-C	Terra rossa	*Quercion ilicis* *Oleo-Ceratonion* *Cisto-Ericion* *Juniperion macrocarpae* *Cymbopogo-Brachypodion ramose* *Laurion nobilis*
	A-(B)-C	Calcocambisol	*Quercion ilicis* *Quercion pubescentis*
	A-E-B-C	Luvisol	*Laurion nobilis* *Quercion pubescentis* *Vulpio-Lotion*
SUBMEDITERRANEAN (201-500m)	(A)-C	Lithosol	*Lichenetea & Ctenidietea mollusci*
	(A)-C	Regosol	*Edraianthion tenuifolii* *Amphoricarpion autariati*
	(A)-C	Sirozem	*Peltarion alliaceae* *Satureion montanae*
	(A)-C	Colluvium	*Peltarion alliaceae* *Orneto-Ostryon* *Chrysopogoni-Satureion*
	A-C	Calcomelanosol	*Paliurion aculeati* *Ostryo-Carpinion orientalis* *Chrysopogoni-Satureion* *Juniperion oxycedri*
	A-C	Rendzine	*Peucedanion neumayeri* *Orneto-Ostryon* *Orno-Ericion*

Orographic/Climatic belt	**Soil profile**	**Type of soil**	**Plant community/Vegetation**
	A-(B)-C	Calcocambisol	*Quercion pubescentis* *Quercion frainetto* *Quercion troyanae* *Scorzonerion villosae*
	A-E-B-C	Luvisol	*Quercion frainetto* *Scorzonerion villosae*
HILLY/MONTANE (501-700m)	(A)-C	Lithosol	*Lichenetea & Ctenidietea mollusci*
	(A)-C	Regosol	*Amphoricarpion autariati* *Potentillion caulescentis* *Stipion calamagrostidis*
	(A)-C	Sirozem	*Corydalion leiospermae* *Chrysopogoni-Satureion*
	(A)-C	Colluvium	*Orneto-Ostryon* *Corydalion ocholeuceae*
	A-C	Calcomelanosol	*Seslerio-Ostryon* *Satureion montanae*
	A-C	Rendzine	*Peucedanion neumayeri* *Satureion montanae* *Orneto-Ostryon* *Pinion austriacae* *Seslerio-Fagion*
	A-(B)-C	Calcocambisol	*Quercion cerris* *Seslerio-Fagion* *Fagion moesiacae* *Bromion erecti*
	A-E-B-C	Luvisol	*Carpinion betuli* *Quercion cerris* *Fagion moesiacae* *Scorzonerion villosae*
MEDITERRANEO-MOUNTANE (701-1200m)	(A)-C	Lithosol	*Lichenetea & Ctenidietea mollusci*
	(A)-C	Regosol	*Potentillion caulescentis* *Stipion calamagrostidis*
	(A)-C	Sirozem	*Corydalion ochroleuceae* *Satureion subspicatae*
	A-C	Calcomelanosol	*Crataego-Corylion* *Satureion subspicatae*
	A-C	Rendzine	*Seslerio-Ostryon* *Seslerio-Fagion*
	A-(B)-C	Calcocambisol	*Quercion petraeae-cerris* *Seslerio-Fagion* *Fagion moesiacae* *Scorzonerion villosae*
	A-E-B-C	Luvisol	*Quercion petraeae-cerris* *Fagion moesiacae* *Scorzonerion villosae*
HIGH-MOUNTANE (1201 – 1650m)	(A)-C	Lithosol	*Lichenetea & Ctenidietea mollusci*
	(A)-C	Regosol	*Micromerion croaticae* *Potentillion caulescentis*
	(A)-C	Sirozem	*Corydalion leiospermae* *Satureion subspicatae*
	A-C	Calcocambisol	*Seslerio-Ostryon* *Satureion subspicatae* *Abieti-Rhamnion fallacis*
	A-C	Rendzine	*Orneto-Ostryon* *Pinion heldreichii* *Seslerio-Fagion* *Satureion subspicatae*

Orographic/Climatic belt	***Soil profile***	***Type of soil***	***Plant community/Vegetation***
	A-(B)-C	Calcocambisol	*Aremonio-Fageion* *Quercion petraeae-cerris* *Corylion avellanae* *Pinion heldreichii* *Bromion erecti*
	A-E-B-C	Luvisol	*Abieti-Fagenion* *Aremonio-Fagion* *Pancicion* *Caricion ferrugineae*
SUB-ALPINE (1651-2000m)	(A)-C	Lithosol	*Lichenetea & Ctenidietea mollusci*
	(A)-C	Regosol	*Micromerion croaticae* *Potentillion caulescentis*
	(A)-C	Sirozem	*Bunion alpini* *Peucedanion longifolii* *Seslerion nitidae*
	A-C	Calcomelanosol	*Pinion heldreichii* *Aceri-Fagenion* *Pinion mugo* *Juniperion nanae* *Festuco-Seslerion ten.* *Festucion bosniacae* *Pancicion*
ALPINE (above 2000m)	(A)-C	Lithosol	*Lichenetea & Ctenidietea mollusci*
	(A)-C	Regosol	*Micromerion croaticae* *Potentillion caulescentis*
	(A)-C	Sirozem	*Bunion alpini* *Silenion marginatae* *Salicion retusae*
	A-C	Calcomelanosol	*Seslerion tenuifoliae* *Oxytropidion dinaricae* *Oxytropidion prenjae* *Salicion retusae*

In the mountain belt are characterized cambic soils on which to develop forests and shrubs of *Quercion cerris*, then thermophille community of beech *Seslerio-Fagion* (Table 1). Occupy the largest surface humusne-accumulative A-C soil profile on which the whole spectrum of community rockeries, thermophille grasslands and shrubbery. Only in the depressions and flat terrain are luvisols that inhabits forest vegetation and hemophilic meadows. The Mediterranean-mountain belt, which is normally present from littoral side of Dinaric Alps, the less incline are cambic soils that cover with oak community *Quercion petraeae-cerris* and forests beech *Aremonio-Fagion* (Table 1). Processes of pedogenesis in this belt current of lithosol to luvisol. Luvisols are typical of karstic depressions and flat surfaces.

The mountainous area is the end zone with calcocambisols. Only in the lower parts of this zone, the depressions can be formed luvisol or perceive illuvial processes. This is a belt of forests of beech, fir and beech, and white bark pine *Abieti-Fagenion*, *Aremonio-Fagion*, *Pinion heldreichi* (Table 1).

Sub-alpine belt characterized by the presence of humusne-accumulative soils A-C profile. In the lower part of this zone are low sub-alpine beech forests *Acer-Fagenion* "*subalpinum*", and white bark pine *Pinetum heldreichi "subalpinum* "in the upper part of the timber line is vegetation *Pinion mugi* and *Juniperion nanae* (Table 1).

The alpine belt is above the upper limit of forest vegetation, the Bosnian-Herzegovina's mountains, usually above 2000m. The soils are different variants humusne-accumulative dominated soils with organogenic calcomelanosols. Climatogenous vegetation is alpine pastures or high mountain tundra. Around snow beds are “cryosols" on which the vegetation of alliance *Salicion retusae* (Table 1).

Although in most belts on vertical profile Dinaric karst there are different types of soils, however, can speak of the existence of laws on zonal of soils and climtogenous vegetation (Lakušić, 1975; Lakušić et al., 1982; Redžić et al., 1984; Lakušić & Redžić, 1989, 1991).

It was also the rule of the diversity of soils and vegetation diversity. What are soil shallower intensive processes are taking a free ecological niche, thus endemogenesis and processes, which results in high level of species and ecological diversity. So in endemic development center Prenj-Čvrsnica and Čabulja, on the shallow and undeveloped humusne-accumlative soils, was found enormous number of endemic species of plants and plant communities, of which more than 80% endemic character. Thus, in the flora of this development center found of the 579 endemic species from 211 genera and 52 families (Figure 5). The majority of endemic species (more than 70%) have ecological optimum on undeveloped land (A)-C profiles in the vegetation in the crevices of rocks and scree, and on humusne accumulative A-C soil profile in the zone of mountain meadows and rocky, going up to the sub-Mediterranean to sub alpine belt.

The highest level of ecological diversity is on the shallow soils (Figure 6). With the highest level of diversity and endemism of communities in the crevices of rocks, scree and mountain meadows and rocky grasslands (Figure 6). So in endemic development center Prenj-Čvrsnica and Čabulja found even 236 plant communities from 116 alliances, 63 orders and 34 classes (Figure 6) which is about 80% of all communities in Bosnia-Herzegovina (Lakušić et al., 1978; Redžić et al ., 2007; Redžić et al. 2009). Therefore this area has been identified as a "hotpots" in the context of biodiversity "hotspots" of Mediterranean region (Redžić, 2008b).

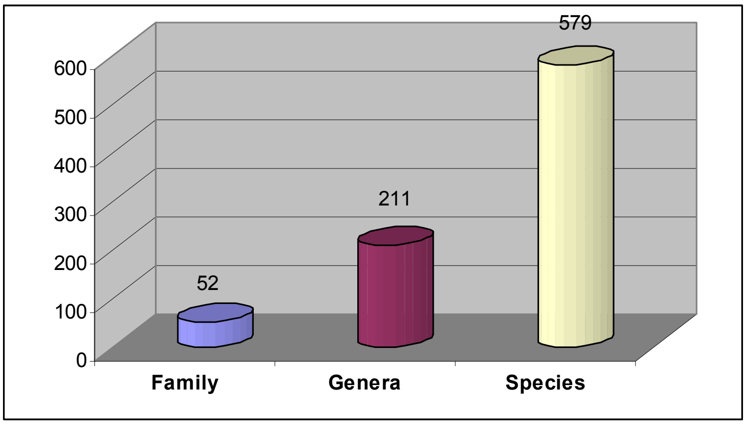

Figure 5*: Endemism of vascular plants at the endemic development center Prenj-Čvrsnica-Čabulja Mts*

Level of endemism is the highest in terms of intense fighting for the survival of certain plant species. Such habitats are bare, rocky cliffs on which the very dynamics expressed in the variation of basic environmental factors, especially hydro-thermal regime. In addition, they are soils that are extremely poor nutriment. With increasing depth of soil (Fgure 7), reduce the amplitude variation of dominant environmental factors, increases the amount of organic matter and soil repletion nutriment.

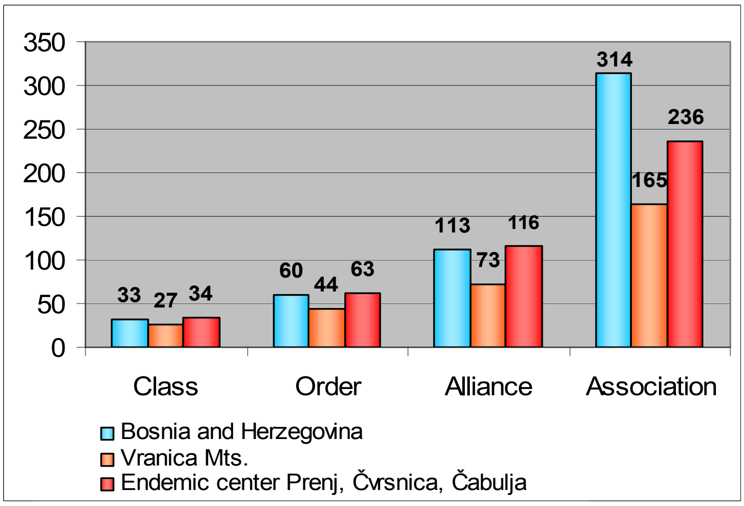

Figure 6: *Comparative overview of syntaxonomical diversity of endemic development centre Prenj-Čvrsnica-Čabulja Mts.*

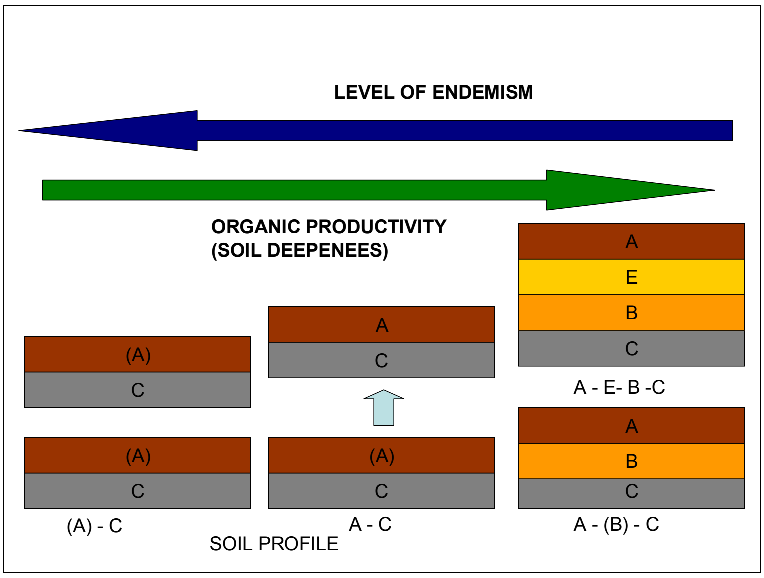

Figure 7: *The relationship od soil deepnees and level of endemism at the karst of Dinaric Alpes*

In this way, a reduction in the number of endemic species. On the undeveloped and humusne-accumulative soils with shallow A horizon is more than 80% of endemic species, and the deeper, cambic and luvisol soils that number is very small. Regardless of the poor productivity of organic matter, shallow soils are extremely important role in the determination and preservation of unique forms biodiverstiy. A typical example that confirms this statement is a living world in the Bosnia-Herzegovin's karst. This imposes the need for the development of the Soil Information System (SIS) in order to make an evaluation of the value of soil debris, and assess their threat in the context of integral protection of the natural ecosystem. One of the first steps is the estimate of threat karstic soil, and creating »red book of soils«. These goals and intentions correspond with the development documents in the field of sustainable management of biological diversity and landascapes (Redžić et al., 2003, 2008).

4 Summary / Conclusions

On the basis of research on horizontal and vertical profile Bosnian and Herzegovina's limestone, with special emphasis on the catchments area of the river Neretva of land as a factor of florogenesis and syngenesis and development of endemism and relict ness, undoubtedly can conclude the following:

(i) The pedogenesis essentially determines the process syngenesis (development of plant communities and ecosystem), and is one of the key determinants of habitat, and development of ecological (spatial) niche. To come together on shallow soils which are held intensive process of fighting for colonization available ecological niche of plants that have fewer requirements for nutriment;

(ii) Syngenesis significantly affects the processes of pedogenesis in the in situ conditions, and so comes the correlation between the structure of flora and fauna and the basic characteristics of land, which causes the creation of new values of pedosphere;

(iii) The diversity of soils in the immediate function of diversity of flora and vegetation. As a typical example of this connection is karst in the Bosnia-Herzegovina's Dinarides. The highest degree of diversity in the Mediterranean and sub-Mediterranean belt, and it's the highest diversity of soils. Diversity decreases with increasing altitude. Thus in the mountain belt is the smallest number of types of vegetation, and the lowest levels diversity of soils;

(iv) The endemism of plants growing with reduced depth of soil. What are the soil and shallow, contains less nutrients, endemism species of plants and plant communities is higher. Most species grow on undeveloped soils, at least on luvisol (deepest soil in researched karst). The karts in the catchment area of the Neretva are one of the richest areas of endemic species of plants and plant communities. How is increasingly threatened, has been marked as a "hotspots" in the Mediterranean region;

The soils on the karst regardless of what the limited productivity have a significant role in the processes of endemogenesis and preserving unique wildlife world. Because of this, they should be protected as integral parts of ecosystem and the key component in sustaining biodiversity in the karst as well as on other substrates. Development of the Soil Information System (SIS) and "red book of soils" can make significant advances made in the conservation of the karst ecosystem that have not suspicious of global values.

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Contents of some inorganic and organic pollutants in soils of Federation BiH

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Abstract

Knowledge about land resources is an essential prerequisite for planning the optimal ways of soil usage, and it occupies a key position in the strategy of development for each country.

Soil, as an important part of ecosystem, is actively involved in natural cycle of substances and it is necessary to investigate their pollutants content in order to establish preventive measures to reduce soil pollution, and thus the preservation of flora and fauna, as well as human health.

The aim of this paper is that on the basis of field and laboratory research, trough results of some chemical characteristics of soil and a total content of pollutants, determine the degree of contamination in soils of Federation of Bosnia and Herzegovina by inorganic (heavy metals: Pb, Zn, Cd, Cu, Ni, Cr, Co, Mn) and organic (TPH and PAH) pollutants.

Based on the obtained results, soils in area of Federation Bosnia and Herzegovina are relatively unpolluted by the researched inorganic and organic pollutants. However, some areas are in need of special attention when it comes to plant production or livestock breeding.

Key words: contamination, heavy metals, TPH, PAH

1 Introduction

Environmental contamination by heavy metals and organic pollutants is a phenomenon of global importance. Unlike the other types of pollution such as air pollution or damage to the ozone layer, soil contamination directly depends on the ways of its exposure to local sources of pollution. When there is a high concentration of pollutants in soil, there is a risk they enter the food chain and cause health problems to plants, animals and humans.

Contamination means the process when the different pollutants enter the soil in all three aggregate states, i.e. gaseous, liquid and solid. Consequences of contamination can be expected on the soil fauna (edafon). First, the changes reflect on the microorganisms, and then the soil fauna. After that, it may come to deterioration of chemical and physical soil properties. Extreme cases may lead to: changes in soil structure stability, reduced content of large pores which leads to lower permeability, lower humus quality, changes in soil adsorptive complex, and in some cases may lead to soil erosion.

Soil is a very complex mechanism. It represents, with its large sorption capacity, the universal decontaminator, because the soil surface keeps colloidal pollutants and prevents their infiltration in the deeper horizons and groundwater. On the other hand, soil contains a large number of useful microorganisms that are decomposing organic matter, and the remains are deposed in insoluble form and do not cause damage to the crops. Also, every soil has its lower or higher buffer capacity, i.e. ability to resist the change of pH reaction - acidification or alkalization. But all the enumerated soil properties have their capacity, which means they are able to oppose the negative impact only to a certain extent.

The term "heavy metals" refers to all chemical elements (metals) of high density that are toxic in low concentrations. They are a natural component of Earth's crust. As well as trace elements, some heavy metals (e.g. copper, zinc) are essential for the metabolism of the human body. However, higher concentrations can lead to poisoning and serious health problems (especially Pb, Zn, Cd, Cu, Ni, Cr, Co and Mn).

Total Petroleum Hydrocarbons (TPH) is a term used to describe a large family of several hundred chemical compounds that originate from naphtha. Since the raw naphtha and other petroleum products contain many different compounds, it is not practical to measure the content of each of them separately. However, it is useful to measure the total content.

Polycyclic aromatic hydrocarbons (PAH) are a class of organic chemicals consisting of two or more fused benzene rings. PAH are components of most fossil fuels and are ubiquitous in the natural environment. Natural sources include release in forest fires and from volcanic eruptions. Most environmental PAH are products of incomplete combustion or pyrolysis of fossil fuels. Although PAH are described as carcinogenic, only the following are considered as possible human or animal carcinogens: benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(l,2,3-cd)pyrene.

2 Importance and goals

Knowledge about land resources is an essential prerequisite for planning the optimal ways of land usage, and it occupies a key position in the development strategy of each country.

Soil is an important part of ecosystem actively involved in the natural cycle of substances, so it is necessary to investigate the content of pollutants and to establish preventive measures on this basis in order to reduce soil pollution, and thus preserving the flora and fauna, as well as human health.

The aim of this work is to determine the degree of soil contamination in Federation of Bosnia and Herzegovina based on field and laboratory research, trough results of some physical and chemical soil properties.

3 Climate data

Due the specific geographical position and relief, climate of Bosnia and Herzegovina is quite complex and can be separated into three climate zones, as follows:

1. In the southwest - , Mediterranean climate
2. In the central part - continental or Alpine climate
3. In the north – semi-continental, Central European climate.

In south-western parts of Federation Bosnia and Herzegovina, because of its proximity to the Adriatic Sea which radiate heat accumulated in the Summer period, the winter temperatures are relatively high (avg. January temperature 3-5^{o}C), while the summers are dry and hot (absolute maximum temperature 40-45^{o}C). The average annual sum of precipitation is between 1000-2000 l/m^2, and the average annual temperature is 12-15^{o}C. Snow is a rare phenomenon in this region.

The central part of FBiH is characterized with continental-mountain climate. The main characteristics of this climate are harsh winters (absolute minimum temperature -24 to -34^{o}C), while the summers are hot (absolute maximum temperature 30-36^{o}C). The average annual sum of precipitation is 1000-1200 l/m^2. Snow precipitation is abundant, especially at higher hills.

The north part of FBiH is characterized with semi-continental climate with plenty of cold winters and warm summers but, compared with the alpine zones, there is a smaller range between winter and summer temperatures. Warmest areas are at Northeast, while the annual temperature decreases towards the southwest, trough the river valleys towards the central belt. Average sum of precipitation is 700-1100 l/m^2. Snow falls are also present, but less than the amount in central region.

Table 1: Climate data for some cities of FBiH

Period: 1961-1990	Average annual temperatures (^{o}C)	Annual precipitation sum (mm)
Bihać	10.6	1308
Tuzla	10.0	895
Zenica	10.1	778
Sarajevo	9.5	932
Mostar	14.6	1515
Livno	8.9	1114

4 Materials and methods

4.1 Law regulation

In accordance with the Agricultural Land Law („Službene Novine Federacije BiH“, no. 2/98, Instructions about establishing the allowable amount of harmful and hazardous substances in soil and methods of examination), the limit values of pollutants are the following:

Table 2: Limiting values for pollutants in total form

Pollutants	mg/kg (ppm)	
	Sandy and skeletal soils	Loamy and clay soils
Cadmium (Cd)	1	2

Pollutants	mg/kg (ppm)	
	Sandy and skeletal soils	Loamy and clay soils
Mercury (Hg)	1	2
Lead (Pb)	100	150
Molybdenum (Mo)	10	15
Arsenic (As)	20	30
Cobalt (Co)	50	50
Nickel (Ni)	50	60
Copper (Cu)	60	100
Chromium (Cr)	60	100
Zinc (Zn)	200	300
Boron (B)	40	50
Fluorine (F)	200	300
Polycyclic Aromatic Hydrocarbons (PAH)	2	2

*Note: These values are related to acid soils. In Carbonate soils, stated values can be increased by 25%.

In addition to this law regulated pollutants, this study includes the analysis of total Manganese (Mn) in soil. Although Manganese is a trace element and is essential for normal plant growth and development, in larger quantities can be phytotoxic or have antagonistic effect on the adsorption of certain nutrients in soil (especially Iron). According to most authors, the limit value is 850 mg/kg of total soil Manganese. Manganese mobility increases with lower pH, so the limit value can be increased by 25% in case of carbonate (alkaline) soils.

In order to explain the real degree of soil pollution, we used two terms: Pollution and Contamination. The term “Soil pollution” indicates the raised content of pollutants in soil, but still not affecting convenient food production. The term “Soil contamination” indicates two or more times higher content of pollutants in soil then allowed (limit values). In this case, there is a risk when such soils are used in agriculture.

Since in the legislation of our country there are no limit values for TPH, we used the limit values of other countries that can be applied in our conditions. For the purpose of this work, the following criteria for TPH concentration will be used:

Criteria from Ontario Ministry of the Environment (Canada)
Maximum allowed concentrations of TPH in soil (µg/g):
- Light fractions (C10 – C22) 100
- Heavy fractions (>C22) 1000

4.2 Field research

Field work included reconnaissance of the terrain and soil sampling for laboratory analysis. Samples were taken from the previously identified points. The 10 km x 10 km grid, which covers the entire territory of the Federation BiH, consists of a total 260 points. Each sample was taken from the soil surface layer (to a depth of 15 cm) with a plastic shuffle, in order to avoid sample contamination with metal tools and equipment.

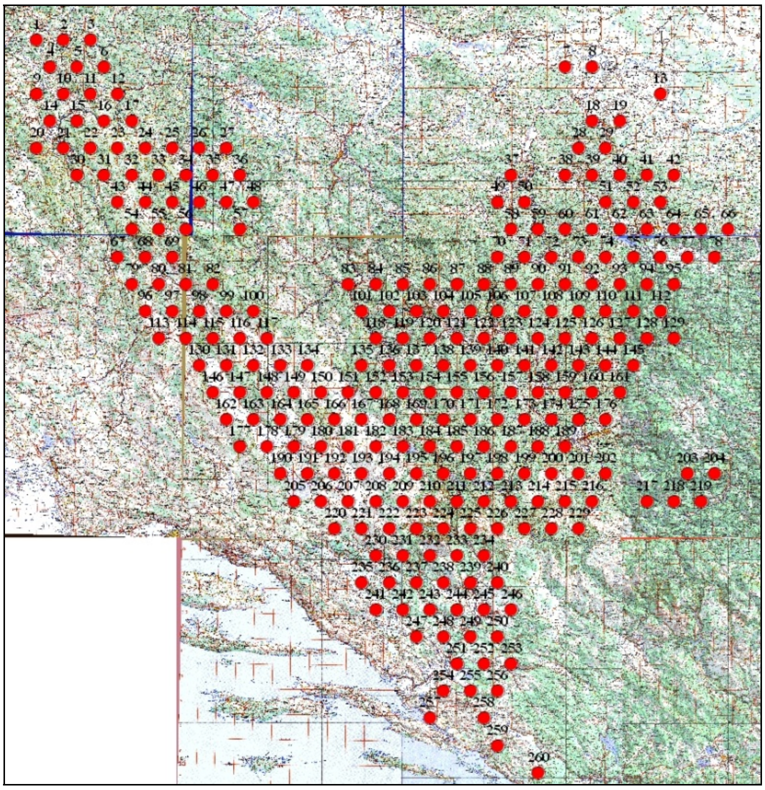

Figure 1: Samples grid

4.3 Field research

Each sample was subjected to the analysis of overall physical and chemical properties. Since the analysis includes some soil properties that do not have influence on the final results of our research, we will only mention the methods related to this research.

Physical properties:

- Determination of soil texture composition using International pipette “B” method
- Determination of the texture classification by Ehwald

Chemical properties:

- Determination of soil pH in water and KCl electrometrically in 1:2,5 suspension
- Determination of humus content - colorimetric method with oxidation in K2Cr2O7
- Determination of total CaCO3 by gas-volumetric method on Scheibler's Calcimeter
- Total contents of heavy metals (Pb, Fe, Mn, Cu, Zn, Cd and Co) in AAS with Aqua Regia as extractor
- Quantitative analysis of TPH (Total Petroleum Hydrocarbons) using EPA methods (3510, 3540/3550 and 8000)
- Quantitative analysis of PAH (Polycyclic Aromatic Hydrocarbons) using EPA methods (3580 and 8270)

5 Results and discussion

The research results are presented through:

- Heavy metals contamination
- TPH contamination

- PAH contamination

In this section, you can see the final results of the analysis. Detailed analysis of each sample is too extensive to be published in this occasion.

5.1 Heavy metals contamination

A total of 260 samples in the area of the Federation BiH was tested to the total number of the following heavy metals: Lead (Pb), Zinc (Zn), Cadmium (Cd), Copper (Cu), Nickel (Ni), Chromium (Cr), Cobalt (Co) and Manganese (Mn). The results are shown in Table 3.

Table 3: Results of the analysis of total heavy metals content in soils of FBiH

	Pb (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Cr (mg/kg)	Co (mg/kg)	Mn (mg/kg)
Uncontaminated samples	253 (97,8%)	259 (99,6%)	203 (78,1%)	259 (99,6%)	155 (59.6%)	235 (90,4%)	249 (95,7%)	143 (55%)
Polluted samples	5 (2%)	1 (0,4%)	40 (15,4%)	1 (0,4%)	66 (25,4%)	15 (5,8%)	8 (3,1%)	103 (39,6%)
Contaminated samples	2 (0,8%)	0 (0%)	17 (6,5%)	0 (0%)	39 (15%)	10 (3,8%)	3 (1,2%)	14 (5,4%)
Total samples	260 (100%)	260 (100%)	260 (100%)	260 (100%)	260 (100%)	260 (100%)	260 (100%)	260 (100%)

Higher values of some heavy metals do not have an anthropogenic origin in every case, but may be due to larger amounts of heavy metals in the substrate on which the soil was created.

To determine whether the presence of heavy metals caused by the properties of lythological parent substrate or anthropogenic origin, it is necessary to take samples of rocks to determine the presence of these elements. According to the data of Hendel and Fleig (1991), some rocks may contain the following amount of heavy metals:

Table 4: Contents of heavy metals in some soil parent substrates

Heavy metals	Loess	Claystone	Sandstone	Limestone	Granite	Alkaline rocks	Ultra-alkaline Rocks
	Amount (mg/kg)						
As	6,5	6,5	1,0	2,0	1,5	2,0	0,5
Cd	0,03	0,3	0,0	0,035	0,1	0,19	0,05
Cr	67,0	100,0	35,0	11,0	25,0	200,0	2.000,0
Cu	15,0	57,0	-	4,0	20,0	100,0	20,0
Ni	28,0	95,0	2,0	20,0	8,0	160,0	2.000,0
Pb	34,0	20,0	7,0	9,0	20,0	8,0	0,1
Zn	53,0	80,0	15,0	20,0	60,0	130,0	30,0

Based on the data from Table 4, it can be concluded that the raised content of certain heavy metals, particularly Nickel and Chromium, originates from substrates on which soil is created.

5.2 TPH contamination

Total of 260 soil samples were analyzed for the presence of Total Petroleum Hydrocarbons (TPH). In all 260 analyzed samples, TPH concentrations were significantly lower then the value that is considered contaminated by both light and heavy fractions.

This is an indicator that soils in Federation of Bosnia and Herzegovina are **not contaminated** by this group of pollutants.

5.3 PAH contamination

Total of 260 soil samples were analyzed for the presence of Polycyclic Aromatic Hydrocarbons (PAH). The results are shown in Table 5.

Table 5: Results of the analysis of total PAH content in soils of FBiH

Uncontaminated samples	240 (92,4%)
Polluted samples	10 (3,8%)
Contaminated samples	10 (3,8%)
Total samples	260 (100%)

Based on the obtained results, it can be concluded that the soils of FBiH are relatively unpolluted by his group of pollutants, although a small part of samples shows that in some locations PAH concentrations are higher then limit value of 2 mg/kg, and ten samples shows the concentration two or more times higher than allowed.

6 Summary / Conclusions

Environmental contamination by heavy metals and organic pollutants is a phenomenon of global importance. Unlike the other types of pollution such as air pollution or damage to the ozone layer, soil contamination directly depends on the ways of its exposure to local sources of pollution. When there is a high concentration of pollutants in soil, there is a risk they enter the food chain and cause health problems to plants, animals and humans.

Knowledge about land resources is an essential prerequisite for planning the optimal ways of land usage, and it occupies a key position in the development strategy of each country.

Soil is an important part of ecosystem actively involved in the natural cycle of substances, so it is necessary to investigate the content of pollutants and to establish preventive measures on this basis in order to reduce soil pollution, and thus preserving the flora and fauna, as well as human health.

The research results are presented through:

- Heavy metals contamination
- TPH contamination
- PAH contamination

After the analysis of 260 samples analyzed for the total content of heavy metals and organic pollutants (TPH, PAH) in soil, the results are as follows:

Lead (Pb) Only 5 analyzed samples (2% of the total) are marked as polluted and only 2 samples (0.8%) have contamination values. Based on these results, it can be concluded that the soils of FBiH are not contaminated with lead. The exceptions are Prenj Mountain areas and Breza surroundings.

Zinc (Zn) Only one analyzed sample showed a slightly higher content of this element (polluted sample), while there was no contaminated samples. Based on these data, it can be concluded that the soils of FBiH are not contaminated with zinc.

Cadmium (Cd) 40 samples (15.4%) are polluted, and 17 samples (6.5%) are marked as contaminated.

Based on these data, the conclusion is that soils in FBiH are sporadically contaminated by this element. Attention is required if agricultural production is present in regions where the contamination is established. Risk areas: Travnik district (Vlašić mountain), Kupres field, Podlugovi (near Road M-17), Konjic district (Bjelašnica mountain), Stolac surroundings, entire Southern Herzegovina, mountains: Vranica, Čabulja, Prenj, Visočica.

Copper (Cu) With only one polluted sample, and no contaminated samples, it can be concluded that the soils FBiH are not contaminated by this element.

Nickel (Ni) 66 polluted samples (25.4%) and 69 contaminated samples (15%) are an indicator that the soils of FBiH have raised contents of this element. Although almost half of the samples have the concentrations above the limit values, the origin of this high content is probably not anthropogenic but lythogenic (from soil substrate). Risk areas: Tuzla Canton (Tuzla and western part of Canton), Zenica-Doboj Canton (Maglaj district and Valley of Krivaja River), Herzegovina-Neretva Canton (southern part).

Chromium (Cr) 15 samples (5,8%) are polluted, and 10 samples (3,8%) have contamination values. Like in case of Nickel, the origin of this high content is probably not anthropogenic but lythogenic. Risk Areas: Vareš (Ravan Mountain), Maglaj district, Valley of Krivaja River.

Cobalt (Co) 8 samples (3,1%) are polluted, and 3 samples (1,2%) are contaminated.

Soils in FBiH are not contaminated by this element. Samples with higher values originate from soils which substrates are rich with Cobalt. Risk areas: Ravan Mountain, Valley of Krivaja River.

Manganese (Mn) In total, 103 samples (39,6%) are polluted, while 14 samples (5.4%) are considered as contaminated. It is known that the geological substrates in our country are rich with Manganese, so it's the cause of such a high content. Although these values are relatively high in some areas, with the application of agrotechnical measures (humisation, liming) and cultivation of crop varieties resistant to high amounts of soil Manganese, agricultural production can proceed unhindered.

TPH contamination In all 260 analyzed samples, TPH concentrations were significantly lower then the value that is considered contaminated by both light and heavy fractions. This is an indicator that soils in Federation of Bosnia and Herzegovina are not contaminated by this group of pollutants.

PAH contamination After the analysis, the results are following:

- 10 samples are marked as polluted (3.8%)
- 10 samples are marked as contaminated (3.8%)
- Total 20 samples (7.6%) have higher values than allowed.

Overall, soils in FBiH are relatively uncontaminated by this group of pollutants, with sporadical exceptions.

Risk areas:

- Town surroundings: Drvar, Donji Vakuf, Vareš, Široki Brijeg
- River valleys: Neretva southern of Boračko Lake, Bregava near Stolac
- Mostar field surroundings

In overall, soils in area of Federation Bosnia and Herzegovina are relatively unpolluted by the researched inorganic and organic pollutants. This conclusion is justified by the fact that the Federal law is quite rigorous in terms of individual pollutants content in soil, compared to other, especially developed countries. Another mitigating circumstance is that most soils investigated by this study are alkaline (pH > 7), so the concentration of pollutants in their mobile form is relatively low. This situation opens up many possibilities from the aspect of agricultural production, with the special emphasis on organic production. However, some areas are in need of special attention when it comes to plant production or livestock breeding. Regular monitoring and, in some cases, application of recommended measures for soil protection and remediation are required.

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Influence of nitrogen fertilization on spring barley yield, and on soil and water chemical properties

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Abstract

Key issues of today's and future agricultural production are soil and water rational management and protection. Surplus of applied nutrients that plants do not absorb is a potential source of emissions from the soil into the water. This paper presents the results of a field experiment that was conducted at the faculty experimental field in Rodoč near Mostar during 2008. The experiment was set up by randomized block layout and it was consisted of five variants with four repetitions. Variants used in the experiment were: 1. Control, 2. N_{50}PK, 3. N_{100}PK, 4. N_{150}PK and 5. N_{200}PK. Fertilization of spring barley was performed prior to seeding with a 7:20:30 NPK formulation and with different amounts of KAN on the variants 4 and 5. The first feeding was conducted during barley tillering stage and the next one a month later. Statistical processing of research results revealed that there were significant effects of fertilizer variants on barley yield, plant density, straw length, ear length, number of florets in the ear, number of grains in the ear and nitrogen content in grain. For the 1000-grain weight, carbon content (% in dry matter), sulfur content (% in dry matter), hydrogen content (% in dry matter) and water content in grain (% moisture) significant effects of fertilizer variants were not detected. In the soil there was no significant effect of fertilization according to individual variants. Mean values of certain ions concentration in rinse waters in June there were significant differences respectively in the content of nitrate, nitrite and sulphate, while for the other analyzed parameters statistically significant differences were not determined. Due to comparison and relevance of the research, experiment is continuing in 2009 with the same variations and repetitions.

***Key words**:* fertilization, nitrogen, soil, water, nitrates

1 Introduction

Sustainable agriculture means successful management of agricultural resources in order to meet changes in human needs while at the same time maintaining or increasing the quality of the environment. Most important aspects of environment protection are soil and water. Only science, based on exact indicators, can provide reliable answers to many open questions in future agriculture management, where the question of optimal nitrogen fertilizer application is a priority. The term "sustainable" doses of mineral nitrogen implies the application of such quantities of mineral nitrogen which, if applied duly, will lead to a maximum yield increase of crops, and at the same time will not lead to significant losses of nitrates by rinsing into surface water and ground water. Out of the total amount of nitrogen that enters in the soil through the mineral fertilizers, only about 50% is absorbed by plants, while significant amount of it is lost due to rinsing, denitrification and other processes (Klačić et al. 1998). The necessity of determining optimal quantities of nitrogen fertilizers in crop production in terms of agronomic, ecological and/or economic aspects was indicated by Mesić et al. (1998, 1999, 2000, 2003, 2007), Leto (2005); Žugec et al. (2006); Plavšić (2006); Zgorelec et al. (2007); Dabić et al. (2008); Kristek et al. (2008) (Jurić et al., 2008); Vukobratović et al. (2008); Zebec et al. (2009).

With the aim of determining the optimal fertilization required for crop production efficiency increase while at the same time protecting the environment from nutrients loss, especially nitrogen, field experiment was set up in the faculty experimental field in Rodoč, the municipality of Mostar. Fertilizers used in the experiment were complex mineral fertilizers and individual nitrogen fertilizers. The experiment was set up with 5 fertilizer variants with 4 repetitions.

The parcel on which the test was conducted has not been cultivated since the time the Austrian-Hungarian monarchy (about 100 years) and this work will show results of the first scientific experiment in this area.

2 Materials and methods

The trial area was selected in the fall of 2007. In order to determine so-called zero state, prior to agro-technical and agro-ameliorative interventions, average soil samples were taken from depths of 0-30 cm, from every test plot (plot sizes were 50 m^2 (5x10)). Basic soil tillage was conducted in early January and fertilization prior to the sowing in late January 2008. Sowing of spring barley cultivar “Novosadski 294” (Agrocoop a.d. Novi Sad), was carried out manually on February the 14^{th}. Feeding was done in two occasions: first during tillering stage and second in barley boot leaf stage.

Fertilization experiment consisted of five variants with four repetitions: 1. Control (unfertilized), 2. N_{50}PK (50 kg/ha/yr of nitrogen), 3. N_{100}PK (100 kg/ha/yr of nitrogen), 4. N_{150}PK (150 kg/ha/yr of nitrogen) and 5. N_{200}PK (200 kg/ha/yr of nitrogen). Prior to sowing variants 2, 3, 4, and 5 were fertilized with 3.6 kg of NPK 7:20:30 per plot, the variant 4 with 0.46 kg of KAN and the variant 5 with 0.92 kg of KAN. First feeding was carried out for the variant 3 with 0.56 kg, for the variant 4 with 0.84 kg and the variant 5 with 1.11 kg of KAN. The second feeding was carried out for the variant 3 with 0.37 kg, for the variant 4 with 0.56 kg and for the variant 5 with 0.74 kg of KAN.

Barley harvesting and threshing was done manually on two occasions. For the variants 2, 3, 4, 5, harvesting and threshing was performed on 19^{th} and 20^{th} of June, and for the variant 1 one week later. The plots' average soil samples were taken again after the harvest.

The rinse water collecting was done during the vegetation season on three occasions, in March, May and June.

Analyzed properties of spring barley were: yield, total nitrogen content in grain, 1000-grain weight, number of plants per m^2 (density), straw length, ear length, number of florets per ear, number of grains per ear, grains weight per ear, grain water content, absolute mass of 1000 grain, hectoliter mass, total grain carbon content, total grain sulfur content and the total hydrogen content. Laboratory analysis were conducted with the following methods: total nitrogen-HRN ISO 13878:2004, total carbon-HRN ISO 10694:2004, total sulfur-HRN ISO 15178:2005, total hydrogen, hectoliter crops weight, absolute weight of crops.

Chemical characteristics of the soil were analyzed with the following methods: total nitrogen content-HRN ISO 13878:2004, total carbon-HRN ISO 10694:2004, humus by Tjurin (bikromat method), pH value (KCl)-HRN ISO 10390:2004, and P_2O_5 and K_2O-AL method.

The methods used for water analysis were: water samples preparation-HRN ISO 5667-3:1999, pH value HRN 10523:1998, electrical conductivity-HRN 7888:2001, determination of individual elements with IR technique anions-HRN ISO 10304-1: 198 and cations-HRN ISO 14911:2001.

The research results were analyzed in statistical software package SAS (SAS Institute, 2003).

Analysis was partially performed at the Faculty of Agriculture and Food Technology, University of Mostar, and the other part of the analysis was performed at the Department of General Agronomy, Faculty of Agriculture University of Zagreb.

3 Results and discussion

3.1 Agro-ecological conditions

3.1.1 Climate

The climate of a certain area is primarily conditioned by its geographic position. With its effects and influence on crop production, the climate acts as pedological and edaphic factor. Šegota and Filipčić (1996) divide the climate of Bosnia and Herzegovina into three climatic zones, which was accepted by the Federal Hydro-meteorological Institute (official letter, 2009): 1 southwestern part - the Mediterranean, or Maritime climate, 2 central part - the Continental Mountain climate, or the Alpine climate and 3 northern part - a moderate Continental climate. Area of the city of Mostar is in the Mediterranean climate zone with average annual precipitation of 1515 l/m^2 (for the period 1961-1990), with maximum temperatures exceeding 40ºC (August) during summer and average winter temperature from 3 to 5ºC. Precipitation is unevenly distributed, so autumn and winter are rainy, while summers are extremely hot and dry. It is well known that the quantity and distribution of precipitation during a year has a very significant impact on rinsing nutrients from the soil (Šestić, 1988).

Table 1 shows monthly precipitations sum and average monthly temperatures of the meteorological station Mostar, separately for 2008 and for the period 2004 to 2008. It is noticeable that the precipitations were less in February (the germination period) and in May, compared to the five-year average (2004 - 2008). However, in the whole vegetation period of spring barley precipitations were equal to those of five-year average. Precipitations in the vegetation period ranged from 30.3 - 220.5 l/m^2. Average monthly air temperature did not significantly differ from five-year average value. In terms of maximum monthly temperature there were significant differences in values for February, May and June.

Table 1: Sum of precipitations and temperatures of the meteorological station Mostar

	Feb. 2008	2004 - 2008	Mar. 2008	2004 - 2008	Apr. 2008	2004 - 2008	May 2008	2004 - 2008	Jun. 2008	2004 - 2008	2008	2004 - 2008
Precipitation 2008 l/m²	49,9	161,0	220,5	172,4	162,0	107,2	30,3	90,4	121,9	64,6	584,6[1]	595,6[2]
Air temperature ºC	8,1	7,0	10,2	10,0	14,0	14,9	20,0	19,4	23,5	23,4	15,2	14,9
Max temperature ºC	22,8	18,5	23,5	23,6	26,5	27,1	35,6	32,4	38,2	35,6	29,3	27,4
Min temperature ºC	-4,7	-3,5	0,8	-0,7	5,6	5,6	11,0	9,4	12,5	10,3	5,0	4,2

[1] Sum of precipitations for the growing season 2008.
[2] The average sum of precipitation for the period 2004-2008 (February-June).

3.1.2 Soil

In the tested area the soil is brown, calcareous, on the alluvial deposits. Stratigraphy of the profiles is shown in Figure 1. The soil is of lighter mechanical composition and with a lot of skeleton. Skeleton content increases with the depth. The largest amount of clay particles is at a depth of 11-27 cm so this soil horizon is of somewhat heavier texture composition.

Figure 1: Brown, calcareous, soil on the alluvial deposits

According to the data from Table 4 (zero state) soil reaction, measured in 1M KCl, is neutral to mildly acid. Given the fact that the soil has not been cultivated for quite a number of years, the soil surface layer (0-30 cm) is quite rich with humus and nitrogen. It’s very poorly supplied with physiologically active phosphorus, and moderately supplied with potassium.

3.2 Barley yield, yield components and chemical analysis of grain

Analysis of barley yield and yield components showed significant effects of fertilization variants for the most properties, except for 1000-grain weight, carbon content (% in dry matter), sulfur content (% in dry matter), hydrogen content (% in dry matter) and grain water content (% moisture). After significant F tests, LSD tests were conducted and difference in average values of variants was established.

Differences in yield were significant at P=5%. The lowest yield was in the variant 1 (control) with 0.3 t/ha^{-1}, and the highest yield was achieved in the variant 3 (100 kg/ha/yr of nitrogen) with 1.87 t/ha^{-1} (Table 2). Based on the above mentioned it is clear that fertilization with increasing amounts of mineral nitrogen to the quantity of 100 kg has a positive impact on increase of barley yield, so this amount could be considered justified in respect to barley produced in the given agro-ecological conditions. For such intensity of production, this can be the optimal fertilization. However, considering the fact that between all the varieties of nitrogen fertilizer application there were no statistically justifiable differences, fertilization with 50 kg of nitrogen could be recommended as sufficient.

The lowest value of the barley 1000-grains mass refers to the variant 4 (150 kg/ha/yr) and amounted to 35.88 g. The highest value was in the variant 2 (50 kg/ha/yr) and amounted to 37.69g.

According to the results for the plants density, there was a statistically significant difference between some variants (Table 2). Highest plants density were in the variant 1 (control) and amounted to 227 plants/m^2. The lowest plants density was detected in the variant 4 and amounted to 285 plants/m^2, which is 58 plants more, than in the variant 1 (control).

Based on the data (Table 2), it can be concluded that fertilization with increasing amounts of nitrogen leads to statistically significant increase in the number of plants/m^2 in the variants 2, 3, 4, 5 compared to the variant 1 (control). Barley density should have been considerably higher, but due to lack of mechanization during seeding, the optimum amount of seed was not used.

For the “straw length” statistically significant differences were determined between the average value of the variant 1 (control) in relation to all the other variants (2, 3, 4, 5) of the experiment. Differences were also found in the variants 3 and 5 compared to the variant 2.

The largest average value for “straw length” was in plants of the variant 5 (200 kg/ha/yr of nitrogen) and amounted to 65.1 cm, and with 28.72 cm, the lowest straw length was in the variant 1 (control) and amounted to 28.72 cm. The results show that fertilization with increasing amounts of nitrogen increased the straw length in spring barley.

For “ear length” statistically significant differences were determined between the average value in the variant 1 (control), compared to all other variants (2, 3, 4, 5). Differences were also found between the variants 3 and 5 compared to the variant 2 (Table 2.).

The highest average value for “ear length” was measured in the plants of the variant 5 (200 kg/ha/yr of nitrogen) and amounted to 7.5 cm, and the lowest average value for ear length was in plants of the variant 1 (control) and amounted to 3.71 cm. These results show that fertilization with increasing amounts of nitrogen increase the straw length in spring barley.

For “number of florets per ear” statistically significant differences were determined between the average value in the variant 1 (control), compared to all the other variants (2, 3, 4, 5).

The highest average value was in the variant 3 (100 kg/ha/yr of nitrogen) and amounted to 22.29 florets/ear, and the lowest average value was in variant 1 (control) with 11.45 florets/ear. Fertilization with increasing amounts of nitrogen caused the increase in the number of florets per ear in all the variants in experiment compared to the control variant.

For “number of grains per ear” statistically significant differences were determined between the average value in the variant 1 (control), compared to all the other variants (2, 3, 4, 5).

The highest average value was in the variant 3 (100kg/ha/yr of nitrogen) and amounted to 19.91 grains/ear, and the lowest average value was in the variant 1 (control) with 9.34 grains/ear. Fertilization with increasing amounts of nitrogen caused an increase in the number of grains per ear in all the variants in experiment compared to the control variant.

For "grain weight per ear" statistically significant differences were determined between the average value in the variant 1 (control), compared to all the other variants (2, 3, 4, 5). The highest average value was in the variant 3 (100 kg/ha/yr of nitrogen) and amounted to 0,74g, and the lowest average value was in the variant 1 (control) with 0,33g. Fertilization with increasing amounts of nitrogen caused an increase in the grains weight per ear of all variants in experiment compared to the control variant.

Table 2: The results of the analyzed barley traits

Experiment variants	*Yield (t ha^{-1})*	*1000-grain weight (g)*	*Plant density (number of plants /m^2)*	*Straw length (cm)*	*Ear length (cm)*	*Number of florets per ear*	*Number of grains per ear*	*Grain weight per ear (g)*
1 Control	0,30	36,70	227	28,72	3,71	11,45	9,34	0,33
2 N_{50} PK	1,49	37,69	254	54,18	6,13	19,82	17,53	0,69
3 N_{100} PK	1,87	36,82	273	62,2	7,47	22,29	19,91	0,74
4 N_{150} PK	1,50	35,88	285	57,45	6,6	20,69	17,8	0,61
5 N_{200} PK	1,75	36,33	270	65,1	7,5	21,27	18,97	0,69
LSD 5%	0,43	n.s.	72,79	7,63	1,20	3,99	3,42	0,20
LSD 1%	0,59	n.s.	102.17	10,71	1,68	5,60	4,80	0,28

With barley grains the following features were analyzed: nitrogen content (% in dry matter), carbon content (% in dry matter), sulfur content (% in dry matter), hydrogen content (% in dry matter), water content in grain (% moisture) and hectoliter mass. F tests were significant only to hectoliter mass and nitrogen content (% N), while for the rest there were no significant differences between the variants of the experiment. For hectoliter mass and nitrogen content (% N) LSD tests were conducted and the differences in the average were determined.

Based on data shown in Table 3, it is noticeable that the highest average value for nitrogen content is detected in the variant 5 (200 kg/ha/yr of nitrogen) with 2.30% while the lowest value was in the variant 2 (50 kg/ha/yr of nitrogen) with 1.47%. Fertilization with increasing amounts of nitrogen caused an increase in the nitrogen content in barley grain.

According to the results for the amount of carbon in barley grain compared to the amount of applied fertilizer, there were no statistically significant differences. The highest carbon content in barley grain was in the variant 4 (150 kg/ha/yr of nitrogen) and amounted to 43.36%. According to the results for the amount of sulfur in barley grain, compared to the amount of applied fertilizer, there were no statistically significant differences. The highest content of sulfur in barley grain was in the variant 5 (200 kg/ha/yr of nitrogen) with 0.32%, while in the variant 1 (control) sulfur content was the lowest and amounted to 0.31%. It is evident that the sulfur content in barley grain is reduced by increasing amounts of nitrogen fertilizer application. According to the content of hydrogen in barley grain, the experiment was not statistically significant. The highest hydrogen content in barley grain was in the variant 3 (100 kg/ha/yr of nitrogen) with 6.99%, and the lowest in the variant 2 (50 kg/ha/yr of nitrogen) with 6.83%. According to the barley grain water content (% moisture) during the harvest, the experiment was not significant (Table 3). The highest average water content in barley grain was in the variant 1 (control) with 6.99%, and the lowest in the variant 4 of the experiment (150 kg/ha/yr of nitrogen) and it was 5.94%.

From the obtained results (Table 3), it is obvious that the average value of "hectoliter mass" for the variant 1 (control) differed compared to the average value in the other four variants (2, 3, 4 and 5). The largest average value of hectoliter mass was found in the variant 1 (control) and amounted to 61.78 kg and the lowest average value was recorded in the variant 4 (150 kg/ha/yr of nitrogen) and amounted to 51.66 kg. Fertilization with increasing amounts of nitrogen did not increase the average value of hectoliter mass, because the results are showing that the highest average value of hectoliter mass was in the variant 1 (control).

Table 3: The results of the analyzed traits of barley grain

Experiment variants	***% N***	***% C***	***% S***	***% H***	***% moisture***	***Hectoliter mass (kg)***
1. Control	2,04	43,06	0,31	6,88	6,99	61,78*
2. N_{50} PK	1,47*	42,79	0,28	6,83	6,20	54,5
3. N_{100}PK	1,95	42,88	0,28	6,99	5,98	54,29
4. N_{150}PK	2,20	43,36	0,28	6,93	5,94	51,66*
5. N_{200}PK	2,30*	43,34	0,32	6,90	6,99	52,55

* Significant difference between variants of analyzed traits (P=0,05)

3.3 Chemical analysis of soil

The results of chemical analysis of average soil samples for November 2007 (zero state) and June 2008 are given in Table 4.

