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Content

SPECIFIC PROBLEMS OF ANTHROPOGENIC SOILS, THEIR QUALITY AND CONSERVATION

PREFACE

An unprecedented development and extent of soil anthropization over the world is stated, we suppose, that the role and significance of anthropogenic soils in future will be increased due to progressing various human activities on soils. Soil survey and mapping is recognized as insufficient in many countries. E.g. at present, there is a urgent need of definition, survey and classification of anthropogenic soils and their intergrades.

Generally, the weak points are definitions of anthropogenic soils and their intergrades in national and world reference soil systems. Examples of definition problems are: soil or non-soil (soil bodies formed only by human-induced activities), soil horizon, layer, geogenesis, pedogenesis (where are limits for their distinguishing?). Also time factor and site history is inevitable to recognize and define.

Classification and correlation of anthropogenic soils, incorporating problems of anthropically influenced soils, problems of anthropogenic substrata classification, differentiation of anthropogenic classification principles is considered as well. Problems of classifying of contaminated, eroded, accumulated (Colluvisols?) and/or by other kind of human impact influenced soils is recognized, too.

Multi-functional use and management of anthropogenic soils is the second point of this proceeding. Definition of main human-induced impacts in/on soil, like agricultural, urban, industrial, mining, and other impacts that improving or degrading soil quality is needed to research.

Problem of agricultural soils management and its reflection in all soil properties is presented: morphological, physical, chemical, biological properties changes (as ploughed horizon description, subsoil compaction, phosphorus presence, organic matter change, other characteristics which are unusual for native soils, etc.).

Urban soil managring system is presented as totally new soil science field with stressing of many environmental functions. Also specific characteristics of urban soils are recognizable like low age, substrate soils developed from natural or technogenic anthropogenic materials, cultural layer and artefacts presence, heterogeneity in soil profile, extreme morphological, physical, chemical and biological properties. Also mining soil managering system is presented as specific case of this soil group.

Specific problems of anthropogenic soils, their quality and conservation must be solve. Detailed studies can be supporting above mentioned points, e.g. unusual soil structure, bulk and specific density, heavy metals and organic pollutants contamination, salinization, acidification, pathogen micro-organisms presence, etc.

I am firmly convinced, that a future work in this soil science field may continue and will be succeed.

Jaroslava Sobocká
chairman of the workshop

ANTHROPOGENIC SOILS, THEIR SURVEY, METHODS AND CLASSIFICATION

Soils of Low Age as Specific Features of Urban Ecosystem

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Abstract

Numerous of the urban soils are young in age. Some have not developed diagnostic horizons and properties through genetic processes induced by the environment. The soils are raw soils, which can be already distinguished according to their substrate features. A large group are the Lithosols. Types of Lithosols are Autolith, Allolith, Phyrolith, Ekranolith and Aerolith. Other raw soil groups are those of phänotypes and relictic soils. The Lithosols are in most cases transition stages to AC - soils which will occur within one to several decades.
A great group of other soils have already diagnostic horizons by dust deposition, compaction, humus accumulation, stagnic or reducing properties. Therefore Aerosols, Structosols, Compactosols, Hortisols, Nekrosols, Humus Fossil Soils, Stagnic Gleysols, Saline Soils, Reductosols are existing.
Intrusion of particles and organic liquid results in Intrusols. Particle and Organic Intrusols are formed. Some soils are leached. Therefore calcareous, gypsic and saline soils loose their carbonate, gypsum and other salts. Decalcisols, Degypsisols and Desalinisols will occur.
Special development by stronger concentration of water and compounds but also organic matter will happen in stony soils and soils occurring in regular intervals, e.g. in gaps of pavements. They are Leptosols and Dialeimmasols.
Some of the urban soils have been chemically altered in a very short time. This is found for sulphide containing soils, which will be Sulphuric Acid Soils and calcium oxide containing soils, which will develop to Carbonatosols. In many soils also oxidation of iron of the substrate can be observed. These soils have some similarity to Cambisols. Some soils have signs of strong reduction by different reasons. They are Reductosols.

Introduction

For a long time cities have been regarded as non-soil areas. Under view point of occurrence of natural soils or soils similar to soils of rural areas this assumption does not meet the reality at least for the suburbs and many of the backyards and parks of the cities.

The problems appear when areas with soils occur which are not proper placed in the existing soil classification scheme. This we have to face in urban, industrial, traffic and mining areas. The categories we find are:

- known soils;
- deviations of well known soils;
- soil formations which have not be included in the system due to their rarity, and
- bodies, which show all signs of soil development, but have been unknown until now.

Characteristics of soils

There will be still large areas of the city left which can not be included into our traditional idea of a soil. For that we have to start in soil science the discussion of our understanding of soils. Which properties make solid bodies at the boundary of the earth surface to a soil ? Table 1 gives some characteristics of bodies as soils at the boundary of atmosphere and lithosphere.

Table 1: Properties which make solid bodies at the boundary of the earth surface to a soil.

What we define as soils are bodies:
– of substrates of geogenous origin and we have to add those of anthropogenous origin,
– of geogenous surface morphology and we have to add those of anthropogenous surface morphology,
– penetrated by air, water and organism,
– which are the primary location in and on which organism are living, or
– which have the potential for this, human interest refers to plant growth,
– which are sinks and sources of compounds, matters and energy,
– which properties and morphology will develop and change under the influence of the environment, and
– which are environment to other members of the geosphere.
Most of the surface bodies of the cities have the one or the other of the above properties. All soils have an environment which interacts with them.

Soil defined as a natural body

Secondly soil is defined as a natural body (Soil Survey Staff 1999). The question will be: are urban bodies natural and what are the criteria to be natural. In nature both substrate and soils fulfil this demand. In cities many of the substrates are artificial by material, way of deposition, or treatment.

Table 2: Features of urban soils as a natural body (Burghardt 1993).

Urban soils are:
– results of the factors of the environment and of processes caused by them,
– individuals,
– but close related to each other and the other components of the landscapes ecosystem,
– carrier of information of the past and of potential development in the future.
These features equally to those found in nature.

But when tipped the substrates are exposed to an environment which parameters have changed due to socio-economical, technogenous, planning and management activities but in spite of that behaves on its influence on soils in the same way as the components of a natural environment. That means the surfaces of cities are accessible to an environment which is part of the regional and global ecosystem. Therefore they may develop all features of creations of ecosystems (Table 2).

Soils of low age

The main problem for soil taxonomy will be the feature of urban ecosystem components that most surfaces in the cities are very young. In a much larger extend than in nature young soils occur. Soil taxonomic concepts have to realize this. Otherwise it would not be possible to use them in large scale inventory of soils in the urban ecosystem. For that purpose soil classification has to discriminate more units on the level of low soil development stage (Table 3).

Table 3: Components of designation of soil units on the level of soil development stage.

The components of designation are:
– designation of short time development,
– short termed developing features of soils, resulting in a distinct number of new soils and criteria of designation,
– the most visible factors determining soil development and soil properties, which are the * substrate, * water household, and * and historical and recent use of the ground.

For practical use soil information should have an indicator value for those soil properties which are not visible at the profile due to the predominant low age.

Urban landscape formed recently are from raw soils up to soils of temporal limited development. The concept of the German Soil Science Society (Arbeitskreis Bodensystematik 1998) contains already elements to classify soils of low development stage of urban areas which will be supplemented by substrate classification (Arbeitskreis Stadtböden 1997).

The dual soil classification concept

Concerning the acquirement of soil information as main intention for soil inventory of urban soils the most paying are those of substrate features to assess the potentials of soils and of processes to assess the dynamic of soils under the existing environment. The German Soil Science Society (Arbeitskreis Bodensystematik 1998) has established a dual classification concept which is based on both columns substrate and genetic development equally. The classification of substrates of urban areas by material, skeleton or fine earth content, way of deposition and modification by treatment is described by Burghardt (2000). An overview of proposed genetic soil types and additions to the momentary state of knowledge about these soils contains Table 4.

Taxonomy of raw soils

Raw soils have no significant diagnostic horizons from development processes. That means there are no signs of relationship to other components of the environment until now. But there may occur in future diagnostic horizons. Raw soils will be often a transition stage or soils of plots which ground use shifts in short time. The characterization of them is only valid for a limited time. Therefore there exist a need to characterize also the future state of the more developed soil. We have the problems of a preliminary soil documentation and of prognosis of soil development.

The discrimination of raw soils is based on the nature of substrates which can be of natural or man-made material and imported substrate forming material. According to the dominance of properties of the substrate the low developed soils are **Lithosols**. Different types of **Lithosols** can by already distinguished (Table 5).

Table 4: Young soils of urban areas.

1. Lack of profile morphological changes

1.1 Raw Soils

Autolith Allolith Technolith Phyrolith Ekranolith Aerolith

1.2 Phänosols

Phäno-Cambisol Phäno-Gleyosol Phäno-Ferralsol Phäno-Chernozem
and others

1.3 Relictic soils

Relictic Gleysol Relictic Reductosol Drowned Terrestrial Soil
Relictic Hortisol Relictic Nekrosol

2. Occurrence of profile morphological changes

2.1 Atmospheric deposited dust

Aerosol Structosol

2.2 Compacted soil

2.3. Stony and gravely soils

Leptosols

2.4 Deep humus accumulated soil

Hortisol Nekrosol Humus fossil soil

2.5 Stagnic water influenced soils

Stagnic Gleysol Saline soil

2.6 Altered by chemical processes

Sulphuric Acid Soil Carbonatosol Cambisol

2.7 Soils of reductomorphy

Gas Reductosol Organic Substance Reductosol Compaction Reductosol
Ekrano Reductosol

2.8 Material and process concentrated soils

Dialeimmasol

2.9 Intrusols

Organic Liquid Intrusol Particle Intrusol

2.10 Leached soils

Calcium leached soil (Decalcisol) Gypsum leached soil (Degypsisol)
Salt leached soil (Desalinisol)

Table 5: Types of Lithosols.

– **Autolith** from exposed natural not moved substrates,
– **Allolith** from tipped natural substrates,

– **Technolith** from man-made substrates (e.g. rubble, ashes, slag, sewage mud, industrial mud, dust),
– **Phyrolith** (Greece: mixed) from mixtures of man-made and natural substrates,
– **Ekranolith** from solid surface material,
– **Aerolith** from aerial deposited dust.