Table 4: The results of soil chemical analysis for November 2007 (zero state), and June 2008.

Analyzed soil properties		***variants***					$\overline{X}$
		1. Control	***2. N_{50}PK***	***3. N_{100}PK***	***4. N_{150}PK***	***5. N_{200}PK***	
November 2007- zero state							
Dry matter %	TN (%)	0,25	0,27	0,26	0,25	0,26	0,26
	TC (%)	2,32	2,86	2,43	2,33	2,49	2,49
	Humus (%)	4,11	4,29	4,07	4,11	4,13	4,14
pH 1M KCl		6,48	6,62	6,46	6,65	6,49	6,54
P_2O_5		2,00	1,07	2,37	0,10	0,18	1,14
K_2O		14,53	15,90	15,90	14,33	15,45	15,22
June 2008							
Dry matter %	TN (%)	0,21	0,20	0,22	0,21	0,22	0,21
	TC (%)	2,59	3,38	2,59	2,51	2,41	2,69
	Humus (%)	2,88	3,33	3,35	2,48	3,55	3,12
pH 1M KCl		6,83	6,91	6,63	6,95	6,72	6,81
P_2O_5		1,97	1,95	1,38	3,83	1,98	2,26
K_2O		13,88	19,50	22,45	23,25	25,38	20,89

Statistical processing of the results of analyzed soil properties showed that there was no statistically significant differences between the variants (different fertilizer applications) in November 2007 and June 2008.

By comparing the results of soil chemical analysis for November 2007 and June 2008 it is evident that the content of total nitrogen in soil in all the variants was higher in November 2007 than it was in June 2008 (Table 4). The reasons for such representation of total nitrogen may be multiple: soil tillage, absorption of nitrogen by plants, leaching, etc. We believe that deeper soil tillage is main reason for this due to mixing of soil analyzed layer (before tillage), with a layer (transition horizon (B)/C) containing very little or no nitrogen. This fact is indicated by increase of physiologically active soil reaction (pH in KCl-in) in all the samples in June 2008 compared to November 2007.

Content of total carbon in the soil after harvest was lower in all the variants except the variant 5 (200 kg/ha/yr of Nitrogen). Due to the tillage, as expected, horizons with different amount of humus were mixed, so the final result is negative balance of carbon in the upper 30 cm of soil.

In June 2008 the content of physiologically active phosphorus in the soil in fertilizer variants 2 (50 kg/ha/yr of nitrogen), 4 (150 kg/ha/yr of nitrogen) and 5 (200 kg/ha/yr of nitrogen) was higher than the content of physiologically active phosphorus in the soil in November 2007, while in the control variant the phosphorus content in both years is the same. Phosphorus content in the variant 3 (100 kg/ha/yr of nitrogen) was significantly lower in the second year (graph 1). It is evident that the most significant increase of P_2O_5 in the soil was in June in the variant 4 (150 kg/ha/yr of nitrogen), and then in the variant 5 (200 kg/ha/yr of nitrogen). In June the content of K_2O in soil was higher in all the variants except in the control variant (graph 2).

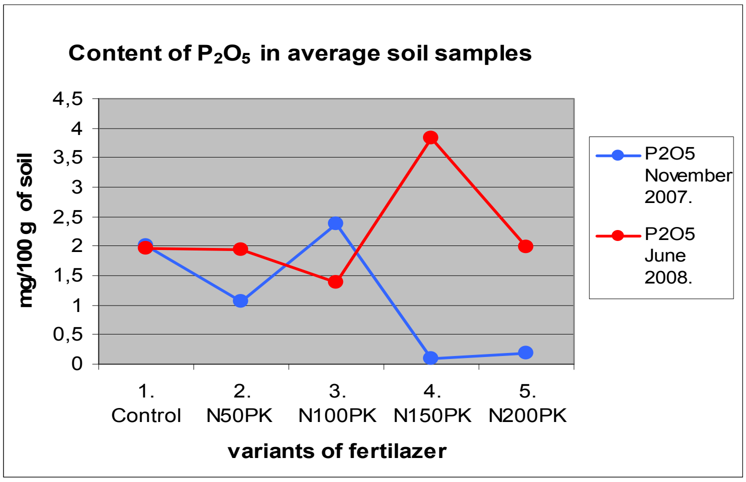

Figure 2: *Content of P2O5 in average soil samples*

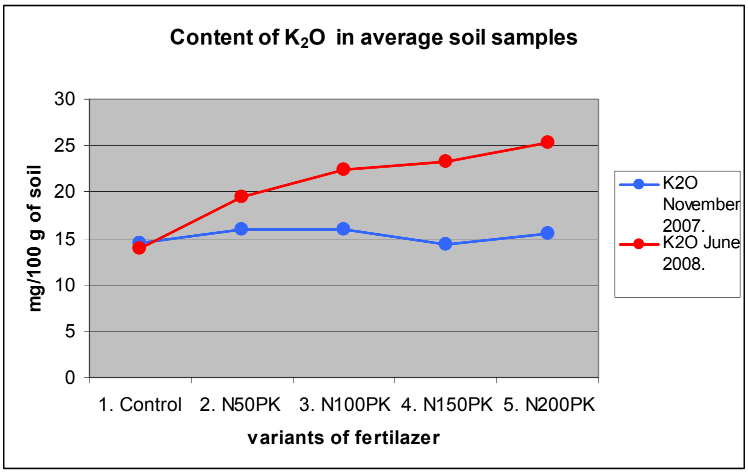

Figure 3: *Content of K_2O in average soil samples*

3.4 The chemical composition of water

During the vegetation season collecting of rinse water occurred on three separate occasions: before the first feeding, after the first feeding and after the second feeding.

Table 5: Part of the analyzed parameters of rinse water by variants and sampling periods

	variant	sulphate	$N-NO_3^-$	$N-NO_2^-$	K	Mg	Ca	$N-H_4^+$	pH	EC / mS/cm
31.03.2008.	1. Control	8,27	0,77	0,12	0,58	0,85	18,71	0,67	8,22	217,00
	2. $N_{50}PK$	8,71	0,77	0,11	1,42	1,68	37,33	0,37	8,07	195,60
	3. $N_{100}PK$	9,03	0,89	0,00	1,67	1,22	16,33	0,00	8,15	119,80
	4. $N_{150}PK$	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	5. $N_{200}PK$	34,10	3,75	0,47	13,75	8,24	106,86	2,07	8,22	689,00
12.05.2008.	1. Control	11,03	5,99	0,21	0,85	6,07	51,94	0,05	7,87	229,35
	2. $N_{50}PK$	8,78	0,59	0,06	1,76	7,21	64,79	1,29	7,70	242,73
	3. $N_{100}PK$	10,55	12,82	0,17	3,86	7,86	74,50	3,27	7,80	322,80
	4. $N_{150}PK$	7,56	28,87	0,21	1,31	6,61	75,98	4,68	7,64	321,00
	5. $N_{200}PK$	8,15	15,69	1,10	1,19	8,83	92,82	1,48	7,68	533,00
19.06.2008.	1. Control	5,79	5,84	0,07	0,95	3,73	38,91	2,67	7,80	244,43
	2. $N_{50}PK$	5,38	5,74	0,07	1,03	3,52	38,66	3,02	7,92	246,08
	3. $N_{100}PK$	7,85	8,21	0,11	1,38	4,14	38,62	2,37	7,86	263,50
	4. $N_{150}PK$	6,08	7,58	0,07	1,30	3,67	44,69	2,70	7,90	277,25
	5. $N_{200}PK$	9,28	10,82	0,19	2,06	5,49	47,49	2,64	7,86	326,25

Significant effect of fertilization variants was recorded for nitrate; nitrite and sulfate content (Table no. 6).

Table 6: Significant differences of analyzed parameters

Parameter\ Variant	1. Control	2. $N_{50}PK$	3. $N_{100}PK$	4. $N_{150}PK$	5. $N_{200}PK$
Nitrate mg/l	0,22	0,24	0,35	0,22	0,62 *
Nitrite mg/l	0,07	0,07	0,11	0,07	0,19*
Sulphate mg/l	21,16 *	5,53	7,16	6,03	8,82

*significant difference between variants of the analyzed traits (P=0,05)

4 Summary / Conclusions

Based on the results of research the following facts were established:

- There was a significant effect of nitrogen fertilization to: barley yield, plants density, straw length, ear length, number of florets per ear, number of grains per ear and nitrogen content in grain, while for the 1000-grain weight, carbon content (% in dry matter), sulphur content (% in dry matter), hydrogen content (% in dry matter) and water content in grain (% moisture) there was no significant effects of fertilizer application;
- The highest yield, number of florets per ear, number of grains per ear and grain weight per ear values were in the variant 3. $N_{100}PK$ (100 kg/ha/yr of nitrogen), and the lowest values were in the control variant 1. Based on the above mentioned, the option (variant) 3. $N_{100}PK$ (100 kg/ha/yr of nitrogen) may be considered justified;
- Fertilization with increasing amounts of nitrogen did not increase the average value of hectoliter mass (maximum average value was found in the variant 1);
- In the soil there was no significant effect of fertilization according to individual variants;
- Significant effect of fertilization variants was recorded in nitrate, nitrite and sulphate content of rinse water.

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Soil degradation related to plural use of forests

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Abstract

The forests are a determinant of the quality of life. They are important not only for wood production, but far more in terms of protection of natural resources, e.g. soil, water etc. There are many subjects which intend to use forest resources for different purposes, thus contributing to their plural value. Plural utilization of forests, however, may become a risk if it threats any component of ecosystem. Wood production as well as other forests services, particularly those arising from their ecological functions, depends on soil quality. On the other hand, forests play a significant role in soil conservation. Therefore, excessive and/or unjustifiable use of any of the forest resources causes soil to be exposed to degradation process at first place. This paper is dealing with human impact to forest resources. The major challenges which represent a threat to forest soils presently are inappropriate recreational activities, quarries within forests, mismanagement and excessive use of water resources for electricity production, etc. Leisure activities of people and their demands toward forests are mainly spontaneous and thus unconsciously operate against ecosystem. Similar effect causes thoughtless utilization of mineral resources and non-wood forest products. In addition, forests are often used as dumping spots for waste of various origins. Inappropriate forest management (e.g. over production of timber and imprudent clear cuttings) are among the most important humans activities that cause soil degradation. Forest water resources are closely related to the quality of forest soils and their inhabitants. Unfortunately, it seems that recent excessive use of forest water resources for mini-hydropower plants may also affect not only the biodiversity but structure and nutrients of soil as well. This will result in a substantial and largely irreversible loss in the soil degradation.

Key words: biodiversity, forest management, quarries, soil degradation, water.

1 Introduction

The numbers of subjects with a tendency to use the forest resources are increasing. Most of these subjects are without knowledge about forests, their functions and the values. Uses of forest resources are often excessive thus affecting not only the biodiversity but also soil structure and its nutrients. This may cause a substantial and irreversible reduction in forest services in general and cause the soil degradation in particular. In such a way one may expect that plural use of natural resources may become a risk (e.g. loss of soil productivity) and sometimes may cause a conflict (Anderson and all, 1999; Daniels and Walker, 1999). International regulations related to forests (e.g. Forest Principles *'conservation, management and sustainable development of the world's forests'* recognized at the Earth Summit in Rio de Janeiro in 1992) are not respected what underline need for development of the integrated forest protection system in order to reduce risk toward people, resources and environment in general. Forest ecosystems provide services, which are the outcomes from their functions, and operate on such a grand scale and in such intricate ways that most could not be effectively replaced by technology. Forest services are to the benefit of human beings and if we do not understand this we could not appreciate them.

2 Materials and methods

These studies were oriented to the current most important threats to forest ecosystems. Some of them were only observed and presented here as the photographs. These threats are those that arise from inappropriate recreational activities, numerous quarries within forests and forest clear cuttings. However, excessive use of water resources for electricity production was studied in more details. Special attention was paid to mini hydro-powers plants located within forests. Some of them were selected and observed during a dry summer period in 2007 and 2008 in order to see their impact to forest ecosystems in general and to their biodiversity in particular.

Watershed forest area at the beginning of the river Vrbas was among these locations where the most of our studies were undertaken. Our interest was particularly related to excessive and non-controlled use of forest stream water, which was diverted into tubes leaving open stream beds waterless. Consequences of total water divert from its natural bed to a power plant tube were obvious from the point of biodiversity loss, but consequences to the surrounding forest soil one only may imagine and anticipate.

The following locations of the mini hydro-power systems were observed and criticized here:

- River Vrbas and its tributaries streams Desna and Kozica, which flow along south slope of the mountain Vranica:
- Stream Jezernica that comes out from the glacial lake Jezernica on the mountain Vranica at an altitude of 1636 m. This stream flows down along northern steep slope of the mountain toward the town Fojnica.
- Stream Borovica (tributary of the stream Jezernica) close to the town Fojnica.

3 Results and discussion

3.1 Impact of tourism to forest soils

Consequences of non-controlled use of forests and forest bare land for people's leisure activities may be seen on the Fig. 1. This picture shows the soil degradation process developing close to a dense settlement that is built along the lake Jezernica on the mountain

Vranica. Even the pine *Pinus mugo* stands are under threat here. This forest species is legally protected since it grows at the upper edge of the mountainous tree vegetation and therefore it is exceptionally important for soil protection.

Although tourism is a public economy important for development of any country, it may also cause negative effect to the environment in general and to forests in particular (Uscuplić, 2008). The forest values are not fully known and therefore its perception is different among the subjects that use forest resources. Integrity of forests is in danger today. Forests in Bosnia and Herzegovina are increasingly used as public places for the recreation and/or gathering of non-wood forest products and, unfortunately, as the places for waste deposit thus affecting not only forest soil but other components of the environment as well. One may expect some long term consequences that are not easy to anticipate.

Special problem to forest integrity are unjustified forest clear cuttings in favor of winter sports. Some of them are located at an altitude below 1000 m in spite of the current global climate changes and warming process.

3.2 Impact of quarries to forest soils

Number of quarries inside the forests is increasing as well. Fig. 2 presents the quarry within the high forest on the mountain Bjelašnica, which is proposed to be the National park soon. It is worth to be mentioned here that use of any mineral resources inside a high forests is prohibited by law. There is no need for additional comments about this picture.

3.3 Role of forest in soil protection

There is no doubt that forest may prevent the soil degradation. However, in spite of such knowledge unjustified or thoughtless forest clear cuttings may be seen throughout the country. Deep gullies are usually developed as the result of such forest mismanagement. The consequence is a washing away of forest soil caused by running water that follows an abundant rain. An example of such phenomenon is shown on Fig. 3. Beside the role of forest in the soil protection it also generates soil development as it is shown on the Fig. 4. The pine plantations that may be seen on this picture, which grows at the base of a karsts steep slope, diminished the soil erosion and initiate the soil formation. Lack of forest cover may bring about a mud slide and even total soil removal (Fig. 5).

3.4 Impact of mini hydro-power plants to forest ecosystems.

These studies revealed that some of mini hydro-dams were located inside the forests, and even at the very beginning of forest streams (Fig. 6), diverting all available water into tubes to supply hydro-power plants. Moreover there is an example of illegal water capture from an unknown spring inside a forest as additional water source for hydro-power system (Fig. 7). Unfortunately there is no reaction from the relevant authorities (Uscuplić, 2007).

Monitoring as a foundation of biodiversity control has not been developed yet. Biological minimum of water in stream beds, which is necessary for the inhabitants, has not been properly defined. Decision was left to the hydro-power plants owners. Changes in the regime of forest soil water may be expected with unknown consequences.

Figure 1*: Soil degradation caused by human leisure activities*

Figure 2*: Quarry within a high forests of proposed protected area*

Figure 3*: Effect of trees clear cutting to soil degradation*

Figure 4*: Forest plantations may prevent soil erosion and even generate soil formation*

Figure 5*: First sign of soil sliding*

Figure 6*: Mini hydro-dam within a forest right at the beginning of the river Vrbas*

Figure 7*: Lack of water in the river bed of Vrbas below the mini hydro dam and an additional water supply from unknown forest spring (red pipe)*

4 Summary / Conclusions

How to sustain forest management and satisfy plural requirements is a complex question. Apparently, there is a need for an ecosystem approach to understand the relationships among productive, ecological and social forest services for the mutual well-being both of nature and people. General spirit about forests and men impact arising from their insufficient knowledge about resource's values should be recognized. Inappropriate recreational activities, quarries in high productive forests and excessive use of water resources for electricity production are among those activities that run the risk and are related to subjects out of forestry industry. Therefore there is an urgent need for integrity of our natural forests to be saved, to stop deforestation and unjustified change of forest land use. Forest water resources are closely related to the biodiversity and forest soil quality. Use of any of forest components should be controlled in order to prevent their over usage. This is also a challenging task for scientists.

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Remediation of flotation material of copper mine “Bučim” Radoviš

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Abstract

As a result of the deposition of flotation material of "Bucim" mine in Radovis, 8 ha of fertile soils were covered with hazardous material. In this paper the result of remediation of the flotation dump will be present. Due to the very high toxicity of flotation material there are no present surface vegetation in addition this areas is prone to intensive erosion which endangers the surrounding area. In order to resolve this problem it was decided to cover the flotation material with fertile soil layer. The soil and geological material which was used to deposit over the dump, was excavated on a site which was 1-1, 5 km distanced from the dump. In order to determine suitability of the soil and geological material used for remediation, soil samples were sampled and transported to the laboratory for analysis. The mechanical composition of the soil was determined with the International pipette B method, soil reaction (pH) in water and nKCL was determined electrometrically, SOM with the method of Tjurin, easy available phosphorus and potassium with AL method. Total content of heavy metals was determined with liquid digestion in aqua regia. The results from the analysis showed that the analyzed soil samples have suitable mechanical composition. Soil samples are non-carbonate with neutral or slightly acid pH. As expected soil organic matter is low. The content of easy soluble phosphorus in examines soil samples is very low, while the content of easy soluble potassium is medium or low.

Total content of the following heavy metals was determined (Cu, Cr, Ni, Pb and Zn). According to the Dutch standards, the results of the analysis of heavy metals content proved that its content is far bellow the intervention value and there is no risk of appearance of phyto toxic conditions.

For improvement of the soil parameters and soil fertility a suitable agrochemical measures were proposed.

As a result of these activities the area after the spreading of the soil cover was stabilized with mixture of grass and trees.

Key words: remediation, flotation material, copper mine, heavy metals

1 Introduction

In this paper the results from the recultivation of the flotation dump “Bucim” in Radovish, will be presented. Flotisols are soil types formed with long-term deposition of the flotation material. The thickness of the deposited flotation material can be up to hundred meters. According to Филиповски Ѓ. (1993) the flotisols (flotation material) represents technogenic soils which are formed with deposition of the waste material transported by the water. Resulović, H. (1984) defines flotisols as technogenic soils, when as a result of human impact different types of materials are accumulated above natural soils. Филиповски Ѓ. (2004) emphasize that in Republic of Macedonia and all other Former Yugoslav Republics there are no paper dedicated to flotisoils, nor one single data of field or laboratory investigations. The only existing data refers to the total quantity of the flotation material in the country and the average content of heavy metals in it.

There are only few sentences for flotisols in the papers of Antonović G. (1972, 1980, 1982), Антонови¢ М. Г. et al. (1997), Resulović H. (1984), Škorić A. (1986), Škorić A. et al. (1973, 1985). In Bucim mine (Radovis) in the process of flotation the following elements are separated: copper, gold and silver. Each year aproximately 70 000 tons of solid waste is produced and accumulated in the sedimentation lake (picture 1). According the UNEP study (2000) in the waste water of Bucim mine there are 50-200 mg/l Cu. Flotation material contains 0,045% Cu, 0,27 mg/t Au and 0,7 mg/t Ag (Филиповски Ѓ. 2003). This high content of total Cu can provoke phytotoxicity on plants, which was confirmed with field examinations. During the field examinations it was find out that there is no natural vegetation on the flotation material. From the stated above it can be concluded that the flotation material from the copper mine “Bucim” in Radovish is characterised with significant depth and toxicity. According Skawina (1970), cited by Resulović H. (1978), with reference to the suitability for recultivation, the flotation material belongs to the fifth class.

Figure 12: *Accumulation of the flotation material in the sedimentation lake*

In this class belongs toxic substrate which demands isolation or neutralisation. In a case of melioration of such material, according Ovcinnikova at al. (1970) cited by Resulović H. (1978), more worthwhile is to cover this material with a layer of fertile soil. Thickness of such layer should be between 0,5 and 2,5 m., which depends of its suitability for biological recultivation, agrochemical and physico-mechanical characteristic. According to the proposed classification for dumps with a reference to its suitability for recultivation Resulović H.

(1980), the flotation material of the mine "Bucim" of Radovis belongs in the group of C-toxic, VII class of toxicity.

2 Materials and methods

Field examinations are performed according the methods presented and elaborated by Filipovski G. red. (1967). Mechanical composition is determined by pipette method (Resulović H. red. 1971). Content of carbonates in the soil is examined with volumetric method on Schaibler calcimeter (Митрикески J. et al. 2001). Soil reaction is determined electrometrically with glass electrode in water and 1 M KCl suspension (Bogdanović M. red. et al. 1966). Easy available forms of P_2O_5 and K_2O are examined by AL method (Manojlović et al. 1969). Soil organic matter content is calculated on the base of the total carbonate determined by the method of Tjurin and Simakov (Орлов С.Д. et al 1981, Симаков Н. В. 1957). Determination of heavy metals is performed with the method of AA Spectrophotometry (Varian SpectrAA 800) after previous wet digestion of soil samples in "aqua regia" (Džamić R. et al 1996).

3 Results and discussion

The landscape of the copper mine "Bucim" dump site in Radovish before the campaign of remediation is presented on picture 2. As a result of the depth and toxicity of the flotation material no vegetation can be observed, mining that its immediate recultuvation is needed. Unlike remediation of the coal mines dump sits, recultivation of the flotation material dumps is much more complicated and expensive measure. As mentioned before, during the process of recultivation of the phytotoxic flotation material, most worthwhile is to apply a new layer of soil with proper mechanical composition, correct chemical characteristics and low content of heavy metals. The total area foreseen for remediation is aprox. 8 ha. One part of the dump site envisaged for remediation has a big inclination of 10-20%, while the other part has a inclination of only 5-10%. The flotation dump is on a 610 to 642 m a.s.l. The covering material was planned to be excavated on a adjacent site which is distanced just 1,5 km. from the flotation dump. On this site 3 soil profiles were excavated with a 3 m. depth for collection of soil samples which were further on analysed in a laboratory. Results of these analyses are presented in Tables 1,2 and 3 (sample no. 1,2, and 3).

Figure 2: *The landscape of the copper mine "Bucim" flotation dump site in Radovish*

The results from the analyses of the mechanical composition are presented in the Tab. 1 (sample no. 1,2, and 3). According the classification of Gračanin M. (1940) soil samples 1,2 and 3 are classified as a skeleton soils (10-30% skeleton). The fine soil is classified according the classification of Scheffer and Schachtschabel. According this classification soil samples belongs to the following texture classes: sandy clayey loam (sample No.1) and fine sandy loam (sample No. 2 and3). It can be concluded that the analysed soil samples have generally favourable mechanical composition. Chemical characteristics of the investigated soil samples are presented in Tab. No. 2 (sample No. 1,2 and 3). From the presented results it can be concluded that the investigated soil samples are non-carbonate. According USA Soil Classification (Филиповски Ѓ. 1984) soil sample No.1 has neutral while soil sample No. 2 and 3 have slightly acid soil reaction (pH) in water. This type of soil reaction is considered as most appropriate for plant growth. According the classification of Gračanin M. (Bogdanoviċ M. red. 1966) soil samples No. 1 and 3 have low amount of organic matter, while soil sample No. 2 has a very low quantities of organic matter.

The quantity of easy available phosphorus in all analysed samples is very low. Soil samples 1 and 2 have medium quantities of easy available potassium, while in sample No. 3 the quantity of this element is on a very low level. The content of the total quantities of heavy metals (Cu, Cr, Ni, Pb and Zn) are presented in Tab. No. 3, soil samples 1,2 and 3.

Table1. Mechanical composition of the soil and geological material intended for recultivation of the flotation dump Bucim (in % of fine soil)

No. of sample	***Skeleton >2 mm***	***Coarse sand 0,2-2 mm***	***Fine sand 0.02-0.2 mm***	***Coarse + fine sand 0.02-2 mm***	***Silt 0.002-0.02 mm***	***Clay <0,002 mm***	***Silt + clay <0,02 mm***	***Texture classes acording Scheffer & Schachtschabel***
1	13.70	20.5	40.2	60.7	15.2	24.1	39.3	Sandy clayey loam
2	15.97	18.2	50.5	68.7	16.5	14.8	31.3	Fine sandy loam
3	19.64	20.9	48.9	69.8	16	14.2	30.2	Fine sandy loam
4	22.40	16.2	51.5	67.7	11.9	20.4	32.3	Sandy clayey loam
5	24.82	23.2	50.2	73.4	10.2	16.4	26.6	Sandy clayey loam
6	13.95	14.3	50.4	64.7	13.9	21.4	35.3	Sandy clayey loam
7	13.96	15.8	51.4	67.2	13.4	19.4	32.8	Sandy clayey loam
8	14.33	29.4	45.1	74.5	11.2	14.3	25.5	Fine sandy loam
9	14.66	16.9	54.7	71.6	9.1	19.3	28.4	Sandy clayey loam
10	15.00	23.7	51.2	74.9	8.6	16.5	25.1	Sandy clayey loam

Table 2. Some chemical characteristics of the soil and geological material intended for recultivation of the flotation dump Bucim, Radovish

Soil sample No.	***$CaCO_3$ %***	***pH***		***SOM %***	***Easy available mg/100g soil***	
		H_2O	***nKCl***		***P_2O_5***	***K_2O***
1	0	6,62	4,71	1,53	0,19	12,52
2	0	6,32	4,42	0,79	1,55	14,47
3	0	6,20	4,59	1,18	1,36	10,95
4	0	7,05	6,10	0,80	1,76	11,61
5	0	6,90	5,35	0,80	0,20	8,01
6	0	6,62	4,86	0,51	2,15	16,02
7	0	6,64	4,86	0,55	2,35	13,62

Soil sample No.	$CaCO_3$ %	pH		SOM %	Easy available mg/100g soil	
		H_2O	nKCl		P_2O_5	K_2O
8	0	6,59	5,07	0,68	0,39	8,01
9	0	6,59	5,27	0,64	1,37	9,21
10	0	6,51	5,20	0,69	0,78	8,41

Table 3: Content of total forms of heavy metals in the soil and geological material intended for recultivaton of the flotation dump Bucim

Soil sample No.	Total content in mg/kg				
	Cu	Cr	Ni	Pb	Zn
1	65,73	97,81	30,37	39,37	130,81
2	47,74	71,44	17,02	110,17	119,86
3	36,04	36,04	19,02	68,41	144,5
4	39,66	66,00	23,00	64,67	138,34
5	22,33	39,67	12,33	66,00	102,34
6	41,34	60,35	23,67	107,03	169,38
7	43,00	71,67	22,67	105,00	153,33
8	18,34	46,01	11,34	49,69	101,71
9	29,33	66,33	20,00	58,33	129,33
10	24,67	55,01	11,67	60,68	98,02

According the Dutch standards which are most commonly in use, the referent values for total Cu are 36 mg/kg soil, while the intervene values are 190 mg/kg, referent values for tot. chromium are 100 mg/kg and 380 mg/kg for intervene values, referent values for tot. nickel are 35 mg/kg whilst the intervene values are 210 mg/kg , for lead the referent and intervene are 85 and 530 mg/kg , respectively and for zinc these values yields 140 mg/kg for referent and 720 mg/kg for intervene values. According these standards if the content of heavy metals in the soil is bellow the referent values all agricultural crops can be planted without any limitations. If the quantity o the tot. forms of heavy metals are in the range between referent and intervene values, a careful and appropriate selection of the agricultural crops is needed, and monitor the quantity of the available forms and heavy metals in the plants. If the quantity of heavy metals in the soil is above intervene values such soil is inappropriate for agricultural production and should be remediated.

Out of the presented data in Tab. 3 it can be noticed that the quantity of heavy metals in the soil and geological material intended for recultivation is far bellow the intervene values and there is no threat of phytotoxic effect. Based on what was stated above it can be concluded that the soil and geological material has proper mechanical composition, adequate chemical characteristics and low contents of heavy metals and is suitable for recultivation of the floating material. The soil and geological material intended for recultiation was applied onto the flotation material with thickness of aprox. 30 cm. (picture 3). Out of the applied material seven soil samples were taken for further laboratory analyses.

Figure 3: *Flotation dump after applying of the soil and geological material*

The results of these materials are presented in Tab. No. 1 (soil sample 4,5,6,7,8,9 and 10). Results have shown that the mechanical composition is suitable and similar to the previously investigated soil samples. Similarly to the soil samples no. 1,2 and 3, this second group of samples belong to the same texture classes, sandy clayey loamy and fine sandy loamy. Chemical characteristics of the investigated soil samples are presented in Table no. 2 (soil sample no. 4,5,6,7,8,9 and 10).

Similarly like in the previous group of soil samples, soils samples from no. 4 to no. 10 are noncarbonate. The content of carbonate in soil is very important characteristic. Growth of some forest plants can be limited with the presence of carbonates and appearance of Fe-chlorosis. Since the investigated soil samples are noncarbonate the choice of forest plants for recultivation is unlimited.

The results of soil reaction (pH) are also similar to the previously investigated group of soil samples (soil sample no.1,2 and 3). The soil samples have neutral pH which implies that the applied soil layer is optimal media for plant growth.

According to our expectations soil organic material (SOM) content is low and according to the classification of Gracanin M. (Bodanovic M. red. 1966) the investigated soil samples can be classified as soil with low content of SOM. Due to the low content of organic matter it can be assumed that the content of total and mineral forms of N are low. In order to increase the SOM content application of manure is recommended. The SOM can be increased also with sowing of mixture of grass and clover. With implementation of such measures the in-stabilized thin soil cover will be protected against soil erosion, soil structure will be improved and the content of nutrient increased. On this base the overall chemical, physical and biological condition of the soil cover are improved.

Similarly like in the samples 1,2 and 3, the content of easy available phosphorus in the samples from 4 to 10 is very low, whilst with easy available potassium the soil samples are very weakly provided. In order to increase the level of nutrient up to the optimal content it is necessary to incorporate high doses of complex mineral fertilizers.

The low content of heavy metals (Cu, Cr, Ni, Pb and Zn) in these samples was confirmed. The content of heavy metals is far bellow the intervene values, due to what there is no risk of phytotoxicity and inhibiting effects to the growth of the planted crops.

For improvement the positive characteristics of the applied soil and geological material the following agrotechnical and agromeliorative measures should be implemented: ameliorative fertilization with mineral P and K fertilizers, fertilization with mineral N fertilizers, humification and phytomelioration. Fertilization with mineral fertilizers will optimise the level of nutrients in the soil and nutrition of plants, while humification and phytomelioration will increase the SOM content which will improve soil structure and diminish soil erosion.

For effective protection of soil erosion the applied soil and geological material was initially prepared for plating of forest species (picture 4).

Figure 4*: Preparation of the surface for planting of forest species*

After the preparation of the surface the area foreseen for recultvation was planted with the following species: Robinia pseudoacacia and Cupresus arizonica (picture 5). Planitng distance between rows is 2,5 m. and 1 m. in the row. The area between rows will be covered with clod of Cynodon dactilon,

Figure 5: *Planting the seedlings of Robinia pseudoacacia and Cupressus arizonica*

On area of 1000 m^2 an trial field will be established. On this trial field different varieties of trees and shrubs will be tested, so the most effective ones will be further used for the next phases of biological recultivation of the flotation dump.

4 Conclusions

- Due to the high toxicity of the flotation material it was decided to be covered with new layer of soil and geological material.
- The soil and geological material have a appropriate mechanical composition, good chemical characteristics and low content of heavy metals which makes it a good material for recultivation of the flotation material.
- For improvement the characteristics of the applied layer of soil and geological material it is essential to implement the following agro-technical and agro-meliorative measures: meliorative fertilization with mineral phosphorus and potassium fertilizers, incorporation of mineral forms of nitrogen, humification and phytomelioration.
- For effective conservation of the applied soil and geological material from erosive processes, the area will be planted with forest wood species Robinia pseudoacacia and Cupressus arizonica, while the space in-between the rows will be covered with clod of Cynodon dactylon.

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Tillage erosion in growing arable crops

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Abstract

Our objectives were to quantify tillage erosion (referred as a soil loss) during the 14-year investigation cycle (1994-2008) on Stagnic Luvisols, in central Croatia, under common agricultural grown crops in six tillage treatments. This paper presents the results relating to the total soil loss, with special reference to the time occurrence of soil loss per crop and development stages of the grown crops: Maize (Zea mays L.); Soybean (Glycine hyspida L.); Oil-seed rape (Brassica napus var. oleifera L.); Winter wheat (Triticum aestivum L.) and Spring barley (Hordeum vulgare L.). The largest erosion in the 14-year period was recorded in the check treatment. Following variant was the variant that involves ploughing up and down the slope. Much smaller soil losses were recorded in no-tillage and treatments with ploughing across the slope. Much higher soil losses were recorded in the growing of spring row crops (maize and soybean) than in the growing of winter crops (winter wheat, spring barley and oil-seed rape). In the growing of spring row crops, soil losses were not evenly distributed, quite contrary. The period of seedbed preparation, or the period immediately after sowing spring crops (laste decade of April, May and first decade of June) is the most critical period with the highest risk of erosion. In that time in growing spring row crops over 70% of the overall annual soil loss occurs in all tillage treatments. From that reason the period from May to mid-June is the riskiest period for water erosion in the agroecological conditions of central Croatia if low-density spring row crops (maize, soybean, potato, tobacco, sugar beet, and sunflower) are grown in the field. The trend of increasing participation of low-density spring crops compared to high-density winter and fodder crops on the arable areas in the Republic of Croatia indicates that the problem of tillage erosion on sloping terrains will be increasingly present. One of reason for more row spring crops in crop rotation is production of bio fuels. During the winter crops growing (wheat, barley, oil-seed rape - crops of high density), no critical periods were observed and water erosion was insignificant. According to 14-years of investigation we are recommending no-tillage (or some other reduced tillage) and ploughing across the slope due to the all advantages and drawbacks of studied tillage methods in 14 years investigation for a wide application in growing crop on this soil type.

And the last but not the least, we find that erosion control in the future requires a new, integral approach. Instead of the so far individual (personal) scientific attitudes to the problems of soil protection from erosion, an integral approach to erosion control should be adopted. Relevant work should include teams of specialists from various fields, such as agronomists, civil engineeringist, geologists, hydrologists, foresters, etc. The so far isolated and scattered activities in agriculture, forestry, water management, energetics, traffic and similar disciplines aimed at fighting the soil erosion and torrential watercourses were not governed by a unique conception of managing torrential watersheds and erosion areas. The ultimate aim is to preserve the environment for the future generations.

Key words: Tillage erosion, Crops, Runoff, Soil loss.

1 Introduction

Water induced soil erosion is influenced by tillage (especially the plowing direction in relation to slope), crop selection, planting direction or orientation, and the amount, distribution, and intensity of rainfall. The primary goal of the investigation is to determine the characteristics of erosion on Stagnic Luvisols (ISSS-ISRIC-FAO, 2006) and then to seek for the answer to the question whether it is possible, and to which extent, to reduce erosion on the tolerant level by applying different treatments of soil tillage in the growing of agricultural crops. Based on the obtained results, the optimal tillage has to be determined for Stagnic Luvisols.

Due to its physical composition (high content of fine sand), chemical properties (calcium carbonate deficiency, low content of organic matter) and very low aggregate stability, this Stagnic Luvisols are very prone to water erosion on sloping terrains (Richter, 1980; Le Bissonais et al., 1995; Kwaad et al., 1998; Rejman et al., 1998; Fleige and Horn, 2000). Numerous studies have showed that the conventional up and down the slope ploughing is the least favourable tillage method (Laflen and Moldenahuer, 1979; Edwards et al., 1993; Schultz and Malinda, 1994; Meyers and Wagger, 1996; Rejman, 1997 and Basic et al., 2004). It leads to the highest erosion whereas ploughing across the slope and no-tillage are much more effective in terms of erosion control. Moldenhauer and Wischmeier (1969); Alberts et al., (1985) and Rejman (1997), dealing with the problem of erosion on arable areas, maintain that high erosion losses are most likely to occur in growing spring crops.

2 Materials and methods

The experiment was located near Daruvar in central Croatia (N: $45^{o}33^{'}48''$ E: $17^{o}02^{'}06''$) and was initiated on Stagnic Luvisols in the summer of 1994. Tillage erosion was measured on six plots, according to the USLE protocol (Universal soil loss equation - Wischmeier and Smith, 1978), which specifies a plot area of 41.3 m^2 (22.1 long and 1.87 wide) on a 9 % slope. The grown crops on each experimental plot followed a typical rotation in this agricultural area: maize (1995; 2000 and 2008), soybean (1996; 2001; 2005 and 2009), winter wheat (1996/97; 2001/02 and 2005/06), oil-seed rape (1997/98; 2002/03 and 2006/07) and double crop – spring barley with soybean (1999 and 2004).

Mechanical operations, tillage direction (with respect to slope), and the row orientation or planting direction for the six treatments are:

1. The check or standard plot = SBF, according to USLE, which was tilled up and down the slope. Applied tillage practices include: ploughing to 30 cm depth, discing and seedbed preparation with a harrow, however the plot was not sown. This is the treatment in which maximum erosion was expected. Compared with it, all the other tillage methods and crops grown on the trial field reduced erosion.
2. Ploughing up and down the slope to a depth of 30 cm = PUDS. Discing, seedbed preparation with a harrow and sowing were performed in the same direction.
3. No-tillage = NT, sowing with a special seeder into dead mulch up and down the slope. Two to three weeks before sowing weeds were controlled by herbicides.
4. Ploughing across the slope to a depth of 30 cm = PAS. This was the same as the PUDS treatment, except for the different ploughing direction.

5. Very deep ploughing across the slope (to a depth of 60 cm) = VDPAS. In contrast to all other ploughing practices, which were done with multi-furrow ploughs, a single-bottom plough was used in this method.
6. Subsoiling to a depth of 60 cm, subsoiler tines spaced 70 cm apart, with ploughing across the slope to a depth of 30 cm = SSPAS. In the last three tillage methods, discing, seedbed preparation with a harrow and sowing were performed across the slope.

Crop development is monitored per stages according to USLE (*Wischmeier, 1960*): Period F - rough fallow (primary tillage - plowing to secondary tillage for seeding); Period SB – (seedbed) - secondary tillage for seedbed preparation until the crop has developed 10 % canopy cover; Period 1 – (establishment) – end of SB until crop has developed a 50 % canopy cover - for winter crops includes the winter period; Period 2 (development) – end of period 1 until canopy cover reaches 75 %. Period 3 (maturing crop) – end of period 2 until crop harvest); Period 4 (residue or stubble) - harvest to plowing or new seeding.

3 Results and discussion

3.1 Soil properties

Parent material at this site is transformed loess (i.e. mottled, non-carbonate loam from the Upper Pleistocene - Riß, Würm). Soil texture throughout the profile (0-95 cm) is an homogenous sandy loam. Soil compaction measured by bulk density, is a concern for these soils and one reason often used to justify tillage. Our data (20 replications) show data after 14 years of investigation, average bulk densities (ρ_b) in the Ap+Eg horizon for all treatments. The soil was acidic throughout the profile and there was very little organic matter in the plough layer. Phosphorus availability was classified as medium and potassium availability was classified as good (Table 1).

The long-term average and data (rainfall, the mean annual temperature, number of rainy days and maximum daily rain) for investigation years are shown in Table 2.

Table 1: Physical and chemical characteristics of Stagnic Luvisols evaluated on the experimental plots

Soil horizon	Depth of horizon, cm	Particle size distribution (g kg^{-1})[a]				Texture
		Coarse sand (2-0.2 mm)	Fine sand (0.2-0.02 mm)	Silt (0.02-0.002mm)	Clay (< 0.002 mm)	
Ap + Eg[b]	0 – 24	18[c] ± 4.7	586 ± 37	242 ± 35	154 ± 25	Sandy loam
Eg + Btg	24 – 35	21 ± 5.5	571 ± 59	260 ± 54	148 ± 44	Sandy loam
Btg	35 – 95	5 ± 2.3	545 ± 69	254 ± 32	196 ± 40	Sandy loam

Average value of soil bulk density (ρ_b)[d] after 14 years of investigation, Mg m^{-3}, 0-10; 10–20 and 20 -30 cm					
Check treatment	Plowed to 25 cm, up/down	No tillage	Plowed to 25 cm, perpendicular	Plowed to 60 cm, perpendicular	Subsoiled to 60 cm, perpendicular
1.57 ± 0.10	1.57 ± 0.15	1.53 ± 0.10	1.50 ± 0.13	1.54 ± 0.10	1.46 ± 0.10
1.61 ± 0.10	1.64 ± 0.15	1.54 ± 0.10	1.65 ± 0.13	1.70 ± 0.10	1.66 ± 0.10
1.67 ± 0.10	1.66 ± 0.10	1.58 ± 0.10	1.66 ± 0.10	1.63 ± 0.10	1.61 ± 0.10

		pH in KCl	Organic matter (g kg^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
Ap + Eg	0 – 24	4.21[c] ± 0.15	16 ± 3.3	172 ± 18	308 ± 6
Eg + Btg	24 – 35	4.20 ± 0.18	14 ± 4.2	65 ± 4	123 ± 8
Btg	35 – 95	4.81 ± 0.23	6 ± 3.8	244 ± 24	502 ± 12

[a]Average of all treatments; [b]according to ISSS… (2006); [c]data expressed as an average of four replications ± standard deviation; [d]average of 20 measurements

Table 2: Major indicators of climatic conditions, long time average (1994-2008)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
15 year average	Average monthly precipitation, mm												
	55	47	58	73	88	97	85	82	88	70	83	63	889
	Average monthly temperature, C												
	-0.4	1.9	6.3	10.9	15.5	18.9	20.6	19.9	15.9	10.9	5.7	1.6	10.7
	Number of rainy days												
	12	11	13	13	14	13	11	11	10	9	13	13	12
	Maximum daily rain												
	30,3	26,8	22,7	34,5	121,0	58,2	37,9	34,6	71,2	47,6	38,4	23,2	

3.2 Soil loss in growing low density spring crops

Numerous studies were conducted around the world (Govers et al., 1994; Tebrüge and Düring, 1999; Van Muysen et al., 2002; de Alba, 2003 and Bertola et al., 2008) have proven that up/down the slope ploughing is the least favourable tillage method, since it leads to highest soil loss, whereas no-tillage and perpendicular ploughing are much more efficient in terms of erosion control. This has also been confirmed by our investigations. Soil loss in all investigation period according to crops and tillage systems is shown on Figure 1. Average soil loss was determined per different stages of crop development (Wischmeier, 1960) and is shown in Table 3 and Figure 2. It is obvious that the convincingly highest soil loss (108.44 t ha^{-1}) was recorded in the check treatment (black fallow). This quantity is several times higher than the tolerant level of soil loss - T, which for this type of soil amounts 10 t ha^{-1} (Schwertman et al., 1987 and Kisic et al., 2003). This is followed by the variant involving ploughing up/down the slope with 26.79 t ha^{-1}, respectively, of average soil loss. A smaller quantity of average soil loss was recorded in the no-tillage (6.43 t ha^{-1}) and very deep perpendicular ploughing with the total average erosion of 6.30 t ha^{-1}. It is followed perpendicular ploughing with 5.25 t ha^{-1}, respectively. Convincingly best results in soil conservation were achieved in the variant with subsoiling with perpendicular ploughing, where average soil loss was only 2.83 t ha^{-1}, respectively.

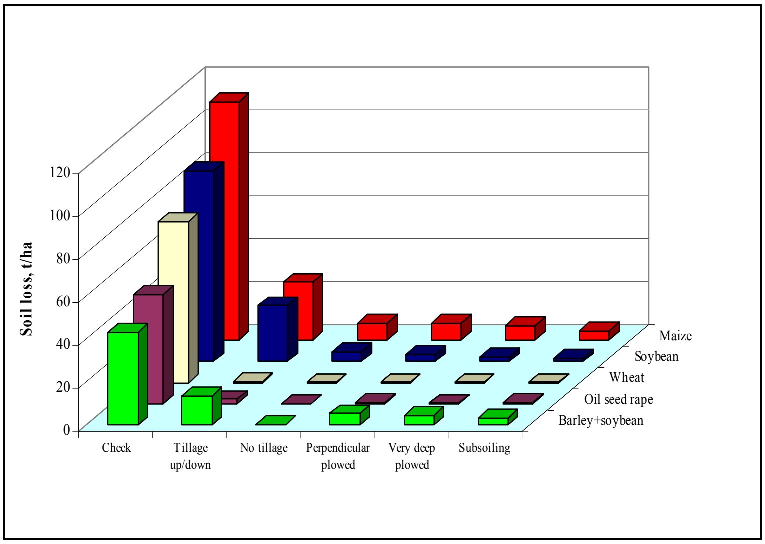

Figure 1: *Soil loss on different tillage systems and growing different crops*

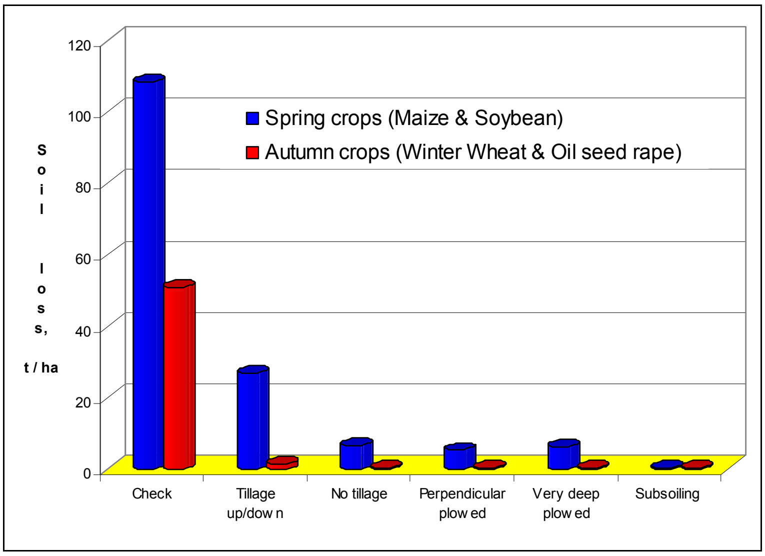

Figure 2: *Average soil loss in growing spring crops and winter crops*

Table 3: Soil loss (for six years average) in growing of spring row crops - maize and soybean

Cropstage	*Black fallow*	Up/down the slope	No-tillage	Ploughing	Deep ploughing	Subsoiling +ploughing
		ploughing		Perpendicular		
Rough fallow	*0.14*	0.03	0.02	0.001	0.001	0.01
Seedbed – SB	*18.60*	14.02	5.37	3.61	4.97	1.83
Period 1 – establishment	*16.41*	4.52	0.15	0.84	0.71	0.79
Period 2 – development	*20.98*	5.72	0.32	0.45	0.30	0.07
Period 3 – maturing	*47.89*	2.46	0.58	0.35	0.31	0.11
Residue or stuble	*4.43*	0.05	0.001	0.001	0.001	0.01
Soil loss, t ha^{-1} year $^{-1}$	***108.44***	**26.79**	**6.43**	**5.25**	**6.30**	**2.83**

The results gave absolute advantage to perpendicular ploughing (Figure 3). Up/down the slope ploughing should be omitted altogether. Maize, soybean and we believe other spring row crops are considered to be high risk crops by all the authors studying erosion problems on arable land, regardless of the direction of tillage (Laflen and Moldenhauer, 1975; Alberts et al., 1985; Govers et al., 1999, Tebrüge and Düring 1999 and Riegerb et al., 2008). Besides, early sowing at a time when the soil is bare and unprotected by spring crops of low population density, the large intra- and inter-row spacing enables intensified erosion. Therefore, all row spring crops cannot be fully protected from the direct impact of raindrops even in later stages, which leads to erosion also in its later stages. Ploughing across the slope may reduce erosion to a tolerant level by comparison with the up/down the slope ploughing and sowing. The orientation of furrows in this tillage methods prevents excessive surface run-off and thus reduces erosion. In the treatments with deep tillage, the larger depth of the plough-layer enables stronger descendent movement of water and in this way additionally decreases surface run-off. The results shows that the critical period in growing spring row crops is that of bare soil and the seedbed (SB). On the check treatment 17.15 % of the average soil loss value was recorded in that period. Essentially, different results were obtained in other treatments of tillage. In ploughing up/down the slope, the SB period erosion amounted for 52,3, respectively, of the average erosion while in the no-tillage variant it amounted 83.4%, respectively. In the variant involving perpendicular ploughing, the SB period erosion amounted 68.8 of average erosion while in the variant with very deep ploughing across the slope to 78.9%, respectively. In the variant of subsoiling with perpendicular ploughing, the SB period erosion amounted 64.8%, respectively, of average erosion for six years. The reasons for such high values are that this is the period when the soil is bare and unprotected -

without any vegetation cover, immediately after sowing. Raindrops of high intensity falls directly on the soil, which leads to surface run-off and occurrence of erosion in all treatments.

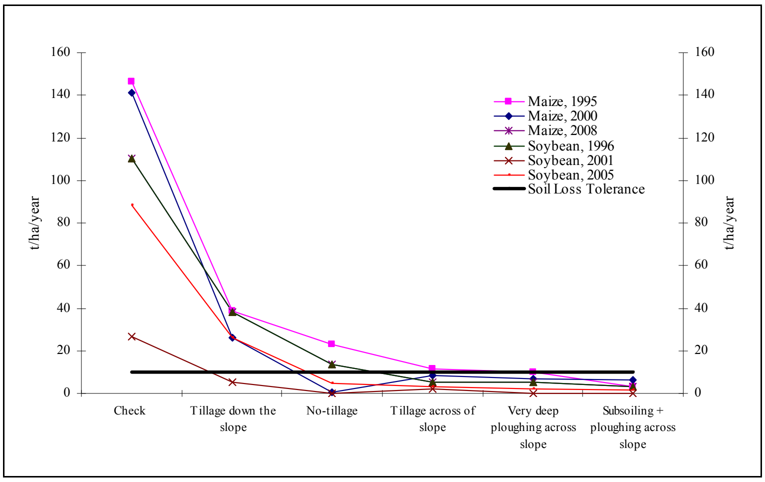

Figure 3: *Soil loss in growing low density spring crops*

3.3 Soil loss in growing winter crops (Winter Wheat and Oil Seed Rape)

Winter crops were growing on experimental field according to next crop rotation: winter wheat (1996/97; 2001/02 and 2005/06) and oil-seed rape (1997/98; 2002/03 and 2006/07). Average soil loss in these years was determined per different stages of crop development and is shown in Table 4 and Figure 4. Like in the growing of spring row crops (what is expected), highest erosion was recorded in the check treatment. During the annual growth of winter crops, the average soil loss for six years was 50.83 t ha^{-1}. Although average soil loss was lower than in the period of spring row crops growing, this is still very high erosion, which exceeds the tolerant threshold of soil loss of 10 t ha^{-1} per year for this soil type alone. This is followed by the variant involving ploughing up/down the slope with 1.25 t ha^{-1}, respectively, of soil loss. Average soil loss recorded in all other experiments was from a 100 up to a few hundred kilograms (Table 4). Accordingly, soil loss in the growing of winter crops was much lower than in trial years when spring crops were grown. This is the reason why in controlling erosional processes we lay greater importance on the crop grown than on the tillage method applied. Difference between soil loss in growing spring row crops and winter crops are shown in Figure 2.