Most of them will be vegetated within a seasons period. The development to **Regosols** or **calcaric Regosols** will be achieved within a time which can be assumed of 10 to 25 years. For stony soils the process of visible humus accumulation to a depth of 3 cm can be achieved in a shorter time. In these soils the organic matter is accumulated in a reduced amount of fine earth what increases the content of organic matter to a visible amount earlier.

It seems in the first moment off the track to include solid surfaces as soils. We have the problem that the city is to a large extend sealed and therefore many of the areas are from those solid surface materials. What would justify to name a street or roof a soil? At least both contain some organic material in the pores and on the surface and produce CO_2 which indicates that the solid body carries life. At least both materials will be, when not longer used and repaired, in few decades soil with morphological visible features. Why not should they be accepted as raw soils or at least as soil forming substrates?

Some of the tipped materials are natural and are from already developed soils. The features are similar to those of the excavated soils. They have e.g. colours of Cambisols or Ferralsols, mottling of Gleysols or humus content of Chernozems. But they are not longer these soils and have lost their original environment and in part their properties. The new soils are phaeno-types (Burghardt 1995), e.g**. Phaeno-Cambisol, Phaeno-Gleysols**. From the process of deposition they are raw soils. New soil development will occur in accordance to the environment.

In the city the environment of the soil is changing in some cases extremely. Mostly it concerns the height of groundwater table level and the kind of soil use. We will find e.g. **Relictic Gleysols, Relictic Reductosols, Drowned Terrestrial Soils, Relictic Hortisols,** etc. The change in the environment results in new horizons in the already genetic old soil formation. For example the **Hortisol** not longer used as garden soil develops a second Ah-horizon in the already existing one. How should this be classified? The **Hortisol** as substrate and the new soil formation as **Regosol?** This will make sense in respect of designation of the dynamic and processes of the soil but also for the function of soils as sinks.

Developed soils

Some soils have peculiar morphological features which can be used to separate them from others. It is surprising that there exists already a number of more or less developed soils on recently tipped materials (Table 4).

Some substrates are not capable to be vegetated. Such substrates are from ashes, slag, mining spoil, and highly contaminated material. Similar behave abandoned streets. What happens is the accumulation of atmospheric dust in holes or the colonization by mosses. In the dust deposits plants will grow. Around these plants more dust will be deposed and with time a thin new soil layer occurs. The soils are **Aerosols**. Mosses catch dust from the atmosphere. Each year they produce a new layer. The soil developing has therefore a platy like structure. According to their horizontal orientation they are named **Structosols**. It differs from other platy soils by the loose state of the platy aggregates. After the thickness of the dust layers reached some centimetres they are vegetated by higher plants.

The new soils developed are from thin layers. They have distinct diagnostic features of plainness, stratification and different characteristics than the underlying material. They are wide spread.

It can be assumed that even other soils are covered by dust deposits which change the soil quality. We have an example that within 45 years an ash layer was covered by 5 to 8 cm of soil forming material which indicates a high transport rate of dust near the soil surface. The soil movement can be also observed on paved strips between double lanes. There occur small dunes of 1 to 4 cm height within a year. For unpaved stripes between lanes it is well known that they grow in high with time. There will be more examples for this in the city. They can be important for the soil quality of the ground and should be incorporated in urban soil classification systems.

Young soils in cities are compacted by heavy machinery to a degree which is above that of rural areas. The depth exceeds also that found on farm land. The soils have platy to compact structure or in part change to this of an originally granular or blocky structure. The **Compactosols** are dominating large areas of cities today. Therefore they should be introduced as soil type. It must be discussed if they are raw soils or accepted developed soils.

More often soils of deep humus accumulation are described. Known are **Hortisols** from compost manure of vegetable gardens or to a lesser extent **Nekrosols** of burial ground. This group can be extended by the frequently found soils with one or more buried Ah-horizon. International **Hortisols** are called **Fimic Anthrosols**. The problem is, that the depth is not the international required one. **Hortisols** often have a depth of 35 to 40 cm, which should be used as minimum depth to define them.

Similar problems occur for the soils of high stone and gravel content. They have properties like **Leptosols,** but the stone content is below 90 %. What we need is a definition of a type for soils which have 30 to 80 % skeleton content.

To a large extend the compaction of urban soils results in **Stagnic Gleysols**. They develop on many areas and are frequent under streets. In arid areas these soils will be saline when irrigated.

Some chemical processes run very fast in urban soils. This concerns the oxidation of sulphides to sulphuric acids and the carbonatisation of calcium oxides. Sulphides are occurring in mining wastes, slag and some ashes. Therefore **Sulphuric Acid Soils** from mining wastes and ashes occur. Calcium oxides are released from some slag and are also from acetylene production sludge. The soil developing are **Carbonatosols**.