Table 4: Soil loss (for six years average) in growing winter crops - winter wheat and oil seed rape

Cropstage	Black fallow	Up/down the slope	No-tillage	Ploughing	Very deep ploughing	Subsoiling +ploughing
		ploughing		Perpendicular		
Rough fallow	0.35	0.02	0.05	0.001	0.02	0.001
Seedbed – SB	2.50	0.04	0.01	0.01	0.03	0.02
Period 1 – establishment	7.94	0.17	0.01	0.03	0.02	0.01
Period 2 – development	6.07	0.12	0.07	0.01	0.01	0.01
Period 3 – maturing	26.24	0.84	0.02	0.34	0.16	0.25
Period 4 – residue	7.73	0.06	0.001	0.01	0.01	0.001
Soil loss, t ha^{-1} $year^{-1}$	**50.83**	**1.25**	**0.15**	**0.40**	**0.24**	**0.28**

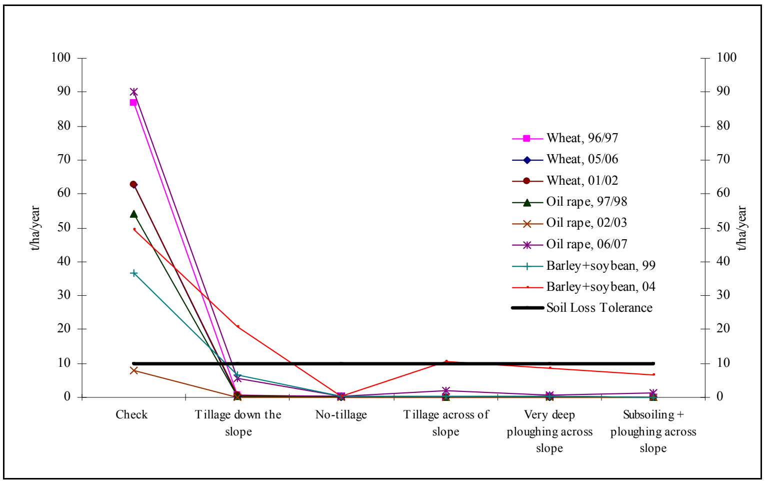

Figure 4: *Soil loss in the growing high density crops*

In the next few sentences, we will try to give answer to the question why was the soil loss much lower in the growing of winter crops. Winter crops were sown at the end of August (oil-seed rape) and October (winter wheat or barley). Sowing was preceded by a long and dry summer period, during which rather coarse structure aggregates were formed, which reduce or prevent surface run-off. Besides, there are usually no high intensity rains after wheat and oil-seed rape sowing, rain falls on dry soil and the soil can take up large quantities of water for saturation to field capacity. No surface run-off occurs in such conditions. In the winter period of the year when the soil is fully saturated and if it does not get frozen, erosion occurs but the soil loss is small. In the growing of winter crops there are no critical periods with occurrence of large quantities of soil loss. Data from Table 4 show a uniform distribution of erosion during the whole growing season of winter crops. In the period of the highest erosion risk in the studied area (May-June), winter crops fully covered soil surface with a dense cover. This vegetation cover efficiently protects the soil from the direct impact of raindrops (which are often very intensive for this period of the year) and thus contributes to the reduction of the total quantity of soil loss.

4 Summary / Conclusions

The presented results shows that erosional processes cannot be completely stopped; however they can be reduced to a tolerant level by choosing an appropriate tillage method. Appreciably higher soil loss was recorded in the growing of low-density spring crops than in high-density winter crops in the same tillage systems. The time immediately following the sowing of spring row crops (SB-seedbed) is the most critical period, that is, the period when highest soil loss occur. Spring crops, which are mainly grown at a low crop density, will still be dominant in the crop rotation; however, their growing on sloping terrains will require a balanced tillage system and an appropriate crop sequence. Efficient protection from erosion on Stagnic Luvisols slope can be achieved by no-tillage and all across the slope ploughing treatments. Summing up all the advantages and drawbacks of the studied tillage methods for a wide application in crop growing on this soil type, we recommend no-tillage and ploughing across the slope.

And last but not least. We find that erosion control in the future requires a new, integral approach. Instead of the so far individual (personal) scientific attitudes to the problems of soil protection from erosion, an integral approach to erosion control should be adopted. Relevant works should include teams of specialists from various fields, such as agronomists, geologists, hydrotechnicians, foresters, etc. The so far isolated and scattered activities in agriculture, forestry, water management, energetics, traffic and similar disciplines aimed at fighting soil erosion and torrential watercourses were not governed by a unique conception of managing torrential watersheds and erosion areas. This seems to be the reason for the relatively scarce investigations of erosion in Croatia, which is quite disproportional to the problem encountered over the entire state territory. The ultimate aim is to preserve the environment for the coming generations.

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Impact of ash and cinder from thermal power plants on environmental conditions in the Tuzla Region

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Abstract

Ash and cinder (or coal combustion residues – CCR) are normal by-products in the power production at the thermal power plants (TPP), as they are incombustible fraction of coal. At the Tuzla TPP, which is located in northeastern part of Bosnia and Herzegovina, the incineration of coal produces approximately 200 kg of CCR per ton of fuel, which is a specific yield of 0.4 to 0.9 m^3 per MWh of energy produced. The annual volume of CCR is approx. 600,000 m^3, or 1,660 m^3/day. The CCR has been disposed of over the years at several disposal sites around the TPP, which are all located in the vicinity of the city of Tuzla. So far, more than 40,000,000 m^3 of CCR have been deposited at these locations.

Physical and chemical properties of CCR greatly depend on the type of coal being used, technology of incineration, and the CCR treatment and disposal method. For example, 90 % of CCR from the Tuzla TPP is composed of silicium, iron, aluminum and calcium oxides. The CCR from the Tuzla TPP also contains trace heavy metals (As, B, Ca, Mg, K, Na, Cu, Zn, Fe, Mn, Mo, Pb, Cd). The CCR is highly alkaline (pH 12 – 13) due to high concentration of bicarbonates.

This paper presents the results of the research carried out at the Tuzla TPP with the objective to determine methods to reduce negative impacts of the CRR disposal sites on surface and ground waters. The research covered in-situ and laboratory investigations of the natural processes of self-purification at the disposal sites, assessment of feasible and affordable leachate treatment methods, and analysis of adsorption mechanisms of sorbents used for the leachate treatment. It was assessed that the natural process of pH decline will require approx. 50-85 years for the leachate from the disposal sites to reach national discharge standards (pH 9.00). The leachate treatment was tested under laboratory conditions with different types of readily available sorbents, such as activated carbon, brick, anthracite, beech sawdust, quartz sand, bauxite and clinker (local reddish material generated from clay and marl that were in contact with coal during the process of carbonization). In-situ investigations at a pilot filter column, using clinker- and bauxite-bed filters, indicate that these materials can be used to reduce pH and toxicity and remove some trace metals. Both clinker and bauxite reduce pH from initial 10-13 in the influent to 6-9 in the effluent. The in-situ investigation has shown that clinker has to be replaced two months after the startup of the plant, whereas bauxite maintains good adsorption capacity in a 9-month period. Further advantage of bauxite is a good removal capacity of As and B, while clinker removes only As.

Key words: ash and cinder, CCR, disposal site, environment, water flow, alkalinity,

1 Introduction

In the Western Balkan Countries (WBC) a significant percentage of the energy production comes from the coal burning thermal power plants (TPP). Ash and cinder are normal by-products in the power production, as they are incombustible fraction of coal. The quantities of ash and cinder (or coal combustion residues – CCR) produced are fairly high. For example, at the Tuzla TPP, which is located in northeastern part of Bosnia and Herzegovina, the incineration of coal produces approximately 200 kg of CCR per ton of fuel, which is a specific yield of 0.4 to 0.9 m^3 per MWh of energy produced. The CCR disposal sites in the WBC region are typically located in the vicinity of the TPPs and human settlements, which poses a great risk for the human population.

In the process of power production, organic matter from the coal is incinerated, whereas the inorganic matters are concentrated in the remaining CCR. Physical and chemical properties of CCR greatly depend on the type of coal being used, technology of incineration, and the CCR treatment and disposal method. For example, 90 % of CCR from the Tuzla TPP is composed of silicium, iron, aluminum and calcium oxides (EIHP *et al.*, 2007). The CCR from the Tuzla TPP also contains trace heavy metals (As, B, Ca, Mg, K, Na, Cu, Zn, Fe, Mn, Mo, Pb, Cd). In general, the CCR pH varies from 4.5 to 12, depending on the sulfur contents in the parent coal (Dellantonio *et al.*, 2008) and the contents of alkaline-earth metals and their oxides. At the Tuzla TPP, CCR is highly alkaline (pH 12 – 13) due to high concentration of bicarbonates.

Because of these properties, CCR may have a significant impact on the environment. In the WBC area, CCR is landfilled at disposal sites that are often not properly designed and built, so they are real hazard to the terrestrial and aquatic ecosystems and the human population during the period of landfilling. After the sites are abandoned, they are often used by the local population as agricultural or grazing land, which may introduce heavy metals present in the disposal site into the food chains.

Many studies investigated the application of coal ash as a soil conditioner or construction material. It has been reported (e.g. Bardhan *et al.*, 2009) that small quantities of coal ash may improve the soil quality, particularly adjust pH, improve the soil texture, increase the water holding capacity, and improve the availability of some micro- and macro-nutrients. On the opposite side, introduction of coal ash may increase the availability of trace metals (As, B) in the soil, creating phytotoxic conditions (e.g. Carlson and Adriano, 1993).

The remediation of the CCR disposal sites by the application of the soil cover and use of the land in agriculture has been investigated since 1950s (e.g. Hunt and Farrant, 1955). The studies emphasized variability of physical and chemical properties of the coal ash (e.g. Woodbury *et al.*, 1999) and suggested detailed investigations prior to the use of the CCR disposal sites for the agricultural production (e.g. Arthur *et al.*, 1992). Although Le Seur Spencer and Drake (1987) determined that the leachate from the abandoned CCR disposal sites remains an environmental threat for years, research on the remediation methods regarding the leachate treatment is very scarce. Boreli and Pokrajac (1990) in their research identified arsenic as the most toxic pollutant in the CCR disposal site leachate. They found that recirculation of the leachate is not suitable method of treatment because of the multiplication of the As concentrations in time.

This paper presents the results of the research carried out at the Tuzla TPP with the objective to determine methods to reduce negative impacts of the CRR disposal sites on surface and ground waters. The research covered in-situ and laboratory investigations of the natural processes of self-purification at the disposal sites, assessment of feasible and affordable leachate treatment methods, and analysis of adsorption mechanisms of sorbents used for the leachate treatment.

2 Methodology

2.1 Study area

The research was carried out at the existing CCR disposal sites that have been used by the Tuzla TPP for several decades. The capacity of the Tuzla TPP is 779 MW, and the annual power production in the period 2000-2005 varied from 1,968 to 3,073 GWh (EIHP *et al.*, 2007). The Tuzla TPP uses lignite and brown coal in large volumes, 1,930 to 3,180 kilotons annually. The annual volume of CCR is approx. 600,000 m^3, or 1,660 m^3/day.

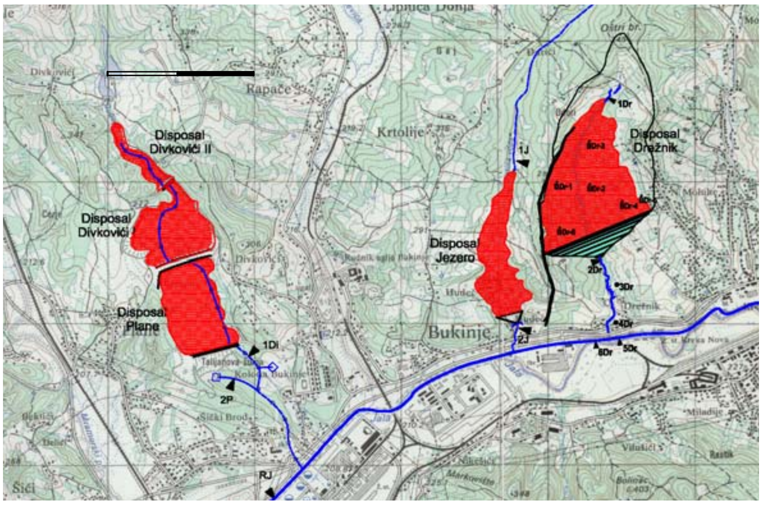

Figure 1: Location map of the CCR disposal sites around the Tuzla TPP

The CCR has been disposed of over the years at several disposal sites around the TPP, which are all located in the vicinity of the city of Tuzla (Figure 1). The oldest site, named Plane, has been abandoned for over 35 years. The Divkovici I disposal site was closed 25 years ago, and the Dreznik site some 15 years ago. The Tuzla TPP currently utilizes the Divkovici I and Jezero disposal sites, which are reaching their capacities and should soon be replaced or extended. So far, more than 40,000,000 m³ of CCR have been deposited at these locations. All the disposal sites are located in deserted surface mines or in the catchments of the water streams discharging into the Jala River.

Initial investigations were carried out at all disposal sites at the Tuzla TPP. The pilot investigations were carried out at the Dreznik disposal site.

2.2 Methods and materials

2.2.1 Site investigations

Gradual decline of the leachate pH happens over time, but at a very slow rate. The following model was used for the estimate of the leachate pH in time:

$$pH_t = (pH_o - pH_n) \cdot e^{-\alpha \cdot (t - t_o)} + pH_n ,$$

where pH_o represents the leachate pH value at the time CCR disposal site was closed (t_o), pH_t is the leachate pH measured at the time interval t, pH_n is the pH of the surface water that enters the respective disposal site, t_o represents the initial time, that is, the time when the site was abandoned (in years), t is the time of measurement of pH (in years), and α is a decay coefficient (-). In the model, the initial leachate pH (pH_o) will in time drop to the pH of the surface waters (pH_n). This comes from the following boundary conditions:

$$\text{for } t = t_o \quad \Rightarrow \quad e^{-\alpha\cdot(t-t_o)} = 1 \quad \Rightarrow \quad pH = pH_o\,,$$

$$\text{for } t \rightarrow \infty \quad \Rightarrow \quad e^{-\alpha\cdot(t-t_o)} \rightarrow 0 \quad \Rightarrow \quad pH = pH_n\,.$$

Site investigations at the Dreznik location for the assessment of hydrogeological and groundwater parameters were carried out at 5 boreholes drilled inside the site and one borehole located just outside the disposal site. Casing of the boreholes was installed in order to enable later monitoring of the groundwater table and water sampling. During the drilling, physical and chemical properties of the deposited material and groundwater were analyzed. The samples of material were taken at the root depth (0.5 m), in the vadose zone, and in the groundwater zone. For the assessment of the natural processes inside the disposal site, surface water entering the site and the leachate from the site were sampled and analyzed. All physical and chemical analyses were done according to the standard methods for the examination of water and wastewater (Eaton *et al*., 1995).

2.2.2 Leachate treatment

The leachate from the CCR disposal sites is characterized by high pH and conductivity, and high concentrations of trace metals, such as As and B. The objective of the experiment was to determine cheap options for the leachate treatment, which will provide the effluent with lower pH and reduced As and B concentrations. The treatment method was based on the application of different types of readily available sorbents, such as activated carbon, brick, anthracite, beech sawdust, quartz sand, bauxite and clinker (local reddish material generated from clay and marl that were in contact with coal during the process of carbonization). These sorbents were first tested in the laboratory, and the selected sorbents were afterwards tested at a pilot filter column installed downstream from the Dreznik disposal site. This paper presents the results of the application of bauxite and clinker as the filter bed. The filter influent was sampled on a bi- to three-weekly basis, and the effluent was sampled every five days. The samples were analyzed at the laboratory applying standard methods for the examination of wastewater (Eaton *et al*., 1995).

2.2.3 Analysis of sorption mechanisms

In order to determine the buffer capacity of sorbents, the change in the pH value has been observed for the 10 % mix of sorbent with water, to which 0.1 N solution of sodium hydroxide (NaOH) was added during filtration. During the process, the change in pH caused by gradual adding of NaOH was observed, and the buffer capacity was established.

The capacity of adsorption is measured by the amount of the substance adsorbed per mass unit of sorbent used. The amount of the substance adsorbed is often presented by the Freundlich isotherms (Mekejević, 1999), in the following form:

$$\frac{x}{m} = K \cdot C^{\frac{1}{n}}\,,$$

Where x represents the adsorbed quantity of substance (mg), m is the mass of sorbent (g), K represents the adsorption coefficient (-), C is the initial concentration (mg/l), and n is an empirical constant.

Applying the logarithm to the above function, the equation is transformed into the following form:

$$\log\left(\frac{x}{m}\right) = \log(K) + \frac{1}{n}\cdot\log(C)$$

The Freundlich adsorption isotherms were formed on the basis of the values of parameter x/m, and equilibrium concentrations C, which were determined experimentally. The adsorption coefficient K was determined from the above equation, applying the least square fit to the set of observed values of parameter x/m and the concentration C.

For the purpose of the testing of the clinker and bauxite capacity to adsorb arsenic and boron, the following experiment was carried out: Samples containing arsenic and boron in different concentrations, ranging from 0.2 to 10 mg/l, were prepared. Sorbent was added to the arsenic and boron solutions in the 1:3 ratio, followed by periodical stirring over the 8-hour period. The mixture was left at the room temperature for 24 hours. The concentration of arsenic and boron in the supernatant was then analyzed for each equilibrium concentration.

3 Results and discussion

3.1 Analysis of natural processes of self-purification at the disposal sites

The leachate from the abandoned Tuzla TPP disposal sites is characterized by high pH, which exceeds 10 units. The leachate originates from the water that enters the deposited material either by precipitation or by inflow via natural streams in the catchment of the disposal site. During the flow through the body of deposited material, physical and chemical properties of the water are substantially changed (Table 1). The main characteristics of the leachate are high alkalinity, conductivity and toxicity.

Table 1: Main physical and chemical characteristics of water entering the Dreznik landfill and the leachate from the site

Parameter	Water entering the landfill		Leachate from the site			
	12.04.2005.	06.03.2006.	12.04.2005.	27.06.2005.	12.09.2005.	06.03.2006.
pH	6.76	7.70	10.62	10.99	11.25	10.70
Conductivity (μS/cm)	164	153	1,012	1,003	1,047	1,061

Data from the Plane disposal site show that 36 years after the site was closed the leachate pH is still quite high (pH 10.50). The rate of decline of the leachate pH in time was estimated using the model presented in section 3.2.1. The model was developed for two disposal sites, Plane and Dreznik. The parameters of the model are presented on Table 2. Based on observed leachate pH in year t_o (pH_o), observed leachate pH in year t (pH_t) and observed pH of the surface water that enters the body of the disposal site (pH_n), decay coefficients α were estimated for two selected disposal sites (Table 2).

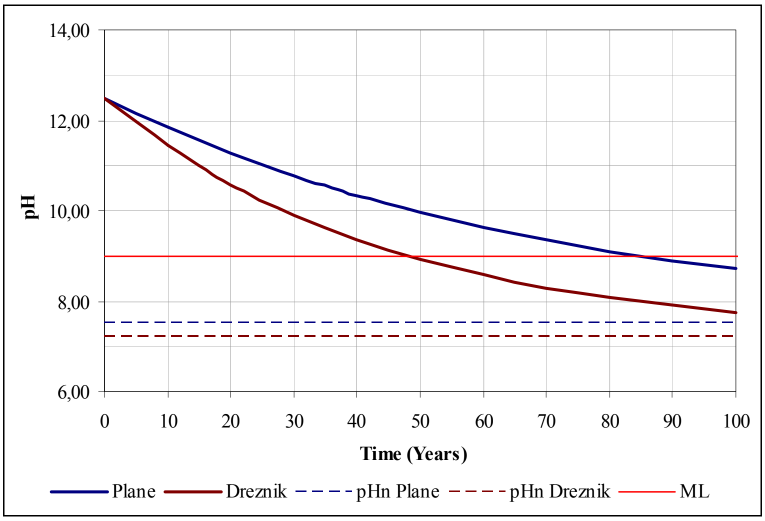

Figure 2: Modeled change of pH in time at the Dreznik and Plane disposal sites

The results of the model are presented on Figure 2. Thick solid lines indicate the leachate pH from the two sites, and the dashed lines the surface water pH. The red solid line is the maximum level allowed in the effluent discharged to surface waters according to the water legislation in the Federation of B&H. The model indicates that the natural process of pH decline will require approx. 48 years for the leachate from the Dreznik site to reach national standards. For the Plane site, this process is estimated to be even slower, some 85 years. It has to be considered that the model was developed with very limited data, and the estimates are therefore not perfectly accurate. It was assessed that the model for the Plane disposal site is more realistic, as it is based on a longer observation period of 36 years.

Table 2: Leachate pH and decay parameters for two selected disposal sites, Plane and Dreznik

Disposal site	t_o (yr)	pH_o	pH_n	t (yr)	pH_t	α (-)
Plane	1970	12.50	7.50	2006	10.50	0.014190
Dreznik	1990	12.50	7.20	2006	10.90	0.022461

3.2 Assessment of the processes inside the disposal site

The observed groundwater table at the Dreznik disposal site is presented on Figure 3a. The contour lines indicate that the hydraulic gradient is not uniform throughout the body of deposited material. This is due to the existing leachate collection system installed at the disposal site.

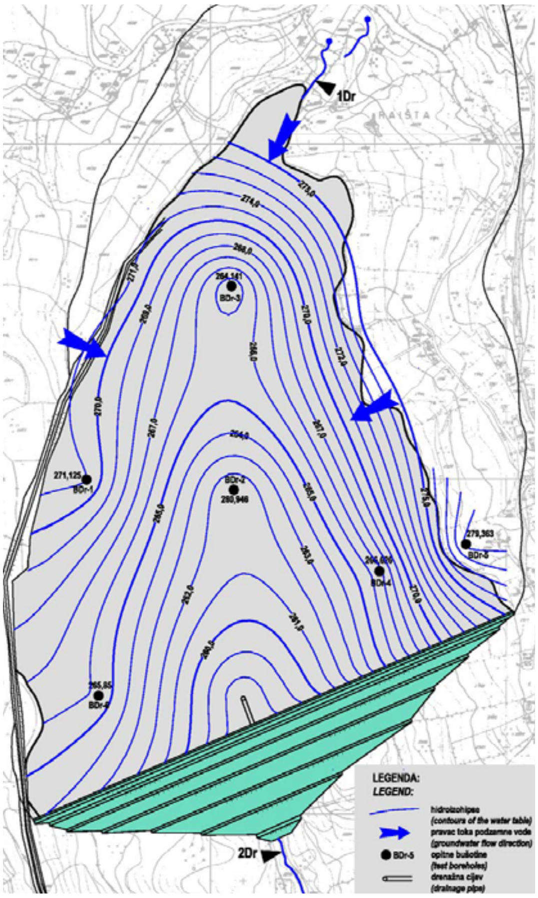

Figure 3a: Iso-lines of groundwater table at the Dreznik disposal site

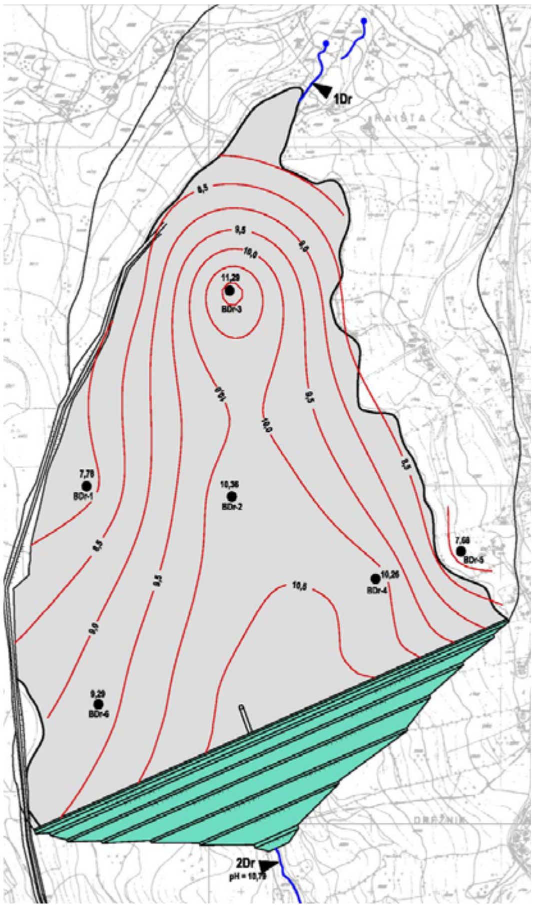

Figure 3b: pH contour lines at the Dreznik disposal site

Based on the observed elevations of the water table, hydrogeological parameters of the deposited material were estimated. The estimate was made for three directions of groundwater flow: the flow along the disposal site (between the boreholes BDR3 and BDR2), and the flow running to the site easterly (BDR1-BDR2) and westerly (BDR5-BDR4). The estimated Darcy's velocity and transmissivity of the deposited material are presented in Table 3. The estimate of the parameters was based on the hydraulic conductivity determined for the disposal site (K_{ds} = $5.77 \cdot 10^{-3}$ cm/s) and clayey soil outside the deposited material (K_c = $2.89 \cdot 10^{-3}$ cm/s). For the sections BDR3-BDR2 and BDR1-BDR2, coefficient K_{ds} was used for the estimate and for the groundwater flow between BDR5 and BDR4 the average of the two coefficients.

The results (Table 3) indicate that Darcy's velocity along the principal flow direction is approx. 4 times lower than for the lateral flow components, whereas the transmissivity is 10 times lower in the latter case. Lower transmissivity indicates that the volume of surface water entering the disposal site from the lateral side is not significant in the overall water balance.

Table 3: Darcy's velocity and transmissivity of the deposited material at the Dreznik disposal site

No.	Section	Distance between boreholes (cm)	Piezometric head (m)	Hydraulic gradient (-)	Darcy's velocity (m/day)	Transmissivity (m^2/s)
1	BDR3-BDR2	303	3.2	0.011	0.055	$2.8 \cdot 10^{-2}$
2	BDR1-BDR2	224	10.2	0.045	0.22	$2.8 \cdot 10^{-3}$
3	BDR5-BDR4	138	12.7	0.092	0.23	$2.8 \cdot 10^{-3}$ (*)

(*) average values at boreholes BDR-4 and BDR-5

Lower Darcy's velocity along the principal flow direction is the result of low hydraulic gradient, as compared to the lateral flow directions. Due to higher velocities, the rate of exchange of water is higher along the lateral directions. Because of this, the deposited material along the sides of the disposal site is washed out at a higher rate than in the central part of the site. Consequently, pH of deposited material is lower at the lateral parts of the site (8.50 – 9.50) than in the central part (10.00 – 10.50). This is confirmed by the pH contour lines, presented on Figure 3b, which fully correspond to the groundwater table contours (Figure 3a). The leachate pH (Table 1) corresponds to pH values determined at central boreholes BDR3 and BDR2.

The analysis indicates that the exchange of groundwater quality over time inside the disposal site happens at a lower rate in the central part of the site. The main reasons are low Darcy's velocity of only 5.5 cm/day, and high transmissivity of the deposited material ($2.8 \cdot 10^{-2}$ m^2/s). Because of high retention time, surface water receives the properties of the deposited material, and for this reason the natural process of self-purification is very slow. The leachate treatment is therefore an option that has to be considered at the CCR disposal sites if the environmental standards are to be satisfied.

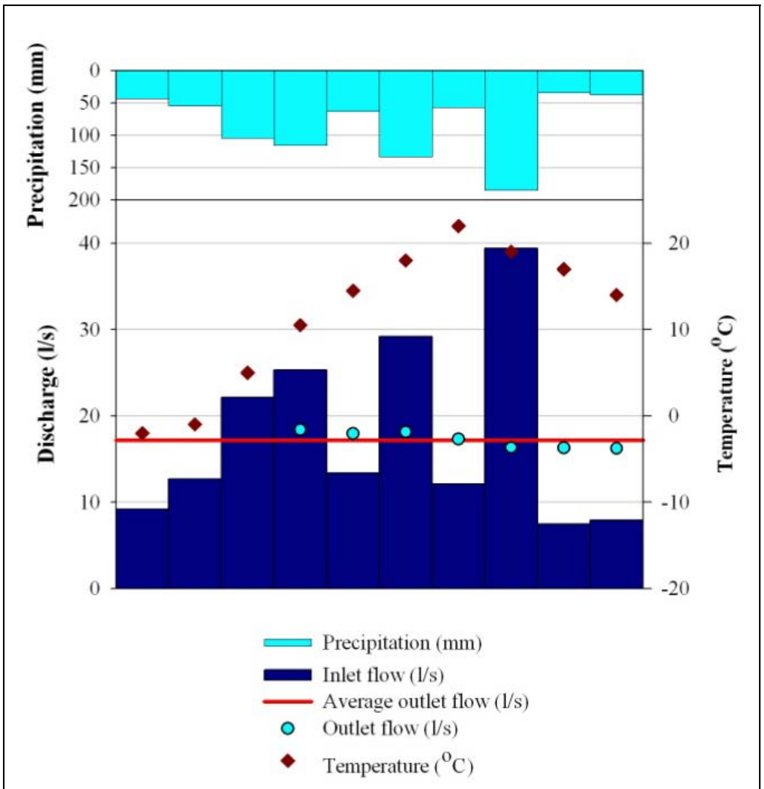

Figure 4: Elements of water balance at the Dreznik disposal site

Figure 4 presents the elements of the water balance at the Dreznik disposal site, specifically the average monthly precipitation (in mm) in the area, the average monthly inflow to the site (l/s), and the average leachate outflow of 17.2 l/s. The figure indicates that the inflow to the site is highly correlated to the precipitation. The inflow variation (7.50 to 39.40 l/s) is the result of stochastic character of precipitation. The outflow, however, varies only from 16.2 to 18.4 l/s, which shows that the disposal site has the function of a retention tank for the surface water entering it.

3.3 Leachate treatment

The results of the laboratory investigations showed that the filter bed made of clinker, beech sawdust and quartz sand reduces the leachate pH below the threshold levels according to the national regulations. Similar results with respect to pH were obtained when clinker was replaced by bauxite. In addition to the sorbents, chemical treatment of the leachate was tested using carbon dioxide and aluminum sulfate. The two substances reduced pH only. The combination of chemical pretreatment and application of bauxite resulted in an efficient reduction of pH and toxicity, and removal of As and B.

Site investigations were carried out at the pilot plant located downstream from the Dreznik disposal site. The testing of the effects of clinker as the filter bed was performed during an 8.5-month period starting in May 2006. Bauxite was tested during a 9-month period in 2007. The effects of the filtration of the leachate through the clinker- and bauxite-bed filter are presented on Figures 5a and 5b. The figures show the leachate (influent) and effluent pH and conductivity during the investigation period. DR2 refers to the leachate from the site, or the influent to the plant, and E3 to effluent from the plant.

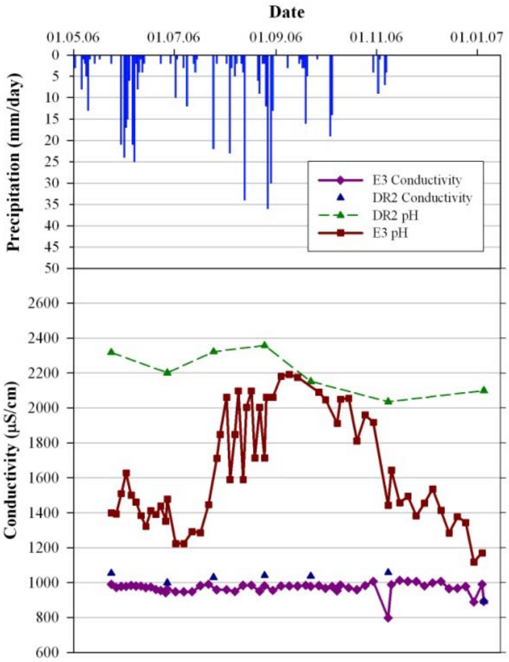

Figure 5a. Treatment effects using clinker as the filter bed

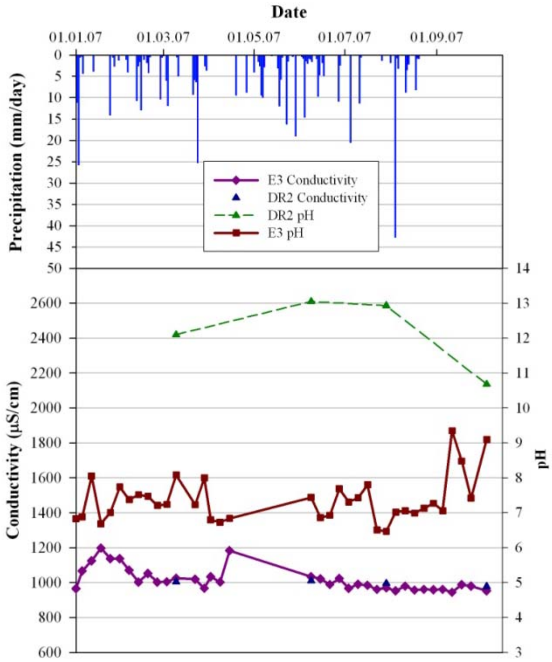

Figure 5b. Treatment effects using bauxite as the filter bed

Figures 5a and 5b show that both clinker and bauxite reduce pH from initial 10-13 in the influent to 6-9 in the effluent. The adsorption capacity and durability of clinker, however, is much lower than of bauxite. Two months after the startup of the clinker-bed filter, the adsorption capacity of the filter bed was reached (Figure 5a), and the effects of the filter on the pH reduction sharply declined. After the filter bed had been replaced in November 2006, the effects of the filter were reestablished again. Bauxite on the other hand showed no signs of the loss of the adsorption capacity throughout the research period (Figure 5b).

Sorption properties of clinker and bauxite have no significant effect on the conductivity (Figures 5a and 5b). The decline of pH was, however, followed by the reduction of the water toxicity in the samples. The leachate toxicity for example varied from 0.4 to 10 %, whereas the effluent (E3) toxicity was reduced to 50 – 70 %. The toxicity is expressed as 48hLC50 to *Daphnia magna*. The clinker-bed filter also reduced the concentration of As, whereas bauxite removed B in addition to As.

3.4 Analysis of sorption mechanisms

3.4.1 Buffer capacity

Table 4 presents the change in pH value during the process of titration of 10 % mixture of sorbent with water, to which 0.1 N solution of NaOH was gradually added.

The results are presented on Figure 6. The diagram shows that the buffer capacities of clinker and bauxite significantly increase beyond pH 10. Maximum increase in capacity is reached between pH 11 and 12. The results show that bauxite has only a slightly higher buffer capacity than clinker.

Table 4: Change in the pH value of 10 % mix of sorbent (clinker and bauxite) in the process of gradual adding of 0.1 N solution of NaOH

Bauxite		Clinker	
ml 0.1 N NaOH	pH	ml 0.1 N NaOH	pH
0	6.6	0	6.6
0.46	9.3	0.32	9.1
1.29	10.3	0.88	10.1
2.29	10.7	1.88	10.6
4.29	11.2	3.88	11.0
7.29	11.6	6.88	11.4
11.29	11.8	11.88	11.9
12.29	11.9	16.88	12.2
14.29	12.1	-	-

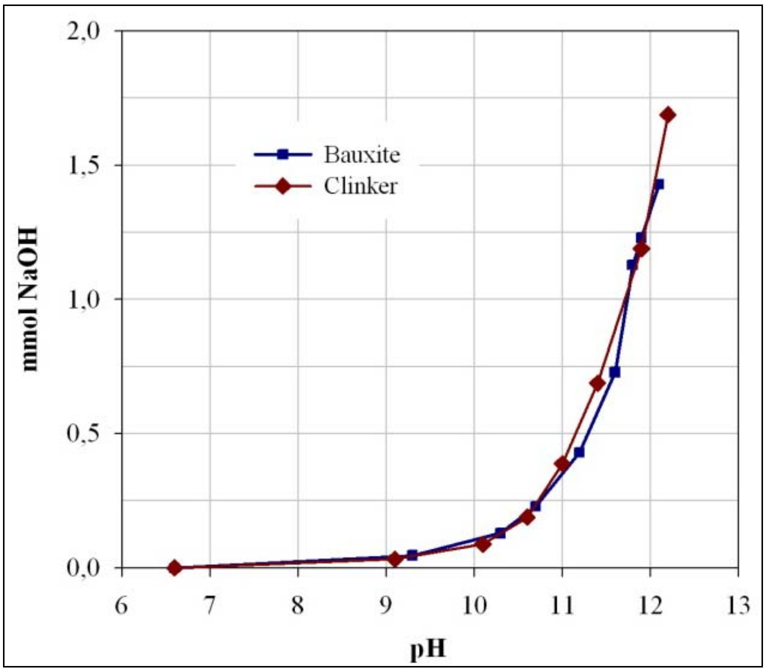

Figure 6. *Change in the buffer capacity of clinker and bauxite*

3.4.2 Adsorption isotherms of clinker and bauxite

Results of As and B adsorption by clinker and bauxite are presented on Figures 7a and 7b. The results indicate that bauxite demonstrates good adsorption capacities with regard to both heavy metals considered (As and B), whereas clinker does not adsorb boron at all. With respect to the adsorption of boron by bauxite, it may be observed that the adsorption capacity decreases beyond the boron concentration of 6 mg B/l. The adsorption capacities for arsenic are virtually equal for bauxite and clinker.

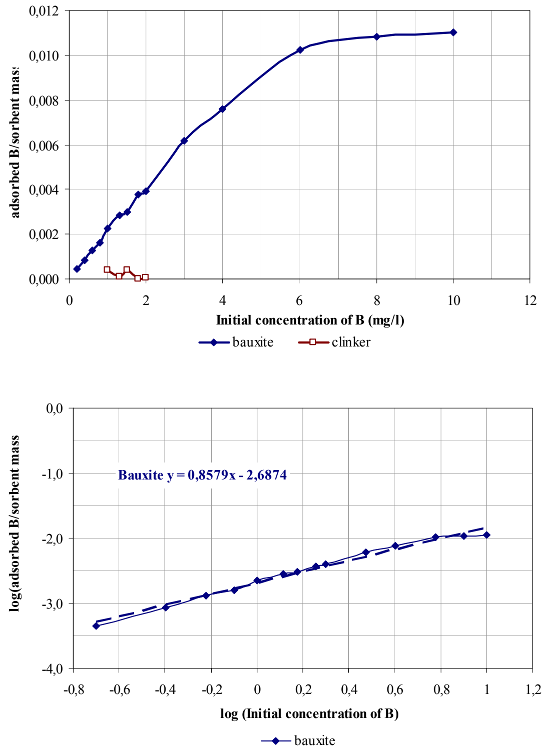

Figure 7a: Boron adsorption by clinker and bauxite

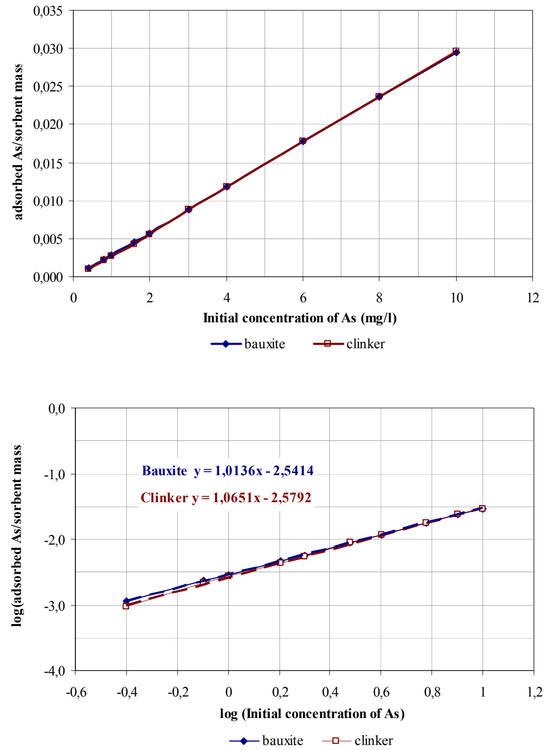

Figure 7b: Arsenic adsorption by clinker and bauxite

Table 5 presents the adsorption parameters from the Freundlich equation for the two tested sorbents.

Table 5: The Freundlich equation parameters for arsenic and boron adsorption by bauxite and clinker

Sorbent used	Boron		Arsenic	
	Adsorption coefficient K	Empirical constant 1/n	Adsorption coefficient K	Empirical constant 1/n
Bauxite	0.002054	0.8579	0.002875	1.0136
Clinker	-	-	0.002635	1.0651

The Freundlich equations for the adsorption of boron and arsenic by bauxite are given as follows:

$$\text{Boron} \quad \frac{x}{m} = 0.002054 \cdot C^{0.8579},$$

$$\text{Arsenic} \quad \frac{x}{m} = 0.002875 \cdot C^{1.0136},$$

and the equation for the adsorption of arsenic by clinker has the following form:

$$\boxed{\frac{x}{m} = 0.002635 \cdot C^{1.0651}}.$$

4 Conclusions

This paper presents the results of the research carried out at the Dreznik CCR disposal site that was abandoned by the Tuzla TPP 36 years ago. The objective of the research was to assess simple treatment methods aimed at reducing the impact of the CCR disposal site leachate on the environment.

The main characteristics of the leachate are high alkalinity, conductivity and toxicity. The leachate pH remains high for years and decades following the cessation of the landfilling activities. Based on the observed data, a simple model was developed which indicated that the leachate from the Dreznik site would reach national discharge standards (pH 9.00) in 48 years. For other sites, this process was estimated to be much slower. The model was developed with very limited data, and the estimates are therefore not perfectly accurate.

In-situ hydrogeological investigations resulted in the assessment of the hydraulic conductivity ($K_{ds} = 5.77 \cdot 10^{-3}$ cm/s), Darcy's velocity (0.055 – 0.23 m/day) and transmissivity ($2.8 \cdot 10^{-3}$ – $2.8 \cdot 10^{-2}$ m^2/s) of the deposited material. The observed groundwater table and pH contour lines suggest that the exchange of groundwater quality over time inside the disposal site happens at a lower rate in the central part of the site. The analysis of the water balance components shows that the Dreznik disposal site has the function of a retention tank for the surface water entering it.

The leachate treatment at clinker- and bauxite-bed filters indicates that these materials can be used to reduce pH and toxicity and remove some trace metals. Both clinker and bauxite reduce pH from initial 10-13 in the influent to 6-9 in the effluent. The in-situ investigation has shown that clinker has to be replaced two months after the startup of the plant, whereas bauxite maintains good adsorption capacity in a 9-month period. Further advantage of bauxite is a good removal capacity of As and B, while clinker removes only As.

5 Acknowledgements

This research was carried out as part of the RECOAL project (Reintegration of coal ash disposal sites and mitigation of pollution in the West Balkan Area, project INCO-WBC-1-509173), funded by the 6th Framework Programme of the European Union. We thank all the members of the RECOAL project team, and the Tuzla TPP for their support.

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Land demining priorities in Federation BiH

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Abstract

The specific problem on the territory of the Federation of BiH, as a result of war activities, is the large number of minefields. Mined terrain poses a danger to the lives of people, precludes the use of land area for agricultural production, as well as for the exploitation of wood in the forestry sector. According to latest experiences, the best soils are very often covered by mine fields and are excluded from agricultural production.

The aim of this work is to indicate the priorities for agricultural land demining.

Based on the research, Federation BiH has about 112,084.53 hectares of agricultural land under mine fields, (approximately 3.42% of the FBiH territory). The most common soils are automorphic soils (20393.68 hectares under mine fields, or 0.86%). Hydromorphic soils are mined on the area of 3519.68 ha or 1.66%. Three priorities of land demining have been suggested in this paper. The first agricultural land demining priority covers the best agricultural land on which after demining, intensive agriculture should be established. The second agricultural land demining priority covers the soils which have high potential, but possess limitations and are generally less suitable for cultivation. The third agricultural land demining priority covers the soils that are limited for use in agriculture and thus suitable for extensive cultivation. These are mostly soils in mountain areas.

Key words: demining, demining priorities

1 Introduction

In the area of Federation BiH, there are specific problems as a result of war activities. One of them is a presence of landmines at the soil surface. It is believed that the Federation BiH has about 112,084.53 hectares of mined agricultural land (approximately 3.42% of the entire territory). The total number of mined locations is 13,077. Estimations of BHMAC (Bosnia-Herzegovina Mine Action Center) show that a total number of landmines and UXO is around 220,000). In addition to this problem, FBiH agriculture is also threatened by:

- Soil degradation (improper soil cultivation, deforestation)
- Soil destruction (urbanization, industrialization, excavation sites)
- Soil contamination (heavy metals and organic pollutants)

Minefields are usually located in the former war demarcation line. Mines do not lose their function for a very long time and are patiently waiting for their victim hidden. The main problem is that people, even well-informed about the danger, do not pay much attention about this fact. They are in need to cultivate land due their poor financial situation and that is why they enter the dangerous areas. Refugees returning to their homes are in greatest danger, because their homes are mostly at the former confrontation lines, which are mined in most cases. Based on these facts, clearing the most quality land areas of mines in our country is set as **a priority task.** Also, the question is how much agricultural land ready for agriculture Federation BiH has?

2 Objectives

The main objectives of this work are:

- To determine the exact state of mined agricultural land
- Determination of priority zones for mine clearance;
- To determine land reclamation measures after mine clearance
- To make agricultural land safe for production;
- To evaluate the land according to production capabilities

3 Materials and methods

Optimal method for determining the priorities for demining is land evaluation, i.e. rating the quality of soil and its productive capacity. Determination of soil categories is made on the basis of morphological, chemical and physical soil properties together with production characteristics. We used research materials used before the war (before mining). For the purposes of categorization, important features include:

- Soil type and its properties (morphological, physical and chemical properties)
- General terrain properties (relief, exposure, inclination, hydrology)

Table 1: The most common causes of soil damage in the area of federation BiH

Contamination	Degradation	Land destruction	
		Temporary losses	Permanent losses
Heavy metals	Incline farming	Coal surface digging	Settlement building
Acid rains	Irregular cultivation	Sand and boulder exploatation	Industry
Organic pollutants	Intensive deforestation	Thatch depot	Roads
		Lignite dust depot	
		Plaster material depot	
		Coal mud depot	
		Minefields	

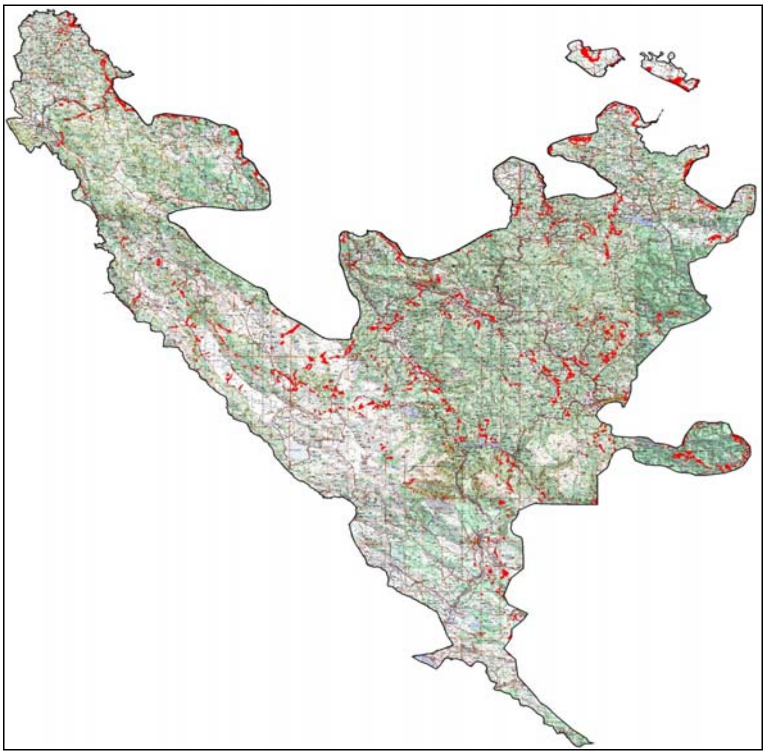

Figure 1: *Landmine map of Federation BiH*

4 Results and discussion

Research results are presented trough:

• Characteristics of researched area (Federation BiH)
• Soil analysis,
• Data analysis of the study area.

Based on the facts above, we made a map of land demining priorities:

1st priority - land suitable for intensive agricultural production;
2nd priority - land suitable for semi-intensive agricultural production;
3rd priority - land suitable for extensive agricultural production;

4.1 Characteristics of soil under minefields in FBiH

Automorphic (Terrestric) soils cover the biggest part of Federation BiH - 2.365.154,86 hectares (90.85%) of the total soil surface area, of which 20.393,68 hectares (0.86%) is under minefields. Soils that belong to this group and are affected by minefields: lithosol, calcomelanosol, rendzina, ranker, vertisol, calcocambisol, Terra rossa, eutric cambisol, dystric cambisol, brunipodzol, podzol, luvisol

Hydromorphic soils are much less represented and they participate with 211.482,25 ha (8.13%), of which 3519,68 ha (1.66%) are in area under mines. Soils that belong to this group and are affected by minefields: Fluvisol (alluvial soils), Humofluvisol (semi-gley), Eugley, Histosol, Pseudogley, Humogley.

4.2 Demining priorities for agricultural areas

1st Priority

The first priority for demining of agricultural land covers the highest quality soils, which have a depth of physiologically active layer of 40 to 120 cm, loamy or sandy texture composition, well permeable, well drained, which can have up to 40% of the skeleton or deep groundwater. They may have a short wetting period and be in the valley or inclined to maximum 25%. These are usually soils that belong to the first four land categories in our national land evaluation.

Soil types under minefields which belong to first priority of demining are mainly: vertisol, terra rossa, luvisol, fluvisol, eutric cambisol, dystric cambisol, etc. The total area of agricultural land under mines for this demining priority is 9486,79 ha.

2nd Priority

Soils from second priority are located in almost every place together with soils from first priority. Agricultural area containing soils from this priority group is found on steep terrain (slope over 20^{o}). The soils have lighter (sandy) texture, skeletal and significantly shallower (depth up to 40 cm). These are soils with certain limitations and generally less suitable for cultivation. These are usually soils that belong to fifth and sixth land category in our national land evaluation.

Soil types under minefields which belong to second priority of demining are mainly: vertisol, terra rossa, rendzina, regosol, ranker, pseudogley, luvisol, lithosol, calcomelanosol, calcokambisol, humofluvisol, humogley, histosol, fluvisol, eutric leptosol, eutric kambisol, eugley, dystric kambisol, brunipodzol etc. The total area of agricultural land under mines for this demining priority is **19.353,82 ha**.

3rd Priority

This group contains low potential soils ususally found in mountain areas, on a large slope. These soils are extremely limited for use in agriculture. They are mainly used as pastures and meadows. These are usually soils that belong to seventh and eigth land category in our national land evaluation.

Soil types under minefields which belong to second priority of demining are: rendzina, regosol, ranker, lithosol, calcokambisol, deposols etc. The total area of agricultural land under mines for this demining priority is **349,06 ha**.

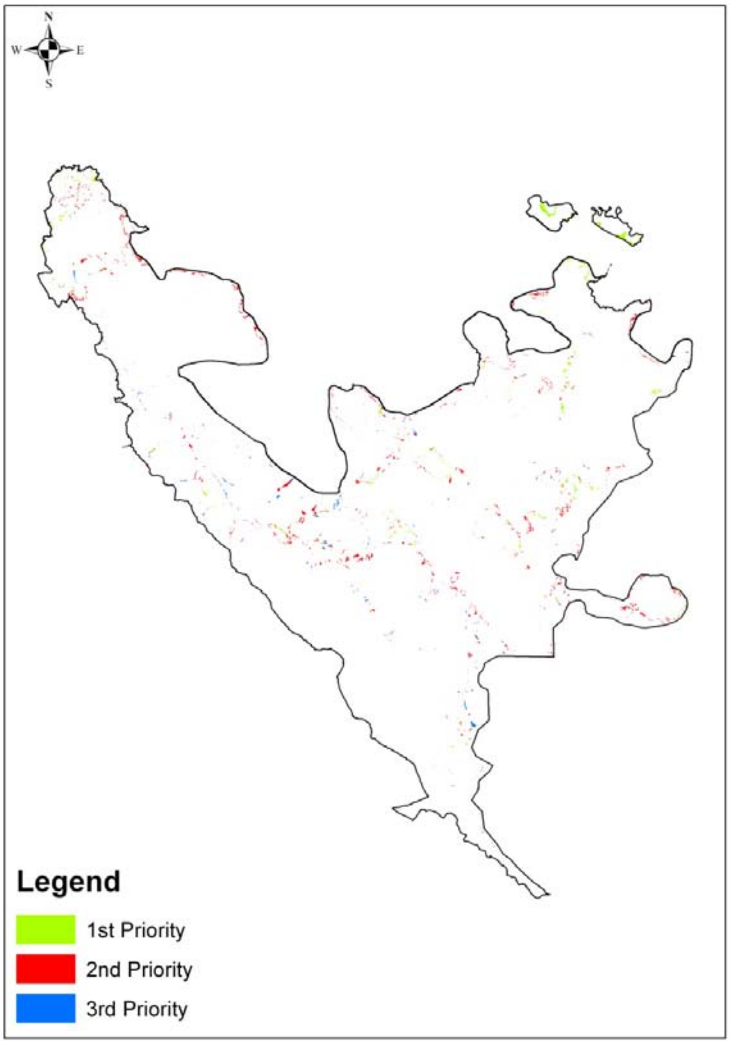

Figure 2: *Demining priorities map for agricultural land*

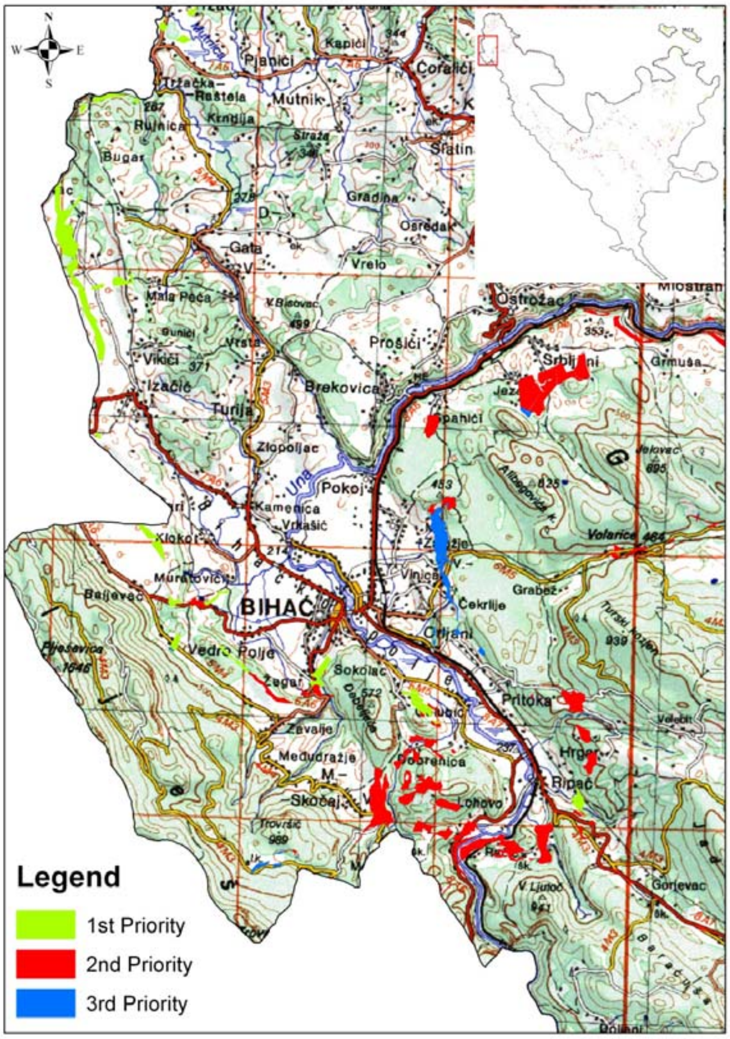

Figure 3: *A closer look to one of the sections*

5 Summary

It is believed that the Federation BiH has about 112,084.53 hectares of mined agricultural land (approximately 3.42% of the entire territory). The total number of mined locations is 13,077. Estimations of BHMAC (Bosnia-Herzegovina Mine Action Center) show that a total number of landmines and UXO is around 220,000). Land under mines in Federation is extremely heterogeneous, from which automorphic and hydromorphic soil types are of the main importance. As a result of researches to this day demining priorities are separated by principle of land categories (I-VIII). Land categorization is done on basis of soil researches and main source is a Soil map of BiH 1: 50.000 with interpretations of sections. There are three main priorities for agricultural land:

- 1st demining priority in area of 9.486,79 hectares
- 2nd demining priority in area of 19.353,82 hectares
- 3rd demining priority in area of 349,06 hectares

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Ways to abbreviate chemical and vital activities in Al Assi water for secure agricultural investment in the middle area of Syria

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Abstract

Is it possible to limit the spread and inflation of alga's and laurencia increasing within Al Assay river by depriving the alive block from the readiness of the chained root of orthophosphate by adding the crushed and gluey gypsum (0.125 micron) diameter, by rate 1/10 until 1/80 and chare the useful bacteria to the drainage water at its end. And since the ammonium root NH4 is considered to be the source of Nitrogen element. It is possible to get rid of it by destroying this root. It is doable by using useful bacteria (pseudomonas sp. & pseudomonas aeruginosa) in the cooperation tie of NH3 which usually scatters leaving proton H+. This single detail reinforces the hydrogen exponent to the river water close to 7.6 hence it prohibits the alive block from the growth element and energy which is phosphorus.

As the irrigation of the crops by using treated river water will raise the saltiness of water in sulphate form. In the end this will be enough to increase the secure agricultural products. Through its stream from Homs to Jisr Al Shoughour within the Syrian lands.

Key words: Appreviate, Chemical and Vital activities, Alassi water, Syria

1 Introduction

Alassi River is considered one of the international rivers, 571 km long inside Syria, from which the most important cities of the Middle Region (Homs and Hama) have their drinking water, and it irrigates their plains and other plains with an area of 72000 Hectares which is one of the most fertile agricultural soils in Syria.

The existence of the biomasses of the mosses and algae in the River's water and the phytoplankton and the zooplankton accompanying them (Directorate of Pollution Control,2003) which are considered the main consumer of the Dissolved Oxygen (DO), leads it to pollution (Erhard,1983), because the carried organic substances, particularly the mosses growing in Al Rastan Dam Lake, and their moving specially at the end of the annual water storage season, cause troubles in using the water for irrigation in Alghab Plain and Alrouj, and sometimes lead to the absence of life in the river in the periods of their concentration in Summer, in addition to the chemical pollutants such as Phosphorus and Nitrogen which play an important role through their forming with water the nutrient medium appropriate for the growth of the mosses, algae and other various forms of the phytoplankton and the zooplankton, in addition to the sewage wastes such as sludge and the dissolve organic substances (ACSAD, 1998).

The research aims at enriching Alassi River water with the Dissolved Oxygen through restricting the bioactivity and the increase of the chemical pollutants.

- Adding the colloidal ground gypsum compound (as a fixation factor).
- Using the bacteria assisting in the reduction of Ammonium Radical.

2 Materials and methods

Water Specimens were taken from 28 distant sites affiliated to Observation Stations located along Alaasi riverbed, every week during two consecutive years (Monthly Bulletins). The agricultural mediums and the microorganisms were used through the farming, insulation and purification mediums, such as the Selective Mediums, the Differential Mediums, the Enrichment Mediums and Natural Mediums from the river water.

The Laboratory Analyses included:

- Measuring the temperature by using a Mercury Thermometer and the pH by using Sension 1 Device.
- The amount of the Dissolved Oxygen, and the BOD5 by Winkler Method (Rodier J. 1978), and COD was estimated by Titration with Potassium Permanganates (Rodier J. 1978).
- The Total Hardness TH and the Calcic Hardness: by the adding the Tri-Complex EDTA 50 Standard (Rodier J. 1978).
- Nitrate NO3- by Titration with Sodium Salicylates (Rodier J. 1978).
- Nitrate NO2- by using the Reagent (Griess A & B) (Rodier J. 1978).
- Ammonium $NH4^+$ by using Nessler Reagent (Rodier J. 1978).
- Electric Conductivity on Sension 5 Device.
- Turbidity by using 2100 P Device.
- The Suspended Solid Materials SS by using DR 890 Colorimeter Device.
- In addition to the calculation of the Sodium Adsorbed Rate SAR, Chloride and Sodium.

- First, the manual grinding process was conducted on the gypsum specimens, then they were sifted with sifts of fine meshes gradually starting from 2 to 0.125 micron meshes.
- Chloride Cl- by Mohr Method by using the Chromes as Reagents, then the seepage was treated by using 0.01 of Silver Nitrate AgNo3.

The Statistical Analysis was done by using the Mathematical Relations of the Second Degree.

- (Figure 1) shows the development of the pH in Alassi River water.
- (Figure 2) shows the development of the Hardness in Alassi River water.
- (Figure 3) shows the relation between Orthophosphate Phosphorus and the pH in Alassi River water.
- (Figure 4) shows the relation between Orthophosphate Phosphorus and the Total Hardness in Alassi River water.
- (Figure 5) shows the relation between Orthophosphate Phosphorus in Alassi River water.
- (Figure 6) shows the development of Ammonium Nitrogen in Alassi River water.
- (Figure 7) shows the relation between BOD and DO in Alassi River water.
- (Figure 8) shows the relation between the Chloride and the Sodium Adsorbed Rate in Alassi River water.
- (Figure 9) shows the relation between SAR and EC in Alassi River water.

3 Results and discussion

3.1 The relation between the phosphorus, acidity and total hardness:

It is noticed from “Figure 1” that the mainstream for the change of the pH is in decrease, though there is dispersion at the two sides of the linear relation, sometimes upwards and sometimes downwards. The rise represents Kattina, Muhardeh and Alasharna Lakes, while the drop is attributed to the ports of the untreated sewage water in Arzeh, Khattab, Jisser Alshoghour and Hammamat Alsheikh Issa, where the pH value ranged between 7.4 (Khattab Station) and 8.45 (Kattina Lake Station). The drop in the Hydrogen pH values in Karkour and Jisser Alshoghour Stations (1 and 2), and Alassi after Alabiad and Hammamat, is interpreted by the rise in the hardness values in the water of these Stations (Figure 2). The high hardness of the water is attributed to its containing the soluble Calcium Chloride and Magnesium Chloride such as Calcium Bicarbonates and Magnesium Bicarbonates, and the little soluble Chlorides such as Calcium Sulphates and Magnesium Sulphates. The Calcium Ions contained in this water may accelerate the process of Orthophosphate Phosphorus fixation in the form of Di-Calcium-Phosphate $Ca(HPO_4)_2$ and Tri-Calcium-Phosphate $Ca_3(PO_4)_2$. However, it is noticed that the fixation process had not taken place actually except by the rise in the hardness values over 320 mg/l. (Figure 4).

Table 1: The average values of the water specimens analysis for the selected Stations on Alassi riverbed during 2002/2003/2004.

StationNo.	TH mg/l	Cl^-	pH	EC	SAR	BOD	DO%	$N-NH_4$	$P-PO_4$
Rableh	221.05	81.55	8.00	341.90	1.76	9.62	89.51	0.39	0.
Alkantara	206.43	82.32	8.11	349.00	0.22	5.00	86.29	0.66	0.39
Alnabi Mando	205.42	86.05	7.92	361.26	0.96	12.05	84.59	0.59	0.52
Kattina lake	210.26	99.66	8.45	368.46	0.40	19.10	83.97	1.55	2.74
Exit lake	238.42	104.74	8.44	396.79	0.93	21.71	69.28	1.38	4.31
Alsham street	245.26	115.59	8.14	458.46	0.49	28.66	57.54	2.71	6.75
Triboli street	284.47	142.53	7.96	613.00	0.95	36.62	40.84	3.02	5.53
Aldouir	319.21	187.34	7.75	836.31	1.16	72.57	32.33	8.87	13.34
AlGhanto	334.74	194.68	7.59	872.83	1.15	77.38	52.29	9.22	14.93
Ghajar Amir	342.63	199.11	7.69	886.76	1.37	73.45	83.62	10.40	14.95
Alrastan lake	264.14	159.59	7.87	631.24	1.29	43.41	76.46	2.25	3.68
Ghor Alassi	261.32	173.34	7.83	672.97	1.00	46.60	79.45	3.88	3.90
AlGhassal at	290.53	188.03	7.90	761.76	1.19	44.88	79.63	1.86	2.43
Aljinan	296.84	188.21	7.92	758.90	1.24	46.10	63.23	1.84	2.35
4	289.47	175.36	7.82	737.39	1.56	48.52	46.98	2.89	2.92
Aldahirye h	256.84	190.00	7.64	729.48	1.17	62.62	28.06	4.87	6.52
Arzeh	256.84	200.00	7.50	816.48	1.36	84.97	18.00	9.53	12.32
Khattab	260.00	207.50	7.43	806.00	1.52	134.23	18.00	9.87	10.05
Muhardeh dam	243.68	175.00	8.27	714.50	1.09	49.32	69.10	4.83	9.07
Sheazer	310.26	210.36	7.80	860.18	0.88	55.29	66.37	5.07	7.43
Alsafsafie h	317.63	211.80	7.75	758.14	1.23	43.45	48.90	6.23	4.71
Alasharna	310.53	223.40	8.10	767.88	1.09	38.41	72.46	3.53	2.20
Karkour	537.63	255.48	7.85	1149.79	1.91	48.47	79.89	0.95	0.64
Jisser Alshogho ur 1	559.47	284.19	7.77	1258.85	1.25	51.24	80.65	1.88	1.30
Jisser Alshogho ur 2	556.32	275.37	7.60	1246.85	2.15	95.67	41.63	9.51	6.85
Alassi after alabiad	514.67	322.02	7.65	1205.50	1.47	82.67	56.02	1.82	2.55
Hammam at Alsheikh Issa	596.36	338.48	7.73	1274.70	2.06	74.80	67.83	1.71	5.69
Darkoush	418.39	237.85	7.61	1033.67	4.83	45.09	74.83	0.89	1.12

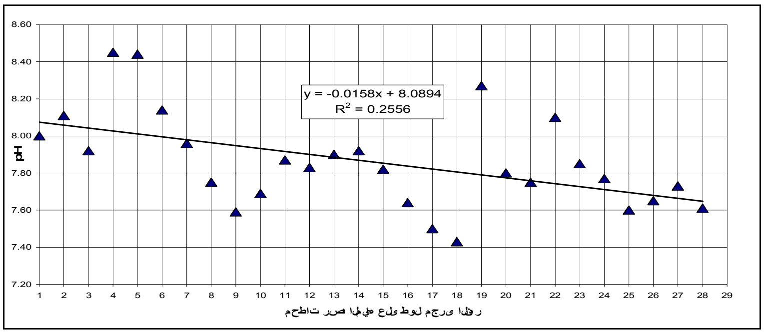

Figure 1: *The development of the pH in Alassi River water..*

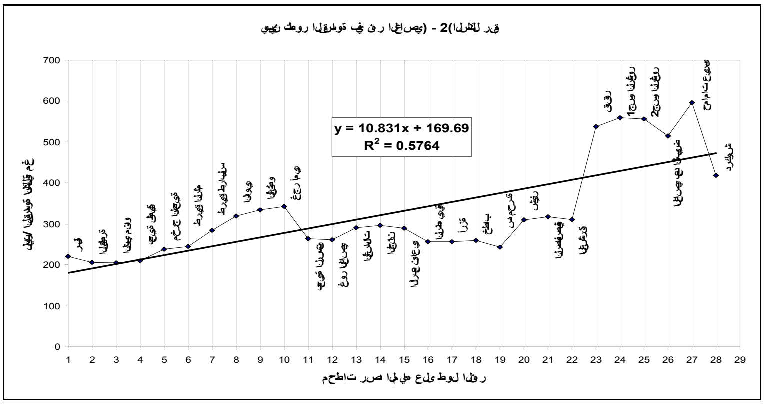

Figure 2: *The development of the Hardness in Alassi River water.*

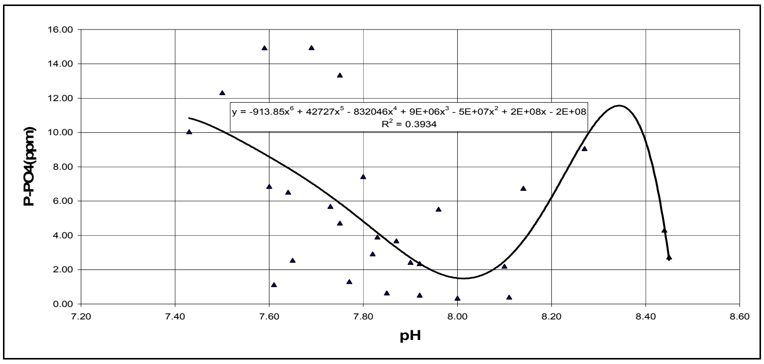

Figure 3: *The relation between Orthophosphate Phosphorus and the pH in Alassi River water.*

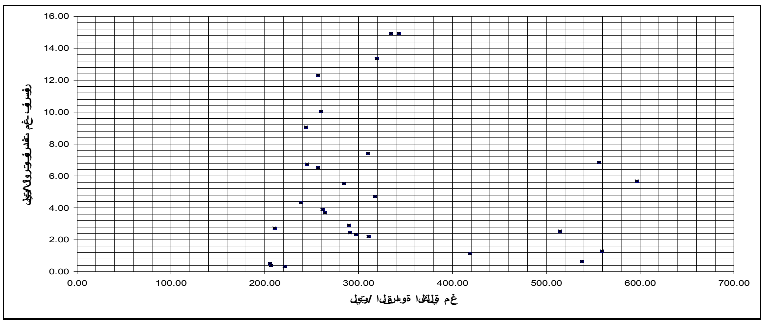

Figure 4: *The relation between Orthophosphate Phosphorus and the Total Hardness in Alassi River water.*

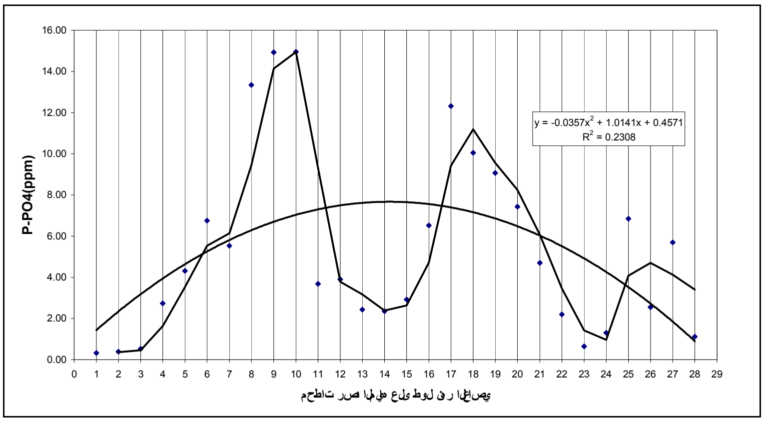

Figure 5: *The relation between Orthophosphate Phosphorus in Alassi River water.*

This And "Figure 5" shows the rise in the Phosphorus values in Alassi River water after its entering the Syrian Territories, to record more than one maximum value. These maximum values correspond to maximum values in Hardness, indicating the enrichment of the river water with Calcium and Magnesium Compounds from the Bicarbonates (the temporal hardness) and Sulphates (the constant hardness), by which the total hardness is measured.

The rise of the Orthophosphate Phosphorus concentration in the sites of the maximum values is interpreted by its relation to the sewage ports, industrial ports and sewage and industrial ports together, and the correspondence by rise in the hardness value. However, the Phosphorus change range in the water content of the Observation Stations has been restricted within a hardness range between 200 and 320 mg/l. beyond this range, the Orthophosphate Phosphorus is being fixed. The fixation range is restricted beyond the Power of Hydrogen range between 7.6 and 8, i.e. the Orthophosphate Phosphorus is changed into an insoluble form and is precipitated producing Di-Calcium-Phosphate and Tri-Calcium-Phosphate due to the rise of the Calcium Ions in river water beyond these two limits, according to the following two reactions:

$Ca(H_2PO_4)2 + Ca_2+ = 2CaHPO_4 + 2H^+$

$2CaHPO_4 + + Ca_2+ = Ca_3(PO_4)^2 + 2H^+$

3.2 Behavior of ammonium nitrogen in Alassi river water:

It is noticed from "Figure 6" that the behavior of Ammonium Nitrogen is relatively affiliated to the behavior of Orthophosphate Phosphorus, through giving maximum values corresponding to the outlets of the sewage and industrial ports to the River Basin. This maximum value amounts to 9.5 mg/lt. (Observation Stations 8-9-10-17-18).

Nitrate Ion (NO3) is considered the top of the Nitrogen Oxidation Stages. This Ion is distinguished by high dynamics, where it is soluble in water and has no connection to the colloidal soil complexes, leading to the speed in washing it, where it reaches the groundwater and pollutes it (Yassin, 2006). It is one of the nutrient enrichment elements in the general water, lakes and reservoirs. This Ion is produced from the industrial pollution sources, particularly the factories of the Nitrate Fertilizers and Agricultural Sewage Networks. While the Ammonium Ion (NH4+) exists in the surface and polluted water, and its concentrating in the groundwater is little since it represents an Ion liable to absorption and adsorption by the surfaces of the colloidal complexes in soil.

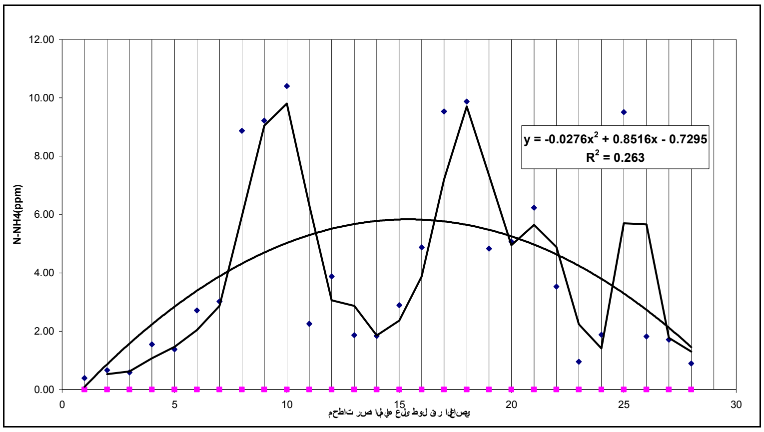

Figure 6: *The relation between Orthophosphate Phosphorus in Alassi River water*

This It behaves as the Potassium Ion, and it is produced from the hydration of the organic substance containing Ammonium Radical or from the hydration of the Urea by bacteria or what the bio-cell discharges in general. It might also be produced by the industrial sewage, particularly the Nitrogen Fertilizers Industry, or the Agricultural Sewage or the Sewerage Networks.

3.3 The relation between BOD and DO in the river water:

The rise of the Phosphorus and Nitrogen content in Alassi River water is accompanied by an increasing growth of the Algae, Mosses and Microorganisms such as the phytoplankton and the zooplankton. All these organisms need the Oxygen dissolved in water either for breathing or for the oxidation of the organic substances. An Index should be accredited here for indicating the pollution degree in the River water, such as what is known as the Bio-Oxygen Demand BOD5 or what is known as the Oxygen amount in water which is used for the oxidation of the organic compounds (BOD) or the chemical compounds (COD) contained therein (Habib, Ibrahim Mohammad, 2003). The bigger the organic pollution has been the more oxygen will be demanded. This could be known through measuring the Dissolved Oxygen before and after incubation. The water will be clean or little polluted if the value of the BOD5 has been less than 2.9 mg/lt., and will be polluted if over 10 mg/lt. There is a reverse relation between it and the Dissolved Oxygen, where its value in the clean and little polluted water reaches 8 – 11 mg/lt. according to the Season, and in the most polluted water reaches 0.5 - 2 mg/lt. according to the Season, as shown in the Second Degree Mathematical Relation as per “Figure 7”.

The Percent of the Dissolved Oxygen (DO %) rises in proportion to the purity of water, the decrease of its temperature, the rise of the atmospheric pressure, and the existence of the green organisms producing it by presence of light. The safety limits in water uses is 55 % of the saturation limit of this gas in water, where the aerobic bacteria consumes the dissolved oxygen for using it in its bioprocesses, in producing energy and in fixing the substances liable to oxidation in water, while the demanded Bio-Oxygen (B.O.D) is one of the most important and most common indicators for determining the degree of general water pollution with the carried organic materials, according to which the rivers are classified and the treatment units are designed and their operation yield and efficiency is determined.

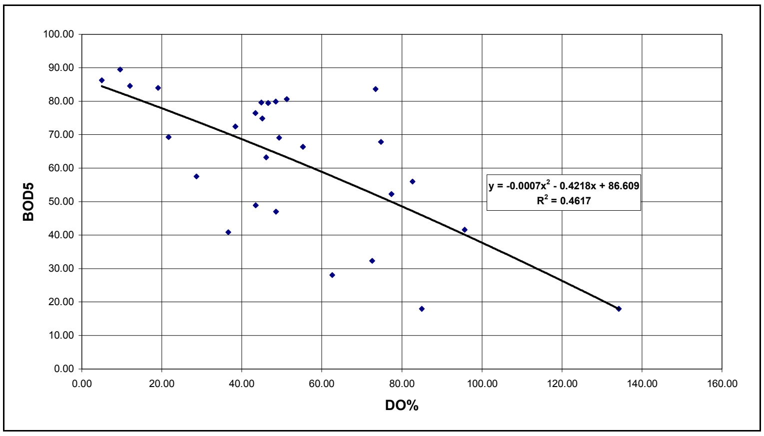

Figure 7: *The relation between BOD and DO in Alassi River water*

3.4 Salinity quality and amount, and alkaline risk:

The Chloride Values for the Water Specimens of the Observation Stations along Alassi Riverbed in the Syrian Territories were concentrated between two values of the Sodium Adsorption Rate(SAR) Values (1-2) to reach its maximum value of 322 mg./lt. The relation between the Chloride and SAR (Alkaline Effect) adopts a Second Degree Equation, where the salts soluble in the River water prevail in the form of Chloride Salts with Sodium, Magnesium and Calcium (Figure 8).

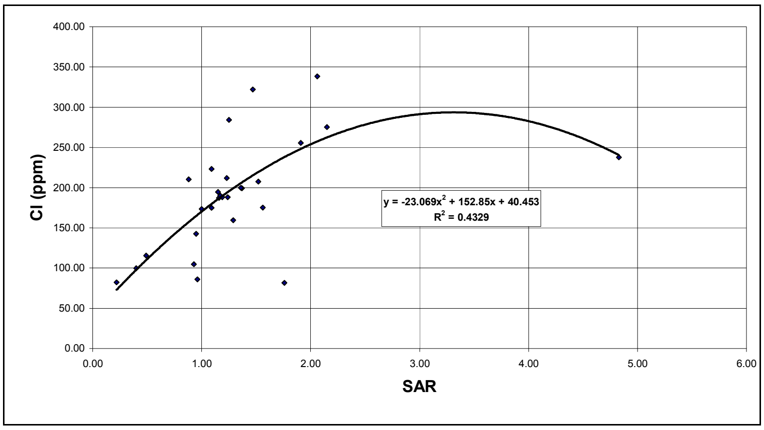

Figure 8: *The relation between the Chloride and the Sodium Adsorbed Rate in Alassi River water*

The rise of the Magnesium and Calcium Ions in the River water is the element that restricted the rise in SAR Value (to less than 2) in most of the Stations which showed a relatively increasing relation with the rise of salinity, expressed by an electric conductivity estimated by Microsiemens /cm (to less than 1400 Microsiemens /cm) as shown in “Figure 9”. This is what interpreted the fixation of the Orthophosphate Phosphorus by Calcium Ions, where the hardness increased over 320 mg/lt., and under those circumstances of the Ionic composition, Di-Calcium-Phosphate (Ksp = 1.10-7) will be formed and also Tri-Calcium-Phosphate (Ksp = 1.10-26), and their precipitation due to scarcity of their dissolution.

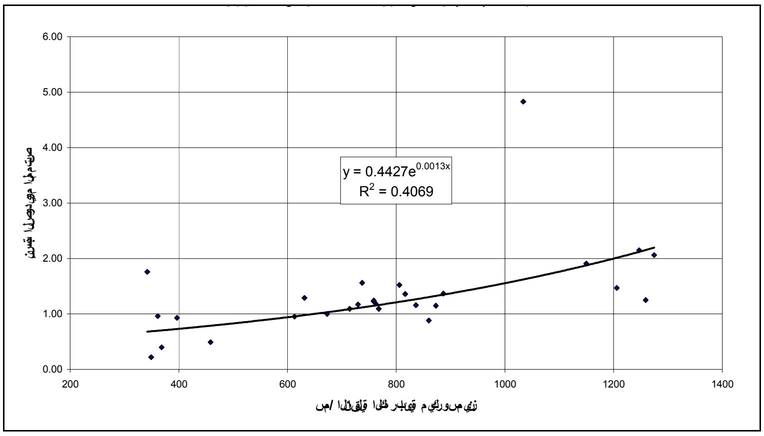

Figure 9: *The relation between SAR and EC in Alassi River water*

Microsiemens /cm) as shown in “Figure 9”. This is what interpreted the fixation of the Orthophosphate Phosphorus by Calcium Ions, where the hardness increased over 320 mg/lt., and under those circumstances of the Ionic composition, Di-Calcium-Phosphate (Ksp = 1.10-7) will be formed and also Tri

4 Summary / Conclusions

Alassi River comes from the South to the North in a sedimentary basin lacking gypsum compositions $CaSO_4.2H_2O$. Gypsum is a compound that crystallizes in a mono-inclination system, and 2.1 gr./lt. of it dissolves. Its dissolution increases with the absence of the co-Ions, to 6.3 gr./lt., as the case in Alassi River Water where the Chloride Salts with Sodium, Potassium, Calcium and Magnesium prevail. The Biogeochemical technology (Safar, 1997) can be applied through grinding it colloidally (Mesh 0.125 Microns) for the purpose of increasing its specific surface, and adding it to the ports which form the outlets for the industrial, agricultural and sewage water, where the total hardness in those ports is less than 300 mg./lt., for the purpose of precipitating the Orthophosphate Radical in form of Di-Calcium-Phosphate and Tri-Calcium-Phosphate Compounds within the field of the Power of Hydrogen Range between 7.6 and 7.9 (due to the existence of the gypsum compound) according to the following reactions:

$Ca(H_2PO_4)_2 + CaSO_4.2H_2O$ ---------- $2CaHPO_4 + H_2SO_4 + 2H_2O$

$2CaHPO_4 + CaSO_4.2H_2O$ ---------- $Ca_3(PO_4)_2 + H_2SO_4 + 2H_2O$

In order to overcome alkaline effect of the irrigation water resultant from the increase in the Sodium Ions concentration, this water is to be passed over the Sulphate and Calcium Carbonates Stones. However, the dissolution of the first is estimated by about 2.1 gr./lt. and the second by about 11 mg/lt. . It should be mentioned here that with overcoming the alkaline effect, the salinity effect of the water containing the Calcium Salts will increase, and the increase rate in the salinity is expressed by the electric conductivity (Table 2).

For the purpose of gradual change from relative salinity in the Chloride form into a salinity in the Sulphate form, it is preferable to irrigate the farming crops with water where the latter prevails, in order to avoid the effect of the Chloride as a radical oxidizing to the membranes of the phyto-cells and zoo-cells first, and second to reduce the alkaline effect of the Sodium Ions (SAR) in the soil property for protection from the deterioration in Homs, Hama, Alasharna, Alghab and other Plains.

As for removal of Ammonium Radical NH_4^+ as a source for the Nitrogen Element, this is conducted through breaking this radical by useful bacterial such as Pseudomonas sp and

Pseudomonas aeruginosa (Yassin, Mufid, 2006), and in the location of the Coordination Bond in order to release the Ammonia Gas NH_3 which spread leaving behind a Proton Ion H^+, which in turn consolidates the Power of Hydrogen for the River Water (where it remains close to 7.6). Thus, the biomass will be deprived from the growth factor and the energy element (Phosphorus), and there will be oxygen available (high values of DO and low values of BOD) adequate for breaking the sludge carried with the sewage water; thus reviving the river in its storage lakes and its riverbed inside the Middle Region of Syria.

(Table 2) shows the effect of adding an increasing quantity of the ground gypsum on the change of the electric conductivity and the Hydrogen pH in two kinds of water: Euphrates River Water and the Mediterranean Sea Water after diluting it with distilled water (1/10 and 1/80) (on behalf of Kamel, 1988)

Table 2: The effect of increasing quantity of the ground gypsum on the change of the electric conductivity and the Hydrogen pH

pH	EC (ds/m)	crushed and gluey gypsum (g/l)
8.04	0.400	0.0 Euphrat water
7.85	0.494	2.5
7.85	2.210	5.0
7.85	2.360	10.0
7.04	7.400	0.0 Sea water (1/10)
7.95	8.240	2.5
7.95	8.520	5.0
7.85	8.520	10.0
-	1.240	0.0 Sea water (1/80)
7.75	2.490	2.5
7.75	3.050	5.0
7.75	3.200	10.0

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Impact assessment of Road M-17 (Sarajevo-Zenica) on land

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Abstract

Analysis of the current situation of contamination on the part of road M-17 have to establish the extent and size of the influence of road on the surrounding soil, as well as to determine possible forms of damage (contamination). Trying to determine whether there, and if it is to what extent the road studied cause of soil pollution with heavy metals. Researches are carried out at different distances from the road (5 m, 15 m, 30 m, 50 m, 100 m, 200 m and 300 m) from two depths and 4 locations.

The following elements have been analyzed: Lead (Pb), Cadmium (Cd), Cobalt (Co), Zinc (Zn), Copper (Cu) and Manganese (Mn).

Based on the research, it can be stated that one analyzed area (closer to road) is polluted with some inorganic pollutants.

Most of the researched samples were in the domain of contamination.

In this paper the decontamination measures are proposed, as well as the choice of agricultural crops that may grow on soils with increased content of individual pollutants

Key words: contamination, heavy metals

1 Introduction

Soil is the basic natural resource and one of its most important functions is the food production. It is one of the largest if not the greatest natural wealth of each country. However, the soil is used by other users too, outside the field of agriculture and forestry, such as urban planning, transport, industry, etc.

Land exploitation in the fields outside of agriculture and forestry has been especially intensive in the last half-century. Increased industrialization and technological progress have undoubtedly multiple benefits, but at the same time, have caused the whole range of consequences which have been manifested on the surrounding area including the land.

1.1 Goals

1. Identifying the level of the land contamination at a particular distance of the road;
2. Identifying levels of contamination in relation to the depth of soil;
3. Establishing the contamination impact on agricultural and forest soil, and how it is manifested in different ways of soil usage;
4. Identifying accurate causes of contamination, or whether it is only caused by traffic contamination and in which form;
5. Defining contamination bandwidth for different road categories

2 Materials and methods

Field work

- Oversight of the field and the choice of location
- Terrain probing
- Opening the soil profiles
- Taking the samples from the soil surface

Laboratory testing

a. Physical properties:

- Determination of the texture composition by International pipette,"B" method
- Determination of the texture by Ehwald
- Determination of skeleton in the soil by Fiedler
- Determination of macrostructure aggregate's stability by Gračanin-Şekera
- Determination of permanent and specific density by pycnometer
- Determination of soil density in the Kopecki cylinder
- Determination of the absolute air and water capacity from the Kopecki cylinder

b. Chemical Properties:

- Determination of soil pH in water and in 1M KCl electrometrically in suspension 1:2,5
- Determination of humus with a colorimetric method with oxidation in $K_2Cr_2O_7$
- Determination of total $CaCO_3$ by gas-volumetric method on Scheibler's calcimeter
- Determination of easily dissolvable P_2O_5 and K_2O by AL method by Egner-Rich-Domingo
- Determination of Aluminum mobility by Sokolov
- Determination of replaceable basis content and soil adsorption capacity by Kappen
- Determining the saturation level of the soil's adsorptive complex with basic cations

- Determining the content of total forms of Pb, Cd, Cu, Co, Zn and Mn in AAS with Aqua Regia as extractor.

Methodological criterion

- Soil classification based on genesis
- The criteria of soil fertility (pH in H_2O, humus in %, P_2O_5 and K_2O in mg/100g of soil, Al_2O_3 mg/100 g of soil)
- Land categorization values (based on morphological, chemical, physical and biological properties)
- Elements of soil contamination with heavy metals
  - the importance of understanding the contamination,
  - contamination causes (lithogenic, anthropogenic and technogenic),
  - limiting values

Table 1: Content of heavy metals in various rocks in mg / kg

Rock type	Mn	Cu	Zn	B	Mo	Co	Cr	Ni	As	Cd	Hg	Pb
Ultra-alkaline rocks	1600	10	50	2	0,3	150	1600	2000	1	0,05	0,02	1
Basalt and Gabbro	1400	90	100	5	1	50	170	130	1,5	0,15	0,02	4
Phyllite	700	25	80	50	1,5	13	75	25	4,3	0,15	0,02	20
Granite	325	15	50	15	1,8	4	12	7	1,5	0,09	0,03	30
Claystones	850	45	95	100	1,3	20	90	70	10	0,03	0,45	22
Sandstone	50	5	15	35	0,2	0,3	35	2	1	0,05	0,03	7
Limestone	700	4	25	20	0,4	2	11	15	2,5	0,16	0,03	5
Loess	500	13	45	60	1,2	8	35	20	7	0,3	0,05	25
Marlstone	500	11	40	50	1	6	30	18	5	0,3	0,04	20

Table 2: Limit values of heavy metals in the total form

Element	mg/kg (ppm)	
	sandy and skeletal soils (light soils)	Loamy and clay soils (medium and heavy soils)
Lead (Pb)	100	150
Cadmium (Cd)	1	2
Copper (Cu)	60	100
Zinc (Zn)	200	300
Cobalt (Co)	50	50
Manganese (Mn)	850	850

•Cabinet work

- Data processing and research results (characteristics of the surveyed sites, processing the results of research, damage description, and land recovery measures and recommendations)
- Creating : maps, graphs and tables
  - Territory map M 1:100 000
  - Soil maps M 1:2 000
  - Land category maps M 1:2 000
  - Maps of soil fertility M 1:2 000
  - Contamination of heavy metals M 1:2 000
  - Development of water balance
  - Tables of the research results
  - Photographs of researched places and profiles

3 Research results

Site: **Luka**

Table 3: Minimum and maximum values of elements in on the right side of the road

Distance (meters)	Depth (cm)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Pb (mg/kg)
5	0-10	1.265,00	39,20	72,00	4,20	11,20	142,80
	10-30	1.380,00	34,72	67,50	2,60	22,40	55,60
15	0-10	1.242,00	39,20	70,20	**8,40**	22,40	142,80
	10-30	1.288,00	34,90	64,50	**10,40**	22,40	37,30
30	0-10	1.205,20	39,20	78,00	8,40	11,20	142,80
	10-30	1.278,80	39,06	72,00	2,60	22,40	107,10
50	0-10	1.311,00	34,72	72,00	2,60	22,40	142,80
	10-30	1.242,00	34,90	64,80	2,60	22,40	71,40
100	0-10	1.209,80	39,06	79,50	5,20	11,20	142,80
	10-30	1.255,80	30,38	64,80	4,20	33,60	71,40
200	0-10	1.297,20	47,74	82,50	2,60	33,40	107,10
	10-30	1.352,40	43,40	81,00	<1,00	22,40	107,10
300	0-10	1.012,00	34,90	69,00	2,60	22,40	55,60
	10-30	1.113,20	39,20	63,00	2,60	22,40	107,10

Site: **Luka**

Table 4: Minimum and maximum values of elements on the left side of the road

Distance (meters)	Depth (cm)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Pb (mg/kg)
5	0-10	1.370,80	34,90	75,80	<1,00	22,40	107,10
	10-30	1.269,60	39,20	70,20	<1,00	22,40	93,75
15	0-10	694,60	39,20	63,00	<1,00	22,40	**171,40**
	10-30	621,00	34,90	54,00	<1,00	11,40	**171,40**
30	0-10	933,80	43,60	69,00	5,20	22,40	107,10
	10-30	1.039,60	43,60	69,00	2,60	<1,00	142,80
50	0-10	**1.554,80**	39,20	84,00	5,20	<1,00	138,35
	10-30	**1.508,80**	34,90	72,50	5,60	<1,00	71,40
100	0-10	1.408,80	39,20	101,50	5,60	22,40	71,40
	10-30	1.067,20	39,20	100,50	2,80	22,40	71,40
200	0-10	561,20	26,04	64,80	<1,00	22,40	62,50
	10-30	561,20	21,70	64,50	<1,00	22,40	62,50
300	0-10	538,20	25,60	55,10	5,20	22,40	71,40
	10-30	446,60	26,20	55,10	7,80	22,40	71,40

Site: **Donja Zimča**

Table 5: Minimum and maximum values of elements on the right side of the road

Distance (meters)	Depth (cm)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Pb (mg/kg)
5	0-10	809,60	28,30	43,50	2,60	33,60	**107,10**
	10-30	828,00	26,20	46,40	7,80	28,00	93,75
15	0-10	800,40	34,90	49,50	**7,80**	22,40	71,40
	10-30	846,40	26,20	45,00	2,60	28,00	71,40
30	0-10	800,40	30,50	55,10	2,80	<1,00	62,50
	10-30	864,80	26,20	46,10	2,80	<1,00	62,50
50	0-10	713,00	30,50	57,00	<1,00	<1,00	65,50
	10-30	782,00	26,20	55,50	2,60	22,40	37,30
100	0-10	841,80	28,30	56,40	2,60	22,40	62,50
	10-30	855,60	32,70	58,00	**7,80**	33,60	**107,10**
200	0-10	851,00	28,30	57,00	5,20	22,40	71,40

	10-30	851,00	30,50	55,50	5,20	33,60	**107,10**

Site: **Donja Zimča**

Table 6: Minimum and maximum values of elements on the left side of the road

Distance (meters)	Depth (cm)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Pb (mg/kg)
5	0-10	763,60	30,50	61,50	2,60	38,00	65,50
	10-30	846,40	30,50	64,50	<1,00	39,00	62,50
15	0-10	736,00	44,00	67,50	<1,00	28,00	71,40
	10-30	759,00	34,90	72,00	<1,00	11,20	35,70
30	0-10	708,40	28,30	55,00	<1,00	19,40	<1,00
	10-30	671,60	22,00	50,10	<1,00	11,20	30,60
50	0-10	442,00	30,50	48,00	1,50	25,80	61,20
	10-30	403,00	26,20	47,80	3,10	12,90	61,20
100	0-10	604,50	39,20	58,50	<1,00	12,90	71,40
	10-30	680,80	32,70	49,40	<1,00	25,80	61,20
200	0-10	**1.311,00**	39,60	91,70	6,20	38,80	91,80
	10-30	**2.001,00**	44,00	93,10	<1,00	38,80	61,20

Site: **Smiljevac (Mioče)**

Table 7: Minimum and maximum values of elements on the right side of the road

Distance (meters)	Depth (cm)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Pb (mg/kg)
5	0-10	877,50	35,20	79,50	1,50	45,20	61,20
	10-30	877,50	35,20	73,30	**9,20**	38,80	61,20
15	0-10	966,00	35,20	74,70	**3,10**	**51,70**	91,80
	10-30	887,80	35,20	56,40	<1,00	**51,70**	91,80
30	0-10	**1.251,20**	39,60	98,70	<1,00	**51,70**	76,50
	10-30	**1.278,80**	35,20	96,00	**4,60**	25,80	71,40
50	0-10	1.035,00	48,00	96,00	3,10	38,80	71,40
	10-30	1.039,60	39,60	91,70	<1,00	**51,70**	61,20
100	0-10	**851,50**	45,80	76,50	<1,00	19,40	**107,10**
	10-30	838,00	43,60	70,50	<1,00	<1,00	**107,10**
200	0-10	1.053,00	35,20	123,00	<1,00	<1,00	71,40
	10-30	1.196,00	26,40	97,50	<1,00	<1,00	45,90

Site: **Gradina**

Table 8: Minimum and maximum values of elements on the left side of the road

Distance (meters)	Depth (cm)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Pb (mg/kg)
5	0-10	690,00	39,20	120,00	<1,00	<1,00	71,40
	10-30	795,80	34,90	107,20	<1,00	6,50	71,40
15	0-10	381,80	30,50	104,30	3,10	<1,00	71,40
	10-30	381,80	30,50	107,20	3,10	<1,00	71,40
30	0-10	501,40	39,20	115,60	**6,20**	25,80	61,20
	10-30	561,20	39,20	119,90	4,60	12,90	61,20
50	0-10	**883,20**	48,40	147,00	**6,20**	12,90	91,80
	10-30	**897,00**	34,90	109,50	4,60	12,90	91,80
100	0-10	450,80	35,20	109,50	4,60	<1,00	91,80
	10-30	510,60	33,00	112,50	**7,00**	<1,00	91,80
200	0-10	611,80	35,20	138,20	<1,00	<1,00	**107,10**
	10-30	680,80	39,20	130,50	<1,00	<1,00	**137,70**

4 Summary / Recommendations

- One part of the area was contaminated with **Lead**, particularly the area of Luka. At other sites the contamination was significantly lower;
- Concerning **Cadmium,** the largest contaminated area was also at the area of Luke. Increased content on the left side of the road is a result of the river Bosna flooding. Contamination was also found at Donja Zimča and Gradina site. Minor contamination was present at the site of Smiljevac (Mioče);
- No location was found with the exceeding limit values of **zinc**. Average contamination was found at the Smiljevac (Mioče) and Gradina site ;
- Content of **Copper** is within the limits at all locations;
- Values of total **Cobalt** in soil are not exceeding limit values. Most investigated samples were in the domain of low contamination;
- The contents of **Manganese** at the site of Luke, Smiljevac and Gradina was above the limit values, but the origin is probably geological;

4.1 Remediation measures for contaminated area

Liming - in case when the soil pH reaction is acid (<6.5 in KCl), chopped limestone, dolomite and marl are used.

Growing plants (biological remediation) that do not accumulate toxic substances in their edible part.

Growing plants (Phyto-remediation**)** that can extract larger quantities of heavy metals from the soil (mowing, burning and ash burial).

Table 9: Choice of crops in case of soil contamination with **Cadmium**

Can grow	Avoid growing
Potatoes	Cabbage
Corn (grain)	Salad
Barley (grain)	Spinach
Oats (grain)	Celery

Table 10: Choice of crops in case of soil contamination with **Lead**

Can grow	Avoid growing
Corn (grain)	Celery
Wheat (grain)	Spinach
Oats (grain)	Cabbage
Potatoes	
Carrots	

Table 11: Choice of crops in case of soil contamination with **Zinc**

Can grow	Avoid growing
Corn (grain)	Celery
Wheat (grain)	Spinach
Barley (grain)	Cabbage
Sunflower (seed)	
Potatoes	
Tomato	

4.2 Recommendations for future researches

1. Monitoring the changes of heavy metals content at different distances from the road
2. Monitoring the changes of heavy metals content at different depths
3. To investigate the cause of changes (lithogenic, anthropogenic and technogenic)

4. Monitoring the content of organic pollutants (oil and oil derivatives)
5. Monitoring the content of heavy metals in certain agricultural crops that are grown near the road

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Causes of soil damages in Bosnia and Herzegovina and soil protection measures

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Abstract

Soil is one of the most important natural resources. Its primary function is in the production of food and raw materials, in the spheres of agriculture and forestry. Bosnia and Herzegovina is under the intensive influence of many soil degradation processes, which are in some areas especially expressed. This paper describes the main causes of soil damage in Bosnia and Herzegovina. It groups as follow: surface exploitation of various raw materials, the building of settlements on arable land, the development of water erosion and land sliding and the presence of land mines. Consequences of soil damage in Bosnia and Herzegovina groups into four different classes: soil infection, soil contamination, soil degradation and soil destruction. The paper ends by examining some of the actions taken towards protecting and rehabilitating soils in Bosnia and Herzegovina. These include: soil recultivation and remediation, harmonization of the relationship between ecological and technical soil functions, changes in the kind of soil use on slopes, soil monitoring, soil information system establishment, de-mining processes and the important need to elaborate one special law, i.e. a law for soil protection.

Key words: soil, damages, protection, measures

1 Introduction

Soil is one of the most important natural resources. Its primary function is in the production of food and raw materials, in the spheres of agriculture and forestry. These uses will be present into the future, and as populations grow and develop, society will need more food, new settlements and industry, roads, exploitation of various raw materials, etc, potentially increasing the pressures upon soil. It is therefore important to consider how these potentially conflicting tendencies may be addressed in harmony. It is necessary immediately to emphasize that absolute measures for soil protection do not currently exist. However, it is possible to apply such measures and care, by which the loss of good soils may be reduced. In doing this, it is possible to harmonize the relationships among the great number of diverse pressures on soil resources.

Bosnia and Herzegovina is under the intensive influence of many soil degradation processes, which are in some areas especially expressed. Efforts towards harmonisation and decreasing the damage are just beginning, and so the problems of soil degradation remain serious at present. The reasons for this are numerous. They include: the relationship of society to the soils - where people do not understand the importance of soil, no responsible policies exist for its protection. Also, the war, which was in this region, had many consequences for the soil. In addition, the use of land has an extensive character with strong features of irrational and elementary treatment.

2 Materials and methods

In this paper we have caracerized three main topics:

1. The relief, climate and soils specific of Bosnia and Herzegovina,
2. The causes and consequences of soil damages and
3. Soil protection measures for decreasing the negative consequences of soil degradation.

3 Results and discussion

3.1 The relief, climate and soils of Bosnia and Herzegovina

Bosnia and Herzegovina (BIH) is characterized by hilly-mountain relief, which occupies 83,5 % of the land area, of which 57,2 % is mountainous. The majority of soils are on slopes above 13 %. Of the total area of BIH which amounts 5.112.900 ha (51.112 km^2) 49,4 % is considered agricultural, 45,6 % is forest, and the area without vegetation and soils takes up about 5 %. Hydromorphic soils (i.e. soils which are under the influence of water surpluses) cover 568.860 ha, respectively 11,13 % of the agricultural area.

There are 0,59 ha of agricultural land per inhabitant, respectively 0,36 ha of arable land. As a consequence of the war the population has changed, from 4.300.000 (in 1991) to 3.300.000 (in 2002). The main reasons for the population decline are the high numbers of victims of war and the large numbers of refugees, driven from their homes because of the war in BIH.

In the relation to the climate, the amount of rainfall differs between the various parts of the country. The average amount of rainfall is 1.200 mm. In relation to the specific zones, these amount from 800 mm in the northern zone to 2.000 mm in the southern zone. By its position, Bosnia and Herzegovina is a Balkan country, but it is a Mediterranean country too.

Table 1: General situation of agrohydrological balance in BIH (mm).

Hydrological parameter	*BIH average*	*South area*	*Central area*	*North area*
Precipitation (P)	1.200,00	2.000,00	1.000,00	800,00
Potential ET-PET	725,00	900,00	650,00	700,00
Real ET-RET	600,00	600,00	600,00	600,00
Water Deficit-D	125,00	300,00	50,00	100,00
Water Surplus-S	600,00	1.400,00	400,00	200,00
Drought coefficient-P/PET	1,65	2,22	1,54	1,14
Outflow coefficient-S/P	0,50	0,70	0,40	0,20

Acid soils occupy 49 % of the area. The next most commonly distributed soils are: dystric cambisols, luvisols, pseudogley and gley soils and calcocambisols. Karstic fields occupy an area of about 150.000 ha.

3.2 The causes and consequences of soil damages in BIH

3.2.1 The causes of soil damages

The main causes of soil damages in Bosnia and Herzegovina groups as follows:

a. Surface exploitation of various raw materials

   There are a lot of deposits of coal, iron ore, and bauxite in Bosnia and Herzegovina. Mostly these are extracted through surface mining. During these operations, very deep and wide craters form. These areas are like the surface of the moon today. Surface mining has created about 20.000 ha of such degraded areas.

b. Agricultural soil Sealing

   This kind of soil damage is a result of war activities, which resulted in the movement of inhabitants away from some areas, causing them to concentrate in other zones. Such migration concerns mostly the movement of village inhabitants. For the possibilities of their relocation to new areas, it was necessary to built new settlements. In these actions, the building of the new houses mostly occurred on the best soils (I agro zone). The problem is greater because there are not very extensive areas of good soils in Bosnia and Herzegovina (only about 14 %). It is such pressure on this soil fund that caused the loss of large areas of the best soils. Inappropriate policy is a prime cause of this consequence, especially because policy was responsible for the development of the new settlements.

c. Disposals,

d. Water accumulations,

e. Infrastructure construction (roads, railways,…),

f. Industry,

g. Development of water erosion and land sliding,

   The problem of water erosion is present at the moment but also took place in earlier periods in this area. The great inclination of area favours water erosion, particularly when cultivation of the slopes takes place in order to grow crops. Increased intensity of water erosion results from the cutting of forest cover, which has the character of so-called "total cutting". During the war, the forest areas were cut very intensively, as a result of the needs of the army. The process of forest cutting is continuing, and during the post-war period, this has become much more intensive. This is especially because of the following reasons:

- need for wood and goods made of wood,
- need for new settlements,
- need for export of wood materials.

As a consequence of the lack of planning and elemental deforestation, especially on the strong inclined surfaces, very strong gullying appeared as a result of water erosion. Also, land-sliding developments have appeared as a result of such behavior. Very large areas have been affected by these processes.

h. Presence of land mines,

During the war, land mines were placed over large areas of land. It is estimated that about 420.000 ha of territory of Bosnia and Herzegovina is covered with land mines. It is calculated that there are more than 1 million mines on the 30.000 minefields. With such pressure of mines (besides bringing large dangers for inhabitants) comes significant economic consequences. These areas can no longer be used for agriculture. The process of de-mining is very expensive and needs to take place over a long period of time. It is estimated that the process of de-mining will last 20 to 30 years.

i. drought.