Visible change of horizons is also the result of reduction. There will be some reasons of reduction. It can be surplus of CH_3 and CO_2, high content of organic matter, lack of aeration by strong compaction, or inhibited gas release under streets. The soils are **Reductosols.**

The soils of pavements occur in intervals in gaps. The main feature is the strong accumulation of compounds and strong water flow in the gaps. The soils have humus accumulated and can show signs of strong bleaching. They are **Dialeimmasols**.

Other types of accumulation show the **Intrusols**. There are two types distinguished. One from gravel and stones e.g. of railway berth. The voids between the gravel are filled by intrusion of dust. The soils are **Particle Intrusols**. A second group has the feature of intrusion of organic liquids as oil, petrol and tar oil. The soils are **Liquid Intrusols** (Burghardt 1994).

A last group is formed by soils which are strongly leached. This is important for soils containing carbonates and gypsum. When they are leached voids occur and the soil will subside. The soils are **Decalcisols** and **Degipsysols**. To this group belongs also **Desalinisols**.

Conclusions

To our to days knowledge there exist in the cities numerous kinds of soil formations. The most are not well known and must be investigated in detail. It can be assumed that there are much more soils with diagnostic features from genetic processes exist around the world. There is a great deficit on soil investigations in the cities. The research until know is to much concentrated on pollutant content than on the understanding of the medium soil which determines the effect of the pollutants.

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Problems of the Systematic of Technogenic Surface Formations

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Abstract

Technogenic surface formations (TSF) are artificially constructed bodies for any purpose, or casual, or are by-products of human activities. Along with soils, technogenic surface formations are mapping units and objects to classify. Technogenic surface formations may resemble soils, if they are composed of strata, which are similar to soil horizons. Where is the conceptual boundary between SOIL and NON-SOIL**?** Is it possible to expand the pedogenetic ideology over “non-soils”? The conceptual boundary between “soil” and “non-soil” is determined by the presence or absence of a system of genetic horizons. When classifying TSF, soil criteria cannot be applied. Technogenic surface formations possess a lack of genetic (diagnostic) horizons, therefore they should not be included into pedogenetic taxonomies. They are mapping units and functioning bodies. They may be grouped with soils in terms of functioning.

Introduction

At present, the mapping units in soil surveys and other types of environmental mapping comprise along with the natural soils, all kinds of humanly modified solid-phase surface bodies, namely, technogenically and agrogenically transformed soils, and solid-phase *technogenic surface formation (TSF).* They all are functioning in natural-technogenic systems.

Technogenic surface formations embrace soil-like artificially made bodies, landfills, unconsolidated sediments used for constructing roads and industrial sites, heaps of waste rocks produced by mining industries, dredged material replaced to the land surface, industrial waste and garbage storage areas, urban “soils”, etc.

Technogenic stratification, being either casual or purposeful, may resemble the soil horizons. The majority of technogenic substrates support plants and may be inhabited by living organisms, thus, function like a soil. Moreover, a few evidences of pedogenetic processes may be identified in them: weak humus accumulations, secondary carbonates and gley features, efflorescence of easily soluble salts. These and some other properties of TSF enable to regard them as being prior to soils (*pre-soils*).

The above-enumerated objects need to be identified and categorized. When attempting to classify them, we face some interrelated conceptual problems:

- What is SOIL we classify?
- Where is the conceptual boundary between soil and obviously not a pedogenetic object – NON-SOIL?
- Is it possible to expand the pedogenetic ideology over the obviously “non-soils”, and apply the pedogenetic criteria for their systematic?

Results and Discussion

We assume that the principles for classifying the TSF, and the taxonomic position of TSF as related to natural and humanly modified soils strongly depend on the answers to these questions.

If we perceive “soils” in accordance with the ideas of V.V. Dokuchaev, as natural or natural-anthropogenic bodies with a system of genetic horizons, which derived of the mineral substrate owing to the combined effect of soil-forming agents (including the biotic ones), then the majority of TSF are not soils. In few cases individual layers similar to soil horizons may be recognized in TSF. These horizon-like layers are, however, in no way genetic soil horizons, since their origin is not related to natural soil-forming agents. Therefore, two answers may be given to the above questions:

- **The conceptual boundary between “soil” and “non-soil” is determined by the presence or absence of a system of genetic horizons in the body we classify**
- **When classifying TSF, soil criteria cannot be applied, and the TSF themselves cannot be objects of a soil classification system.**

There is an alternative approach to the perception of soil. Soils may be qualified as solid-phase surface formations functioning in an ecosystem. If so, true soils and TSF may be regarded within the same system and may be categorized in accordance with the same criteria. However, criteria used for this purpose should be different of those applied to categorize soils in a soil classification system. They must record functioning mechanisms, which are described by the dynamic features, or parameters of water-physical properties, heat and moisture regimes, and also the particle-size composition, concentrations of chemical compounds, pH, instead of characterizing morphology or fabric elements. Unavailability of reliable data on soil or TSF regimes is a reason for introducing the parameters of soil-forming agents directly into the classification system; most suitable are the data on climate. Thus, it needs no argumentation that the functioning of a landfill will be different in the taiga and steppe zones. A similar approach was used in Soil Taxonomy for assessing heat and moisture regime components.