3.2.2 The consequences of soil damages

The main consequences of soil damages group into four different classes:

1. Soil infection,
2. Soil contamination,
3. Soil degradation and
4. Soil destruction.

Soil infection - this form of soil damage is necessary to separate as a special form of soil contamination. It is a consequence of households keeping a large number of dogs and cats, and may be attributed to their movement through the gardens, children playgrounds etc. Children are especially influenced by this. Soil infection in this form can cause all kinds of diseases (e.g. brucellosis, etc).

Soil contamination is caused by the deposition of various pollutants on and in soil, in various states of aggregation (Fig. 1 and 2).

Figure 1: *The sources of soil contamination (orig).*

Figure 2: *The sources of soil contamination (orig).*

Soil degradation in the narrower sense represents the soil damage caused by the use of soils in agriculture. The symptoms of degradation include soil compaction, unstable soil structure, erosion, etc (Fig. 3 and 4).

Figure 3: *The soil structure damages (orig.).*

Figure 4: *The soil structure damages (orig.).*

Soil destruction represents physical soil damage. This is the most common form of soil loss, and it has the character of pedocide. By this alone, Bosnia and Herzegovina loses about 3.000 ha yearly. In the frame of this process we summarise the main causes of this kind of soil loss in Table 2.

Table 2: The most frequent loss of agricultural land in BIH (estimation)

Cause of soil destruction	***Soil losses (per year)***	
	ha	***%***
- surface mining	900,00	30,00
- disposals	300,00	10,00
- settlements	600,00	20,00
- water accumulations	300,00	10,00
- roads	300,00	10,00
- industry	300,00	10,00
- erosion, sliding, etc.	300,00	10,00
TOTAL	3.000,00	100,00

3.2.3 Soil protection measures

There are different groups of soil protection measures form which we will mentions the present soil protection measures and preventional measures.

3.2.3.1 Present soil protection measures:

3.2.3.1.1 Amelioration of soil degradation due to surface mining

Re-cultivation (reclamation) measures have taken place over an area of about 1.500 ha. Orchards, crop cultures, grassland and forests have been planted on these re-cultivated areas.

3.2.3.1.2 Recultivation of fly ash disposals

On one part of this area recultivation has been carried out by fly ash coverring by the soil (Fig. 5).

Figure 5: *Covering of fly ash disposal by soil - combating the fly ash (orig.)*

3.2.3.1.3 Other present measures

5. Terraces,

Figure 6: *Terraces – combating the soil erosion (orig.)*

6. Mulch system,

Figure 7: *Mulch system - combating the soil degradation (orig.).*

Figure 8: *Mulch with irrigation (orig.).*

7. Irrigation.

3.2.3.2 Preventive soil protection measures:

1. Legislative measures - elaboration of a special law, i.e. the Law for Soil Protection,
2. Assessment of potential and active soil erosion processes in BIH, implementation of significant and experimental watersheds according to European experience for monitoring soil erosion processes and sedimentation in relation to land use,
3. Assessment of drought effect in different parts of BIH,
4. Programmes for the protection of hilly-mountainous areas (83,5% of the national territory) from water erosion by introduction of soil and water conservation measures with sustainable agricultural development,
5. Sustainable use and management of land (SLM),
6. Elaboration of NAP (National Action Plan) according to UNCCD instructions and obligations,
7. Revitalization of the karstic sub-mediterranean areas (lime-stones and dolomites) - areas that covers more than one-third of National territory which is drastically eroded and desertified,
8. Protection of high-quality soils from non-agricultural use and introduction of legislative governing the water and soil management,
9. De-mining of BIH territory represents an extremely important and urgent task for social, economic, environmental and security reasons for many people,
10. Flood control and land drainage of flatland in the river valleys and karstic fields (that covers totally about 400,000 ha),
11. Capacity building - creation and strengthening of scientific-research institutions in order to enable them to apply the modern technologies in soil protection,
12. Soil monitoring - evaluation of soil fertility, soil contamination and remediation measures for polluted soils,
13. Different methods of soil reclamation and recultivation,
14. Elaboration of good Soil information systems (SIS using GIS),
15. Transfer of knowledge and education on “soil damages and protection measures”

4 Summary / Conclusions

This paper has discussed the main problems of soil damage in Bosnia and Herzegovina. These have been considered as 4 different kinds of damages: infection, contamination, degradation and destruction. Annual losses, by processes of soil destruction alone, are about 3000 ha.

Special intensive processes which are problematic today in B-H include: surface exploitation of various raw materials, the building of settlements on arable land, the development of water erosion and land sliding, and the presence of land mines.

For the purpose of actions towards soil protection in the countries of this region, several various measures have been proposed. These include: collaboration in the domain of soil recultivation and remediation, changes in the kind of soil use on slopes, and the important need to elaborate one special law, i.e. a Law for Soil Protection.

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Monitoring Quality of Vojvodina Soils

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Abstract

Soil monitoring is an integral part of environment protection system and a major instrument of decision-making for the sustainable management and cost-efficient utilization of this resource. The Vojvodina Province being distinctly an agricultural region, the soil is of particular importance for it. Soil quality monitoring may be performed at several levels, from global estimates for the entire country or its parts to estimates for a single production plot. This paper presents most important results obtained in projects conducted by Institute of Field and Vegetable Crops in cooperation with government agencies. Within the framework of these projects, agricultural and non-agricultural lands have been analyzed for fertility parameters and contents of hazardous and harmful substances (organic and inorganic). Investigations conducted so far have indicated that the soils of the Vojvodina Province have high quality and are suitable for production of high-value food, providing that each production plot is analyzed for fertility parameters. Most of the indicators of environment status specified by the European Environment Agency (EEA) are already monitored and the data and methodologies are adequately stored, but data presentation is differently organized and it should be modified to fit EEA requirements.

Key words: soil, monitoring, Vojvodina

1 Introduction

Soil is a natural resource which is nonrenewable in real time because it takes a long time to form and it is destroyed quickly. Soil is subject to increasing pressure exacted by the global progress and it cannot be considered separately from other environmental factors but only within the framework of an all-inclusive system of environmental protection.

The Vojvodina Province has been recognized as having a high potential for field crop production on account of its fertile soils, moderate climate, abundant water resources and a long tradition in crop production. Therefore, soil protection is of critical importance for the Vojvodina Province. Regarding the distribution of soil types, as much as 60% of the area of the Vojvodina Province is chernozems which are considered ideal for crop production according to their physical and chemical properties. The other fertile soil types that occupy considerable areas are the hydromorphic black soil at 16% and the alluvial soil at 9% (Škorić et al., 1985). From the total area of the Vojvodina Province (2,150,600 ha) the agricultural land covers 1,763,000 ha or 82%. According to the mode of land exploitation, the Vojvodina Province is a typical rural region in which plowed land and gardens 90% of the agricultural land (Statistical Yearbook of Serbia, 2008). A variety of human activities jeopardize the soil quality. To develop instruments for primary and secondary soil protection, it is necessary to monitor the soil status, which may be performed at several levels. The highest level is a global estimate performed at the national level, where each sample represents 1000 ha. The next level is the municipal one, where each sample represents 100 ha. Finally, at the level of each production plot, each sample represents 3 to 5 ha. The most effective measure of soil protection and maintenance is soil status monitoring at selected locations. This is a way to continually observe all changes occurring in the agricultural and nonagricultural lands, with special attention being given to hazardous and harmful substances. Hazardous and harmful substances are divided into inorganic (macro-elements, micro-elements and heavy metals) and organic [total petroleum hydrocarbons (TPHs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticide residues and metabolites, etc.].

The current act on allowable concentrations of hazardous and harmful substances in soil and irrigation water (Official Gazette of the Republic of Serbia No. 23/94) stipulate only maximum contents of individual metals in agricultural soils and irrigation water and maximum contents of triazine pesticides (atrazine and simazine) for agricultural soils. It is essential to legislate new regulations which would include all relevant contaminants, both inorganic and organic, according to the terms such as tenement zones, parks and children playgrounds, natural soils, agricultural soils, industrial soils, contamination of ground water, etc.

2 Materials and Methods

2.1. Monitoring nonagricultural land in the Vojvodina Province

In the period 2003-2005, Provincial Secretariat for Environmental Protection and Sustainable Development of Executive Council of AP Vojvodina subsidized a program of monitoring of nonagricultural land in the Vojvodina Province, which included locations differing in protection level (Fruška Gora National Park, special nature reserves, nature parks) and locations in industrial zones of large cities in the Vojvodina Province (Novi Sad, Pančevo, Subotica, Zrenjanin, Sombor and Vrbas) (Sekulić et al., 2003, 2004, 2005).

Total contents of micro-elements and heavy metals were determined after digestion with $_{cc}HNO_3 + H_2O_2$, contents of available metals by EDTA extraction. The samples prepared in that way were used for metal content determination on an ICP-OES Vista Pro Varian.

Contents of the 16 characteristic compounds from the groups of polycyclic aromatic hydrocarbons (PAHs), naphthalene, acenaphthalene, phenanthrene, acenaphthene, fluorene, anthracene, fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b) fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, benzo[g, h, i]perylene and indeno(1,2,3-cd)pyrene, were extracted with a solvent mixture in a Soxhlet apparatus (US EPA methods 3540C and 3630C), the obtained extract was purified on a silica gel column and analyzed by capillary gas chromatography on an Agilent 6890NI gas chromatograph, using an 8975B MSD Agilent mass detector and a 30-m DB5-MS column with 0.32-mm inner diameter.

2.2. Soil fertility control at the level of production plot

In 2002, Provincial Secretariat for Environmental Protection and Sustainable Development of Executive Council of AP Vojvodina launched a program of agricultural soil fertility control. So far, about 120,000 soil samples from the private sector have been analyzed at Institute of Field and Vegetable Crops and 13 regional extension stations across the Vojvodina Province. Standard methods were used for analyses of basic chemical properties of soil: pH values (active acidity in soil suspension with water and substitution acidity in soil suspension with 1M KCl) determined potentiometrically; $CaCO_3$ content determined volumetrically with a Scheibler Calcimeter; humus, i.e., organic matter content, determined with a modified method of Tjurin based on the principle of soil organic carbon oxidation with $K_2Cr_2O_7$; available phosphorus P_2O_5, ammonium lactate extraction (AL method of Egner and Riehm), detection by spectrophotometry; lakopristupačni kalijum K_2O, ammonium lactate extraction (AL method of Egner and Riehm), detection by flame photometry.

All laboratory analyses discussed in this paper were performed at Laboratory for Soil and Agroecology, which had been certified by Accreditation Agency of Serbia (AAS) in accordance with ISO 17025.

3 Results and Discussion

3.1 Hazardous and harmful substances in nonagricultural soils in the Vojvodina Province

Heavy metals present a serious problem for the environment. Once introduced into the soil, they may persist there for hundreds and even thousands of years. This is why soils polluted with heavy metals require special methods of utilization.

The Act on allowable concentrations of hazardous and harmful substances in soil (Official Gazette of the Republic of Serbia No. 23/94) defines Cd, Pb, Hg, As, Cr, Ni and F as hazardous substances, and Cu, Zn and B as harmful substances. The criterion for determination of origin of the metals (geochemical or anthropogenic) was the percentage of available portion in the total content. The data obtained in the project of monitoring of nonagricultural land of the Vojvodina Province in the period 2003-2005 indicated that the protected natural landmarks in the province are not contaminated with heavy metals (Table 1). An alarming level of lead contamination was registered in the industrial zone of Sombor, in close vicinity of the battery factory. The contents of zinc and cadmium in the same samples did not exceed the MAC. Increased copper concentrations were found in 2 samples taken at natural landmarks. The first location are former vineyards on Vršac Mountain, the second is

Kovilj-Petrovaradin Swamp. The maximum value obtained, 115.1 mg/kg, was close to the MAC value of 100 mg/kg.

Table 1: Number of samples with heavy metal values over MAC and origin of contamination obtained in the project of nonagricultural land monitoring in the period 2003-2005

Element	Protected natural landmark n=38	Industrial zone n=9
Cu	2 samples anthropogenic	0
Pb	0	1 sample anthropogenic
Ni	10 samples geochemical	1 sample geochemical
Cr	2 samples geochemical	0

With the MAC for lead at 100 mg/kg, the maximum value registered in the course of the three-year study was 18,888.2 mg/kg (in 2004), found in Sombor industrial zone, the battery factory. That value is 188 times larger than the allowable one, while the content of the available lead was 25 times larger than the MAC for the total content. Undoubtedly, this value is the consequence of anthropogenic contamination with byproducts from the process of battery making. The high variability between the 2003-2005 data obtained in the same location is the consequence of a high heterogeneity in the level of contamination among the soil in the vicinity of the battery factory. Because of this, in 2005, we took yet another average sample from arable land some 15-20 m away from the factory fence. This sample too showed an increased lead concentration, 157.4 mg/kg, which was relatively close to the allowed one. However, the content of available lead was high (69.6 mg/kg), as was the proportion of the available form in the total content (44.2%). These high lead contents in this location call for and urgent action on soil reclamation and remediation.

The monitoring of organic contaminants of soil within the framework of the three-year study was represented by the analyses of PAH contents (Table 2).

Table 2: Sum content of the 16 PAHs in the analyzed soil samples, in mg/kg of absolutely dry soil

Year	**Protected land**			**Industrial zone**		
No. of samples	**2003 n=37**	**2004 n=37**	**2005 n=37**	**2003 n=9**	**2004 n=9**	**2005 n=7**
Average	0.83	1.49	0.47	1.17	1.89	0.36
Min.	0.09	0.52	0.16	0.13	0.51	0.15
Max.	3.57	5.68	2.23	6.34	11.9	0.73

The Republic of Serbia does not have a legislative act defining maximum allowable concentrations of individual polycyclic aromatic hydrocarbons in the soil. According to a German law (Federal Soil Protection and Contaminated Sites Ordinance – BbodSchV, 12.07.1999), the MAC of benzo(a)pyrene in park soils is 10 mg/kg, in industrial soils 12 mg/kg. The results of monitoring the Vojvodina soils indicated that that the analyzed soils were not contaminated by polycyclic aromatic hydrocarbons. Benzo(a) pyrene was not detected at all in most of the samples (68%) of soils under the different categories of protection. The highest detected concentration of benzo(a)pyrene was 0.54 mg/kg, which is several times lower than the MAC given in the German soil ordinance.

Out of the 25 soil samples taken from the vicinities of industrial plants, 40% of the samples were free of benzo(a)pyrene. The highest detected concentration of 2.07 mg/kg was considerably below the MAC given in the German soil ordinance.

3.2 Soil fertility control at the level of production plot

The Soil Fertility Control System Control analyzes soil fertility parameters and provides fertilization recommendations for the next 4 years which take into account the requirements of the plant species planned for cultivation and the targeted yield level. Soil fertility control is a legal obligation of owners or users of agricultural land. Since the campaign began in 2002, its positive effects for Vojvodina fields are expected in foreseeable future.

The analysis of the obtained results indicated that, according to the content of calcium carbonate, poorly to highly calcareous soils are equally represented in the Vojvodina Province. According to the pH reaction, the Vojvodina soils are neutral to slightly alkaline. Due to the aridity of the climate and the geological substrates rich in bases (usually sedimentary rocks - loess), the soils of Vojvodina dominantly belong to the class alkali soils (61%, Table 3).

Table 3: Proportion of classes of arable land in the Vojvodina Province, classified according to soil reaction in 1M KCl, based on 70,189 samples of arable land

Soil class	pH in M KCl	Proportion in the total analyzed land, %
Highly acid	< 4.5	0.9
Acid	4.5 – 5.5	4.8
Slightly acid	5.5 – 6.5	8.9
Neutral	6.5 – 7.2	24.3
Slightly alkaline	7.2 – 8.2	60.9
Alkaline	> 8.2	0.2

The Vojvodina soils are predominantly alkaline, as indicated by the high proportion of calcareous and highly calcareous soils (52%, Table 4).

Table 4: Proportion of categories of arable land in the Vojvodina Province, classified according to the content of $CaCO_3$, based on 70,189 samples of arable land

Soil category	% $CaCO_3$	Proportion in the total analyzed land, %
Limeless	0	5.6
Slightly calcareous	0 – 2	23.6
Medium calcareous	2 – 5	18.6
Calcareous	5 – 10	26.4
Highly calcareous	> 10	25.8

Another parameter that was analyzed within the framework of the campaign of soil fertility control was humus content (organic matter). The fact that even 39% of high-quality soils of Vojvodina belong to the class of low humic soils (Table 5) is a matter of serious concern. This situation was created due to insufficient application of organic fertilizers (underdeveloped animal husbandry in Vojvodina) and negligence in the practice of plowing under of harvest residues. Burning of harvest residues is practiced for a long time in the Vojvodina Province (due to additional costs for fuel and machinery needed for plowing under of residues and a low education level of private farmers). This practice brings enormous damage, both to agricultural production where it causes loss of organic matter and destruction of soil fauna, and to the environment due to the emission of carbon dioxide and harmful combustion products into the atmosphere. Harvest residues burning is legally prohibited. Control has been intensified in recent years and perpetrators have been fined for gross negligence.

Table 5: Proportion of soil provision with humus, based on 70,189 samples of arable land from the Vojvodina Province

Humus provision	% of humus	Proportion in the total analyzed land, %

Very slightly humic	0-1	1
Slightly humic	1-3	39
Humic	3-5	60
Highly humic	5-10	0

The campaign of soil fertility control showed that, regarding the contents of phosphorus and potassium, the agricultural soils are under a strong anthropogenic influence, i.e., their quality depends on their previous management. Adjoining plots frequently differ regarding the contents of nutrients.

On the basis of potassium data for 70,000 fields in the Vojvodina Province (Graph 1), it was evident that 50% of the area had been excessively fertilized with this nutrient. Of that percentage, 43% of the samples had a high potassium content, which represented a "zone of no effect" on yield performance, but at the same time significantly increased production costs, and 7% of the samples represented an area that is toxic to plants, where potassium concentration reduces yields and pollutes the environment. Forty-two percent of the fields are optimally provided with potassium, which means that, in general, 92% of the fields are well-provided with this nutrient.

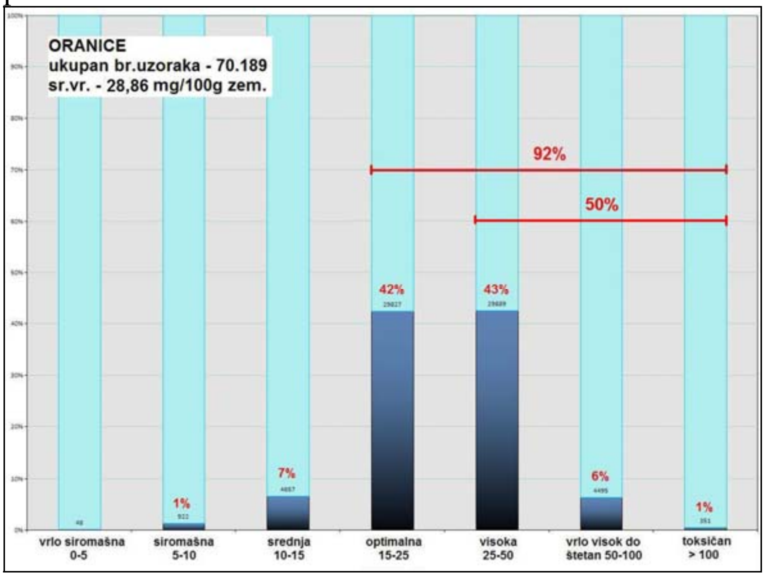

Figure 1: *Proportion of samples per classes of soil provision with available potassium, for the Vojvodina Province*

Based on the data for phosphorus content (Graph 2), 24% of the arable land of Vojvodina had been excessively fertilized - 17% of the area have a high phosphorus content, and 7% have harmful or toxic contents. Thirty-one percent of the samples were optimally provided with phosphorus, which means that a half of the analyzed fields were provided with this nutrient.

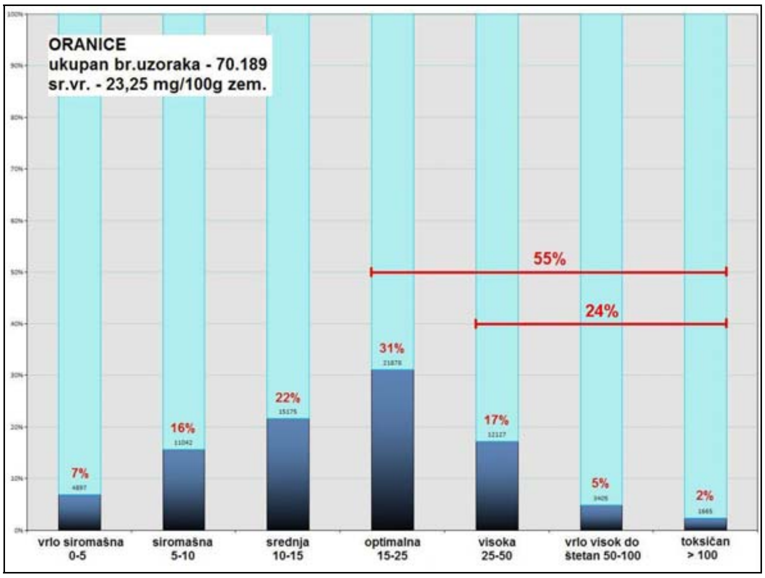

Figure 2: *Proportion of samples per classes of soil provision with available phosphorus, for the Vojvodina Province*

The above situation developed as the result of the use of inappropriate and yet most frequent fertilizer formulation on the market, the one with the nutrient ratio of 1:1:1 (NPK fertilizer 15:15:15). It should be emphasized here that the displayed results (Graphs 1 and 2) present a global assessment, and that it is possible that individual field are very different with respect to the nutrient contents in the soil, which depends on previous management. Therefore, it is necessary to continue analyzing the soil fertility separately in each production unit.

4 Summary / Conclusions

According to the analyses performed so far, the soils of the Vojvodina Province are generally nonpolluted and suitable for production of high value and safe food. As the Vojvodina Province is predominantly a rural region which ranks high in Europe as well as on the global scale with regard to the fertility and quality of its soils, the system of protection and maintenance of these resources should be designated and treated as a strategic project of national interest.

It is necessary to establish a system of continual monitoring of soil quality and to harmonize the method used with European standards. It is also necessary to continue the practice of soil fertility and cost-efficient fertilizer application control at the level of individual production plots as a scientific basis for a high, stable and profitable crop production combined with the protection of the agro-ecosystem. To effectively protect the soils of Serbia, it is vital to pass ordinances stipulating maximum allowable concentration of hazardous and harmful substances (organic and in inorganic) for soils of various categories of use.

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Environmental EU acquis in federation of Bosnia and Herzegovina, state and perspective

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Abstract

State wishing to become the European Union Member State (EU MS), has to accept decisions from the inaugural contract, as well as to carry out the appropriate transposition of the EU regulations, i.e. to bring into accord its laws, institutions and policies with the Acquis Communautaire. Taking into consideration the complexity of constitutional-legal organization in Bosnia and Herzegovina, significant fragmentation of institutions, this is a great challenge. The existing environmental legislation in the Federation of Bosnia and Herzegovina, the Republika Srpska and Brcko District, has been developed on the basis of EU standards. It has been estimated that it is enough at this stage, but by signing the Stabilization and Association Agreement (SAA), and getting candidate status a lot of work would be necessary to be done. At this stage, it is needed to be focused on the most important EU directives referring to: horizontal legislation, air quality, water quality, waste management, nature protection and industrial pollution control. These are the main branches for which the European Commission carries out the progress monitoring (once a year) in the accessory states.

In order to carry out the environmental policy in adequate way in Bosnia and Herzegovina, particularly in the context of the Stabilization and Association Process, it is necessary to have the review of the state of institutions and regulations relevant to the environment in general meaning, the review of major EU environmental directives, as well as to analyze the corresponding implementation considerations for Bosnia and Herzegovina.

Carrying out the environmental policy in adequate and contemporary way is not possible without harmonization with other sartorial strategies and policies (integral and individual), that particularly refer to Bosnia and Herzegovina, having in mind the state of its economic, ecological, social, political, constitutional-legal, and other realities.

Horizontal and vertical fragmentation of institutions, responsibilities overlapping, insufficient and badly equipped and educated civil servants, professional and scientific capacities are additional difficulties in the whole process.

Key words: environment; laws; institutions; Acquis Communautaire; strategy; directives;

1 Introduction

Along with sustainable development, main framework of the Federal Strategy for Environmental Protection, which is currently in the procedure of final harmonization (it is similar in Republika Srpska as well), is the process of Stabilization and Association to the EU, which basically means the issue of harmonization of existing and drafting of new environmental and other regulations functionally related to the environment, in accordance to EU standards. Also, this means the identification of existing and the establishment of new required institutions, referential to the environment, so that activities related to association to EU could be adequately implemented. In the post-war period Bosnia and Herzegovina approached series of Environment Conventions and other international contracts inherited from the former state, which represents an additional formal framework for pursuing of the appropriate environmental policy.

These activities adequately need to be coordinated at the State level, especially when Bosnia and Herzegovina signs the Stabilization and Association Agreement with EU. Acquis Communautaire is one of the most important legal and political principles of European Integrations. The phrase refers to entire law, obligations and commitment to the Community (Union), which have accumulated with the development of integration process. Formally, the Acquis includes the following: primary law - foundation agreements; international agreements; secondary law – legislation adopted by EU institutions (Directives, Regulations); practice of the EU Court, etc).

2 Methods

Federal Strategy for Environmental Protection, with a 10-year Action Plan (2008 – 2018), among other things, has an objective to achieve in the Federation of BiH a high level of harmonization of regulations and institutions relevant to the environment with EU "Common Aquis" (French: Acquis Communautaire). The objective of this work is the make a review of the condition of institutions and regulations relevant to the environment, in the broadest sense of that word, more important environmental considerations for Bosnia and Herzegovina.

Taking into consideration the complexity of constitutional – legal system in Bosnia and Herzegovina, considerable fragmentation and functional disconnection of institutions, where the Environment Sector isn't adequately integrated, this represents the big challenge. The existing legislation on environment in Federation of BiH, Republika Srpska and Brčko District is based on EU standards. Estimates point that it is sufficient in this phase, but once the Stabilization and Association Agreement of BiH with EU is signed, a lot of work remains to be done. Focus in this work should be on the most significant EU Directives that cover: horizontal legislation; air quality; water quality; waste management; nature protection; control of industrial pollution and chemicals.

With available documentation (printed and electronic), make an overview of institutions and legislation relevant to the environment of Bosnia and Herzegovina, with a detailed review for Federation of BiH, with appropriate analyses inter-sector functionalities and identifications of existing problems. Make an overview of the important EU Directives for following areas: horizontal legislation; air quality; water quality; waste management; nature protection and the control of industrial pollution, with brief description and basic parameters, and then, by using the results of the recently realised European Commission projects, along with other available sources, give evaluation of EU legislation transposed into regulations of the Federation of BiH (BiH), shown in percentages. Based on that data, comparatively using the experiences of other EU States (especially those that have recently joined the EU), give appropriate proposals for the improvement of condition, mainly for better and more functional connectivity of existing institutions (horizontally and vertically), i.e. the necessity for establishment of new institutions. Give examples of improvement of existing federal regulations, within the framework of EU standards (IPPC Directive and Framework Directive on waters, in the context of the FBiH Law on Environmental Protection and FBiH Law on Waters), with the objective of simplifying the administrative procedures.

3 Results

3.1 Bosnia and Herzegovina, Institutional and legal framework of environmental protection

According to the Constitution of Bosnia and Herzegovina, there is not any explicit competency related to the environmental protection, at the level of BiH, it is the constitutional competence of entities, where Federation of Bosnia and Herzegovina has joint constitutional competence with cantons, whilst Republika Srpska has a higher level of centralization because there are no cantons. At the same time, the State of Bosnia and Herzegovina shall be the signee of the Stabilization and Association Agreement with the EU, like it had signed and ratified numerous environmental conventions and protocols, which means that in the forthcoming period it will have to find adequate legal and institutional model for distinct and efficient connection of state and entity institutions, with primary objective being the adequate implementation of agreed commitments. Additionally, primarily within the entities, environment has to be functionally and operationally connected with other Sectors, considering its emphasised inter-sector dimension and the successive planned implementation of European environmental standards, taking into consideration specifics of the economy of Bosnian and Herzegovinian society and development needs.

This “constitutional handicap” of the State of Bosnia and Herzegovina is partially mitigated by the BiH Law on Ministries and other government bodies (BiH Official Gazette No. 5/03), with which the Ministry of Foreign Trade and Economic Relations is given the competence over the tasks and duties related to defining of policy, basic principles, coordination of activities and harmonization of plans from the entity government bodies and institutions at the international level in the area of environmental protection, development and usage of natural resources. Council of Ministers of BiH has also, with its Decision, entrusted the Ministry of Foreign Trade and Economic Relations to manage the activities related to drafting of the Law on Environment (working title), which should include the establishment of BiH Agency for Environment, and on that matter, certain activities have started. Important role in implementation of Stabilization and Association Agreement of BiH with EU shall have the Direction for European Integration (DEI). Main documents of the DEI, relevant to this issue are the Integration Strategy of Bosnia and Herzegovina into the European Union and the Manual for harmonization of BiH regulations with the regulations of EU. Bosnia and Herzegovina has ratified most of the important global and regional environmental conventions, protocols and agreements, which cover areas like: international waters, air pollution and climate changes; nature protection and biodiversity; waste management and transportation, and some conventions are presently in the procedure of ratification.[1]

[1] Espoo Convention on evaluation of influences on environment in the cross-border context; Convention on access to information on participation of the public in the matters of decion making and the access to the Judiciary relating to the environment, Aarhus 1998, and the so called Stockholm Convention on permanent organic pollutionists are in the ratification procedure.

3.2 Federation of Bosnia and Herzegovina

In Federation of BiH, at federal and cantonal level, several appropriate ministries and other institutions have been established, which directly and indirectly deal with environment, so there are departments and institutions competent for: environment, physical planning, agriculture, forestry, water management, mining, tourism, health, soil research science, geology, statistics, etc.

A number of Laws have been adopted in the post-war period, that relate to previously mentioned areas, and in some cases, regulations from the former Republic of BiH are still used. It is indicative that appropriate inter-sector harmonization of regulations in horizontal structure and vertical from federal level towards cantons still doesn't exist, and that European standards and standard taken over through international conventions often aren't established and used. For set of Laws on Environmental Protection, that was simultaneously carried out in Federation BiH and Republika Srpska, high level of harmonization was accomplished at inter-entity level. Similarly was carried out for new Laws on Waters in both entities. There are certain provisions in the new FBiH Law on Waters (Official Gazette No. 33/03). So, even with the integral environmental permit, which was normatively transposed into the Law on Environmental Protection, based on the principles of the Directive on Integrated Preventive Pollution Management (IPPC – Integrated Preventive Pollution Control), where all aspects of potential pollution are detail and systematically processed, including waters, new Law on Waters maintains "the old" Water Acts (opinion on waters, agreement on waters, and permit for waters). With administrative proceedings for Water Acts issuing certain procedures are duplicated, the ones carried out in the proceeding of environmental permit issuing, and parties are faced with needlessly long, often expensive administrative proceedings as well. This is an example how new laws, created after the principles and important regulations of European Directives, need additional mutual harmonization and improvements, primarily to simplify administrative procedures without affecting solutions of the good quality.

Furthermore, for example, Strategic Environmental Assessments, as one of the instruments in the Law on Environmental Protection, based on the EU Directive, although obligatory, was not applied during the drafting of some Sector Strategies so far (Federal Strategy for Agriculture, FBiH Energy Strategic Plan, etc.).In Table 1. is an overwlook of Federal institutions ands Laws relevant for Environment.

Table1. Federal institutions and Laws relevant to the Environment

Competent Ministry or other federal institution	***Institution within Ministries***	***the Relevant Law***
Federal Ministry of Environment and Tourism	Fond	Law on Environmental Protection Law on Nature Protection (FBiH Law on Air Protection (FBiH Law on Waste Management (FBiH Official Gazette No. 33/03).
Federal Ministry of Physical Planning		Law on physical planning and land usage on FBiH Gazette No. 02/06)
Federal Ministry of Agriculture, Water Management and Forestry	Agency for "Water area of Sava river basin"; Agency for "Water area of Adriatic Sea river basins"; Federal Administration for Forestry	Law on Waters (FBiH Official Gazette No. 70/06) Law on Forests (FBiH Official Gazette No. 20/02) Law on Agriculture (FBiH Official Gazette No. 88/07) Agricultural Land Law (FBiH Official Gazette No.01/98) Law on Hunting (FBiH Official Gazette No. 04/06)

Competent Ministry or other federal institution	*Institution within Ministries*	*the Relevant Law*
Federal Ministry of Health	Federal Administration for Protection from Radiation and Radiation Security	Law on Ionian Radiation and Radiation Security ("FBiH Official Gazette No. 15/99) Law on transport of dangerous substances ("RBiH Official Gazette No. 2/92)
Federal Ministry of Energy, Mining and Industry		Decree Regulation on Mining (RBiH Official Gazette No.24/93) Decree Regulation on Geological research (RBiH Official Gazette No.3/93)
Federal Hydrometereological Institute		
Federal Institute Soil Research Science		
Federal Institute for Geology		
Fond for Environmental Protection of FBIH		Law on Fond for Environmental Protection of FBIH (Official Gazette No.33/03)

3.3 EU legislation relevant to the environmental protection

The legislation of EU for environmental protection has more than 300 different legal acts (regulations; directives; decision; etc.). However, EU legislation with which potential member states have to harmonize their legislation and administration, as a condition for EU membership is considerably smaller. It consists of about 70 directives - some of which have been amended a few times and to which subordinating directives were added and 21 regulations.

All EU potential member states countries have to provide material means for harmonization with the EU Environmental Policy. These means are to be planned systematically and in the long-term. The end result of investments into environment would reflect in various ways, like: better drinking water quality and waters in general, purer air, more efficient exploitation of natural resources and energy, better quality and more efficient waste management and similar. The studies have shown that in the most important environment sectors such as air and water, the sole health improvement that will be the outcome of environment condition improvement, will cover almost all invested means.

In Member States industry, the transfer onto purer production makes the industrial process cheaper and it leads to modernization and reduction of the waste. Additionally, pollution processes are becoming more expensive than the purer production thanks to application of “salary pollution” principle, which is one of the key aspects of the EU Environmental Policy.

Neither EU member state candidates nor the EU member states can choose the Directives or set up their own objectives. Every individual law must be done on the day when country becomes a member of the Union. EU environmental legislation cannot be negotiated although certain flexibility exists in the implementation.

First set of priorities that need to be considered are the environmental priorities which relate to specific environmental problems and priorities of the country. They cannot be determined by abstract analyses, but must be based on detailed evaluation of the environment situation in the country.

Second set of priorities implicates the legislative and administrative shortcomings, which must be eliminated due to fulfilling the EU demands.

Identification of legislative and administrative priorities must be based on detailed comparison of the existing national environmental legislation and the EU legislation, article by article, focused on identification of the shortcomings that need to be improved. This cannot be per se analysis but it must be accompanied with the evaluation of administrative and institutional needs that need to be met so to ensure effective implementation, monitoring and the control of legislation measures.

This is a challenge for future member states to not repeat the 20-yer-old environment neglect like it was the case in West Europe, who initiated in 1970s an environment protection activity programme at European and International level.

Enlargement offers challenges and possibilities for the environment, not only for applicant countries but for the entire Europe. Unification of the environmental issues in all policy segments could therefore be considered as a part of sustainability development process.

According to the Agenda 2000, applying countries ought to define and begin implementation of real national strategy prior to association which will guarantee gradual harmonization in the longer period of time. This strategy must include priority activities, key objectives that will be achieved prior of association, and the schedule for association achievement. Identified details must be taken into consideration by applying counties during the drafting of their national policies.

There are several types of challenges that countries should meet:

- Legislation: incorporation of the Environment Acquis demands in advance the detailed analyses of the laws of countries so that the identification of priorities could be enabled;
- Institutional challenges: applying countries must strengthen their administrative structures, become more efficient and coordinate departments responsible for Environmental Policy Management;
- Financial means: elaboration of financial strategy is essential and it should be the priority.

Main sector-specific challenges:

- Air pollution;
- Waste management;
- Water pollution;
- Control of the industrial pollution and risk management;
- Nuclear security and protection from radiation.

European Commission has defined certain priority objectives which bill help applying countries in drafting of their national programmes for adoption of Acquis. These priorities must be determined on basis of detailed analyses of the environmental situation in each country. Applying countries must amend shortfalls of their legislation and administration, in order to improve the environment and at the same time, to improve economy and the competitiveness.

Most of the EU environmental laws are the Directives. This form of laws is unique for EU. They are created in order to determine the duties of applying countries, but also to be flexible enough so to take into account different legislative and administrative traditions. Choice and methods of harmonization of legislative and administrative systems is left to the will of member states.

Directives oblige all Member States, but can contain different demands taking into account different environmental and economic circumstances of each Member State.

Framework directives set up general principles, procedures and legislative demands in different sectors. They are adopted in air, water and waste sectors so far. Other sub-directives in each sector must correspond to general demands of the framework directive.

Since 2006, European Commission has started to monitor the level of transposed EU environmental regulations into regulation of South East Europe countries, including Bosnia and Herzegovina through the Project "Monitoring of Progress of the South East Europe Countries". All available environmental regulations (laws, regulations, rulebooks) are analysed in detail, article by article, with appropriate questioners and harmonization tables. Entire job is carried out by civil servants of Entity Ministries competent for environment and waters, all of it exclusively in English. At the end, according to adequate methodology, level of harmonization is calculated in percentages. Considering that activities are not finished for this year, appropriate interim assessment is made, based on the analyses of adopted regulations in the past one-year period (Table 2.).

Table 2. An overlook of some important EU directives and current state of their transposition in the Federation of Bosnia and Herzegovina

Sector/directive	***Transposition in 2007[2] [%]***	***Transposition in 2008[3] [%]***
HORIZONTAL DIRECTIVES • EIA Directive (85/337/EEC) as amended by Directives (97/11/EC and 2003/35/EC) • SEA Directive (2001/42/EC) • Environmental Information Directive (2003/4/EC) • Public Participation Directive (2003/35/EC)	**28%**	**36%**
AIR QUALITY • Ambient Air Quality Framework Directive (96/62/EC), as amendedby Decree(EC 1882/2003) • Limit Values for Sulphur Dioxide, Nitrogen Dioxide and Oxides of Nitrogen, Particulate Matter and Lead in Ambient Air Directive (99/30EC) • Benzene and Carbon Monoxide Directive (2000/69/EC) • Ozone Directive (2002/3/EC) • Directive on arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air (2004/107/EC)	**19%**	**25%**
WASTE MANAGEMENT • Directive on waste (2006/12/EC) • Hazardous Waste Directive (91/689/EEC) • Sewage Sludge Directive. (86/278/EEC) • Packaging Waste Directive (94/62/EC) • Waste Incineration Directive (200/76/EC) • Waste Shipment Regulation ((EEC) 259/93)	**25%**	**30%**
WATER QUALITY • Water Framework Directive (2000/60/EC) as amended by Decision (2455/2001/EC) • Urban Waste Water Directive (91/271/EEC, as amended) • Drinking Water Directive (98/83/EC), as amended by Decree EC) 1882/2003 • Nitrates Directive (91/676/EEC) as amended by Decree (EC) 1882/2003	**37%**	**46%**
NATURE PROTECTION • Wild Birds Directive (79/409/EEC), as amended by Directives (85/411/EEC; 86/122/EEC;91/244/EEC; 94/24/EC;97/49/EC) and Decree (EC) 807/2003	**6%**	**10%**

[2] Results of the EC project-Monitoring progress in B&H (2006/2007) COWI
[3] Assessment results of authors for 2008 based on progress analysis

Sector/directive	*Transposition in 2007[2] [%]*	*Transposition in 2008[3] [%]*
• Habitats Directive (92/43/EEC), as amended by Directive 97/62/EC and Decree (EC) 1882/2003.		
INDUSTRIAL POLLUTION CONTROL • IPPC Directive (96/61/EC), as amended by Directive (2003/35/EC) and Decree (EC) 1882/2003 • COMAH Directive (96/82/EC), as amended by Decree (EC) 1882/2003 • Large Combustion Plants Directive (2001/80/EC)	**37%**	**40%**
CHEMICALS • Dangerous Substances Directive (67/548/EEC) with numerous of amendments • Risk Assessment Regulation (EC) 793/93, as amended by Decree (EC) 1882/2003 • Import and Export of Dangerous Chemicals Regulation (EC) 304/2003, as amended by Decree (EC) 1213/2003, 775/2004, 777/2006	**0%**	**0%**

4 Discussion

Integration Strategy of Bosnia and Herzegovina into EU elaborates Environment Sector as a special area. Due to other strategic priorities at this phase, Environment Sector has not neither been adequately processed, nor was it given the appropriate significance. That has to be changed and harmonized with priority objectives defined by European Commission, especially after the signing of Stabilization and Association Agreement with European Union and achievement of candidate country status, because the Environment Sector, after the Agricultural Sector, is the most complex and demanding sector in entire association process. This means the establishment and strengthening of state institutions, with adoption of regulations, in order to introduce standards and to coordinate the process of steady transposition of EU legislation, in whole country area. Considering that Monitoring of Progress on the Harmonization of Environmental Regulations shows that the area of chemicals is barely included, it is needed to adopt a regulation at state level which will regulate import and export of dangerous chemicals, and at entity level, to adopt regulations on dangerous substances and related risk evaluation.

Bosnia and Herzegovina has ratified most of the more important global environmental conventions and protocols, which is important for the entire association process, knowing that European Union is (and its individual Member States), the world's leader in promotion and implementation of International regulations, but also Bosnia and Herzegovina hasn't got adequate capacities, neither at state nor at entity level, to implement taken commitments. This is additional argument for strengthening and settling of environmental institutions, at all levels.

5 Conclusions

At the level of FBiH, with drafting of regulations and strategies relevant to the environment, it is needed to ensure adequate inter-sector harmonization and integration of environmental standards especially in sectors of Physical Planning, Water management, Energy, Industry, Mining, Agriculture, Health, Civil Engineering, Concessions, etc.

It is also important that the Environment Sector is, like all mentions sectors, strictly controlled and monitored during the drafting of regulations by FBiH Government Office for legislation and Harmonization with the EU regulations. It is important that this Office is adequately and expertly capacitated and trained for EU Legislation, which is not the case at the moment.

Existing expert state institutions (administrations, agencies, institutes) competent for: waters, forests, hydrometeorology, soil research science and agriculture, geology, statistics, standardization, etc., must be included in entire "system for the environment", primarily doing the environment monitoring, building of database and information, reports, expert basis, certification and accreditation etc.

These institutions have to be profiled as National Reference Center for certain components or areas of environment, in entire system of Environment Information and Observation network (EIONET – Environmental Information and Observation Network), which is one of the prerequisites for membership in the European Environment Agency.

The establishment of the State Environmental Agency of Bosnia and Herzegovina is crucial issue in this context.

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Irrigation requirements and potentials of agricultural land in the river Drava basin in Croatia

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Abstract

The principal aim of the study is to illustrate, on the example of Virovitica-Podravina County, irrigation requirements and potentials in the River Drava basin, one of the most important agricultural regions in Croatia. Irrigation potentials are presented through the analysis of land and water resources, while irrigation requirements are shown through the calculated water deficit in intensive agricultural production

Highly valuable land resources for irrigation have been determined in the territory of the said county. The soil map of the current land suitability for irrigation shows that of the total agricultural land area amounting to 120,286.0 ha, 74.4% are soils suitable for irrigation. Out of these soils, 22.8% are highly suitable, 22.7% moderately suitable and 28.9% are marginally suitable for irrigation. Soils not suitable for irrigation spread over 30,807.1 ha or 25.6%. Among these soils, 25% are soils currently not suitable for irrigation, which can be developed into suitable soils by the application of ameliorative measures. Permanently not suitable soils account for only 0.6% of agricultural land.

The principal source of irrigation water is the River Drava, which is characterized by maximum discharges during dry periods. Thus, from the water source aspect, the county has a high irrigation potential since sufficient amounts of irrigation water are available in dry periods.

Required amounts of water vary in dependence on crops grown and on precipitation. At the long-term precipitation average, maximum amounts of water were recorded for tomato (84.6 mm), while the smallest amounts of water were determined for cabbage and kale (34.9 mm). Water requirements were on average two to three times higher in dry years. The highest water requirement was determined for sugar beet (181.4 mm), and the lowest again for cabbage and kale (123.0 mm).

The studied example of Virovitica-Podravina County allows the conclusion that there are great requirements as well as great potentials for irrigation in the River Drava basin, and that the available resources should be exploited for further agricultural development.

Key words: soil, suitability, irrigation, water deficit, River Drava basin, Croatia

1 Introduction

Only 9,264 ha or 0.46% of arable land is irrigated in the Republic of Croatia, which in this respect holds one of the last positions in Europe (Tomić et al., 2007). Frequent droughts in recent years influenced the public opinion regarding irrigation demands. For this reason, the Croatian Government initiated the «Project of irrigation and management of agricultural land and waters». This project is fully justified because the Republic of Croatia has about 2,020,626 ha of arable land, of which as many as 244,150 ha are suitable for irrigation while 588,163 ha are moderately suitable with minor limitations (Romić et al., 2005). The available amount of renewable water per capita per year is 35,000 m^3 (Kos, 2004). Climate characteristics and soil water regime, as well as their highly changeable and complex interrelationship define the efficacy of plant production, because a large part of plant production is concentrated in the region frequently struck by droughts. This problem could be partly solved by supplying the required water by irrigation. Irrigation, as an ameliorative measure, would help maintain optimal soil moisture during the growing period, thereby ensuring more stable and higher agricultural production. According to Beltrão et al. (1996), the highest yields are achieved when the air-water relation in soil is most favourable, especially in critical periods for each crop. Further, for efficient irrigation it is necessary to know the soil water supply and soil water storage capacity (Gerakis and Zalidis, 1998; Šimunić et al., 2006). Irrigation and irrigation planning are a demanding task, which requires multidisciplinary engagement of several professions to determine and calculate all the relevant factors and parameters.

The principal aim of this study is to illustrate, on the example of Virovitica-Podravina County, irrigation requirements and potentials in the River Drava basin, one of the most important agricultural regions in Croatia, and to highlight the need for introducing irrigation into regular agricultural production.

2 Materials and methods

Irrigation potentials in the territory of Virovitica-Podravina County are presented through the analysis of land and water resources, while irrigation requirements are shown through the calculated water deficit in intensive agricultural production as well as potential yield increase of major crops.

To identify soil properties, a soil map was made (scale 1:100 000) on the basis of the data from the Basic Soil Map of the Republic of Croatia, scale 1:50.000 (Husnjak and Šimunić, 2006). Land suitability assessment was made according to the FAO method (FAO 1976), taking into account, besides soil properties, also climate and relief characteristics, as well as requirements of major agricultural crops in intensive production.

Climate data of the meteorological station Virovitica for the period 1961-2003 were used in the study, while insolation data were taken from the meteorological station Osijek.

Reference evapotranspiration (ETo) was calculated by the Penman-Monteith method. Effective precipitation was calculated by the method of USBR (United States Bureau of Reclamation) from the long-term mean monthly precipitation values as well as monthly precipitation amounts, which were separated by the lower quartile ($Fa \leq 25$). Computer program «Cropwat» was used for data calculations. Crop evapotranspiration (ETc) was calculated from the relation of ETo and the crop coefficient (Kc), taking account of the different stages of crop development. The soil considered belongs to the order of suitable soils having the following properties: silty clay-loam texture, field water capacity (Fwc) =39 vol% and Wp (wilting point)=11 vol%. Crops considered for irrigation were the major crops of the climate zone: silage maize, sugar beet, cabbage and kale, green pepper and tomato. Soil water balance (water requirement) for each crop was calculated using the Palmer method (corrected and calibrated according to Vidaček, 1981). Irrigation water resources are presented pursuant to the available data on the River Drava annual discharges for the period 1961-2002.

3 Results and discussion

3.1 Main characteristics of the space, relief and climate

The River Drava basin, extending along the state border with the Republic of Hungary, is the most important agricultural region of Croatia (Husnjak and Šimunić, 2005). As five counties are located within the basin, this paper shows the research results for the Virovitica-Podravina County because this county is situated in the central part of the Drava basin and thus represents the basin in the best way. Virovitica-Podravina County is positioned between the northern slopes of the mountains Bilogora and Papuk in the south and the River Drava in the north. It covers an area of 2022.04 km^2, or about 3.1% of the total area of the Republic of Croatia, Figure 1.

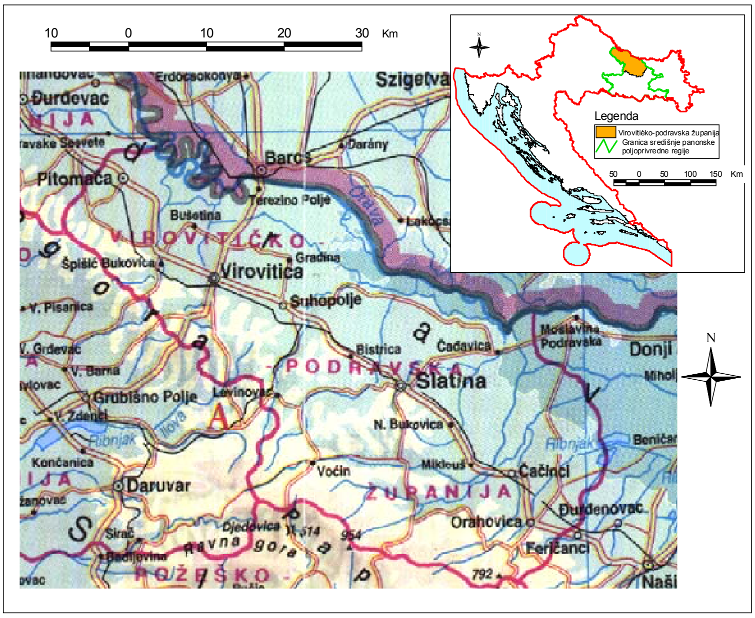

Figure 13: *Position of Virovitica-Podravina County in the Republic of Croatia*

Agriculture is highly developed in the form of field, vegetable and animal production on the alluvial terrace as well as on the Pleistocene plateau, while fruit and wine production prevail on the hilly Tertiary Mt. Bilogora and the slopes of Mt. Papuk (Husnjak 2003). The lowest part is the Holocene plateau with its altitude above sea level ranging from about 90 to 120 m. It extends along the Drava valley and is built of multilayered alluvial deposits of different thickness of individual layers and of heterogeneous materials – from gravel and sand to loamy and clayey materials. The plateau covers about 55% of the County territory, Figure 2. It passes into the Pleistocene terrace, altitude above sea level up to ca 200 m, built of loess, luvic loess or marmorized redeposited loams. The Holocene plateau and the Pleistocene terrace spread over ca 80% of the County area. Slopes and foothills of Mt. Bilogora and Mt. Papuk rise in the southern part of the County, intersected by numerous drainage ditches and torrential watercourses.

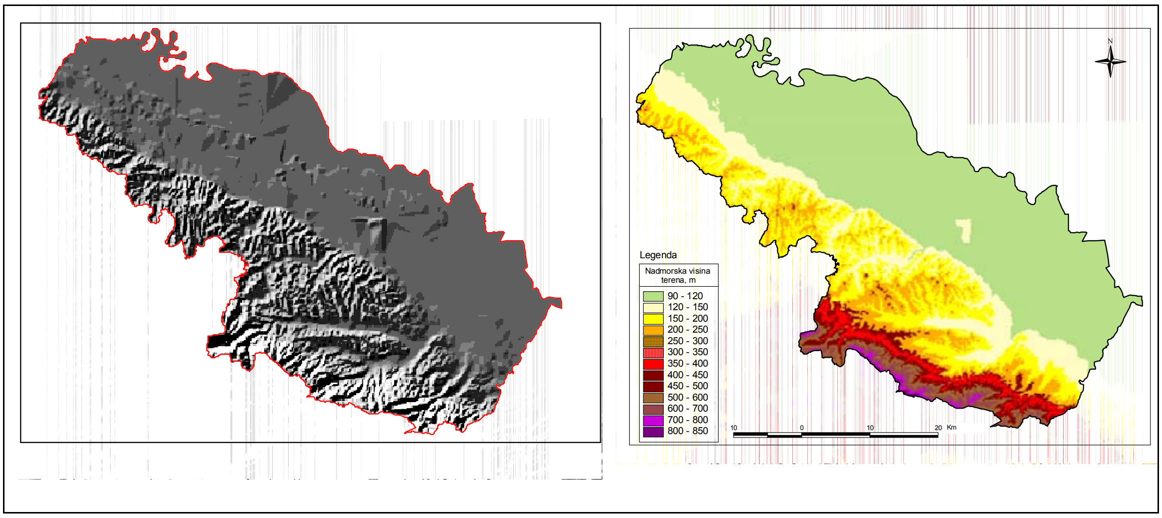

Figure 2**:** *Relief and altitude-above-sea-level maps of the County*

Annual precipitation ranges from 553 to 1.115 mm, the average annual precipitation amounting to 800 mm. On the basis of average monthly precipitation values, it was calculated that only 450 mm of precipitation can be generally expected in the growing period and slightly less (350 mm) in the non-growing period. Mean annual air temperature is 11.0 ^{o}C, the annual temperature varying from 9.3 ^{o}C to 14.7 ^{o}C. Mean monthly temperature ranges from –0.5 ^{o}C in January to 21.4 ^{o}C in July.

3.2 Irrigation potentials

3.2.1 Assessment of land suitability for irrigation

To assess land suitability for irrigation, a soil map, scale 1:100 000, was made and served to define the properties of systematic and map soil units. Ninety map units were selected from the soil map and their analysis showed occurrence of 17 soil types and their lower units at the levels of subtypes, varieties or forms. Properties of systematic and map soil units were determined. Land suitability assessment was done according to the FAO method, taking account of soil properties and limitations, climate and relief characteristics, and requirements of major agricultural crops, on the basis of which the soil suitability map was produced, Figure 3. Assessment of the current suitability of systematic and map soil units was made by classifying soil units into orders, classes and subclasses of soil suitability for irrigation, in which orders define soil/land suitability (S) or unsuitability (N). Order S – suitable: contains soils on which irrigation is expected to yield benefits that will justify required inputs without adverse impacts. Order N – not suitable: includes soils that are currently or permanently unsuitable for the application of sustainable irrigation. Classes define degrees of suitability within the orders:

Class S-1: suitable soils without significant limitations to application of irrigation or with limitations that will not have a significant effect on productivity, benefits and the application of irrigation.

Class S-2: moderately suitable soils, with limitations that constitute a moderate risk to productivity, benefits and the application of irrigation.

Class S-3: marginally suitable soils, with limitations that constitute a severe risk to productivity, benefits and the application of irrigation.

Class N-1: currently not suitable soils, with limitations that at the current state preclude technologically and/or economically justified application of irrigation.

Class N-2: permanently not suitable soils, with limitations that preclude any possibilities of technologically and/or economically justified application of irrigation.

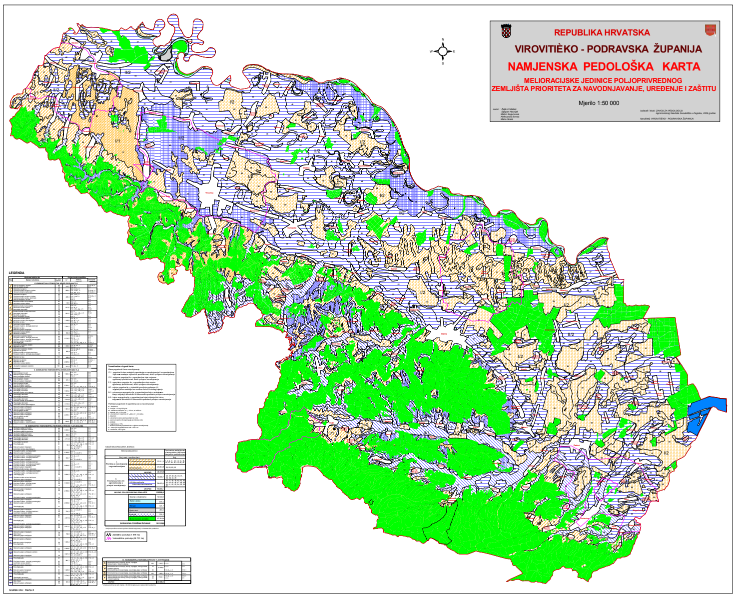

Figure 3: *Map of land/soil suitability for irrigation*

Further analysis of the current suitability map indicated that the studied County possesses very valuable land resources for irrigation. Namely, soils suitable for irrigation spread over an area of 89,478.9 ha, or 74.4% of total agricultural land. In this, 22.8% are suitable soils, 22.7% moderately suitable and 28.9% marginally suitable soils for irrigation, Table 1. Not suitable soils cover 30,807.1 ha or 25.6%. Among these soils, 25% are soils currently not suitable for irrigation, which can developed into suitable soils by the application of ameliorative measures. Only few soils are permanently not suitable for irrigation (0.6% of agricultural land).

Table 1: Area of irrigation suitability classes

Suitability class	Area	
	ha	%
Suitable soils	27,409.2	22.8
Moderately suitable soils	27,262.7	22.7
Marginally suitable soils	34,807.0	28.9
Currently not suitable soils	30,062.8	25.0
Permanently not suitable soils	744.3	0.6
TOTAL	**120,286.0**	**100**

3.2.2 Water potential for irrigation

Virovitica-Podravina County is also rich in water resources for irrigation. The main source of irrigation water is the River Drava, which is characterized by its glacial-snow component, that is, occurrence of maximum discharges in June and minimum discharges in January, Figure 4. The riverside is characterized by a typically rain-snow regime, with maximum discharges occurring in April and minimum discharges in August.

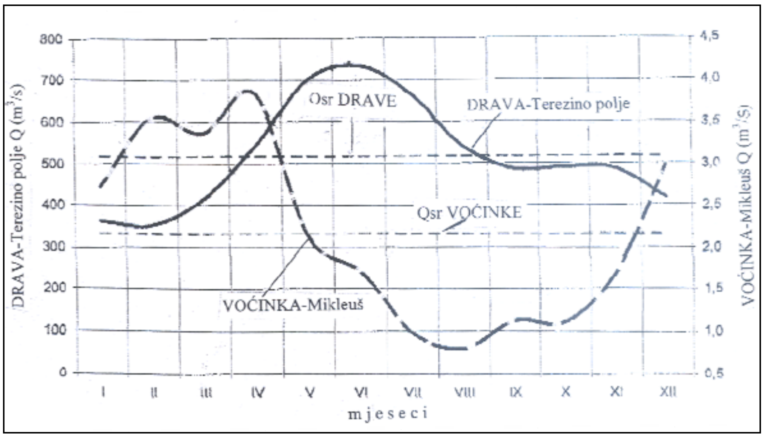

Figure 4: *Average monthly discharges for the Drava and its banks*

Thus, maximum discharges occur due to snow thawing in the Alps during dry periods in the Drava basin. From the aspect of water sources, the County has a very high potential, since sufficient amounts of water are available for irrigation in dry periods.

3.3 Crop water requirements

3.3.1 Reference evapotranspiration (ETo) and precipitation

Table 2 shows the values of ETo and the sum of long-term precipitation average (calculated effective precipitation); ETo and the sum of long-term precipitation average in the growing period and its calculated effective precipitation; the values of ETo and the sum of precipitation at Fa≤25% occurrence probability and its calculated effective precipitation; and ETo and the sum of precipitation at Fa≤25% occurrence probability in the growing period and its effective precipitation.

Table 2: Values of ETo and the sum of long-term precipitation average (effective precipitation); ETo and the sum of long-term precipitation average in the growing period (effective precipitation); ETo and the sum of precipitation at Fa≤25% probability of occurrence (effective precipitation); and ETo and the sum of precipitation at Fa≤25% probability of occurrence in the growing period (effective precipitation), for the period from 1961 to 2003

1961-2003	ETo (mm/mj.)	Precipitation (mm/mnth)	Effective precipitation (mm/mnth.)
	A	B	C
ETo and long-term precipitation average	705.5	799.4	710.9
	A-C= **-5.4**		
ETo and long-term precipitation average in the growing period	577.7	448.8	394.2
	A-C=**183.5**		
ETo and precipitation at Fa≤25% probability	705.5	469.9	437.4
	A-C=**268.1**		
ETo and precipitation at Fa≤25% probability - in the growing period	577.7	275.5	253.5
	A-C=**324.2**		

It is evident from Table 2 that effective precipitation in the long-term precipitation average was higher than ETo, the difference amounting to 5.4 mm. In the growing period, however, ETo was higher than effective precipitation, the difference being 183.5 mm. The difference was even more marked at the Fa≤25% probability of precipitation occurrence, that is, ETo was higher than effective precipitation by 268.1 mm, while this difference was 324.2 mm in the growing period.

The interrelationship between ETo and effective precipitation points to the logical conclusion that irrigation is a necessary measure for a safer and higher production of the studied crops.

3.3.2 Soil water balance

Table 3: Water deficit for long-term average precipitation and water deficit at Fa≤ 25% probability of precipitation occurrence in the period from 1961 to 2003

Crop	Water deficit for long-term average (1961-2003) (m^3/ha)	Water deficit at Fa≤25% probability of precipitation occurrence (1961-2003), (m^3/ha)
Seed maize	498	1239
Sugar beet	846	1814
Cabbage and kale	349	1230
Pepper	370	1254
Tomato	431	1349
X	**499**	**1377**

It can be seen from Table 3 that water deficit was calculated for all crops, both for the long-term precipitation average and for the probability of precipitation occurrence at Fa≤ 25%. It is thus evident that crops have different water requirements and that in more humid years (Fa≤ 25%) the average water deficit was by ca 2.75 higher compared to water deficit for the long-term precipitation average. The overall amount of water that will have to be supplied by irrigation will depend on crops grown and their share in the crop rotation. For irrigation requirements, use will be made of the results on water deficit at Fa≤ 25%. Calculated water requirements will serve as the basis to solve issues relating to water sources and adequate elements of the irrigation engineering design.

3.4 Further trends of irrigation development in Virovitica-Podravina County

Pursuant to the national plan for irrigation of agricultural land in the Republic of Croatia, each county passes the county irrigation plan and defines the irrigation priorities, taking into account land suitability, water sources and user requirements. Further steps in the irrigation development program of the county are:

- Execution of the county pilot project (at the conceptual design level - not necessary)
- Execution of conceptual solutions (for smaller basins, mainly over ca 1500 ha)
- Execution of conceptual and general designs (for actual locations and known users)

In dependence on the specificity of a particular location, number of potential users, fragmentation of agricultural plots, potential storage and sale of agricultural products, inadequate development of agricultural land, further planning of the irrigation process activities at the county level includes the following:

- Establishment of cooperatives of agricultural producers for land irrigation in a concrete irrigation system, in case of several users;
- Common policy of the cooperative in dealing with county authorities or particular ministries;
- Designing a program for storage and sale of agricultural products;
- Collaboration of the cooperative with the general design engineer in designing the method of irrigation;

- Participation of the cooperative in setting water prices;
- Consolidation of agricultural land through the cooperative;
- Organization of training courses for irrigation system users;
- Participation of the cooperative in organizing system maintenance in the exploitation phase.

Irrigation plan implementation from the national level to the general design, that is, execution of the system, is a long and costly process that requires collaboration of several professions (agronomists, hydrotechnicians, economists, etc.) with local and county authorities as well as competent ministries. The Croatian Government has therefore formed the National Committee for the Irrigation Project, which has to coordinate the institutions and subjects involved in the project and monitor all activities and completion dates.

4 Conclusions

The described example of Virovitica-Podravina County allows the conclusion that there are great requirements as well as great potentials for irrigation in the River Drava basin, and that the available resources should be exploited for further agricultural development.

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Development of the Croatian soil monitoring system

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Abstract

The establishment of soil monitoring system in Croatia was recommended as early as in 1993 within the Programme for the Protection of Soil in Croatia (Bašić et al.) which, unfortunately, has never become a part of the Croatian legislation. Moreover, we still do not have a system of qualitative and repeatable collecting and processing of soil quality data. Croatian Environment Agency, in 2006, started a project „Development of the Croatian soil monitoring programme with a pilot project" which was financially supported by LIFE Third Countries programme of the European Community. The Faculty of Agriculture of the University of Zagreb was partner in the project.

Final product of the implementation of the Project is the Croatian Soil Monitoring Programme. The Programme has been divided to three parts, according to soil usage: agricultural, forestry and (potentially) contaminated soils. 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 soil condition and characteristics. Field work, 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 three years implementation of the Project has also delivered a publication called The Soil Monitoring Manual – fist edition/working version, which includes procedures and category parameters for monitoring of the agricultural, forestry and contaminated sites, tested by the Pilot projects on each type of site, in order to correct eventual wrong steps and approaches during development of the Soil Monitoring Programme.

The purpose of the whole Project is the establishment of the Croatian Soil Monitoring System, which was already recognized by National Environment Strategy, National Environment Action Plan (OG No 46/02) and Environment Protection Act (OG No 110/07) as an important tool for planning and conducting Soil Protection Strategy and related legal acts at the national level.

Data provided by soil monitoring will be used via Croatian Soil Information System (CROSIS), which is a part of the Environment Information System, developed in Croatian Environment Agency.

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.

Key words: soil protection, soil monitoring programme, environment information system, EU recommendations

1 Introduction

Monitoring of the condition and changes of soil properties is necessary for soil protection, preservation of its natural functions and prevention of degradation processes. Soil monitoring implies continual monitoring of certain parameters of soil with purpose of gathering information on changes of the condition and characteristics of soil, and identifying the form and intensity of soil degradation. Without the development of the system by which information on negative changes in the soil would be continually gathered, there can be no timely response to prevent or alleviate such changes.

The significance of soil monitoring was emphasised by the European Union which, by Decision No 1600/2002/EC, raised the significance of soil protection to the level of water and air protection. In 2006, the European Commission gave a Proposal for a Directive of 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 degraded soils.

The establishment of soil monitoring system in Croatia was recommended as early as in 1993 within the Programme for the Protection of Soil in Croatia (Bašić et al.) which has never become a part of the Croatian legislation. Besides that Programme, there were no other attempts to establish a systematic soil monitoring at the national level, not even in monitoring of agricultural land. Some data have been individualy gathered and analysed by using various, often incomparable methods, within various scientific and research projects and studie 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.

2 Development of the Croatian soil monitoring programme with a pilot project

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. Besides the Agency and the Faculty of Agriculture, during three years implementation of complex project tasks and activities, other 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 main objective of the project was to elaborate the Croatian Soil Monitoring Programme which is to define parameters to be gathered at soil monitoring stations and points, to recommend methods, standards and time dynamics for gathering, analysis, processing and transfer of soil data, to propose locations for spatial positioning of stations and points for soil monitoring, and to recommend an institutional framework and financial structure of the Soil Monitoring System at the national level.

In December 2006, one of the first results of the Project: "The Soil Monitoring Manual - first edition/working version" (CEA, 2006) was published. The Manual unites categories and parameters for monitoring of agricultural, forestry and contaminated soils. Basic division of soil by its usage to agricultural and forestry soil has been extended to the category of contaminated soils since in developed countries more attention is directed towards the monitoring of potentially contaminated and contaminated sites. 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 for physical, chemical and biological analysis, and a time dynamics for data gathering.

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).

Final product of the implementation of the Project is the Croatian Soil Monitoring Programme. The Croatian Soil Monitoring Programme is composed of three parts and proposes number and locations for positioning of monitoring stations (chapter 3), elaborates monitoring procedures for agricultural soil, forestry soil and potentially contaminated soils, taking into account the specificities of soil sampling (chapter 4), special parameters and different time dynamics of monitoring parameters considering the mode of soil usage (chapter 5). 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 (chapter 6) and elaborates cost assessment and recommends sources of funding of the Soil Monitoring System at the national level (chapter 6).

The Croatian Soil Monitoring Programme and The Soil Monitoring Manual are available for download at the web site of the Project: www.azo.hr/smp_life_tcy.

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). CROSIS is a georeferenced database on Croatian soils which enables the entry and processing of soil monitoring data and establishment of undisturbed data flow and data availability.

3 Selection of monitoring stations

3.1 Selection of agricultural soil monitoring stations

Monitoring of agricultural soils is organised on stations of the first and second level. The monitoring 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 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 monitoring stations are arranged through the entire territory of the Republic of Croatia so that each agricultural sub-region is respectfully represented. The monitoring station is consisted of:

- Plot in a square form of 750 m^2 at whose diagonals are located points for single soil sampling,
- Soil profile from which samples are taken in disturbed and undisturbed condition and data are collected on endomorphological properties of soil and
- Lysimeter installed in the soil for collection of drainage water (only level I stations).

Due to expert and economic reasons, the optimum number of proposed monitoring stations is 90 (table 1). There are 9 Level 1 stations (with lysimeters), one per each agricultural sub-region and 81 Level 2 stations (without lysimeters) which number per sub-region depends on proportion of agricultural areas.

Table 1: Maximum, optimum and minimum number of monitoring stations

Agricultural subregion	Monitoring areas	Maximum number		Optimum number		Minimum number	
	Surface (ha)	Level 1	Level 2	Level 1	Level 2	Level 1	Level 2
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 stations		9	91	9	81	9	71
TOTAL	1.474.932,19	100		90		80	

Although small in its area, 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. Agricultural Soil Monitoring Programme paid 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. 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 Agronomy (Bašić et al, 1998-2001) – considering mentioned natural diversity, Croatia has been divided to three clearly defined regions: Pannonian, Mountainous and Adriatic. Each region is additionally divided to sub-regions: Pannonian to Eastern, Central, Western and North-western; Mountainous to Pre-Mountainous and Mountainous and Adriatic to Northern, Central and Southern.
- CORINE Land Cover 2000 – data on the condition of land cover in Croatia. Agricultural areas are divided in four groups – arable land (not irrigated arable land, permanently irrigated land); perennial cultures (vineyards, orchards, olive-grooves);

pastures; various agricultural areas (complex of cultivated parcels, predominantly agricultural land with larger areas of natural vegetation.
- Digital relief model of the Republic of Croatia.
- Pedological map of suitability of soils at the scale of 1:300 000. By overlapping this 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 have been obtained. This map represents the areas of the Republic of Croatia suitable for monitoring of agricultural soils.
- Positioning of meteorological stations. By overlapping each map of 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 monitoring have been obtained. New areas are not at the distance more than 10 km from the closest meteorological station.

All locations for soil monitoring stations have been verified by field trips. 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 surveying field characteristics of locations, data from the map of land cover and the pedologic map have been confirmed. After surveying each location the most suitable sites for establishment of the locations have been determined (fig. 1).

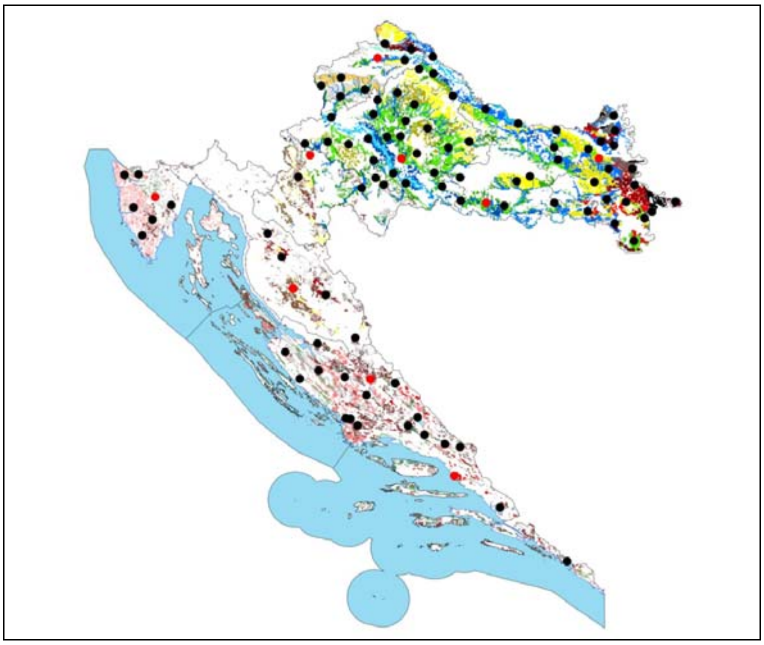

Figure 1: *Layout of agricultural soil monitoring stations (red dots are Level I stations - one per each agricultural region)*

3.2 Selection of plots for forestry soil monitoring

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 (LRTAP). 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. 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 has been made at Level I Network monitoring plots and data have been regularly forwarded to the European centre for data gathering within 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.

Within Croatian Soil Monitoring Programme selection of locations for forestry soil monitoring plots is based on ICP Forests Programme. 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 or they are located in mine fields where access is impossible. On those 95 plots it is foreseen by ICP Programme to conduct soil monitoring every ten years.

The Croatian Soil Monitoring Programme recommends the extension of present monitoring activities and intensive forestry soil monitoring at 30 selected plots (fig. 2) with 5 years time dynamics, to assure quicker data collection and monitoring of forestry soil condition and early warning insight on eventual threats. These 30 plots have been selected according to the following criteria:

- significant damage 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);
- size of forest complex,
- plant community and economically important types of trees,
- uniform distribution of points within ICP Network.

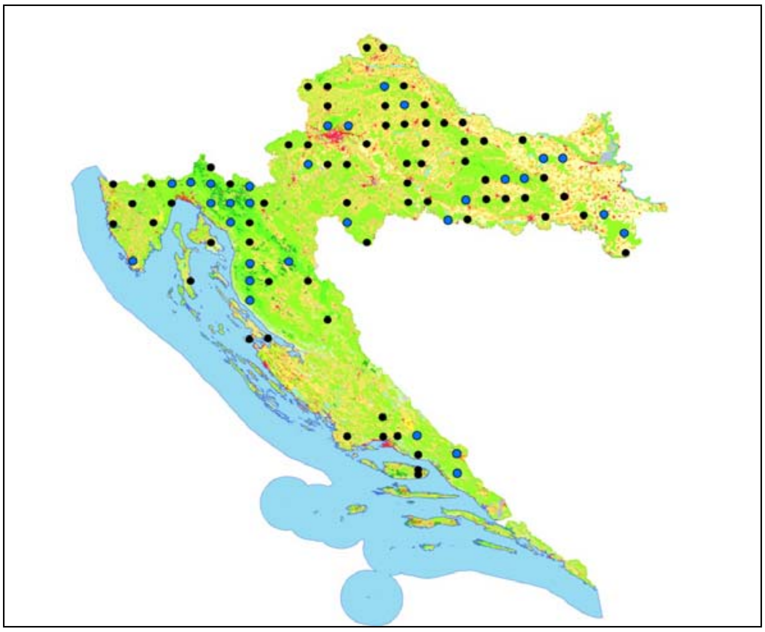

Figure 2: *Plots of ICP Forests Level I Network in Croatia (blue dots – plots for intensive soil monitoring)*

3.3 Selection of locations for potentially contaminated soil monitoring

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 facilities during their activities, but also after their closing. These facilities 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, railway stations…), larger contamination emissions are expected. Spreading of contamination emission from line sources primarily depends on natural vegetation growing by the roads.
- **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.

In the Contaminated Soil Monitoring Programme, as a part of the Croatian Soil Monitoring Programme, potentially contaminated locations have been defined at which is necessary to determine the condition of soil (inventarisation) and, according to results, to establish monitoring points. During 2005/2006, the Croatian Environment Agency developed the Database of potentially contaminated and contaminated locations – GEOL. GEOL was updated in 2007 according to EU legislation: EPRTR Regulation (EC/166/2006), IPPC Directive (EC 61/96) and SEVESO II Directive (EC 82/96). There were no corresponding Croatian legislation in 2007, EU directives were adopted in 2008 and new national legal acts are expected in 2009 and 2010. GEOL database now contains data on 2264 potentially contaminated sites at the Croatian territory owned by 1080 legal entities. The Croatian Soil Monitoring Programme foresees the monitoring of potentially contaminated soil at 247 locations (Figure 3) sorted out considering the type of activity which is being conducted at the location, production capacities and high potential of contamination and the type of pollutants that these activities may generate. Inventarisation is to be conducted at these locations in order to establish the following:

- contaminated sites at which, considering the limiting values of pollutant in the soil according to various modes of soil usage, there is a 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, but it is necessary to monitor them considering potentially contaminating activity which is being conducted at the above mentioned site.

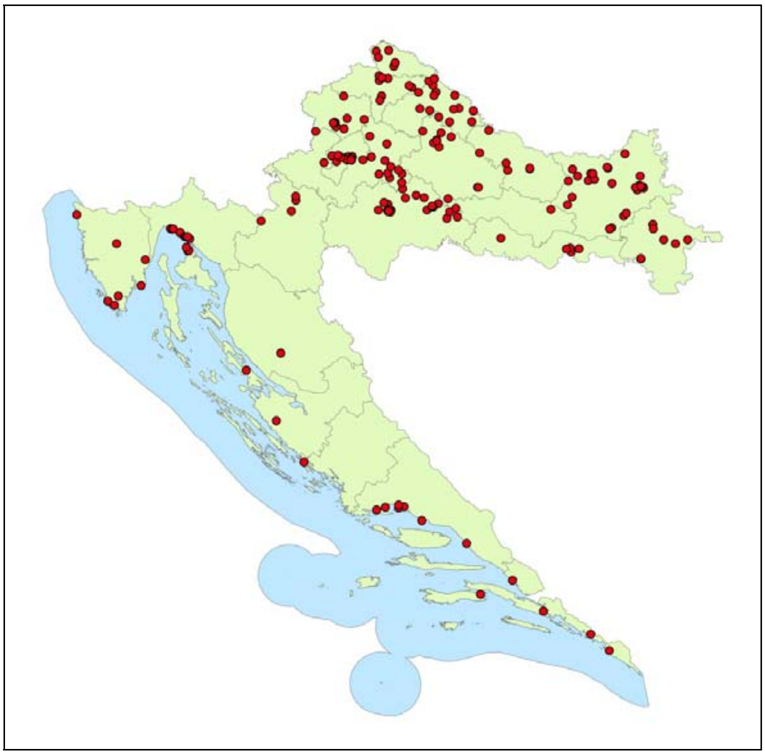

Figure 3: *247 potentially contaminated sites in Croatia recommended for soil monitoring*

4 Soil sampling

4.1 Sampling of agricultural soil

Before the establishment of station (opening and description of soil profile), it is necessary to gather **general information** on the agricultural soil monitoring station (station number, geographical data, administrative data, etc.). Data on the climate, relief, natural vegetation, use of soil, surface properties of soil and importations into soil are also colected.

Sampling of soil profile is conducted when the monitoring station is established, and again after 24 years. The profile is opened to the depth of parent material, 1 m wide and 2 m long. Soil of the station is been clasified according to the Classification of the soil of Yugoslavia (Škorić, A. et al., 1973, 1985) and according to WRB classification (IUSS Working Group WRB, 2006). 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 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 and are stored in plastic bags. When sampling soil in disturbed condition for microbiological analysis, it is necessary to ensure aerobic conditions of storage before laboratory analysis, in a refrigerator (+4ºC).

Samples in undisturbed condition of known volume are taken with the aim to test physical properties of soil. They are taken by impressing a cylinder of 100 cm^3 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.

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.

Sampling of single soil samples is made pursuant to standards ISO 10381-2: 2002 and ISO 10381-4: 2003**.** 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. Part of each sample (it includes its entire depth) is stored to separate bag for **composite sampling** (with indication of station number, depth and the label for which type of analysis it was taken).

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*. Samples taken in disturbed condition 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.*

4.2 Sampling of forestry soil

General data on the Level I Network plot, at which monitoring plot for forestry soil is located, are collected during the first soil sampling.

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). Each profile obtains the mark of the plot according to ICP. Samples from the soil profile are taken in the same manner as it was described in Sampling of agricultural soil profiles (chapter 4.1). Samples are further treated pursuant to ISO 10381-3:2002 and ISO 10381-4:2003. After the soil profile is processed, it has to be surfaced with soil. All data are deposited in the data base of ICP plots.

Sampling of single samples and forming of composite samples at monitoring plots refers to the sampling of organic layer at the soil surface and mineral layer of the soil (fig.4). Five single samples (gathered at all 5 points) are homogenised to form a composite sample. Sampling of single soil samples is conducted according to ISO 10381-2: 2002 and ISO 10381-4: 2003.

Figure 4: *Sampling of mineral layer of soil*

Soil samples are prepared for laboratory analyses pursuant to *HRN ISO 11464:2004.* Conservation and transport of soil samples must prevent chemical modifications in samples. Samples are stored at the samples archives for at least 10 years.

4.3 Soil sampling of potentially contaminated and contaminated soil

During the establishment of a soil monitoring station, **general data** are gathered on potentially contaminated location.

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, depending on contamination. 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: 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. Sampling of single and forming of composite soil samples is being conducted pursuant to standards; ISO 10381-2:2002 and ISO 10381-5: 2003. 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.

Soil sampling of point sources of contamination is conducted in circle around the source of contamination. When **sampling of line sources of contamination** (roads, railways, etc.), samples are taken on both size of the road at 5, 10, 20, 50, 100 m distance.

Preparation of soil samples for the analyses is being conducted pursuant to standard HRN ISO 11464:2004. All **samples are stored** in a storage room for keeping samples in the period of six years after sampling, pursuant to the standard ISO/DIS 18512:2006**.**

5 List of parameters for physical, chemical and microbiological analyses with time dynamics

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 soil condition and characteristics (tables 1, 2 and 3). Field works, laboratory analysis and data processing have been adjusted through recommended ISO standards of which the largest part has already been adopted in Croatia (HRN ISO). Tables contain time dynamics for monitoring certain soil parameters. The time dynamics has been adjusted to possible changes of the values of monitored parameters considering the soil usage, for example most of physical parameters of agricultural soil are tested every 24 years (1/24), except soil compaction (every 3 years – 1/3). Since no changes are expected in physical soil properties in forestry soil (except dry matter content) and potentially contaminated soil, at which there are no agro-technical interventions, physical parameters are analysed on a one-time basis (1), during the first sampling. Because of Chemical parameters need to be more frequently test (every 3, 5 or 6 years) because they are likely to be changed. Microbiological analyses are conducted on agricultural and contaminated sites, with time dynamics adjusted to soil usage.

Table 2: Physical parameters– time dynamics

Parameters	Recommended ISO standard	Agricultural soil	Forestry soil	Contaminated soil
Particle size distribution	HRN ISO 11277:2004	1/24	1	1
Bulk density	HRN ISO 11272:2004	1/24	1	1
Maximum water capacity, pF 0	HRN ISO 11274:2004 HRN ISO 11272:2004 ISO 11461:2001	1/24		1
Water capacity, pF 2,5	HRN ISO 11274:2004	1/24		1
Wilting point, pF 4,2	HRN ISO 11274:2004	1/24		1
Physiological active and easily available water	HRN ISO 11274:2004	1/24		1
Density and porosity	HRN ISO 11508:2004 HRN ISO 11272:2004	1/24		1
Skeletal structure	HRN ISO 11272:2004		1	
Air capacity	HRN ISO 11465:2004 HRN ISO 11508:2004 HRN ISO 11272:2004 HRN ISO 11461:2001	1/24		1
Water porosity	HRN ISO 17313:2004	1/24		1
Dry matter content	HRN ISO 11465:2004		1/5	
Structural aggregates stability	Calculation	1/24		
Soil compaction	Penetrometer	1/3		1

Table 3: Chemical parameters – time dynamics

Parameters	Recommended ISO standards	Agricultural soil	Forestry soil	Contaminated soil
Soil acidity (pH value)	HRN ISO 10390:2005	1/3	1/5	1/5
Carbonate content ($CaCO_3$)	HRN ISO 10693:2004 HRN ISO 10694:2004	1/3	1/5	1/5
Exchangeable acidity	ISO 14254: 2001	1/3	1/5	1/5
CEC (exchangeable Ca^{2+}, Mg^{2+}, Na^+, K^+)	HRN ISO 11260:2005 HRN ISO 13536:2005	1/6	1/5	1/5
Organic and total carbon	HRN ISO 10694:2004 HRN ISO 14235:2004	1/3	1/5	1/5
Total nitrogen	HRN ISO 11261:2004 HRN ISO 13878:2004	1/3	1/5	1/5
Total sulphur	HRN ISO 15178:2005	1/3		1/5
Accessible elements in the soil (P, K, Ca,	HRN ISO 14870: 2005 HRN ISO 11263:2004	1/3		1/5
Total metals and potentially toxic elements: Fe, Al,	HRN ISO 11466:2004 HRN ISO 14869:2004 HRN ISO 11047:2004	1/3	1/5	1/5
Anions and cations: NO_3^-, NO_2^-, NH_4^+, SO_4^{2-}, CN^-, ...	HRN ISO 11048:2004 HRN ISO 11262:2005	1/3		1/5
Electrical conductivity (EC)	HRN ISO 11265:2004	1/6		1/5
Persistent organic polluters: PAH, herbicides,	HRN ISO 13877:2004 ISO 15009:2002 DIN 38414-24:2000	1/3		1/5
Chemical composition of drainage water at	HRN ISO 7888:2001 HRN ISO 10304-1:1998 HRN ISO 14911:2001	1/3		1/5
Total oils	ISO 16703:2004			1/5
Mineral oils	HRN ISO/TR 11046:2005			1/5

Table 4: Microbiological parameters – time dynamics

Microbiological parameters	Recommended ISO standard	Agricultural soil	Contaminated soil
Cellulolytic activity	ISO 23753-1-2:2005	1/3/24	1/5
Activity of dehydrogenase	ISO 23753-1-2:2005	1/3/24	1/5
CO_2 production	HRN ISO 14240-1:2004	1/3/24	1/5

6 Implementation and funding

6.1 Agricultural soil

Considering the existing legal regulations, it is proposed to assign the Institute for Soil, Osijek, which is part of Croatian Centre for Agriculture, Food and Rural Area to be a 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.

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 152/2008), are ensured 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.

The estimated cost for agricultural soil monitoring during the period of 9 years amounts 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. 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.

Institutional framework for the implementation of Agricultural Soil Monitoring System has been already established by the Agricultural Land Act (OG 66/01, 87/02, 90/05, 152/2008), while all other aspects of agricultural soil monitoring have been defined by Croatian Soil Monitoring Programme. In cooperation with the Ministry of Agriculture, Fishery and Rural Development, Croatian Environment Agency shall propose new amendments to the mentioned regulations and put them into adoption procedure within current year.

6.2 Forestry soil

Monitoring of forestry soil is already specified by the Ordinance 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 Croatian Soil Monitoring System 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.

Forest Research Institute, which is a governmental scientific institution, is assigned as a National Referent Centre for the implementation of the Forestry Soil Monitoring System.

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 by Forest Research Institute from the State budget.

6.3 Potentially contaminated and contaminated soil

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 and 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 soil.

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 soils. However, implementation of the Soil Monitoring System at (potentially) contaminated sites (field work, laboratory analysis and data processing), may conduct only authorised legal persons who satisfy expert and technical conditions.

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, OG 110/07) with the time dynamics of 5 years at the location at which the activity is taking place.

The costs of monitoring potentially contaminated soil depend on several factors: the type of contamination, the type of potential contaminating activity, the size of 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.

7 Data flow and access to data

For the needs of the soil condition monitoring, the Croatian Environment Agency has developed 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 Centres have 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 are responsible for accuracy and quality of delivered data.

The availability of soil monitoring data to other potential users is regulated by the Regulation on Environmental Information System (OG 68/2008).

8 Summary/Conclusions

The Croatian Soil Monitoring Programme represents a foundation for the establishment of the Croatian Soil Monitoring System which will ensure monitoring and comparability of soil condition data, in accordance with obligations of reporting on the condition of environment of the Republic of Croatia, as well as according to internationally undertaken obligations. The Programme will ensure continual availability of data, accurate, verified and complete, which are required for the evaluation of the condition of soil and the implementation of the policy of sustainable management and soil protection.

The Croatian Soil Monitoring Programme and simultaneously developed Croatian Soil Information System are based on EU recommendations and thereby the compatibility with the future European Soil Information System - EUSIS has been ensured.

In cooperation with the Ministry of Environment, Physical Planning and Construction, the Ministry of Agriculture, Fishery and Rural Development and the Ministry of Regional Development, Forestry and Water Management, Croatian Environment Agency shall propose new amendments to the existing Croatian regulations and put them into adoption procedure, so the beginning of systematic soil monitoring is to be expected soon, whereby necessary data for planning and implementation of the policy of sustainable management of soil in the Republic of Croatia will be ensured.

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Soil damage processes in Bosnia and Herzegovina – course of action in its future protection

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Abstract

Soil is a part of the ecosystem and represents unrenewable natural resource. Its multifunctional properties encompass the environmental and technical use. Both functions claim the same land areas, hence raise the question whether their inter-relations could be harmonized. As a result of the increasing population growth, development of settlements, industry, introduction of numerous new technologies, exploitation of raw materials, construction of roads, disposal of various waste materials, the process of changing the purpose of ecologic functions as well increases.

Within the scope of their continuous impact, we have identified 4 groups of effects on soil: soil infection (biological contamination); chemical contamination; anthropogenic degradation; and physical destruction. The annual soil loss in BiH is estimated to 3,000 ha (due to physical destruction alone). This paper addresses appropriate soil protection and treatment measures which include remediation, re-cultivation, littering of a special soil layer, calcification, organic mater management and legislation. The necessity of taking more care about soil and its protection has been highlighted. The existence of the Planet's population is dependant on scarce quality soil.

Key words: soil infection, chemical contamination, anthropogenic degradation, physical destruction, remediation, re-cultivation, technosoils, soil indicators, soil elasticity.

1 Introduction

The soil is a part of ecosystem and represents an unrenewable natural resource. Its utilization is manifold, i.e. it happens through the two basic groups of functions – ecological and technical. Both groups tend to claim the same land space, i.e. they behave as rivals. As a result of such competition, we have continuous soil losses, as well as an increased practice of changing the purpose of land use, which, subsequently leads to the share of soil utilized through technical functions being constantly increased. The question arises whether their mutual relationships can be harmonized and most valuable soils protected? (Resulovic, 2000)

In addition to the fact that the modern world – due to the continuous growth of population, extensive construction activities, industry, construction of roads, exploitation of various raw materials, etc. – faces increased disposal of various waste materials and accelerated development of erosion processes, it also suffers from ever growing pressure on the soil. In other words, the consumption of soil, which is reflected in various types of soil damages, is constantly increasing. This has caused a continuous reduction of the area of arable and agricultural land. These relationships have in many areas reached the limit threatening the existence of the mankind. It is our task to find the way of stopping such negative tendencies and help preserving the best quality soils (Blum, 2006).

2 Purpose

Knowing that the soils and land areas are permanently exposed to the negative influence of multiple causes that have led and are still leading to increasingly huge variety of damages, this paper focuses on the following issues:

- Characteristics of the status of BiH land resources
- Causes and effects of various types of soil damages
- Health status of our soils – indicators of unhealthy status of the soil
- Sustainable development of soil – myth vs. reality
- Future course of action in the area of protection

2.1 Characteristics and the status of B&H land resources

The automorphic soils cover 92.9% and hydromprphic 7.10% of the total area of BiH. A significant portion of the total area – 44.0%, has acidic reaction. Good quality soil is scarce and 14.0% of it fall into the first three bonity classes, and if the IV bonity class is added the total participation of good quality soil rises to 32%.

The annual soil loss due to the process of physical destruction reaches 3,000 ha.

The level of contamination of soil with land mines continues to be high, totaling 200,000 ha or 4% of the total space.

Table 1: Status of land resources in BiH

Population (1991)	4,354,911
Population (1995)	3,200,000
Total area of BiH	5,112,900 ha (100%)
Automorphic soils	4,703,868 ha (92,59%)
Hydromorphic soils	363,016 ha (7,159%)
Agricultural area	2,257,400 ha (50,0159
Arable land	1,179,492 ha (52,25% of agricultural land)
Plowed fields	1,077,908 ha (47,75% of agricultural land)
Soils with acidic reaction	995,513 ha (44,1%)

Area under forest Unfertile soil areas Areas contaminated with land mines	2,298,600 ha (44,96%) 256,900 ha (5,03%) -250,000 ha (4%)
Per capita: Total land resources Total agricultural land Arable land	 1,17 ha 0.58 ha 0.36 ha
I-III bonity classes cover 14%, and together with class IV they cover 32% Annual soil loss due to physical destruction total 3,000 ha	

Knowing the ratio between the agricultural and arable land per capita is essential. We are here presenting some of the ratios for individual municipalities.

In many regions of Bosnia and Herzegovina, ratio between arable and agricultural land has been significantly reduced. The Table 1a shows some of them. Obviously, the most difficult situation is in the municipalities of Central Bosnia.

Table 1a.: Ratio between arable and agricultural land in some municipalities – ha/inhabitant

Municipality	*Arable land*	*Agricultural land*
Zenica	0.04	0.11
Banovici	0.05	0.23
Tuzla	0.07	0.13
Kakanj	0.08	0.23
Breza	0.09	0.23
Vares	0.06	0.40
Lukavac	0.19	0.30
Gracanica	0.22	0.33
Ugljevik	0.35	0.49
Limiting values per capita	**0.17**	**0.40**

3 Causes and effects of various types of soil damages

3.1 Causes of soil damages in B&H

The area of B&H has been affected by a number of soil damage causes which continually grow and claim more and more land areas. As a result of the increased population, construction of settlements and roads, industrial development, etc. which claim significant land space, the ecological functions of soil are reduced. When added to the damages caused by war activities, such as land mines contamination, the scale of the affected land areas becomes clearer. The causes of land damages are shown in Table 2.

The causes of land damages in Bosnia and Herzegovina:

- exploitation of various raw materials
- disposal of (various) waste materials
- settlements
- industry
- roads
- water accumulations
- land mines
- archeological excavations
- tourism
- airports

- playgrounds
- unreasonable use of land areas in agriculture
- erosion and land slides
- fires
- lack of care for land protection
- lack of legislation

3.2 Effects of soil damages in B&H

As a result of numerous causes, many different types of land damages have started to manifest themselves. According to the cause, we divide these manifestations in 4 basic groups. Good knowledge of causes and induced processes is crucial for the application of appropriate mitigation measures. The basic groups of processes are as follows:

- infection of soil (biological contamination)
- chemical contamination of soil
- anthropogenic degradation
- physical destruction (pedocide)

3.2.1 Infection of soil (biological contamination)

It is generally believed that the major sources of pollution in agriculture are: pesticides, fertilizers, and continuous application organic fertilizers. In some areas, the pollution may be caused by the utilization of farming machinery (industrial oils, etc.), as well as penetration of solid and liquid waste materials from human settlements.

The group of “classical polluters” has been augmented with the term “biological pollution” and is now used to identify the organisms that are present and viewed as polluters. It includes the weeds, particularly those producing pollen that is harmful for humans’ health (Ambrosia). Some parasitic fungi are also considered to be biological polluters as they produce micro-toxins that are harmful for humans and animals.

It is necessary to update the records in researching the pollution statuses.

Additionally, special attention needs to be focused on the areas of storage, transportation and local processes.

Recently, the soil infection issue is becoming increasingly present in technical and scientific literature. This term refers to the process of soil contamination by biogenic causes which include: bacteria, viruses, parasites, etc. Development of such effects has intensified causing thus various kinds of diseases in animals, as well as in humans. They especially contributed to the increased incidence of diseases such as: brucellosis, Q fever, swine flu, avian influenza, etc. The increase of these diseases incidence is additionally boosted by increased land areas of so called sanitary communal waste disposal sites and their use in agricultural production.

Special interest in this kind of research was taken when urban spaces, such as parks, children’s playgrounds, walking areas, etc., where the level of soil infection with various parasites was considerably high, got included. Very interesting results were obtained and presented in the papers of the experts from the School of Veterinary Medicine (Zuko, Almedina, 1998, Omeragic, 1999, 2003).

The research in this phenomenon showed significant contaminations related to the soil. One of the interpretations states the huge number of house pets (dogs, cats) and their movement around public areas, as a possible cause (Varga, 2004).

Nowadays, there is a huge necessity to expand such researches on other areas as well. Their purpose would be to identify the health status of the soil and protect the farmers and inhabitants from possible consequences. It would be necessary to establish the so called high-risk zones, in terms of unhealthy soil.

Table 3: The length of the survival time of some microorganisms in liquid manure (according to Rafa (cited Tamasi), 2004)

Parasites	*Days of survival*
Brucella spp	1-100
Leptospira spp	60
E. coli	120
Chlamydia spp	27
African swine flu virus	60-160
Ordinary swine flu virus	5-40
Salmonela entereiris	143

3.2.2 Chemical contamination of soil

As a separate process, the area of chemical contamination of soil has been identified. The following causes are included: heavy metals, radio-nuclides, pesticides, mineral and organic polluters. So far, this area has been extensively studied. Subject to the research were also the effects on the soil properties and influence on certain agricultural crops and their safety. The research also encompassed the behavior patterns of various polluters in relation to their retention in soil, leaching processes, impact on underground waters, etc.

For the purpose of remedying the soil damages, we also worked on testing the effectiveness of certain soil sanitation measures.

3.2.3 Anthropogenic degradation of soil

As a consequence of human activities, we are witnessing the increase in negative manifestations in soil properties. It exhibits in the deterioration of physical, chemical and biological properties of soil, as well as in occurrence of unfavorable processes. Such changes are particularly often in disruption of structure, settling, reduced water permeability, compactness, deteriorated aeration, superficial and furrow erosion, acidification, reduction of humus contents, deterioration of soil immune system, reduction of physiological soil depth, etc.

3.2.4 Physical destruction of soil

The most unfavorable processes are the ones which lead to the total physical destruction of soil. Such processes cause the loss of ecological functions of soil, with eventual disappearance of soil as natural resource. Here, we are dealing with settlements, industry, roads, exploitation of various raw materials, disposal of waste materials, etc. (Resulovic, 2000). They have caused a disturbance of the wider land areas, i.e. some kind of desertification processes to take place. Loss of soil in B&H in this way alone amount to 3,000 ha annually.

4 Healthy soil in function of sanitary safe food

Currently, the expansion and improvement of safe food production is being discussed, and partly implemented in practice. Such activities should first and foremost take into consideration the knowledge of the health status of soil. Following the syntagma that without a healthy soil there can not be the production of healthy food, we may conclude that the healthy soil is a *conditio sine qua non* – i.e. essential to the implementation of such activity.

The term healthy soil pertains to the status of physical, chemical and biological properties of soil which ensure the production of good quality food. While considering this status, we have to answer one very important question: how it can be reached, i.e. what are the factors of its creation? Within the scope of creation of such status, three basic phases can be identified:

- natural conditions contributing to the formation of unhealthy soil
- anthropogenic impacts on the formation of unhealthy soil
- technogenic impacts on the formation of unhealthy soil

4.1 Natural conditions contributing to the formation of unhealthy/poor quality soil

During the processes of soil genesis and its evolution, different pedo-systemic units are being formed. They are primarily the result of the activity of a number of factors (pedogenic factors) and pedogenetic processes. A result of their activity is the formation of various types of soil. Within the framework of the existing soil types that can be denoted as unhealthy, in BiH we have identified the following pedosystemic units: Pseudogleys, Gleysols, Histosols,Vertic Cambisols, Leptosols, Fluvisols (skeletal), Heavy clay soil.

4.2 Anthropogenic causes in the formation of unhealthy soil

Among the processes influencing the formation of unhealthy soil, an important role is ascribed to the way of their use. In the situation of unreasonable use of soil, its favorable properties can be significantly affected. Such actions result in development of unfavorable physical and chemical properties of soil.

The unhealthy conditions of soil may manifest in different ways.

4.3 Technogenic causes in the formation of unhealthy soil

These causes drastically alter the properties of natural soils, leading to the formation of entirely new soil formations. These newly formed soils are grouped in separate pedosystemic units, i.e. class of technogenic soils. Their properties depend primarily on the properties of the substrata upon which they are being formed, namely the properties induced by the disposal of various waste materials (industrial, communal, metal, medicinal, animal, etc.)

5 Indicators of the unhealthy soil status

In order to identify the status of unhealthy soil, the following indicators should be first considered:

Physical properties

- Water permeability
- Texture
- Compactness
- Presence of skeleton
- High level of underground water
- Unstable structure
- Poor aeration

Chemical properties

- Soil reaction, i.e. very acidic or very alkali
- Low level of base saturation
- Low content of humus
- Content of salt – salinization
- High reduction processes – high pH values
- Presence of heavy metals
- Radioactivity

Biologic properties

- Small presence of useful micro-flora and mezzo-fauna
- Presence of parasites

6 Sustainable development of soil – myth vs. reality

According to White (2003), the term "sustainable" is often misused in public debates. In such frameworks, it is rarely understood what is "sustainable – and what is not". The eco-systems are adapted to resist, to a certain degree, to the changes (property of soil elasticity).

Everything on this planet is a subject of change – stated White in his further considerations. Hence, due to climate change in the geologic eras, as well as large-scale events such as volcanic eruptions, tsunami waves, earthquakes, etc., the Planet shows us that nothing about the existence of its eco-systems is static. The existing ecosystems are getting adjusted to the changes, many species are being destroyed, while new ones capable of adjusting to the new conditions are being introduced. Any concepts that are based on keeping the *status quo* is anthropocentric. While analyzing the conditions of sustainability of the status of soil, being a part of ecosystem, we are actually judging its capability (elasticity) to resist to the new changes over a period of time.

The sustainable development of soil is currently being extensively discussed. This term anticipates the improvement of production, i.e. increase of soil fertility and productivity, while preserving its original quality and health status.

However, in practice, such meaning and approach can not be identified. Namely, due to the continuous growth of the population, development of new technologies, industry, etc., the pressure on soil is ever building up, and demand for changing the use of soil is increasing as well as the number of technical functions of soil, which result in the reduction of land areas and loss of soil.

While making these analyses, the question arises whether the soil can be protected in such situation? The FAO's definition reads: "The sustainable soil development represents the management and conservation of a natural resource, as well as driving the technology and institutional changes in a way which would ensure that the current and future generations' needs are met and continuously satisfied. Such a sustainable development in agriculture, forestry and fish farming would preserve the land, water, plants and animal genetic resources, and yet remain environment friendly, non-degrading, technically suitable, economically viable and socially acceptable."

The sustainable development of soil is based on meeting the following four requirements (Varaley, 2004):

- Health condition of soil
- Quality food
- Sanitary safe food
- Clean water
- Pleasant environment

Table 4: Overview of the criteria for sustainable development of soil

Myth	*Reality*
Reasonable use of soil	Unreasonable use of soil
Under graded soil	Various kinds of damages
Technically suitable	Chemical contamination
Economically capable	Biological contamination
Socially acceptable	Anthropogenic degradation
	Physical destruction
	Continuous loss of ecological functions of soil
	Reduced areas of arable and agricultural land
	Non-compliance with the legal provisions

	Lack of care about soil

According to Varley (2004): based on the results assessment, around 15% of land areas worldwide is exposed to the influence of one or few processes of degradation. These figures are the highest in Europe and amount to 23%, mainly due to deforestation and implementation of various agricultural activities. The lowest figure – 7% is recorded in North and Central America. There are no absolute measures, only those relative ones can be used in order to protect the soil.

7 Future measures of soil protection

In order to protect the soil, it is necessary to implement a series of actions. The following ones are identified as major:

- registration of causes and effects of soil damages
- determination of the status of the soil bonity classes
- continued follow-up of the soil damages, particularly those related to physical properties
- identification of risk zones affected by biological processes of contamination (infection of soil)
- valorization of soil bonity in karstic areas in B&H which cover approximately 400,000 ha
- mapping of active and potential water erosion of soil
- intensification of measures for re-cultivation and remediation of damaged soil
- conduct continuous monitoring of the change of land use
- develop instructions and handbooks on keeping records about changes related to reduced soil quality, as well as measures for their protection
- adoption of a separate law on the overall protection of soil
- intensification of the cooperation with national and professional organizations with regard to the soil rehabilitation measures
- improvement of the care about soil protection. Within the relevant ministries, particularly the Ministry of environment, establish a team of experts which would work on promoting the overall measures related to reasonable use of land resources
- improve development of projects related to the monitoring of change of land use and promote researches related to changes in soil incurred due to ways of its use

8 Conclusions

The work addresses the multi-functional way of using the land, as well as processes the causes and effects of land damages. In Bosnia and Herzegovina, the automorphic soils take up more than 92% of total area, and hydromorphic 7.16%. Less than 1/3 is good quality land. There is 0.58 ha of agricultural land and 0.36ha of arable land per capita. The soils with acidic reaction take up the area of 44.1%, mined land 4%.

The land damage processes are divided in four groups of effects: biologic contamination (infection) – chemical contamination – anthropogenic degradation – physical destruction (pedocide). The annual loss of soil through physical destruction alone amount to 3,000 ha. The causes of the appearance of unhealthy soils are considered through three different ways: natural, anthropogenic and technogenic.

The paper also addresses the measures for the preservation of good quality soils, as well as the measures for the rehabilitation of damaged land which are considerably delayed. It highlights the fact that the care about protection of land is still far below the care provided to the other members of the eco-system, namely, water and air.