In the majority of the existing soil classification systems (overview of Krasil’nikov 1999; and 1) comprising natural, humanly modified and artificial soils, as well as TSF, both approaches are combined, which means that all the enumerated bodies are regarded in the framework of one system. Hence, they are discriminated according to the same criteria including diagnostic horizons that are assigned to both soils and obviously artificial bodies. In order to identify taxonomic groups, substantive characteristics (horizons, features, particle-size composition, etc.) are used along with agents of soil formation. Sometimes the history and/or technology of artificial bodies taken into account as well.

We presume this approach to categorization of soils and other solid-phase substrates to be eclectic, rather inadequate and insufficiently logical, moreover, it has some shortcomings when applied for practical purposes. For example, the feedback reactions of soil horizons and artificial layers to the effect of natural and anthropogenic events appear to be different.

The authors stick to the above-mentioned Dokuchaev’s definition of soil. Therefore, the TSF lacking any systems of genetic horizons should be considered as a group of specific individual formations in the field of diverse surface solid-phase bodies. Consequently, “soils” and “non-soils” are to be classified according to different principles in a substantive-genetic classification system.

In the same time, we think reasonable and important to introduce some elements of functioning into classification systems of soils and, specifically, TSF. Functioning of soils and artificial substrates determines to a considerable extent their productive potential, susceptibility and resilience to anthropogenic loads. We believe that the most adequate solution of this intricate problem is the development of a *polycomponent (integrated) classification system of soils and TSF*. Such system should comprise individual non-taxonomic (independent) components, namely, *basic derived of substantive properties* of the objects classified, and the *factor* one. For the factor components, those criteria should be applied, that are related to soil-forming agents and are significant for functioning.

The basic component of an integrated classification system depends on its object. When classifying natural and humanly modified soils, the profile-genetic component is the nucleus of the system. In other words, natural and anthropogenic-natural soils are characterized and categorized by the properties of genetic horizons, which form certain sequences, and are supplemented by superimposed genetic features. This basic component is presented by the new substantive - genetic classification system of soils of Russia (2001). When classifying TSF, the profile-genetic approach cannot be applied by definition. It should be substituted by its morphological substitute, termed *stratigraphic criterion (approach).* Unlike genetic soil horizons, defined by sets of diagnostic properties, the stratigraphic criterion presumes the assessment of characteristics of artificial mineral, organomineral, or organic strata .

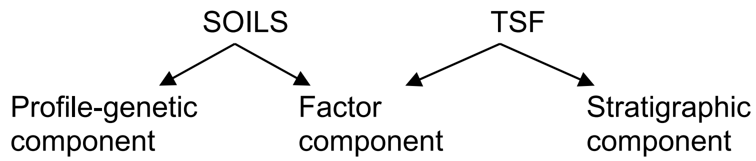
At the highest taxonomic level the TSF may be subdivided by their morphological resemblance to soils. Thus, **quasizems** are enriched in humus, and are rather similar to soils because of their upper humus-containing layer (it may be the humus horizon removed of any other soil and placed on the mineral substrate, or any other fertile organic material). **Fabricats** lack any humus layer, and are composed of any mineral, organic, or organomineral material, as natural, so artificial. This group of TSF may be regarded as concealed, or potential soils; they may evolve into real ones. A more detailed systematics of TSF by their substantive properties is given in the "Classification System if Soils of Russia" (2001).

Table 1. Tentative systematics of technogenic surface formations.

G R O U P S			
QUASIZEMS	NATURFABRICATS	ARTIFABRICATS	TOXIFABRICATS
S u b g r o u p s			
Replantozem	Abralith	Artiindustrat	Toxiurbostrat
Urbiquasizem	Lithostrat	Artiurbostrat	Toxifimostrat
	Organostrat	Artifimostrat	Toxilithostrat
	Organolithostrat		Toxiabralith
			Toxilithostrat

The factor component of the polycomponent classification system comprises direct information on all characteristics of environmental agents that are important for functioning and determine the trend and intensity of the current soil-forming processes. It is worth emphasizing that this component is equally applicable to soils and those TSF that may once become soils (Fig. 1).

Fig.1. Components of classification systems for soils and non-soils.



Proposals of the authors concerning the factor component were published recently (Lebedeva et al. 2000). A brief summary illustrating the approaches to subdivision of factors is presented in the Table 2.

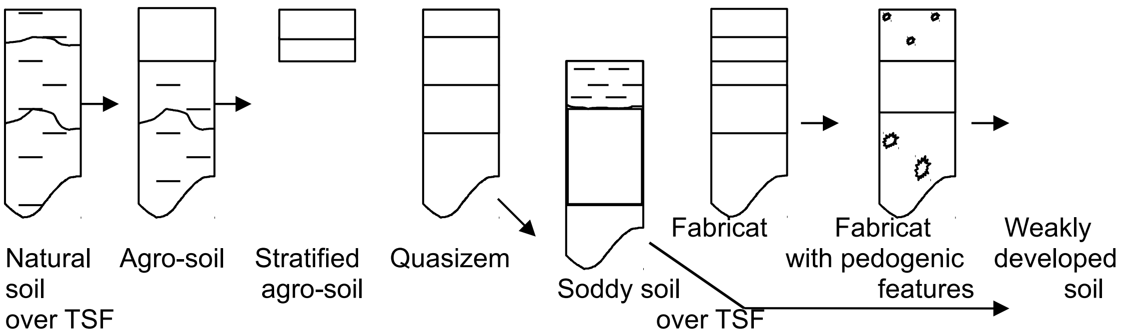
Table 2. An essay of categorization environmental factors in the factor component of a polycomponent system.