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The urbanization of agricultural land in Slovenia between 2002-2007, land use changes and soil quality

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Abstract

With little more than 2 million ha of total surface, Slovenia represents one of the smallest, yet highly diverse countries in Europe where the high quality soils and good agricultural land are very limited resource. Urban sprawl and soil sealing are two of the most significant types of land use change that strongly affect soil resource. We are daily witnessing land use changes. Mainly the agricultural production is abandoned while the quality soil is frequently lost due to urbanisation. The extent of soil sealing was accelerated in last ten years especially in lowlands. This contribution highlights the results of soil sealing analyses and the agricultural land use structural changes affecting soil resource. The study was conducted using the 2002 and 2007 1:5,000 digital land use data for Slovenia. The soil quality data was derived from 1:25,000 digital soil map, soil profile data and other georeferenced data.

The total urbanized area in Slovenia has increased from 88,070 ha in 2002 to 107,919 ha in 2007, which means a total urban land use increase of 19,790 ha or 22.5 % in five years. Total surface of arable land - best quality soils has decreased for 3,557 ha (~ 2 ha/day). The extent of grassland soils decreased due urbanisation and soil sealing for 7,137 ha (~4 ha/day), orchards for 1,408 ha (~0,8ha/day) and vineyards for 613 ha (~0,3 ha/day). The total soil loss was approximately 11 ha per day. The additional spatial analysis, where the soil quality number values (SQN) as a soil quality measure was used, showed that a large part of urbanised soils is of mid quality (SQN between 29 and 53) and a significant part of high quality. Under agricultural land use a high quality soil was urbanised with a highest rate in comparison to the low and mid quality agricultural soil. The extent of soil sealing in Slovenia in last decade is of worrying proportions. To limit this ongoing destructive process strict soil protection legislation accompanied with other mechanisms should be introduced.

Key words: soil sealing, urbanization, soil threats, land use change, soil quality

1 Introduction

Soil is a natural resource while agricultural lands are basis for food and fibre production. Highly productive agricultural areas with fertile soils and favourable climate is a precious natural that enabled good living, the development of industry, arts and culture in the past and recent times.

1.1 Urbanization and soil sealing

Urbanisation and urban sprawl is defined as a physical extension of urbanised areas on neighbouring, in general agricultural areas, by the principles of market economy (EEA, 2006). The term 'sprawl' itself defines the extension of cities in a pejorative meaning as a result of less or ineffective urban planning. Soil sealing is defined as physical covering of soil surface with an impermeable material (European Commission, 2006). The urbanization defines the extension of the urban areas to neighbouring agricultural, semi-natural and natural areas and comprehends wide spectrum of impacts and destructions to soil resources. Total destruction of soil by sealing with impermeable structures, topsoil removal, mixing of natural soil horizons, soil compaction, contamination, mixing soil with building debris and other artificial material, etc., largely or completely change the natural soil profile (Kelly in Thornton, 1996; Biasioli et al., 2006), influence the cycling of matter and energy, impact the health of citizens (Scheyer, 2000; Abrahams, 2002; Lee et al., 2006; Ljung et al., 2006; Rodrigues et al., 2006; Ljung et al., 2006) and significantly lower the capacity of soil to perform its main ecosystem functions (Randrup in Dralle, 1997). Physical removal of soil and its sealing represent permanent loss of soil resource and soil functions.

During 1990 - 2000 the growth rate of urbanized areas in Europe was 5.4 %. Cities areas in Europe, on average, spatially increased by 78 % while the total population increased only for 33 % (EEA, 2006). Land use changes between 1990 and 2000 amounted to 2.8 % of Europe of which a substantial part represent the urbanization of rural areas. The intensive land use changes are observed in Slovenia as well. The number of building permits per year increase in 2007 to 7 %. Land use changes are daily eye-witnessed.

1.2 Effects of urbanization to agricultural land

It is not widely recognised that agricultural soils land generally have, besides the food and fibre production, very a high ability to perform basic environmental functions (retention, transformation / filtering of pollutants, filtering and supplying of underground water, CO_2 fixation, the circulation of matter and energy ...).

Urbanisation not only endangers agricultural functions of soil (food other biomass production) but reduces the ability and the extent of environmental soil functions and, consequently, non-agricultural society needs. The ability of agricultural soil to perform agricultural, environmental, economic and social functions in the appropriate scale is necessary to be preserved for future generations. Urbanization can be, especially at the levels witnessed nowadays, described as a most destructive process that threatens national food security, cultural landscape, and ecosystem functioning. Food security is coming back to the agenda and is becoming a global and strategic issue again.

1.3 Land use changes and urbanization of agricultural soils in Slovenia

Slovenia is smaller area of Central Europe comprising 2.027.300 ha. Large part of the country is mountainous and hilly where the woods are predominant land use (62 %). Highly productive agricultural land is situated mainly in few lowland areas formed on gravel or loamy - clayey river deposits. The soil resource is, especially when compared to some of the neighbouring areas (Po Valley in Italy or Eastern Slavonia in Croatia), modest in size and quality. That is one of the main reasons why high capacity Slovenian soils must be protected and carefully managed. High quality agricultural land must be protected and managed in a rational and more sustainable way.

Rapid land use change processes that we are facing in Slovenia in last ten years are accelerated by general economic, political and social development. Daily we witness the land use transformations in space. Among the most present changes is abandonment of arable land and/or its change into grassland. Among the people exposed as a general negative trend is ubiquitous high degree of urbanization of best agricultural land in valley bottoms. Land use changes are being monitored by the Statistical Office of the Republic of Slovenia (SORS). Land use change records have been elaborated for years 1993, 1997, 2001 in 2005 (www.stat.si) in general by using the Landsat TM image analyses. Land use change information is presented in aggregated way. The land use changes between agricultural, forests and urbanized land do not distinguish different types of agricultural use and their mutual transitions. According to Statistical Office, the share of built-up land in the period 1997 - 2000 was 5.3 % of the total area of Slovenia. The index of urbanization in 1993 was 1.0, in 1997 1.0 and 1.1 in 2001.

In last few years the land use information is improved by elaboration of agricultural land use polygon database in the scale 1:5.000. The database was developed and is un-regularly but frequently updated by the Ministry for the Food, Agriculture and Forestry (MFAF). In the last ten years, the MAFF acquired three versions of the GIS land use polygon databases in the scale 1:5.000 (LU). The first two versions of the year 2002 (LU02) and 2005 (LU05) are the result of expert interpretations of black and white aerial photographs, while the 2007 version (LU07) was elaborated by the interpretation of colour digital ortho photo imagery (DOF). All three databases enable the detection of land use changes at the aggregate level as well as temporal tracking changes in land use of individual areas. The land use interpretation key of the LU02 dataset is marginally different from LU05 and LU07datasets. By additional interpretation of differences of selected land use class definitions, the LUS datasets and the agricultural land use transitions and structural agricultural land use changes can be accurately represented.

The purpose of this study was to assess the land use changes within agricultural land use by using temporal high resolution datasets for the whole country. The intention was: to i) review structural changes of the agricultural land uses, ii) the extent of urbanisation of the agricultural land, and iii) to assess the quality of soil resource lost by the urbanisation urbanised soil in the last ten years' time scale.

2 Materials and methods

Definition of the urbanization: In this study we considered as urbanized: i) all fully built-up land (covered by building or infrastructure facility - the soil is destroyed and only carry out the function of the support for infrastructures), ii) soil completely removed often to the parent material (quarries, gravel pits, expansion of water bodies - soil functions are completely eliminated), iii) the 'restorated' soil close to the buildings within construction areas which were more or less modified during the construction phase (removed the upper A horizons and/or mixed horizons - the quality of such land is generally substantially lowered), and iv) "veiled" to the soil e.g. canopies and bridges, significantly reducing the capacity of soil to perform main environmental functions.

2.1 Data used data processing

In the study digital vector spatial database in scale of 1:5.000 and 1:25.000 and raster elevation models were used.

Land use changes were assessed by using polygon vector land use database in scale 1:5,000 from October 25th 2002 (LU02), (MAFF, 2002) and September 3rd 2008 (LU07), (MAFF, 2007). Both LU02 and LU07 databases were elaborated by the interpretation of digital ortho-photo imagery at 1: 5,000 with a resolution of 0.5 m (DOF5). Black and white DOF5 2002 images were taken between 1997 (some of them in 1995) and 2000. The LU07 database was interpreted from colour DOF recorded in summer 2006. The land use interpretation was made on the basis of the MAFF interpretation key and instructions (MAFF, 2003; MAFF, 2005).

Soil quality was and agricultural suitability of land was assessed by processing the Digital soil map of Slovenia in scale 1:25,000 (DSM25). DSM25 (MAFF, CPVO, 2001a) is a vector polygon layer composed of soil mapping units (SMU). SMU polygons are defined by the area of soil typological units (STU) (Vrščaj and Lobnik, 1997; Vrščaj and Lobnik, 1999). Soil profiles dataset (SP), (MAFF, CPVO, 2001b), is a collection of app. 1700 soil profile data sets comprising the descriptions of locations, morphological descriptions of soil ghorizona and belonging standard analytical parameters. SP data were used as the primary source of information on definition of the average soil properties of SMU polygons and hence soil quality derived from the DSM25 geometry (Vrščaj and Lobnik, 1999).

Relief in Slovenia is one of the main pedogenetic factors and criteria for assessing the quality and productivity of agricultural land. Factors arising from the relief forms (e.g., slope and exposure) co-define the suitability of land for agricultural production. To asses agricultural land quality the elevation raster dataset in a resolution of 12.5 (DEM12.5) (CPVO, 2005) was used.

2.2 Soil quality evaluation

Soil quality for soil types (STU) was summarized to unique soil quality number (SQN). SQN reflects the evaluation of the essential agricultural and universal soil quality indicators. SQN decline not only fertility but also the ability of soil to perform the essential ecological functions. Theoretical range of SQN for STU is from 7 (worst) to 100 (best soil). For each SMU present in the DSM25 geometry the mean SQN was calculated on the basis of the presence of STU within SMU. Calculated for the DSM25 SMU polygons the SMU the average SMU SQN range was from 7 to 96. The detailed description of the soil and agricultural land quality is beyond the scope of this contribution and will be described separately.

2.3 Spatial data processing

Spatial GIS processing was performed in ArcGIS® Workstation module. Vector processing was carried out in the shape and cover form while raster in ArcGRID mode. ArcMap was used for integration, visualization, and verification and presentation of data. Spatial processing was performed by elaboration of Arc Macro Language (AML) software routines. SP and SMU attribute data were processed and evaluated by SQL queries within ORACLE soil data structures maintained at the Agricultural Institute of Slovenia. The territory of whole country was processed.

Data processing of land use change. Vector LU02 and LU07 polygons were converted into raster grid form of 5 m resolution of 5. DSM25 SMU polygon geometry was converted to raster form using the SQN attribute to the SQN grid of 12,5m resolution. The total area of the conversion of LU02, LU05 and DSM25 from vector to raster format deviates from the surface in vector form. The difference was between 0.48 % - 0.33 % of the total vector area.

3 Results and discussion

3.1 Total land use changes of agricultural land

Comparison of the LU02 and LU07 in the raster 5 m resolution databases showed the total decrease of arable land (fields and gardens) for 15.4 %, hop fields for 16.3 %, abandoned agricultural land for 12.9 %, vineyards for 12.4 % and other agricultural land for 20 %. At the same time the total area of forests has increased by 1.5 %, olive plantations by 41.7 % (475 ha), grassland by 6.9 % (24,267 ha) and extensive orchards by 2.2 % (444 ha) (Table 1). Please note, that the figure for total amount of sealed land in the table is misleading because the presented 0.5 % (527 ha) increase in the urban areas was calculated based on total area identified as a sealed or similar to sealed. Land use as available in the LU02 in this category also includes large proportion of non-urban and non-agricultural land and which should be regarded as an anomaly and was corrected in later 2005 and 2007 version. Exclusion of these urbanized areas in 2007, which were in 2002 not identified as urban (real increase in sealed land), show that in total 19,790 ha of land beeing urbanized between the year 2002 and 2007.

Table 1: Total change for agricultural land use between 2002 in 2007

LU code	Agricultural land use categories *(MFAF, 2002, 2007)*	2002 (ha)	Share SLO (ha)	2007 (ha)	Share SLO (ha)	2007-2002 difference (ha)	2007-2002 difference (%)
1100	Arable land and gardens	213.977	10,6	180.941	8,9	-33.035	-15,4
1160	Hop plantations	2.501	0,1	2.094	0,1	-407	-16,3
1211	Vineyards	25.295	1,2	22.164	1,1	-3.131	-12,4
1221	Intensive orchards	5.047	0,2	4.762	0,2	-284	-5,6
1222	Extensive orchards	19.822	1,0	20.266	1,0	444	2,2
1230	Olive groves	1.139	0,1	1.613	0,1	475	41,7
*1	Grassland	350.679	17,3	374.946	18,5	24.267	6,9
1410	Spontaneously afforested agricultural land	25.243	1,2	21.983	1,1	-3.260	-12,9
1500	Mixed land use	18.944	0,9	18.732	0,9	-211	-1,1
*2	Less frequent land uses	630	0,0	8.372	0,4	7.742	1228,4
2000	Forest	1.201.686	59,3	1.219.823	60,2	18.136	1,5
3000	Sealed and/or urbanised land	108.205	5,3	108.732	5,4	527	0,5
*3	Other	54.098	2,7	42.867	2,1	-11.231	-20,8
	Total:	2.027.265	100,0	2.027.296	100,0	0	0,0

*1 Grassland: 1300-permenent grassland 1310-intensive grassland, 1322-ekstenzive grassland, 1321-moor grassland
* 2 Other: 4100 - moor, 4210, reeds, 4220 - remained marshy land, 5000 - dry open land with special vegetation cover, 6000 - open land with negligible or no vegetation cover, 7000 - water
* 3 less frequent agricultural land use: 1180-permanent crops on arable land, 1190 - greenhouse, nurseries, 1212, bee houses, 1240, other permanent crops, 1420 - forest trees plantation, 1600 – uncultivated agricultural land,1800 agricultural land overgrown with forest species trees.

The extent of land use change in total for individual years however does not show the real dynamics of transition between individual agricultural uses and non-agricultural uses, as, for example, proportion of grasslands or abandoned agricultural land somewhere increases and elsewhere decreases. This could be assigned to the 'relocation' or spatial rotation of certain types of uses. If the sum of changes for particular land use is positive, the extent of its use in the total increases and vice versa, if it is negative, it reduces. Where 2007 land use data varied according to use in 2002 the extent of relocation and rotation was estimated by the analysis using GIS tools.

3.2 The extent of structural agricultural land use changes

Agricultural land use between 2002 and 2007 varied from one to another agricultural use. Some changes are normal usually result of crop rotation (arable land and intensive grasslands), while the increase or decrease in some other land uses suggest a long-term processes or trend changes. Table shows changes for those types of agricultural land uses, for which in 2007 the largest discrepancies in relation to the year 2002 were detected. In columns changes in ha are presented and their share in percentages.

3.2.1 Agricultural land uses which declined for the period 2002 - 2007.

Land use code 1100 – arable land. The total change for arable land in 2007 consisted of 55,492 ha, from which 22,457 ha could be assigned to crop rotation, as the total area of fields and gardens decreased by 35,035 ha during the period 2002 to 2007. Arable land mainly changed into permanent pastures (74.3 % change), marsh meadows (7.3 %), sealed and associated land (6.5 %), abandoned agricultural land (2.4 %), forest (2.4 %) and vineyards (1.7 %). The data confirm abandoning of the arable and on the account of meadows and pastures, as the fields and other arable land predominantly changed into various types of grassland. This process could not be categorised as land degradation since it is reversible, expected, partly enhanced and on a short time period welcome to improve the soil quality (organic matter). The change into urbanized land on the contrary should be treated as a strongly negative trend, as for the last 10 years in Slovenia for example; country irretrievably lost 6.5 % of total arable land due to urbanisation. From an agricultural perspective the abandoning of agricultural land, which gets gradually overgrown with forests is a moderate threat for agriculture since, however difficult and costly, forests can still be changed back to arable land. The change of cultural landscape or the aesthetic of Slovenian landscape could have some impact on economy. It is not surprising to see the increase of vineyards on arable land from 2002, which confirms and indicates the present increase of viticulture activities in Slovenia.

LU code 1410 – The total areas of **abandoned agricultural land spontaneously overgrown by forest** has decreased from 25,242 ha in 2002 to 21,938 ha by 3,260 ha. In the same period the trend also shows 14,163 ha of abandoned land was changed in the forest (64.6 % change) and 4,021 ha (18.3 %) in the meadow. In 2007, 1620 ha (7.4 %) was defined as agricultural land covered with forest, 947 ha (4.3 %) as a mixed land use and 439 ha (2 %) as a sealed and similar land. The data confirm transition of agricultural land into forest and slow urbanization of this lower quality agricultural land. As hardly detectable change, part of the reason also lays in a better and improved interpretation DOF5 and land use database 2002.

Vineyards (LU code 1211). Total areas vineyards has on overall decreased from 25,284 ha in 2002 to 22,164 ha (3.131 ha) in 2007. This was a result of a changing structure of the land use, which could be a result of new vineyards being established (6,780 ha) on pastures (2,790 ha - 41.1 % change) and permanent plantations (729 ha - 10.75 %), sealed and related land (633 ha - 9.33 %), and finally arable land (630 ha - 9.29 %). Data suggest that a great share of the abandoned vineyards was turned into grassland which confirms our findings of the changes in the GIS tools, as it detected greater degree of urbanization, many small areas at a mass-sealing - new buildings and renovations of houses and infrastructure in growing areas.

Areas of **intensive orchards** (LU code 1221) decreased from 5.047 ha to 4.762 ha (284 ha in total) comparing to 2002. These changes in land use are mainly a result of transition into permanent pastures (516 ha - 23.9 %), vineyards (409 - 19 %), arable land (309 to 14.3 %) and soil sealing (130 ha - 6 %). These on first site relatively modest changes are structurally and geographically highly disperse. Again a change as a result of urbanisation appears as a significant (cottages and holiday houses).

Hop plantations (LU code 1160) – **b**etween 2002 and 2007 the total surface of hop fields decreased from 2,501 ha to 2,094 ha (407 ha in total). The largest percentage of changes occurred due to abundance of hops and turning the fields into conventional arable land (483 ha - 84.5 %), which is assessed as generally perceived trend of reducing the hops due to their low price on the market. Second important change is to permanent pastures (42 ha - 7.4 % change), orchards (25 ha - 4.4 %), while only 13 ha (2.3 %) of hop fields was urbanised.

3.2.2 Agricultural land uses, which increased for the period 2002 - 2007.

In total areas of pastures, forest and other abandoned agricultural land, sealed and related areas have increased. In absolute terms small but proportionally large changes were recorded into extensive orchards and olive plantations. Due to changes in the interpretation of different types of grass during the processing all categories were united into common ‘grassland’.

Grassland (LU codes 1300-permanent, 1310-intensive, 1322-extensive and 1321-wet grasslands) has for the analysed period increased in total for 24.267 ha from 350.679 ha (17.3 %) to 374.946 ha (18.5 %). In 2007 the biggest change into the meadows was from arable land (46.5 %), forests (14.9 %) and sealed and associated land (12.1 %) plus extensive orchards (6.5 %), dry and open land (5.5 %) and abandoned agricultural land (4.1 %). This trend could explain the use of grass-arable crop rotation however and using DOF5, it was difficult to interpret and distinguish between the 'real' grassland and arable land, scattered grassland sown with grass-clover mixtures. A large proportion of change from urban use was due to inaccurate interpretations and definitions of urban green areas and real grasslands which were all under the same land use. This is a result of an inconsistent distinction between land use and land cover or if explained on the example: land covered with grass can be used for agriculture (pastures and meadows), city park, recreational or sports area (soccer) or golf course, etc. The last are urbanized or otherwise grassy urban areas but not used for food production.

Land use 2000. The total surface of **Forests and abandoned agricultural land** increased for 18,136 ha (1.5 %) comparing to 2002. Areas which were in 2007 database identified as the forest were in 2002, mainly rough grasslands (17,346 ha - 35 %), abandoned agricultural land (14,162 ha - 29 %), under mixed land use (5454 ha - 11.1 %) or intensive grasslands (3354 ha - 6.7 %). The data confirmed a continuing trend of overgrowth of abandoned agricultural areas and the increase in total Slovenian areas under the forest land use.

In 2007 **sealed and associated land** (LU 3000) became mainly forest and rough grassland (4,593 ha - 23.3 % change), extensive meadows (4413 ha - 22.3 %), arable land (3,619 ha - 18 , 29 %), intensive (2,841 ha - 14.4 %) and extensive meadows (1,387 ha - 7 %) and land under the mixed land use (846 ha - 4.3 %).

Extensive orchards (LU 1222) have increased by the total of 444 ha (2.2 %) mainly due to the higher proportion of changes from extensive grasslands (3,505 ha - 34 %) and most likely more accurate interpretation. Sealed and associated land (2792, ha - 27.5 %) were partly due to increased detailness of interpretation of urban land, intensive meadows (1,229, ha - 12.1 %) due to interpretations of the houses orchards. To a lesser extent, the proportion of forest and overgrown land (626 ha - 6.1 %), mixed-use land (509.3 ha - 5 %) and arable land and gardens (445 ha - 4.4 %).

Total areas of **olive grows** (LU 1230) extended for 41,7 % (475 ha) from total 1,613 ha. Mainly extensive grassland was converted to olive grows among all land uses presented in the area (314 ha, 33.5 %), followed by fields and gardens (207, 1 ha – 22 %) and vineyards (146.5 ha – 15.6 %). Forest, afforestation areas and extensive orchards are converted to olive grows in equal extent of 60 ha or app. 6.5 % each. Structure of land use changes to olive grows reflects the agricultural land use structure of Primorje region.

3.3 Quality of urbanised land

The process of urbanization of agricultural land. Urban areas were in the period 2002 - 2007 had grown from initial 88,070 ha in 2002 to 107,919 ha in 2007. The total increase was 19,790 ha or 22.5 % of initial extent of urbanised areas. Throughout all this period predominantly the agricultural land was urbanised (65.2 %). Second most urbanised land use (24.4 %) were forests (Figure 1).

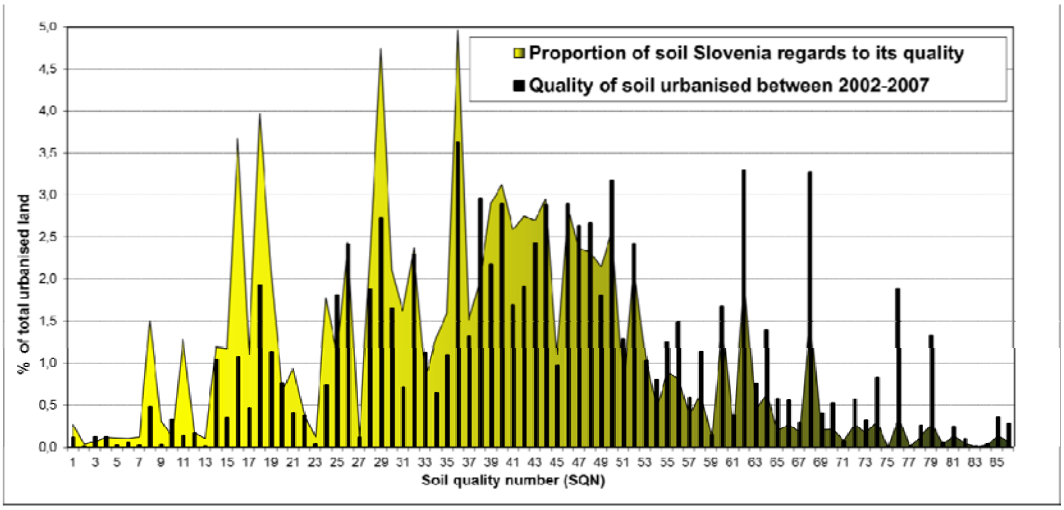

Figure 1: *The surface of urbanised land in regards to the soil quality between 2002 and 2007.*

The quality of urbanised soil. Soil of higher quality was urbanised in larger extent than low quality soils. By the area the largest share of urbanised areas represents the medium quality soils (between 29 and 53 SQN). Best agricultural soil (SQN > 53) were urbanised in smaller extent than medium quality when measured by total area. In regards to the very small share of best quality soils of total available soil in Slovenia in proportion of urbanised best soil was bigger (Figure 2).

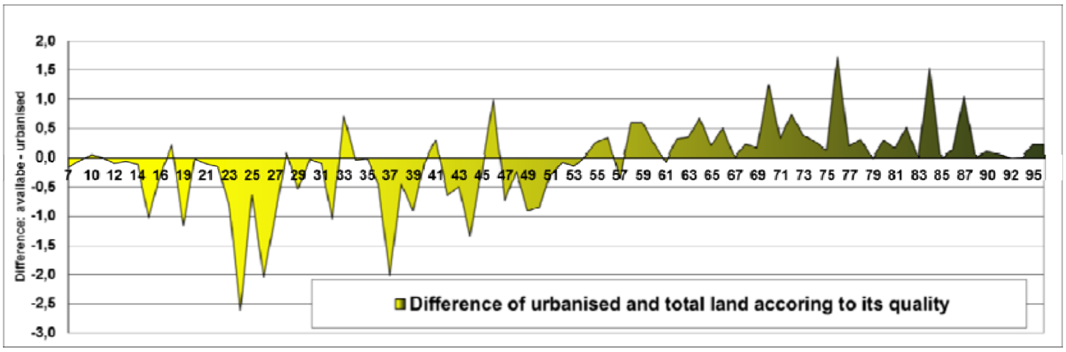

Figure 2: *Differences in proportions of urbanised soils in regards to the proportions of soil quality in Slovenia between 2002 and 2007.*

3.4 Spatial distribution of urbanisation

Urbanisation in Slovenia is spatially speaking highly dispersed process. Major changes are detected along highway corridors and on the outskirts of cities fulfilling the local needs for additional industrial and commercial areas. A significant proportion of urbanised land present a small but very numerous and widely individual housing developments, renovations, expansions and modernizations of housing facilities and the construction of small size infrastructure. The only areas without such significant land use changes are large forestry (Kočevje Javorniki, Pohorje), and the mountainous (Julian, Kamnik and Savinja Alps) areas.

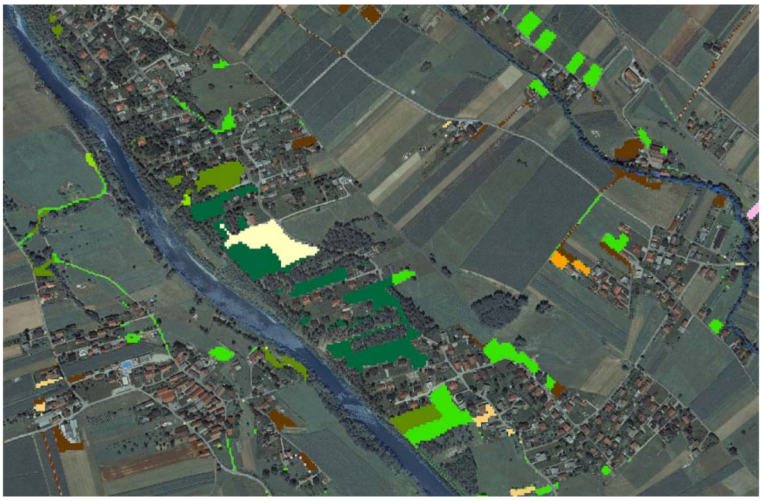

Figure 3: *Dispersed urbanisation of agricultural land – example for individual housing developements.*

Figure 3 shows a good example of frequent dispersed urbanisation of hi quality agricultural land on Eutric Cambisols formed on gravel deposits. This type of agricultural soil sealing occurs very frequently due to socio-economic reasons, fragmented land ownership, low income from small-sized farms and ineffective land use planning.

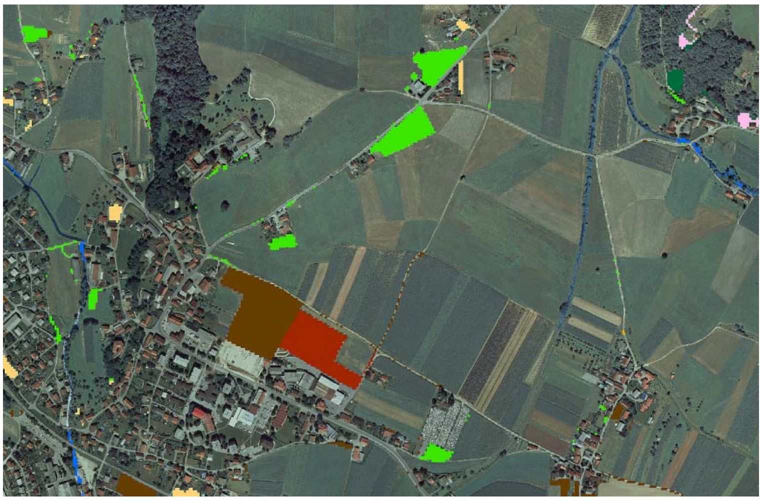

Figure 4: *Urbanisation of hop plantation and a field by building commercial and sport area in smaller city.*

The irrational medium size commercial developments (shopping centre) are presented by the Figure 4, where best available agricultural land (hop fields) are almost completely sealed by large parking lot and ground level supermarket. In this case nearly 2 ha of deep and structured Eutric Cambisol were lost.

Very fertile Eutric Cambilsol of Flysh area in Mediterranean climate was used for intensive vegetable, olive, fruit and vine production. Nowadays it is intensively urbanised for private housing (Figure 5).

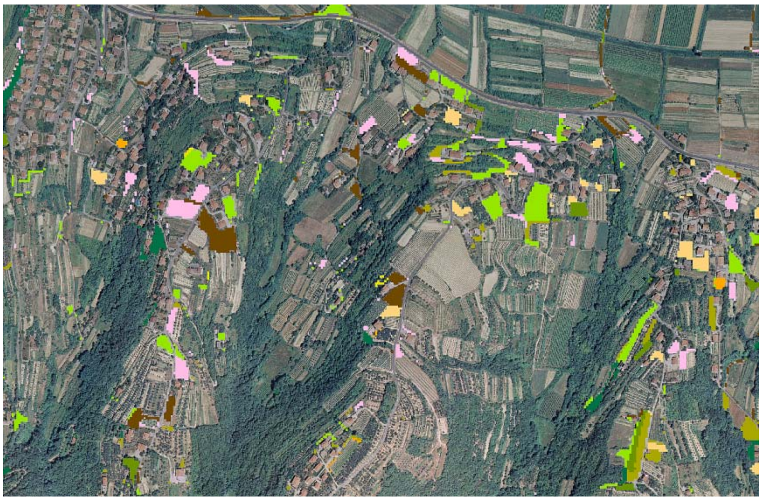

Figure 5: *Dispersed urbanisation of terraces by individual housing on terraces in Mediterranean area.*

4 Summary and conclusions

Environmental changes along with intensity of Slovenian agricultural land use are generally a result of a different socio-economic factors as well as development trends. In areas where agricultural land use is changing, this doesn't have a significant impact on soil resource in terms of its quality and quantity. In cases where agricultural land is lost due to afforestation, this means degradation of cultural landscapes (heritage), demographical identity of the country and potentially less inhabitable areas for people. In some cases afforestation also represents a potential economical risk. It is however possible to convert forests back to arable land, but this process is timely and expensive. From environmental soil perspective afforestation cannot always be treated as soil degradation, but rather as a change of land use hence soil quality. On the contrary, urbanisation and soil sealing are irreversible processes which ultimately destroy soil resource or at least significantly diminish soil quality and its ecosystem functions.

In the last decade, percentage of urbanised land in Slovenia strongly and steadily increased. Because of its relief, country has very limited resource of land suitable for agriculture. This land at the same time mainly located on the plains and in the valleys is being extensively urbanised. For this relatively short time frame in which we analysed the data, we could conclude that in total of 11 ha of land was urbanised each day. Such estimate should have even higher impact considering the fact that for e.g. Germany with one of the highest soil sealing rates in Europe has comparable rate, but at the same time proportionally less hilly and mountainous terrain which means proportionally higher percentage of available land suitable for agriculture. Such rate of best quality land loss for Slovenia represents a very high percentage of total land suitable for agricultural production and should that for be a wakeup call for the nation to action accordingly.

The problem however has multiple reasons. Geographically disperse soil sealing in Slovenia is predominantly a result of poor implementation of land management policies which is predominantly implemented on local – community level. Current legislation simplifies legal procedures for land use change. "In the name of development", it is now easier to get a building permission for the land of highest agricultural quality than ever before. As a consequence extensive areas of best quality arable soil, usually located on city's suburbs are being redeveloped for infrastructural, housing and/or retail purposes.

The common argument, that Slovenian agriculture is negligible and without future prospects, is false. Agriculture of any country represents a very important part of cultural, demographical and national heritage which not only maintains the suitable soil quality but also allows the country to be self-sufficient. Maintaining the present momentum of urbanisation in Slovenia unchanged might result in permanent loss of already limited agricultural soil resources. It is that for important to understand, that agricultural soil/land is strategically important natural resource that has to be preserved for future generations in every country. Considering the main aspects of the EU Thematic Strategy for Soil Protection would be a good ground for more holistic approach per using sustainable development.

5 Literature

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The importance of monitoring and preserving C-pools in organic matter rich soils

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Abstract

Soil Organic Matter represents the biggest terrestrial storage of organic carbon on the planet and holds larger amounts of Soil Organic Carbon (SOC) then the atmosphere and all living creatures combined. Its enhanced mineralisation can potentially contribute significant amounts of CO2 which are potentially discharged to the atmosphere from the soils. Mineralization of SOM is a highly sensitive process that is greatly dependant on climate, type of land use and physical/hydraulic properties of the soil. Data about the SOM contents in European soils is largely incomplete. In the past decade we are becoming more aware of the importance of systematic recording of the dynamics of SOM as well as we understand better the mechanisms which are controlling the levels of Soil Organic Carbon (SOC). Peat is the most concentrated form of organic matter rich soils; hence, it contains high concentrations of SOC. A complex system of mechanisms is controlling the levels of SOC and keeps this un-renewable natural resource in equilibrium. When altered, (eg. change in land use, its intensity…), SOC can be rapidly lost from the soil profile, often into the environment as CO2 or other dissolved forms. The full nature of these mechanisms however was not yet entirely explained. If we want to tackle climate change challenges holistically, we must consider the untapped potential of the soil to sequester carbon and its impact if managed inappropriately. Beside the care for soil fertility it is that for also important to maintain soil organic matter on adequate levels.

Key words: Soil organic matter, Soil organic carbon, carbon sink, monitoring, soil fertility

1 Introduction

In the past decades fast development of environmental sciences and results of new focused studies are revealing interesting facts about the impacts of various human activity on the environment. Land use along with the present agricultural practises is altering not only production capabilities (fertility), but also general environmental properties of the soil (water retention, organic matter content, soil stability…). In that way the natural role of soil is altered and this consequently impacts wider environmental properties. Every management on inappropriate location or scale can degrade soil - a non-renewable natural resource. Changed soil properties can impact the food production capability (fertility) as well as environmentally essential soil properties (eg. water retention, physical properties/stability etc.). Because of soil's complex role a reasonable protection measures are essential in order to balance the food production functions with protection of natural resource in the most sustainable manner. In context of natural resource management, soil preservation strategies should be an essential part of every country's agenda reassuring equal opportunities for generations to come. Agricultural aspect on the other hand should be no different, especially when practised on environmentally vulnerable land.

Soil organic matter (SOM) content is a key parameter for determining soil fertility hence soil quality. From the environmental point of view, SOM also represents a sink for through millennia sequestered atmospheric CO_2 (Lal et al., 1997) and directly controls soil's structure and ability to retain water (flood risk). In that way it represents an important brick in a complex system that balances the environment we all live in.

Moors are delicate and sensitive systems with high quantities of stored organic matter. Their hydrology which also preserves and sustains the peat layers can be easily altered especially when intense agricultural practises (introduced drainage, conventional tillage, heavy grazing...) are introduced. Moors are often used for agricultural purposes because of their flat relief and relatively easy accessibility (Ljubljana valley moor, Slovenia). As a result (especially when used for arable land), carbon within SOM is intensively mobilised and released form the soils through a variety of possible pathways. SOM rich peat is mineralised and soil organic carbon (SOC) is permanently lost from the soil profile. As a result, soil fertility/quality might however temporarily rise, but its environmental value declines. Process of mineralisation greatly depends on climate, physical and hydraulic properties of the soils and the type of land use.

1.1 Moors sequestrate CO_2

By definition, moors are areas with deep layers of peat (at least 30 cm). Peat is at the same time defined as a type of soil with more than 30% of organic matter. It is formed when plant's remains (mainly Sphagnum moss) because of anoxic conditions (high water table), low pH and consequently low availability of nutrients don't decompose and are slowly deposited. This process is very slow and it takes around 100 years for 10 cm of peat to grow. Peat has a great water retention capability and keeps the water table underneath it high. This creates anoxic conditions which preserves peat. When moors are drained, surface layers of peat lose the capability to retain water, consequently water table drops, this creates aerobic conditions and decomposition is enhanced. We are talking about mineralisation of peat and creation of SOM rich, but usually very acidic soils. During these process potentially large quantities of in the past sequestrated OC is released back into the environment. In such context, moors and peat in particular, represent an important pool of terrestrial carbon which, especially when moors are altered trough changed intensity or type of land use can represent an significant source of greenhouse gas CO2 into the atmosphere. Agriculture, especially the tillage techniques are constantly introducing large quantities of nutrients into the soil (fertilisers), aerating it (ploughing and mixing) and in such way significantly changing soils properties. Soil carbon cycle speeds up significantly hence fluctuations of OC content in soils(Bellamy et al., 2005).

1.2 Organic Carbon and its fate

Soil is the largest reservoir of organic carbon on the planet and contains several times the quantities as all living creatures and the atmosphere combined (Dick and Gregorich, 2004). Just the first meter of soils stores one third of all organic carbon on the planet, usually as part of SOM. Soil Organic Carbon (SOC) can be found in a quicker degradable and the more stabile forms (Magdoff and Weil, 2004). Biggest concentrations can be observed in organic matter rich soils such as peat in moors and marshes in for example Canadian and Siberian tundra. Its fate in soils is various. It can be released as CO_2 (Davidson et al., 2000), dissolved in water or washed from the soil surface in form of surface runoff or erosion (Baird and Cann, 1999).

SOM directly impacts the rate of soil bioactivity (Harris and Steer, 2003) which largely depends on temperature, pH, humidity and soil aeration. CO_2 is released as a side product of the microbial respiration, and contributes significantly towards the total emissions of this green house gas into the atmosphere (Bradey and Weil, 1996), (White et al., 2003). Dissolved forms of organic carbon (DOC) or inorganic carbon (DIC) can again enter the process of microbial respiration which ultimately results in CO_2 being released. Dissolved forms that leach trough the profile or are being washed trough surface runoff are ultimately contributing towards the carbon stocks in the world's oceans (Cox et al., 2000),(Freeman et al., 2001).

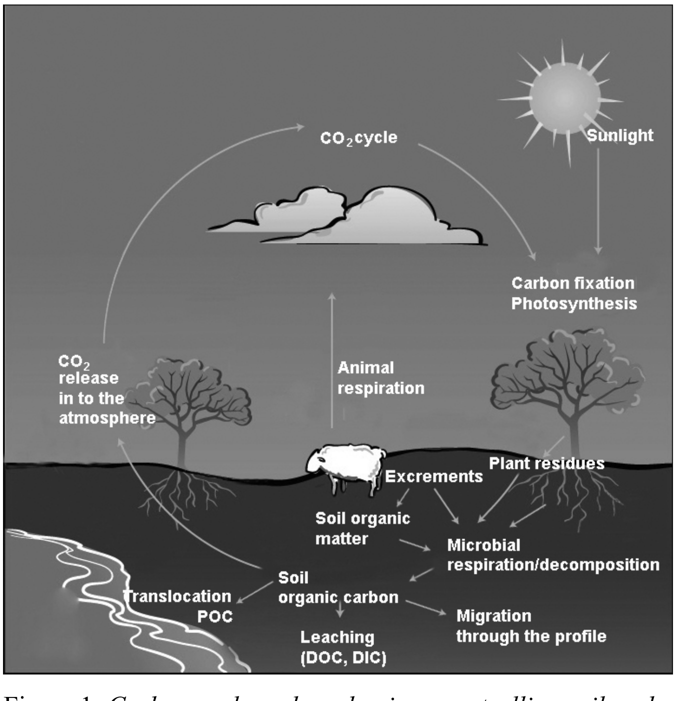

Figure 1: *Carbon cycle and mechanisms controlling soil carbon fate (author: T. Vernik).*

Leaching and vertical migration sometimes result in accumulation of carbon on less permeable soil layers. This could be observed as thin, darker layers on soil profiles. In extreme cases, SOC can be finally washed in to the ground water. CO_2 can also be dissolved in water and as such faces very similar fate.

When lost trough the surface runoff, SOC is washed off in a solid form or as sediment (Particulate Organic Carbon (POC)), which can, when more intense, be visible as surface erosion. POC can only exceptionally and with the assistance of pores, travel vertically trough the profile. Land management and land use have a strong effect on SOM, especially when soil is used for agriculture. Some authors report to find the levels of SOM in regularly fertilised, agricultural soil much lower then in those that were not fertilised (Dick and Gregorich, 2004, Magdoff and Weil, 2004). Some studies also suggest that the efflux of CO_2 from tilled soil is a couple of times higher comparing to that from a no till soil (Aslam et al., 2000).

2 Great Britain's Example – the 2005 Survey in Upland Wales

Great Britain has a well established National Soil Inventory (NSI) system which part is soil quality monitoring, lead by National Soil Resources Institute (NSRI), which is part of Cranfield University(Loveland, 1990).

Since 1970's they are regularly monitoring all main soil parameters including organic matter content in variety of soil types and land uses across England and Wales.

Comparing results of 1978/80 with 2003 champagne revealed big discrepancies in SOC content of the first 15cm from which the biggest were detected in Wales upland peat soils (Bellamy et al., 2005). Several locations proved to have lost 20% or more in SOC content comparing to 1978/80. In 2005 an MSc thesis were designed trying to explain this phenomena, exploring possible factors controlling SOC losses(Vernik, 2006). The analysis of newly collected data accompanied with field observations and site's land use history, implies and interesting correlations between the different types of land management and SOC content.

2.1 Methodology used

The main focus of 2005 survey was to produce comparable data to those from 1978/80 and identify the factors that can potentially influence on presence/content of SOC. According to (Dick and Gregorich, 2004) these possible factors were divided into two groups and classified as:

1.) Natural:
- Climate;
- Landscape position
- Soil texture

2.) Anthropogenic:
- Inputs (fertilisers…)
- Disturbances (top layers)

These factors were highlighted because they also drive soil processes such as: mineralization, humification and leaching, as well as aggregation and the soil erosion. Study concentrated on the upland peat soils which in previous study shown the biggest changes in SOC. Since such alternations potentially represent a threat for a natural resource it was important to make sure that these were not a result of a sampling error.

In 2005 survey almost identical sampling methodology was used as in the 1978/80 and 2003 surveys. Ten sites in Wales were selected from the 5x5 km NSI sampling grid. The selection was designed to cover a range of management regimes within three different areas of upland Wales from north to south. The exact sites were defined by the 5 km grid with a 1 km offset to prevent sites falling on the edge of the maps. Each site had to meet several criteria:

- Non-agricultural land use
- NSI classified as a deep peat soil with at least 40 cm of organic horizon
- Already sampled and tested for SOC in 1978/80 and 2003

- Change in SOC detected between 1978/80 and 2003
- Reasonably accessible from a road and/or track

Two sites in South Wales, four sites in Mid-Wales and four in North Wales were finally chosen. Two sites in South Wales were visited initially. The purpose was to test the selected methodology and become familiar with peat soil sampling. Using information from previous surveys, all farmers/land owners/land managers were first contacted and visited. For courtesy and safety reasons they were informed about the purpose of the survey and the scale of disturbance expected from sampling. During these visits, the opportunity was taken to ask some informal questions about site management. Special attention was given to site history, land use and possible land management problems. This information was included in site descriptions.

2.1.1 Site location and navigation

Sites were initially located using a map in 1:10000 scale and a road atlas. The approximate site area was located using air photographs, which gave a good idea about the actual situation in the field. Precise location of sampling sites (pit site) was done using a Trimble Geoexplorer 3 GPS device, which allowed navigation with accuracy of one to three meters. Only in 2005 all pit sites were located in this way.

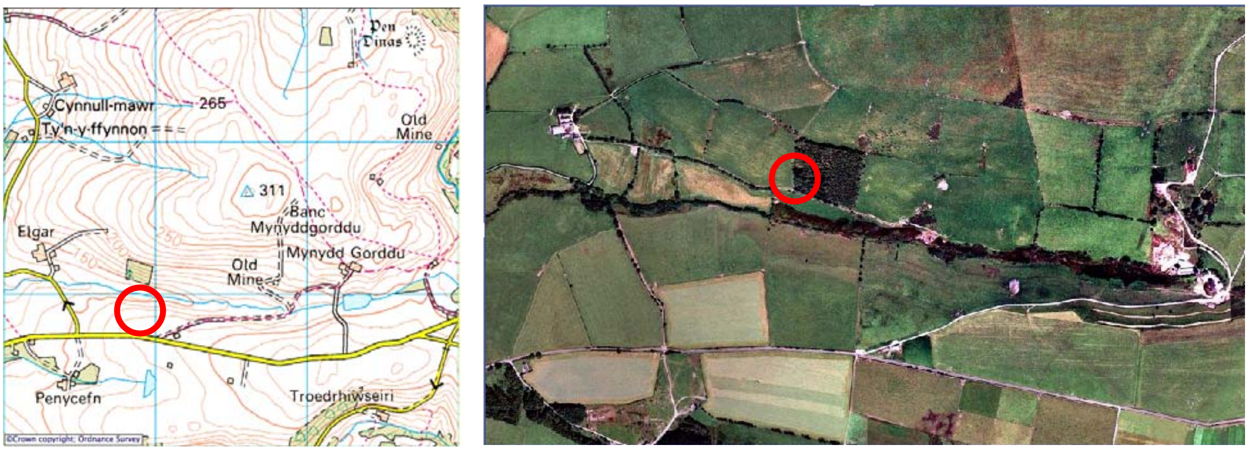

Figure2: *Site location using detailed map and areal photography (source: left; Ordnance Survey and right; NSRI)*

2.1.2 Field observations

At each site, a soil profile approximately 40x40cm wide and up to 70cm deep was opened. All the walls of the pit were cut so that they were as vertical and smooth as possible. Wherever possible an auger was additionally used in the pit to test the depth of the top organic layer (up to 1.20m).

Profile characteristics were then described according to the soil horizons found. Each profile was photographed. A specially designed form was filled-in to record all profile characteristics. An area description was added, including selected and wider surroundings. Additional notes were taken where appropriate.

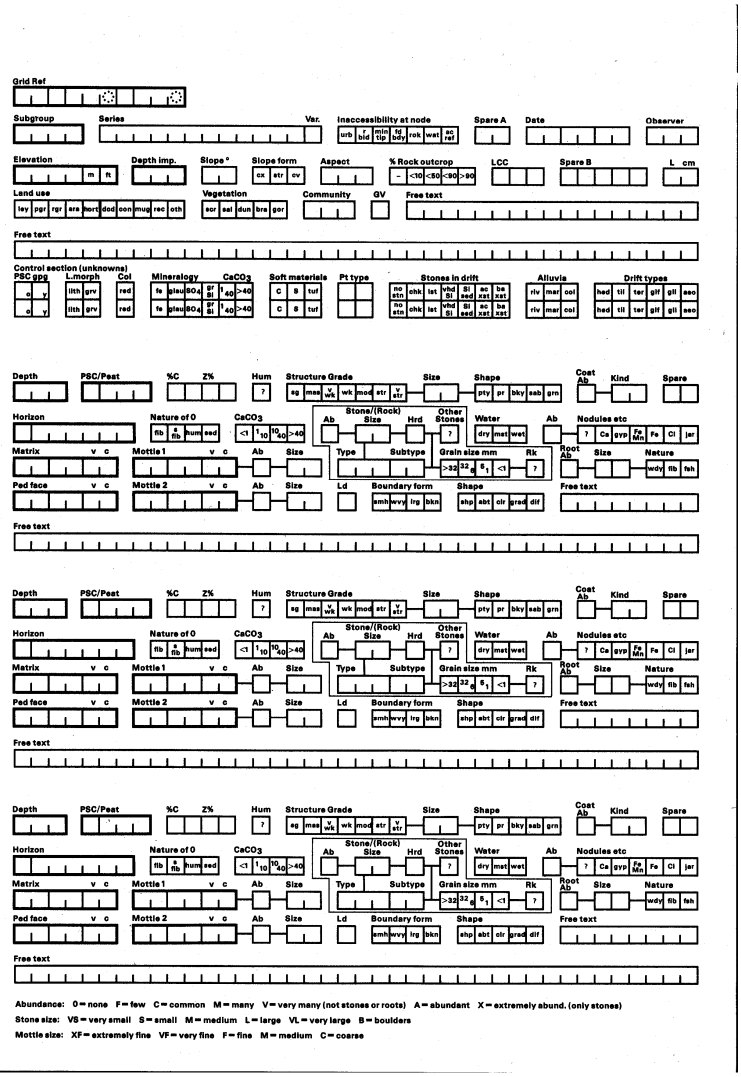

Figure 3: *Field record form (source: NSRI)*

If the site proved to be unsuitable according to one or more selected criteria, alternative pit sites were tested in directions North than East, West and as last south, 100m from original pit site. GPS was again used to measure the distance. If none of the alternatives proved to be suitable, such site was not sampled.

2.1.3 Sampling

The base of each profile was cleaned with a small spade to better identify horizons. A shadow/barrier was created in front of the cleaned profile to allow photography with and without flash. The equalled shadow illumination prevented possible reflections that might be caused by direct sunlight.

Loose soil samples were taken with a small spade from each horizon (cca.1kg/bag), homogenised an labelled. For each horizon the following data were recorded:

- Depth
- Particle size class
- Structure grade
- Coat (where necessary)
- Horizon name and nature
- Size and nature of stones and rocks
- Moisture of the horizon
- Nodules
- Matrix colour using Munsell soil colour charts
- Mottles where visible
- Root abundance, size and nature
- Nature of boundary form and shape

Form was filled in and dated. The following site properties were also recorded:

- Grid reference and elevation read out from GPS
- Slope angle and form
- % of rock outcrop
- Land use

Remarks about the plant community were recorded in free text brackets. Where mineral soils were found texture (mineral soil and particle class) was assessed.

In each pit, bulk density tins (3 at each depth) were filled at depths of 10, 30 and 50 cm or according to profile's properties. The empty tin with top cover on was manually inserted into the profile to fill the whole tin. It was than cut out with a knife. All redundant soil that was not in the tin was cut off making a clear line with the edge of the tin. Each tin was covered with a plastic cover and stored in a plastic bag according to site and depth.

A bulk sample or average sample from 25 cores was taken in a grid pattern around the pit site with a spacing of 4m. Samples were taken using a metal auger up to a depth of 15cm. This method was also used in samplings of 1978/80 and 2003. The auger was cleaned each time directly into the bag. Any plant's residues that were caught in the process were removed from the bag. Only a completely empty auger head was used again for the next sample. Each bag was clearly labelled and stored away from the sun and heat. After sampling, each pit was cleanly and tidily filled with soil, and covered with grass turf, trying to leave the site as intact as possible.

If the site's location proved to be unsuitable according to one or more criteria, alternative pit sites were tested in directions North than East, West and as last south, 100m from original location. GPS was used to measure the distance. If none of the alternatives proved to be suitable, such site was abandoned and excluded from the study. There was one site in 2005 that was based on site selection protocol not sampled and that for excluded form the study.

2.1.4 Sample analysis

Forty-eight soil samples were collected including various horizon samples and one bulk average sample from each site. Before testing, they were stored and refrigerated at approximately 4°C. The sample material was handled, stored prior and during analysis in a manner that best suited the analytical requirements using (BS-7755, 1994a) and (BS-7755, 1995).

The organic carbon content, water content and dry matter of all forty-eight soil samples were determined. Additionally the bulk densities of the undisturbed tin samples were measured. All analytical methods used were adopted from 1978/80 and 2003 surveys and are described in further text:

Soil Organic Carbon Content

SOC was determined by wet oxidation (BS-1377, 1975). The sample was digested in a solution of potassium dichromate, sulphuric acid and orthophosphoric acid at 130-135oC. Excess dichromate was determined by redox titration with ferrous sulphate solution.