Taxonomic levels	**Branches**			
	Climatic	**Soil (substrate) moistening**	**Petrographic-mineralogical**	**Vegetation**
Class	Humidity-aridity	Profile drainage	Consolidation rate	Phytomass
Generation	Heat supply	Duration of waterlogging	Groups of minerals	Phytomass removal with yield
Subgeneration	Active temperatures and freezing	Localization of the water-saturated layer	Mineralogical composition	Ash content
Series	Heat and moisture redistribution	Surface and soil runoff	Rejuvenation of the substarte	Complexes of vegetation cover

The factor component for the technogenic surface formations should comprise information concerning the means of technogenic bodies formation (technology, or history), and their common occurrence in a certain technogenic landscape. For example, rehabilitated lands, urban soils, industrial sites, oil-polluted areas, etc.

When subdividing the solid-phase surface bodies into TSF and soils, with a further subdivision of soils into natural and humanly modified classes, it should be born in mind that the boundaries between all of them are flexible, the changes in properties are gradual; hence, there are many intergrades in the classification system (Fig. 2). For example, a thin layer of humus-poor material on the surface of a soil is a reason to qualify the soil as *stratified* unit, which is an intergrade between soil and TSF. Identification of features testifying to the initial pedogenesis in TSF permits to consider such a TSF as an intergrade to soils, whereas the development of a humus horizon in the upper part of the artificial sediment refers this sediment to soil over a TSF. Moreover, if an evolving humus-rich horizon of a quasizem merges with the human-deposited humus material, and cannot be separated of it, the object should be qualified for a soil.

Fig. 2. Schematic pattern of horizons and strata in the sequence “soil-TSF”.



Conventions

Horizons:

Natural

Agrogenic

Strata:

Artificial humus-rich

Artificial low-humus

Features of natural pedogenesis

Conclusions

Concluding, we should like to emphasize that the absence of genetic (diagnostic) soil horizons in NSF is the main argument in favor of excluding them from pedogenetic taxonomies. A conceptual sequence “soil – non-soil” may be presented by a scheme, its two last members being beyond genetic systems:

SOIL → URBO-(AGRO-)SOIL → URBANOZEM(AGROZEM) →

ANTHROPOGENIC SOIL (ANTHROSOL) → PROGRADED QUASIZEM →

QUASIZEM → *TECHNOGENIC (NON-SOIL) SURFACE FORMATION*

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Urban Soils - a Particular Specific Group of Anthrosols

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Abstract

Soil is an important ingredient of urban ecosystems. Urban civilization existing during millennia produced specific soils, which were formed by intricate combinations of natural soil forming factors and peculiar urban environment. We described surface organic-mineral soil-like bodies occurring in towns as specific natural-anthropogenic soils. They require special methods of investigation, and follow the general soil formation laws.

The main factor of soil formation in towns is the land use type (industrial zones, settlement areas, natural gardens, etc.). Urban soils are essentially distinguished from natural soils by the following characteristics - parent material: filled, washed or mixed sediments, or cultural layers; occurrence of fragments of constructional and household waste in the topsoil; new acid–alkaline balance with a tendency for alkalization; high pollution with heavy metals and oil products; physical-mechanical properties (lower water retention capacity, strong compaction, stoniness, etc.); upward growth of the soil profile due to intensive aerial deposition.

An original classification of soils and soil-like bodies within urban areas is proposed. We distinguished and described in detail two new groups of soils - ”Urbanozems” and ”Ekranozems”.

A procedure of surveying soils in a town was elaborated along with modified methods of profile description with specification of genetic horizons and anthropogenic strata. It was applied to Moscow, and a schematic soil map was compiled.

Introduction

The thousand-year-old urban civilization produced specific groups of soils formed both by the well-known natural driving forces and strongly affected by the urban environment.

Soils of megalopolises are specific ingredients of an open, non-resilient, and unstable ecosystem requiring external maintenance for its functioning.

We define urban soils as soils having a human-made upper layer deeper than 50 cm resulting from mixing, filling, burial and/or pollution of town-produced material – construction and municipal garbage.

Important characteristics of urban soils are continuous destruction and mechanical input of different human-made substances.

Methods

We have studied soils of large and small towns in the taiga zone (Moscow, Saint-Petersburg and others). The approaches to the complex assessment of the status of urban soils derived of an integrated research of their specific chemical, physical and morphological features, and their geographical pattern.

We introduced and described the **urbic diagnostic horizon.** Urbic horizon is defined as diagnostic for urban soils and serves as a criterion to discriminate them with the natural soils. “Urbic” is a surface organic-mineral horizon resulting from mixing, filling, burial, pollution, or it is the upper part of the cultural layer contaminated by industrial or town-produced wastes (more than 5%). It is deeper than 5 cm.

An original (and the first in Russia) classification system of soils and soil-like bodies within urban areas is proposed.

Horizontal and vertical variability of urban soils is too high; therefore, traditional methods of mapping should be partly modified.

We also developed tentative guidelines for the urban soils survey including the procedure of description of their profiles (comprising genetic horizons and anthropogenic layers).

Depending on the scale of surveying, features of territory, and type of functional zone we propose the norms of soil sampling. The methods proposed were tested while compiling the schematic soil map of Moscow.

We compiled a medium-scale schematic soil map of Moscow basing on the following approaches: lithological and geomorphological division of the territory its age (downtown, developing areas, etc.), and the functional zones of the city. Moreover, the differences in soils on the cultural layer, unconsolidated sediments and bedrock were taken into account. The information to compile the map comprised original and literature data, as well as maps published in the state report: "About the Status of the Natural Environment in Moscow in 1992", scale 1:200,000: Geomorphologic map, Map of reconstructed landscapes, Map of functional organisation of the territory, Map of soil pollution and other maps, as well as colour aerial photos at scale 1:25,000 performed by *Aerogeologiya* enterprise.

Results

The soil mantle comprises various soils, namely, natural soils of the forest zone (Soddy-podzolic ~ Albeluvisols) transformed by forest cuttings, fires, farming, along with “urbogenic” human-made soils and soil-like bodies.

The soil-forming agents are the following in the town:

- functional properties and land-use pattern: residential area, industrial zone, recreational or natural zones;
- kinds of substrates, their physical and chemical features: the cultural layer, land fills, mixed and dredged sediments, remnants of natural soils;
- age (ancient centre modern housing estates of suburbs)

Urban soils of the southern taiga zone essentially differ from natural zonal and intrazonal soils. Urban soils are essentially different from natural soils mainly because of:

- parent material – filled, washed or mixed sediments, or cultural layers;
- occurrence of constructional and household artefacts in the topsoil;
- changes in acid–alkaline status with a tendency for alkalization;
- high pollution with heavy metals and oil products;
- changes in physic-mechanical properties (lower water retention capacity, strong compaction, stoniness, etc.);
- upward growth of the soil profile due to intensive aerial deposition;
- high supply of nutrients.

Each of the above features may be inherent to natural soils (volcanic, alluvial, rendzina), while their combination may be unique and «incompatible» with the natural environment.

Urban soil biological systems are subject to considerable structural changes, so that the biological activity profile pattern is unlike that in native soils.

Some specific forms of bacteria may indicate urbanization. Thus, *Azotobacter* has been discovered in soils of Moscow, while it is absent in soils of adjacent areas. Its distribution is irregular both in surface horizons, and along the soil profile.

We have elaborated a system of criteria and parameters to estimate the urban soil ecological status, which is a part of integrated assessment of the environment properties. Specialists for ecological rating can apply this system.

The following principles were suggested to categorize urban soils and soil-like bodies in the southern taiga zone, as well as criteria for main tax.

Natural soils occurring in towns are classified in accordance with the recently published system (1997); soils with urban effects revealed in the upper part of soil profiles, or superficially transformed natural soils are referred to as **urbo-soils** (like agro-soils). The depth of their urbic horizon should not surpass 50 cm. The next group is composed of deeply transformed soils with the thickness of urbic horizon more than 50 cm – **Urbanozems**. The still weaker effect of natural pedogenesis and prominent contribution of lithogenic properties is recorded in superficially humus-enriched human-made soils that are followed by almost unchanged substrates – **Urbotechnozems**.

Urbanozems are genetically individual soils, which comprise features of both natural and human-made soils.

In big cities, the soil surface is often sealed with a solid cover. This causes truncation of the soil profile with its remnants soil being buried and degraded. It is proposed to recognize a separate group of soils, **Ekranozems,** sealed with asphalt concrete, or any other impermeable cover. The following transformations were recorded in all sealed soils: truncation, strong compaction; changes in water, heat and gaseous regimes; functioning of microbial communities under anaerobic conditions; no input of substances from outside. Measures to rehabilitate Ekranozems were proposed with allowance for their use in future.

Natural soil mantle of Moscow has been destroyed at the most part of the territory. Natural undisturbed soddy-podzolic soils have been preserved only in urban forests (such as Losiniy ostrov, Fili-Kuntsevo). In gardens and forest parks boggy and alluvial soils (partly destroyed) remain still recognizable.

The surface-transformed soils (urbo-soils) combine the topsoil presented by urbic horizon with the undisturbed subsoil. Soils are further subdivided according to the way of formation (mixed, filled); profile thickness; abundance and type of artefacts (construction and municipal waste, industrial waste, peat-mucky inclusions); depth of humus-enriched layer; manifestations of gley:

The soil profile of specific urban soils – Urbanozems comprises a set of variants of the urbic horizon (U1, U2…), which is frequently underlain by impermeable layers (asphalt, concrete plates and pipelines); no other genetic horizons may be recognized to the depth of 50 cm and even lower.

The extension of sealing in towns depends on land use and on the urbanisation intensity. The process of sealing of the soil surface is becoming an important reason of the complicated pattern of the urban soil mantle.