Figure 4: *Typical peat soil profile (author: T. Vernik)*

Water and dry matter content

The moisture content of the study material was measured by oven-drying the sample at 105°C (BS-7755, 1994b). Samples were weighted (± 0.xxx g) before and after drying. The moisture content was calculated from weight difference where;

Weight of wet sample = (weight of tin and wet sample) – (weight of tin)
Weight of dry soil = (weight of tin and oven dry sample) – (weight of tin)
Weight of water = (weight of wet sample) – (weight of dry soil)
Moisture content [%] = (weight of water / weight of dry soil) * 100

Bulk density

Fresh samples were first weighted and oven dried at approximately 110°C. Bulk density was calculated as a ratio between weights before and after they were oven dried [g/cm3]. Mean values for bulk density and moisture contents were calculated for each depth.

$$Bulkdensity = \left(\frac{Weight}{Volume}\right) = \left(\frac{63}{35}\right) = 1.8 g/cc$$

Figure 5: *Formula used for bulk density [g/cm3] calculations with random numbers used as an example*

2.2 Results and conclusions of the 2005 Wales survey

For more manageable comparison, each site was first given a generic name that was chosen by a reference to the landowner's name or the name of the nearest farm. Additionally, 2003 and 2005 results were treated as repetitions and the mean values for SOC changes were taken to be compared to 1978/80 results. All sites which locations has been changed before or during the survey were for accuracy reasons excluded from the survey. Site "Hotel" which was due to a shallow organic layer moved for 100 m east could have caused biased results. We have that for excluded it from the further research (see Table 1 below).

Table 1: SOC change based on the calculated confidence interval of ±10,48.

Location's name	SOC 1978/80(%)	SOC mean 2003/2005 (%)	SOC change 1978/80 and 2003/05 (mean) (%)	Confidence Interval	Statistical significance

Elgar	29,2	30,75	1,55	12,04114	-8,94114	No
Dyffryn	46,31	47,5	1,19	11,68114	-9,30114	No
Esgair	42,7	30,35	-12,35	-1,85886	-22,8411	Yes
Opened	38,5	43,85	5,35	15,84114	-5,14114	No
Gorddinan	47,7	16,8	-30,9	-20,4089	-41,3911	Yes
Cwmcoygen	38,8	29,2	-9,6	0,89114	-20,0911	No
Maesglas	47,73	21,5	-26,23	-15,7389	-36,7211	Yes
Hotel	29,8	30,5	0.7	This site was moved and was that for excluded from analysis		

Results for SOC content showed great differences between 1978/80 and 2005. The expected decrease in SOC content was not consistent, however proportionally big changes in SOC between 2003 and 2005 on some sites immediately stand out. Table 1 presents measured SOC (%) in first 15 cm of soil for each site by year of survey. As each site is unique in its properties and the way it was selected only limited statistical analysis of the results between sites was feasible. Mean SOC (%) values between 2003 and 2005 were calculated in order to minimise possible sampling error.

Analysis using the confidence interval proved that three sites have shown a statistically significant SOC change (see Table 1 and Figure 5).These three sites were then taken under scope, trying to identify factors that could have caused such big deviations. Combining results with the records made during the site visits, site photographs and data retrieved from the owners, most probable causes for SOC anomalies were proposed.

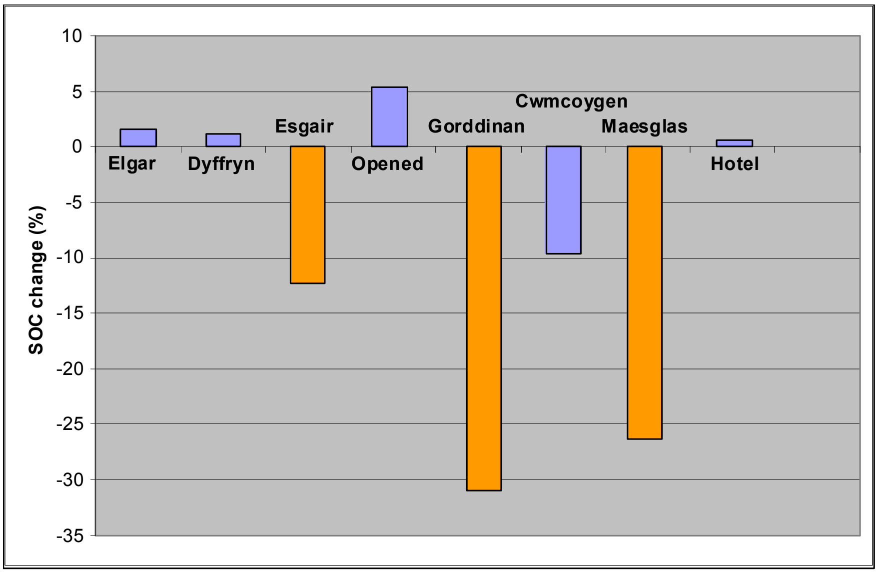

Figure 6: *Total SOC change between 1978/80 and mean of 2003/05 for correctly sampled sites*

Additionally bulk density measurements were used trying to identify causes for SOC loss. For all the sites only results for 10cm samples were comparable due to inconsistent depth of layers. Bigger values may partly correspond with intensity of grazing however larger compaction on site Maesglas is probably a result of sediment movement and the fact that pit site was located on the mountain foothill.

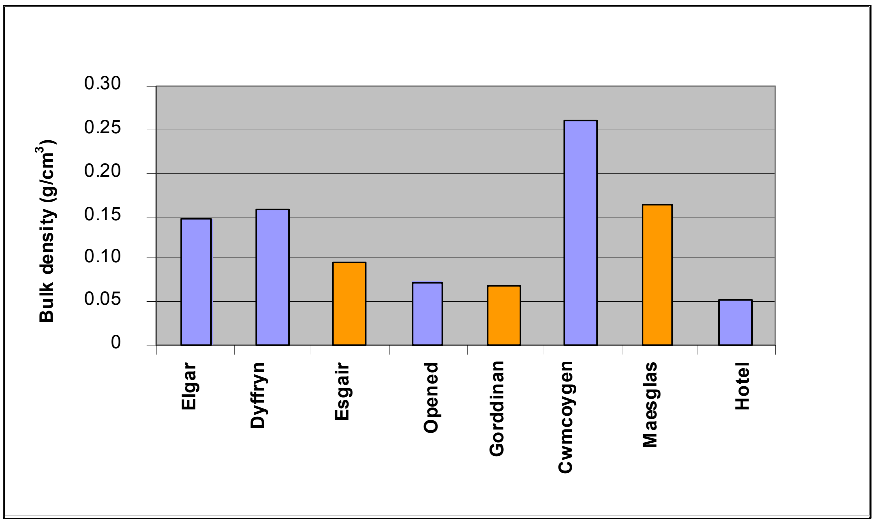

Figure 7: *Bulk density for the first 10cm for all sampled sites*

We also looked into the fact that increase of SOC contents of some sites could regardless the fact that they were during 2005 survey grazed, be a result of a rapid stock decrease or even complete land abundance in late 1990s. According to (DEFRA, 2005) and Welsh Agricultural Census Survey 2003 (UWA, 2005), 1999 was the year when stock densities in Wales significantly decreased due to Foot and Mouth Disease. Since no data was available for that period, it was hard to say whether the increase occurred instantly. It could be assumed however that this could have had an impact on microbial activity. In Figure 6 mean bulk densities for sites with statistically significant SOC change are highlighted.

2.2.1 The importance of location and spatial heterogeneity

During our survey location properties strongly differed from records made during the 1978/80 and 2003 studies. Sites in 2005 were highly heterogeneous with variable topography and soil texture. When pit sites were moved (as part of sampling protocol or as result of GPS navigation), topography and consequently soil texture were altered. Such observations suggest importance of accurate site re-location. Poor site navigation can result in changed soil properties because of terrain heterogeneity. The location can, along with its specific topography, variable soil texture and drainage greatly influence content of SOC. High terrain heterogeneity and site location error could have likely gave the biased results.

2.2.2 The impact of climate

During analysis we considered the influence of changing rainfall patterns as part of a global climate change. Consequentially soil moisture and soil aeration annual fluctuations are changing. This could have increased SOM decomposition rates. It is possible, that dry and wet season partition caused periodic SOC discharge as a result of enhanced microbial respiration in dryer periods of the year. Dark peat layers as a result of dry conditions and light as a result of moist conditions are sometimes available peat indicators which might suggest, such alteration is nevertheless a normal part of climate/soil evolution.

Winter 2004/05 was one of the driest winters in since 1960s. Since November 2004 until June 2005 (with exception of April 2005), a large rainfall deficit was recorded for Wales (MET, 2005). Aeration and with it SOM decomposition trough microbial respiration could have been enhanced, favouring SOC discharge in form of CO_2 emissions rather than dissolved forms. It is, however, highly unlikely that irregular drought could have significantly controlled proportionally such big losses of SOC. It is however important to consider rise of annual temperatures as a vital component acting closely with other factors.

Combined with inputs from grazing, increased microbial activity could have in dryer conditions favoured SOC discharge in form of CO2 emissions. At the same time it should be noted that temperature change can also enhance primary production and so SOM input to the soil profile. There is no clear evidence to conclude that rising temperature had indeed influenced SOC loss. Temperature change could be partly responsible for SOC loss; however its impact in Wales is unknown.

2.2.3 The impact of grazing

The levels of SOC in grazing land are mostly determined by the equilibrium established between inputs from net primary production and microbial respiration. The number of animals in the field additionally contributes inputs of excrement and soil compaction by trampling. Excrements enhance microbial activity. Naturally, plant residues become part of SOM throughout the season. On the grazed grasslands this natural residue is much smaller. Each site where excrement is left gets higher concentration of nutrients. However, due to animal digestion, less OM is finally returned into the soil and SOM input is weakened. At the same time frequency of trampling increases bulk density of surface layers. This means higher compaction and consequently higher volumetric organic carbon. Surface layer becomes less permeable and with fewer pores for water. During the rainfall surface runoff is enhanced and soil underneath gradually loses moisture. Lower soil moisture means more aeration which again enhances microbial activity that result in higher rate of SOM decomposition (SOC content decreases). Enhanced surface runoff and damaged turf (exposed soil) represent high risk for soil erosion. Bigger impacts of trampling might usually be expected around water sources, fold entrances and better grazing areas, where animals spent more time. No such observations were however recorded. On the other hand, if we say that our results are not biased, certain part of the observed SOC increase in 2005 could be attributed to recovery of primary production as a result of decreased grazing hence vegetation recovery. Turf makes soil more stable increasing SOM input. To answer this dilemma no sufficient data about plant recovery was available, however, an interesting hypothesis remained.

2.2.4 The impact of the land disturbances

Different types of land disturbances can enhance SOM decomposition. On two sites sampled as part of 2005 survey a decrease in SOC was observed. Grazing and disturbance of surface layers were specific for both sites. We have observed the newly constructed drainage ditches and a water reservoir.

Introduced drainage could reduce SOC by variety of mechanisms; dryer soil is better aerated, encouraging microbial respiration. Drainage cuts have likely changed natural water paths in surface layers, surface water runoff and soil moisture. Enhanced microbial respiration has had likely resulted in carbon being lost from the profile. Consequently grazing could have intensified, additionally reducing the amounts of organic matter inputs. Losses via surface water might have been enhanced as well. Discharge of SOC in dissolved forms as CO2 and DOC would also be possible. Newly constructed ditches and surface erosion might also impact SOC levels in form of the POC discharge through the surface runoff. There is substantial evidence in measured SOC levels which suggests that introduced drainage alone could have indeed influenced SOC loss. Soil disturbance and temporary increased soil aeration during a reservoir construction could have had similar effect.

Looking at 1978/80 and mean 2003/05 SOC results and listed facts it is highly likely that presence of reservoir as well as the surface dikes indeed influenced altered nature of the site that resulted in overall SOC decrease.

It would be interesting to know to what extend could have forest plantation observed on one of the sites influenced SOM decomposition. SOC content could have been controlled trough logging intensity or altered microbial activity as a result of changed pH (root excrements and plant residues (needle-leafs)). No sufficient data were available to make any conclusion. From observations an assumption was made that fire destroyed a young coniferous plantation 3-5 years ago. Burning however appeared to have been repeated again shortly before the survey. Presence of fire could suggest changed water capacity; however, it is impossible to say to what extent.

2.2.5 Hypothesis of SOC migration

On the end it is highly possible; that many of SOC decreases observed were a result of SOC migration trough the profile and its accumulation in deeper layers. Inspection of photos of all profiles indeed suggests darker layers in bigger depths of some of the sites. No sufficient analysis could have been done to test such assumption. However, in 2005 samples were taken by each described soil horizon, and stored as part of NSI collection. Analyses in further years are that for possible with additional site visits. This hypothesis opens a new interesting question; whether the potential SOC migration represents any difference in sense of threat of carbon pollution?

3 Conclusions and recommendations

The study utilised a detailed NSI and additionally collected data for upland Welsh deep peat soil profiles, trying to clarify the importance of anthropogenic and natural factors and their role in controlling SOC loss. SOC content analysis, surface compaction data and site observations allowed some explanation of SOC controlling factors.

We have concluded:

1. The continuous and inconsistent nature of SOC content fluctuation in deep peat soils of upland Wales.
2. Intensity of grazing is likely to control SOC content on upland pastures; however, there is no direct scientific evidence available to prove such theory. Highly targeted tests of plant recovery and controlled SOC discharge would be needed to prove such theory.
3. Subjective and consistent loss of SOC since 1978/80 suggests that introduced drainage on some sites could have influenced the SOC loss.
4. Poor navigation can due to specific topography and soil heterogeneity greatly influence the SOC content results.
5. Use of GPS, detailed maps and aerial imagery proved as reliable and effective system to re-locate each site with high accuracy. More rigorous sampling protocol is proposed using GPS location and site character recording during every future campaign. More profiles should be considered to be opened on each site.
6. Detailed profile data, site identification and character descriptions from this study enables future surveyors a good insight into history of particular site. However, there are consistent gaps in 2003 records. History of each site that for remains fragmentary.
7. Alternative hypothesis is set, that SOC could have just migrated and has been accumulated in deeper layers of the same profile. Additional analysis in 2005 described and sampled soil layers samples should be done.

This study has also shown a good example for use of data retrieved from organised, regular soil monitoring. It has demonstrated a small proportion of it possible practical applications as a tool for an on-time and effective management of this natural resource. Our study also shown, that every methodology needs to be tested and, if necessary improved to provide reliable clues. Many countries in Europe (Slovenia is no exception) are facing unsufficient of nonexsistant SOM content or bulk density datasets which would allow further analisis such as predicting the carbon stoc and calculating the SOC balance. Sistematic soil monitoring can serve as a useful tool to adjust our management actions in the most sustainable manner.

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Soil and vegetation characteristics of permanent plots on the Slovenian forestry 16 km x 16 km net

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Abstract:

This contribution presents the history of researches on the Slovenian 16 km x 16 km net, the purpose and the aim of the »BioSoil« demo project, pedological and phytocoenological work methods on the sites of the 16 x 16 km net, basic site data on locations and classification of soil of their representative soil profiles according to the international WRB 2006 soil classification, and classification of their forest associations.

In the framework of the EU demonstration project »BioSoil« the state forest soil inventory of the 1995/96 on the Slovenian forestry 16 x 16 km net was repeated. Preparation activities started in 2004, the field pedological and phytocoenological activities were executed in 2005 to 2007, and the laboratory and cabinet activities were finished at the end of 2008.

Pedological works were performed on 45 plots situated at the intersections of the 16 x 16 km net. They turn up at altitudes from 110 to 1500 m, most of them are found in submontane and montane altitude belt. One representative soil profile was dug out, sampled and described in every plot. The soils of these profiles were classified into eight WRB reference soil groups.

The soils of 23 profiles were classified as Cambisols, the soils of 9 profiles as Luvisols, 6 as Phaeozems, 2 as (Folic) Histosols, 2 as Acrisols, and one apiece as Fluvisols, Leptosols and Planosols. The 32 soil subunits as qualifiers and specifiers were determined.

21 different potential forest plant associations, 8 of them clime-zonal (identified in the areas of 17 profiles) and 13 azonal (in the areas of 28 profiles), were assigned to the sites in the representative soil profile areas.

Key words: monitoring of forests, soil classification, site of forest association, Slovenia

1 Introduction

Performing the task »BioSoil – soil module«, *Gozdarski inštitut Slovenije* (Slovenian Forestry Institute, abbr. GIS) repeated the state forest soil inventory of the 1995/96 on the Slovenian forestry 16 x 16 km net in the framework of the project »BioSoil« as the EU program activity »Forest Focus« and performing the task »BioSoil – biodiversity module« carried out the survey of forest vegetation. The preparation activities started in 2004, the field pedological and phytocoenological activities were executed in 2005 to 2007, and the laboratory and cabinet activities were finished at the end of 2008.

Presented are general site conditions, soil units of representative soil profiles and potential forest plant associations of permanent research plots on16 x 16 km net.

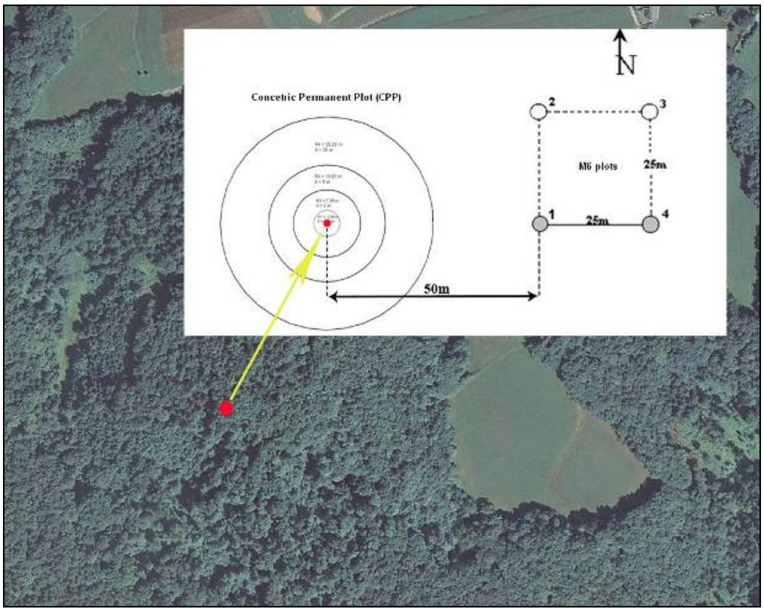

Figure 1*: The scheme of four corners of a quadrant and concentric permanent plot (CPP) on a point of intersection of the Slovenian 16 x 16 km network*

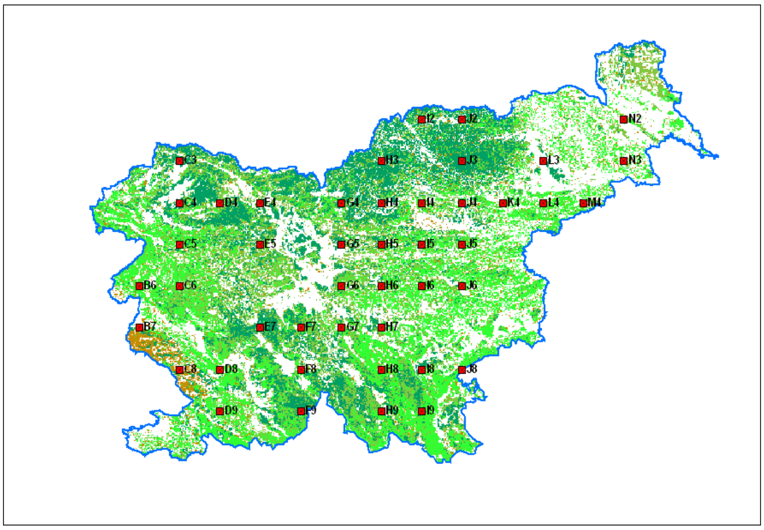

Figure 2*: Location and work designations of geographical coordinates of the Slovenian forestry 16 x 16 km network quadrants*

2 Materials and methods

Each research area on the intersection of the 16 x 16 km net situated in a forest includes a quadrant (size 25 m × 25 m) and concentric permanent plot (Figure 1).

In the state forest soil inventory of the 1995/96 for surroundings of each quadrant vertex, soil conditions and some properties (as soil depth, morphology, composition, humus form etc.) were examined by sounding using a semi-conical probe and from the surroundings of vertex which had, in comparision with areas of the other three verticles, the most representative soil conditions for the entire quadrant area, soil samples were taken from. Volumetric soil samples were taken from fixed soil depths (0 to 5 cm, 5 to 10 cm, 10 to 20 cm) on three spots, using the cylinder probe and scattered soil samples were taken from one representative soil profile in each quadrant.

Performing the task »BioSoil – soil module«, *Gozdarski inštitut Slovenije* (Slovenian Forestry Institute, abbr. GIS) repeated the state forest soil inventory of the 1995/96 on the Slovenian forestry 16 x 16 km net in the framework of the project »BioSoil« as the EU program activity »Forest Focus« and performing the task »BioSoil – biodiversity module« carried out the survey of forest vegetation. The preparation activities started in 2004, the field pedological and phytocoenological activities were executed in 2005 to 2007, using methods and criteria from ICP (2006) manual. and the laboratory and cabinet activities were finished at the end of 2008.

The field pedological works were mostly performed on the same verticle areas as in the past state forest soil inventory. Soil samples on the plots were taken in two ways: in volumetric way and in scattered state where the volume of the extracted sample is not known. At first, using a frame (size 25 cm x 25 cm) we removed volume samples of organic sub-horizons and, using the cylinder probe, samples from fixed soil depths (0 to 5 cm, 5 to 10 cm, 10 to 20 cm, 20 to 40 cm, 40 to 60 cm, 60 to 80 cm) on five spots on the selected interpretational area of the quadrant vertex. Near each treated vertex we dug out, described (according to the international soil profile description guide - FSCC 2005) and sampled (according to ICP 2006) one representative soil profile.

We determined internationally agreed soil parameters of the soil samples (according to the ICP 2006, ISO standards and ÖNORM L 1086-1: 2001) in the laboratory of the institute.

The research of the vegetation conditions on the Slovenian part of the forestry 16 x 16 km net was performed in accordance with the agreed methodology of the international project segment BioSoil-biodiversity. The detailed, precise vegetation survey took place in summer 2006 and 2007 on circular plots with 11.28 m radius (surface 400 m^2). Analytic survey of vegetation in the surrounding of each plot and, above all, on its 25 x 25 m quadrant was also performed. Potential forest association was determined with regard to phytocoenological survey and recognition of stand-vegetation conditions and site conditions on the area of every representative soil profile.

3 Results and discussion

The locations of 45 quadrants turn up at altitudes from 110 to 1500 m, most of them are found in submontane and montane altitude belt (Table 1, 2).

Table 1: The field form for the plot (DK), international plot identification number (PL), its elevation (ELEV), slope gradients(INCL) and orientations (ORIEN), parent material (PAR, c=calcareous, n=non-calcareous, m=mixed), surface rockiness (ROC) and stoniness (STO), organic horizon thickness (Ohor), effective rooting depth (ROOT) and, reduced by the terrain sloping, average depth of the mineral part of soil (DEPTH) of the representative soil profile.

DK	PL	ELEV (m)	INCL (°)	ORIEN	PAR	ROC; STO (%)	Ohor (cm)	ROOT (cm)	DEPTH (cm)
B6	2521	540	25	NW	n	0; 0-2	4,5	131	131
B7	2680	110	20	N	n	0; 5-15	2,5	120	122
C3	2200	1133	27	N	c	5; 20	21,5	40	40
C4	195	1497	0 – 60	E	c	5-15; 5-15	93	90	0
C5	2512	720	20	W	c	30; 30	5	33	33
C6	889	500	15	S	c	15; 25	3	61	61
C8	2685	315	0 - 5	N	c	2-5; 0-2	10,5	55	55
D4	190	1025	27	N	c	0-2; 2-5	6	76	76
D8	971	676	15	SW	n	0; 0	10,5	75	75
D9	2695	532	40	W	c	0-2; 20	5,5	88	88
E4	242	529	0	0	m	0; 0	3,5	100	100
E5	2301	532	42	NE	c	2-5; 20-30	4	89	89
E7	716	519	15	S	c	5-10; 10	3	60	63
F7	2574	799	18	S	c	0-2; 5-15	3,5	50	67
F8	587	648	15	WNW	c	35-70; 5-10	4	48	48
F9	574	1208	20	S	c	20; 30	11	38	38
G4	83	1227	40	S	c	20; 20	65	57	0
G5	2553	453	17	S	c	5-15; 2-5	5	35	35
G6	2565	551	35	E	n	0; 2	4	82	82
G7	2575	611	5	N	c	15; 20	4	40	60
H3	279	910	30	SSW	m	0; 0-2	8	130	130
H4	119	427	35	W	c	0; 5	4	51	51
H5	827	680	35	N	c	0; 5	5	51	51
H6	815	364	20	E	n	0; 0	10,5	63	63
H7	1042	557	20	W	m	0; 0-2	6	150	188
H8	2583	395	10	SW	c	5-15; 20	4	54	59
H9	154	689	15	W	c	35; 25	5,5	82	82
I2	321	628	45	E	n	0; 2-5	4	64	64
I4	408	383	12	W	m	0; 0	4	93	93
I5	762	595	22	SE	m	0; 0	3,5	74	74
I6	31	686	20	SE	c	2-5; 0	5	47	47
I8	1122	316	5	NE	c	0-2; 0-2	1,5	90	120
I9	4000	839	18	NE	c	0-2; 2-5	4	52	52
J2	479	546	25	S	n	0; 0	5	109	109
J3	2656	1318	13	S	n	0; 0	7,5	88	88
J4	4001	367	30	NW	c	0; 0	2	90	104
J5	2641	751	30	NW	m	0; 0	4	87	87
J6	37	352	15	NE	m	0; 0	5	41	41
J8	1148	767	10	N	c	0; 0-2	3,5	80	98
K4	426	319	20	N	m	0-2; 0	5	122	122
L3	2669	272	0	0	n	0; 0-2	3	70	72
L4	2400	352	20	NW	m	0; 2-5	4	94	94
M4	533	262	38	N	c	0; 2-5	2,5	87	87
N2	2679	188	0	0	c	0; 0	2	120	120
N3	537	300	20	NW	c	0; 0	4,5	120	122

Table 2: Distribution of the quadrants according to altitude zones

Altitude zone	Width of zones	No. of quadrants.	%
lowland-hilly	≤ 300 m	5	11
submontane	301-600 m	21	47
mountainous	601-900 m	12	27
alti-montane	901-1400 m	6	13
subalpine	> 1400 m	1	2

Table 3: Working code (DK) and geographical name of the plot (LOCATION), soil use (USE, 311 = deciduous forest, 312 = evergreen forest, 313 = semi-deciduous forest), average yearly temperature (T, in °C), precipitation (P, in mm), number of days with snow (SNOW), insolation (SUN, in W/m^2), potential evapotranspiration (EVAPO, in mm), De Martonn index (DEMAR =P/(T + 10°)), climate type (CLIM, 1 = slightly humid climate (DEMAR 25 to 51), 2 = moderately humid climate (DEMAR 51 to 100), 3 = intensively humid climate (DEMAR 101 to 200)).

DK	LOCATION	USE	T	P	SNOW	SUN	EVAPO	DEMAR	CLIM
B6	Baske	311	10	2202	27	4435	656,0	110,1	3
B7	Merljaki	311	12	1493	3	4458	754,9	67,8	2
C3	Martuljek	313	5	2090	136	3234	517,7	139,3	3
C4	Fužinske planine	312	3	2551	151	4427	345,7	196,3	3
C5	Kneža	311	8	2581	63	3595	596,8	143,4	3
C6	Gorenja Trebuša	313	9	2149	51	4295	646,4	113,1	3
C8	Križ	312	11	1456	6	4785	695,5	69,3	2
D4	Zajama	312	7	1842	86	3706	625,5	108,4	3
D8	Smolovec	311	8	1825	40	4616	587,7	101,4	3
D9	Padež	311	9	1653	30	4292	630,2	87,0	2
E4	Ljubno na Gor.	313	8	1521	58	4406	632,3	84,5	2
E5	Lubnik	313	8	1799	65	3204	632,3	99,9	2
E7	Ravnik	312	8	1788	55	4401	621,0	99,3	2
F7	Rakitna	313	6	1654	82	4552	534,2	103,4	3
F8	Križna jama	313	7	1607	71	4316	576,4	94,5	2
F9	Snežnik	313	4	2358	114	3652	429,7	168,4	3
G4	Podvolovljek	313	4	2067	115	4321	331,8	147,6	3
G5	Rafolče	313	8	1416	47	4329	619,5	78,7	2
G6	Besnica	311	8	1383	56	4603	636,1	76,8	2
G7	Čušperk	311	8	1514	67	4472	635,2	84,1	2
H3	Kavšak	312	6	1628	93	4511	507,1	101,8	3
H4	Okonina	313	9	1484	49	4338	639,4	78,1	2
H5	Trojane	313	8	1451	60	3717	603,2	80,6	2
H6	Jelša	313	9	1313	44	4305	712,1	69,1	2
H7	Sela pri Šumberku	313	8	1316	55	4459	698,4	73,1	2
H8	Hinje	311	9	1471	59	4379	683,3	77,4	2
H9	Stojna	311	8	1607	64	3986	641,9	89,3	2
I2	Gortina	313	8	1206	65	4777	594,3	67,0	2
I4	Andraž	313	9	1278	48	4394	637,3	67,3	2
I5	Čeče	313	8	1370	56	4602	600,4	76,1	2
I6	Gradišče	313	8	1300	63	4822	585,8	72,2	2
I8	Draganja sela	313	9	1434	52	4342	672,6	75,5	2
I9	Sredgora	311	7	1596	82	3897	534,3	93,9	2
J2	Remšnik	312	8	1294	72	4270	582,0	71,9	2
J3	Komisija	312	4	1929	135	4600	379,4	137,8	3
J4	Pogorelec	312	9	1180	47	4471	626,0	62,1	2
J5	Svetina	313	8	1448	66	4538	539,7	80,5	2
J6	Ledina - Sevnica	313	9	1210	41	4314	650,8	63,7	2
J8	Trdinov vrh	311	8	1344	71	–	537,4	74,7	2
K4	Kolačno	313	9	1245	38	4442	649,6	65,5	2
L3	Dravski Dvor	312	9	1123	42	4443	685,0	59,1	2
L4	Rabuda	311	10	1231	46	4019	656,3	61,5	2
M4	Gruškovje	313	10	1165	49	4210	695,7	58,2	2
N2	Bunčani	311	10	897	36	4509	693,2	47,2	1
N3	Runeč	311	10	1051	47	4386	709,6	52,5	2
	Average	312	8	1567	62	4292	604,9	89,5	2
	Min.	311	3	897	3	3204	331,8	47,2	1
	Max.	313	12	2581	151	4822	754,9	196,3	3

The BioSoil plots embrace well the considerable climatic differences in our forests. According to the data from the digitalized meteorological maps (ARSO 2006) we find average yearly temperatures in the range from 12°C to 3 °C, average yearly precipitation in the range from < 900 mm to > 2500 mm, and De Martonn's index values from 47.2 do 196.3; thus we can classify them into three climate types: slightly humid (De Martonn's index values from 25 to 50), moderately humid (values from 51 to 100) and intensively humid (values from 101 to 200). The soils of the plane profiles with intensively humid climate had in average twice thicker organic horizons than the ones in the moderately humid climate (Table 3).

20 quadrants were based on limestones and dolomites. Using pedological probing, we detected already in the years 1994/95 that undeveloped soils (mainly lithosols), kalkomelanosols, rendzinas, kalkocambisols (brown soils on limestones and dolomites) and ilimared (lessivé) soils turned up at the interpretational surfaces of the corners of these quadrants. Eutric brown soils and ilimared (lessivé) soils prevailed on marl (5 quadrants). 9 quadrants were based on non-calcareous rocks (perm carbon clayey shale, siltstone and sandstone, metamorphic shist, quartzite, gneiss, non-calcareous flysch, non-calcareous gravel). Dystric brown soils prevailed on their interpretational surfaces, dystric rankers and ilimared (lessivé) soils with dystric characteristics, also in argiluvic B_t horizon, turned up at some places. Predominantly eutric and/or dystric brown soils and various sorts of ilimared (lessivé) soils (9 quadrants) developed on the rocks with lesser content of calcareous materials or on mixed calcareous – non-calcareous parent materials (calcareous flysch, limestone with chert, mixed scree, Miocene claystone, siltstone and sandstone). In one quadrant, basing on claystone and siltstone, eutric sloping pseudogley was detected. Alluvial soils developed in the quadrant, basing on the loamy to sandy deposits of the Mura River.

One representative soil profile was dug out, sampled and described in every quadrant. The soils of these profiles were filed in the following eight WRB reference soil groups:

The soils of 23 profiles were classified as cambisols, the soils of 9 profiles as luvisols, 6 as feosems, 2 as histosols, 2 as acrisols; the soils of one representative soil profile apiece were classified as fluvisols, leptosols and planosols. We determined 32 soil subunits (or WRB (2006) qualifiers and specifiers) for these soils (Tables 4, 5, 7)

Table 4: Codes, names and number shares (n) of WRB reference soil groups and YSSS soil types, determined on representative soil profiles.

Code	WRB group	n	%	Code	YSSS type	n	%
AC	*Acrisols*	2	4,4	IS	Ilimared soil	11	24,4
CM	*Cambisols*	23	51,1	EC	Eutric cambisol	5	11,1
FL	*Fluvisols*	1	2,2	DC	Dystric cambisol	10	22,2
HS	*Histosols*	2	4,4	KC	Kalkocambisol	8	17,8
LP	*Leptosols*	1	2,2	FL	Fluvisol	1	2,2
LV	*Luvisols*)	9	20,0	KM	Kalkomelanosol	6	13,3
PH	*Phaeozems*	6	13,3	RZ	Rendzina	3	6,7
PL	*Planosols*	1	2,2	PS	Pseudogley	1	2,2
Σ 8		45	100	Σ 8		45	100

Table 5: Codes, names, and number shares (n) of WRB qualifiers and/or specifiers, determined on representative soil profiles

Code	WRB name	n	Code	WRB name	n	Code	WRB name	n
au	*alumic*	1	fo	*folic*	1	rp	*ruptic*	4
ca	*calcaric*	5	ha	*haplic*	5	rz	*rendzic*	2
ce	*clayic*	1	hd	*hyperdystric*	1	sa	*sapric*	2
cep	*epiclayic*	2	he	*hypereutric*	2	sk	*skeletic*	9
cr	*chromic*	5	hk	*hyperskeletic*	5	skn	*endoskeletic*	8
ct	*cutanic*	1	hu	*humic*	1	skp	*episkeletic*	1
dy	*dystric*	4	huh	*hyperhumic*	4	sl	*siltic*	7
ed	*epidystric*	3	mo	*mollic*	3	sln	*endosiltic*	4
ee	*epieutric*	2	ne	*endoeutric*	2	slp	*episiltic*	10
el	*epileptic*	4	nl	*endoleptic*	4	so	*sodic*	10
eu	*eutric*	9	ro	*rhodic*	9	Σ	Total	32

According to ex-Yugoslav Society of Soil Science soil classification (Škorić, Filipovski, Čirić 1973, 1985; Čirić 1984; Škorić 1986 etc.) on the 45 representative soil profiles 8 YSSS soil types, 13 subtypes (st), 18 varieties (v) and 24 forms (f) were determined (Table 6, 7)

Table 6: YSSS (Škorić 1986) codes for soil types, subtypes, varieties and forms, used for classification of the representative soil profiles

Hyerarchy	Name and some characteristics	Code
Type	**Rendzina**	**RZ**
Subtype	on dolomite gravel, on marl, on loess, on moraine, on calcareous sand, on calcareous gravel	**dg, ma, ls, mo, cs, cg**
Variety	calcareous, non-calcareous, brown (with B<A hor.), colluvial	ca, nc, br, co
Form	Sandy, loamy, clayey	*sn, lo, cl*
Form	Few, common (25 – 50 % of volume), many rock fragments	*frf, crf, mrf*
Form	Shallow, moderate deep (20 – 40 cm), deep	*sd, md, dp*
Type	**Kalkomelanosol**	**KM**
Subtype	organogenic	**og**
Variety	Lithic, skeletal colluvial	li, sc
Form	Humus form	*Mull, Moder, Mor*
Subtype	organomineral	**om**
Variety	Lithic, colluvial	li, co
Form	Humus form	*Mull, Moder, Mor*
Subtype	brown	**br**
Form	Humus form	*Mull, Moder, Mor*
Type	Eutric cambisol	**EC**
Subtype	On flysch; On siltstone and sandstone, on marl	**fl, si, sa, ma**
Variety	Typical, ilimered, colluvial, typical gleyed, ilimered gleyed	ty, il, co, tg, ig
Form	Sandy, loamy, clayey	*sn, lo, cl*
Form	Few, common (25 – 50 % of volume), many rock fragments	*frf, crf, mrf*
Type	Dystric cambisol	**DC**
Subtype	Typical, humuous (umbric A hor.), ilimared, pseudogleyed, podzoled	**ty, hu, il, ps, po**
Variety	On siltstone, sandstone, flysch, fluvioglacial gravel, shale, gneiss	si, sa, fg, sh, gn
Form	Shallow, moderate deep (40 – 70 cm), deep	*sd, md, dp*
Type	**Kalkocambisol**	**KC**
Subtype	Typical, ilimered	**ty, il**
Variety	Shallow, moderate deep (35 – 50 cm), deep	sd, md, dp
Form	loamy, clayey	*lo, cl*
Type	**Ilimared (lessivé) soil**	**IS**
Subtype	On silicate and silicate-carbonateous parent material	**si, sc**
Variety	Typical, pseudogleyed, typical gleyed (G hor. >1 m), pseudogleyed gleyed, podzoled	ty, ps, tg, pg, pz
Form	Sandy, loamy, clayey	*sn, lo, cl*
Form	Few, common (25 – 50 % of volume), many rock fragments	*frf, crf, mrf*
Subtype	On carbonateous parent material	**ca**
Variety	Typical, acric (BS of E hor. < 35 %)	ty, ac
Form	Sandy, loamy, clayey	*sn, lo, cl*
Form	Few, common (25 – 50 % of volume), many rock fragments	*frf, crf, mrf*
Form	Out of a sinkhole, in the sinkhole	*out, ins*
Type	**Fluvisol**	**FL**
Subtype	Calcareous , calcareous gleyed, calcareous sodic, calcareous gleyed and sodic, non-calcareous , non-calcareous gleyed, non-calcareous sodic, non-calcareous gleyed and sodic,	**ca, cg, cs, cgs, nc, ng, ns, ngs**

Variety	Shallow, moderate deep (41 – 80 cm), deep (81 – 120 cm), very deep	sd, md, dp, vd
Form	Sandy, loamy, clayey	*sn, lo, cl*
Form	Few, common (25 – 50 % of volume), many rock fragments	*frf, crf, mrf*
Type	**Pseudogley**	**PS**
Subtype	On level, on slope	**le, sl**
Variety	Shallow, moderate deep (effective rooting depth 25 – 50 cm), deep	sd, md, dp
Form	Dystric, eutric	*dy, eu*

Table 7: Work designations of geographical coordinates of quadrants (WD), WRB (2006) codes for reference soil groups, qualifiers and specifiers and of the representative profiles, YSSS (Škorić 1986) codes for soil types, subtypes, varieties, forms and humus forms of the representative soil profiles and Latin names of dominant potential forest plant associations at the representative soil profiles areas

WD	WRB code	YSSS code	Potential plant association
B6	Ha CM (hu,hd,sln)	**DCty,**fl,*dp,*Mull	*Castaneo sativae-Fagetum var.geogr. Calamintha grandiflora*
B7	Ha AC(hu,hd,slp)	**ISsc,**ty,*lo,frf,*Mull	*Carici umbrosae-Quercetum petraeae var.geogr. Sesleria autumnalis*
C3	Nl PH (ca,so,sl)	**KMom,**co,*Mor*	*Anemono trifoliae-Fagetum var.geogr. Helleborus niger subsp.niger*
C4	Nl,sa,fo HS (eu,sk)	**KMog,**li,*Moder*	*Adenostylo glabrae-Piceetum var.geogr. Cardamine trifolia*
C5	mo,hk LP (ca,huh,so,sk)	**KMom,**co,*Mull*	*Ostryo-Fagetum var.geogr. Anemone trifolia*
C6	Nl CM (hu,eu,slp)	**KCty,**dp,*lo,*Mull	*Hacquetio-Fagetum var.geogr. Anemone trifolia*
C8	Nl CM (hu,eu,skn,ce,ro)	**KCty,**dp,*cl,*Moder	*Seslerio autumnalis-Quercetum petraeae*
D4	Nl PH (ca,so,sk,slp)	**KMom,** co,*Moder*	*Anemono trifoliae-Fagetum var.geogr. Helleborus niger subsp.niger*
D8	Ha CM (hu,dy,sk,sl)	**DCty,**fl,*dp,*Moder	*Castaneo sativae-Fagetum var.geogr. Calamintha grandiflora*
D9	ha CM (hu,eu,skn)	**ECfl,**ty,*lo,crf,*Mull	*Ornithogalo pyrenaici-Fagetum*
E4	ha CM (hu,hd,cr)	**DCty,**fg,*dp,*Mull/Moder	*Castaneo sativae-Fagetum sylvaticae var.geogr. Anemone trifolia*
E5	nl PH (ca,so,skn,slp)	**RZdg,**br,*cl,mrf,dp,*Moder	*Arunco-Fagetum*
E7	nl CM (hu,he,sl)	**KCty,**dp,*lo,*Mull	*Omphalodo-Fagetum* 93 *var.geogr. Calamintha grandiflora*
F7	nl,rz PH (so,skn)	**RZdg,**br,*lo,crf,dp,*Mull/Moder	*Ostryo-Fagetum*
F8	nl CM (hu,ee,skp,slp)	**KCty,m**d,*lo,*Moder	*Lamio orvalae-Fagetum var.geogr. Dentaria polyphyllos*
F9	el PH (slp)	**KMom,**co,*Moder*	*Omphalodo-Fagetum var.geogr. Calamintha grandiflora*
G4	sa, fo HS (eu,sk)	**KMog,sc**,*Mor*	*Anemono trifoliae-Fagetum var.geogr. Helleborus niger subsp.niger*
G5	el CM (so,hu,eu,cep)	**KCty,m**d,*cl,*Mull/ Moder	*Hacquetio-Fagetum var.geogr. Anemone trifolia*
G6	ha CM (hu,hd,skn)	**DCty,**sa,*dp,*Mull/ Moder	*Blechno-Fagetum*
G7	nl LV (hu,he,slp,cr)	**ISca,**ty,*cl,crf,out,*Mull	*Hedero-Fagetum var.geogr. Epimedium alpinum*
H3	ha LV (rp,hu,ed)	**ISsc,**ty,*lo,crf,*Mor	*Luzulo albidae-Fagetum var.geogr. Cardamine trifolia*
H4	nl LV (hu,he,skn)	**ISsc,**ty,*lo,crf,*Mull	*Galio rotundifolii-Abietetum albae*
H5	nl,rz PH (so,sk)	**RZdg,**br,*lo,crf,dp,* Mull/Moder	*Arunco-Fagetum*
H6	nl, fo CM (dy)	**DCty,**si,*dp,*Mor	*Blechno-Fagetum*
H7	ha AC(au,hu,hd,slp,sln,cr)	**ISsc,**ty,*cl,frf,*Moder	*Castaneo sativae-Fagetum var.geogr. Epimedium alpinum*
H8	nl LV (hu,he,ce)	**ISca,**ty,*cl,frf,out,*Mull	*Hedero-Fagetumvar.geogr. Epimedium alpinum*
H9	nl CM (hu,eu,sl)	**KCty,**dp,*cl,*Mull	*Lamio orvalae-Fagetum var.geogr. Dentaria polyphyllos*
I2	nl CM (hu,ne,sl,cr)	**DCil,**sh,*dp,*Mull	*Castaneo sativae-Fagetum sylvaticae var.geogr. Anemone trifolia*
I4	ha PL (ne,sln)	**PSsl,**dp,*dy/eu,*Mull/ Moder	*Castaneo sativae-Fagetum sylvaticae var.geogr. Anemone trifolia*
I5	nl CM (hu,dy,sk)	**DCty,**sa,*dp,*Moder	*Castaneo sativae-Fagetum sylvaticae var.geogr. Anemone trifolia*
I6	el CM (so,hu,eu,cep)	**KCty,**md,*cl,*Mull	*Lamio orvalae-Fagetum var.geogr. Dentaria polyphyllos*
I8	nl,ct LV (hu,ed,ne,sl,cr)	**ISca,**ac,*lo,frf,out,*Mull	*Hedero-Fagetum var.geogr. Epimedium alpinum*
I9	nl CM (so,hu,he)	**KCty,**dp,*cl,*Mull	*Omphalodo-Fagetum var.geogr. Calamintha grandiflora*
J2	ha CM (hu,hd,skn)	**DCty,**sh,*dp,*Mor	*Bazzanio trilobatae-Abietetum*
J3	ha CM (hu,hd,sk,cr)	**DCty,**gn,*dp,*Mor	*Luzulo albidae-Fagetum var.geogr. Cardamine trifolia*
J4	ha LV (rp,hu,ed,ne,skn)	**ISsc,**ty,*cl,crf,*Mull	*Castaneo sativae-Fagetum sylvaticae var.geogr. Anemone trifolia*
J5	ha CM (huh,he,rp,sk)	**ECsi,**co,*lo,mrf,*Mull	*Lamio orvalae-Fagetum var.geogr. Dentaria pentaphyllos*
J6	el LV (hu,ee,sk)	**ISsi,**ty,*lo,mrf,*Moder	*Castaneo sativae-Fagetum sylvaticae var.geogr. Anemone trifolia*
J8	ha LV (hu,ne,sl)	**ISca,**ty,*lo,frf,out,*Mull	*Cardamini savensi-Fagetum*
K4	ha LV (hu,ne,slp,sln)	**ISsc,**ty,*cl,frf,*Moder	*Hedero-Fagetum var.geogr. Polystichum setiferum*

L3	ha CM (hu,dy,skn)	**DCty,**fg,*dp,*Mull	*Vaccinio myrtilli-Carpinetum betuli*
L4	ha CM (he,cr)	**ECma,**ty,*lo,crf,*Mull	*Vicio oroboidi-Fagetum*
M4	nl CM (hu,he,rp)	**ECma,**co,*lo,crf,*Mull	*Polysticho setiferi-Abietetum*
N2	mo FL (ca,hu,he,slp)	**FLca,**vd,*lo,frf,*Mull	*Fraxino-Ulmetum effusae* var. *Prunus padus*
N3	ha CM (so,he)	**ECma,**ty,*lo,crf,*Mull/Moder	*Vicio oroboidi-Fagetum*

21 different forest plant associations, 8 of them clime-zonal (identified in the areas of 17 profiles) and 13 azonal (in the areas of 28 profiles), were assigned to the sites in the representative soil profile areas (Table 7). Clime-zonal associations are: subpanonic beech forest with vetch (*Vicio oroboidi-Fagetum* (I. Horvat 1938) Pocs et Borhidi in Borhidi 1960 – in the areas of 2 profiles), submontane beech forest with pyrenees star of Bethlehem (*Ornithogalo pyrenaici-Fagetum* Marinček, Poldini et Zupančič in Marinček 1994 - 1), submontane beech forest with hacquetia (*Hacquetio-Fagetum* Košir 1962 - 2), montane beech forest with dead nettle (*Lamio orvalae-Fagetum* (I. Horvat 1938) Borhidi 1963 - 4), fir and beech montane forest (*Omphalodo-Fagetum* (Tregubov 1957) Marinček e tal. 1993 - 3), high-montane beech forest with bitter-cress (*Cardamino savensi-Fagetum* Košir 1962 - 1), alpine beech forest (*Anemono trifoliae-Fagetum* Tregubov 1962 - 3), alpine fir forest with alpine adenostyles (*Adenostylo glabrae-Piceetum* M. Wraber ex Zukrigl 1973 corr. Zupančič 1993 – area of 1 profile).

Azonal: moderately acidophilic beech forest with chestnut (*Castaneo sativae-Fagetum* Marinček & Zupančič (1979) 1995 – in the areas of 9 profiles), moderately acidophilic beech forest with white wood-rush (*Luzulo albidae-Fagetum* Meusel 1937 - 2), acidophilic beech forest with hard fern (*Blechno-Fagetum* (Tüxen et Oberdorfer 1958, Rives Martinez 1962) I. Horvat ex Marinček 1970 - 2), beech and sessile oak forest with ivy (*Hedero-Fagetum* Košir (62, 79) 1994 - 4), beech forest with goatsbeard (*Arunco-Fagetum* Košir 1962 - 2), termophilic beech and hop-hornbeam forest (*Ostryo-Fagetum* M. Wraber ex Trinajstić 1972 - 2), sessile oak forest with shady sedge (*Carici umbrosae-Quercetum petraeae* Poldini in Marinček 1994 - 1), sessile oak forest with autumn moor grass (*Seslerio autumnalis-Quercetum petraeae* Poldini (64) 1982 - 1), narrow-leaved ash and European white elm forest (*Fraxino-Ulmetum effusae* Slavnić 1952 var. *Prunus padus* Vukelić et Barićević 2004 - 1), acidophilic common hornbeam forest with bilberry (*Vaccinio myrtilli-Carpinetum betuli* (M. Wraber 1969) Marinček 1994 - 1), fir forest with soft shield-fern (*Polysticho setiferi-Abietetum* Košir 1994 - 1 profile), moderately acidophilic fir forest with round-leaved bedstraw (*Galio rotundifolii-Abietetum* M. Wraber (55) 1959 - 1), acidophilic fir forest with three-lobed liverwort (*Bazzanio trilobatae-Abietetum* M. Wraber 1953 – 1).

4 Conclusions and recommendations

Slovenian Forestry Institute performed international demonstration project BioSoil, the largest common forest soil and biodiversity monitoring in EU until now, on the plots of the 16 x 16 km Slovenian forestry net. This article presents basic site data on locations, classification of soil of their representative soil profiles according to international World Reference Base for Soil Resources (WRB 2006) and the ex-Yugoslav Society of Soil Science (YSSS) soil classification, and classification of their potential forest associations.

Results of pedological and phytocoenological research within the project BioSoil reflect rather well high level of site diversity in our forests.

One representative soil profile was dug out, sampled and described in every of 45 quadrants. The soils of these profiles were classified in the eight WRB reference soil groups and 32 soil subunits (qualifiers and specifiers) and at the same time in the eight YSSS soil types, 13 subtypes, 18 varieties and 24 forms. The used classifications differ in principle so much that only few soil units and subunits are the same or similar.

Some soil types, for example lithosol, regosol, colluvium, ranker, terra rossa, podzol, brunipodzol, gleysol, peat histosol etc. are not considered by Biosol study due to their too small shares or nonappearance on studied research areas.

21 different forest plat associations, 8 of them clime-zonal (identified in the areas of 17 profiles) and 13 azonal (in the areas of 28 profiles), were assigned to the sites in the representative soil profile areas.

Clime-zonal associations are: *Vicio oroboidi-Fagetum* – in the areas of 2 profiles, *Ornithogalo pyrenaici-Fagetum* - 1, *Hacquetio-Fagetum* - 2, *Lamio orvalae-Fagetum* - 4, *Omphalodo-Fagetum* - 3, *Cardamini savensi-Fagetum* - 1, *Anemono trifoliae-Fagetum* - 3, *Adenostylo glabrae-Piceetum* – area of 1 profile.

Azonal: *Castaneo sativae-Fagetum* – in the areas of 9 profiles, *Luzulo albidae-Fagetum* - 2, *Blechno-Fagetum* - 2, *Hedero-Fagetum* - 4, *Arunco-Fagetum* - 2, *Ostryo-Fagetum* - 2, *Carici umbrosae-Quercetum petraeae* - 1, *Seslerio autumnalis-Quercetum petraeae* - 1, *Fraxino-Ulmetum effusae* - 1, *Vaccinio myrtilli-Carpinetum betuli* - 1, *Polysticho setiferi-Abietetum* - 1, *Galio rotundifolii-Abietetum* - 1, *Bazzanio trilobatae-Abietetum* – area of 1 profile.

In Slovenia the total of about 150 forest plant associations (without geographic variants) have been determined.

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Abstract

The conference S*oil Protection Activities and Soil Quality Monitoring in South Eastern Europe* was organized in Sarajevo as a joint action by the Soil Science Society of Bosnia and Herzegovina and the Soil Science Society of Slovenia. The main objectives of conference were to review the soil protection and soil quality monitoring activities in SEE including research activities, project reports, good practice guides and various methodologies and monitoring strategies. The special emphasis was laid on the ecological and technical soil functions, remediation and re-cultivation measures, data collection and processing, soil protection policy, soil quality and soil resources management issues on the regional level. The conference was an opportunity to key regional soil science research institutions to present activities and achievements with further prospects of cross - border scientific collaboration.

This publication presents a selection of 20 conference papers prepared by the authors from SEE countries (Croatia, Bosnia and Herzegovina, Serbia, Former Yugoslav Republic of Macedonia) and guest contributions from Austria, Slovenia and Syria.

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