The proportion of open unsealed plots (with open soils) ranges from 3 to 5 % in the downtown and from 70 to 80 % in the suburbs. In industrial zones, there is 80 - 90 % of the areas sealed, while 10 - 20 % is recorded in resort and agricultural areas. A residential area intergrades in this respect. The degree of their sealing varies within 20 to 75 %.

Discussion

Urbanization and economic activities of population dominate the natural soil-forming effects, so that specific groups of soils and a specific soil cover respond to this new environment in Moscow. The prominent relief of Moscow, hence, variations in drainage facilities and different moisture regimes are responsible for the diversity of the soil cover. The parent-rock and time factor contributes to the complication of the soil cover: soils of the downtown occur on a deep cultural layer, whereas soils of new sleeping sectors are being formed on landfills or recently outcropping sediments. These cultural layers were not once mixed during many centuries of the Moscow life; they alternate with series of buried paleosols strongly differing in age.

Unlike the soil cover structure of Moscow suburbs, the soil cover of the city has the following particular features:

- Absence of homogeneity, and continuous quick restoration of heterogeneity enhanced by local human impacts. The soil mantle pattern of Moscow territory is peculiar by its mosaic character; it is true in terms of time, vertical and horizontal directions. Heterogeneity originated with the birth of the town.
- Discreteness of the soil mantle, its fragmentary occurrence. In Moscow, as in any other city, true soils and soil-like bodies alternate with sediments, buildings, pipelines, quarries, sealed soils under highways and asphalt-concrete covers.
- Artificial boundaries between soil mapping units along with a rectangular geometrical shape of mapping units. The boundaries of mapping units are determined by the location of buildings and roads.
- Small size of mapping units, rather irrespectively of the scale of survey.

The urban soils perform important ecological functions in the town, which are essential and diverse. They provide conditions for the growth of vegetation, absorb pollutants and prevent penetration of the latter to soil and ground waters.

Nearly 85 % of the area of Moscow (residential areas, municipal districts, industrial and transport areas, road network, and so on) is subject to the impact of adverse processes, which influence the ecological status of soils. According to a prediction of ecologists, this impact will intensify. So, the vegetated area will shrink, while the increasing degree of soil sealing with houses, stone, asphalt and others will decrease the surface of biologically productive and biogeochemically active soil cover. In addition, hydrological conditions in soils will deteriorate (waterlogging, bogging, subsidence, and karst). The pollution of the near-surface layer of air and of the urban environment as a whole will increase. Standards on recreational use (allowable visiting rates) will be exceeded.

Conclusions

The properties of Urbanozems and conditions of their formation are controlled by features of the urban environment and the living activity of people. These peculiarities of urban pedogenesis gave rise to a new branch in soil science - urban soil science that deals with genesis, properties, functions and ecology of Urbanozems, and recognizes specific rules governing the spatial arrangement of the soil cover of urban areas.

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Position, Arrangement and Definition of „Colluvien and Anthrosols“ in the Austrian Soil Classification 2000

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Abstract

An anthropogenic influence have to be given more consideration as well in a classification system. This has been respected in the Austrian Soil Classification 2000. In the class Colluvien and Anthrosols both the soil type colluvium and the types Cultivated raw soil, Hortisol, Trenching soil (Rigosol), Shipping soil and Depot soil are summarized. Subtypes are differentiated depending on their carbonate content.

Introduction

Increasingly intensive soil management, limited crop rotation as well as continuing intensive settlement activities accompanied by the loss of land on the one hand and deposition of waste and refuse on the other hand has a strong impact also on soil. Consequently, soils that have not been formed primarily by natural factors by to a large extent due to anthropogenic influence have to be given more consideration as well in a classification system. This has been respected in the Austrian Soil Classification 2000 and will be the main focus of my short contribution.

Results and Discussion

In the class **Colluvien and Anthrosols** (cp. Table 1) both the soil type colluvium and the types Cultivated raw soil, Hortisol, trenching soil (Rigosol), Shipping soil and Depot soil are summarized.

Colluvien are soils resulting from natural processes. They are mostly deep and consist primarily of accumulated erosion material (transported by wind or water) and, with the exception of the A-horizon, they do not show any sedentary genetic horizons. If the type of origin can still be recognized, it is added to type, e.g. colluvisol from Cambisol or from Chernozem.

These soils are preferably to be found in concave positions such as troughs, ditches and valleys.

Due to the accumulation of hums-rich material, their depth and external water supply, they are, in most cases, high-grade agricultural soils that also attract pioneer tree species (grey alder, willow). Theses soils are further sub-classified according to their carbonate content and possible gleyification.

The following five soil types can generally be referred to as anthrosols, since they show the following features to a varying extent:

1.) Profound changes due to long-standing and/or intensive human activity. These changes may involve removal and/or mixing of material origin or the may be of technogenic nature with potential enrichment with organic substances and nutrients.

2.) These soils exhibit strata /layers/horizons that have undergone major change and whose minimum thickness has to be 20 cm in case of technogenic material and 40 cm in case of other materials.

3.) No site-specific soil formation can be observed yet in the topmost 40 cm.

Table 1. Excerpt of the Austrian Soil Classification 2000. Order: Terrestrial Soils, Class: Colluvien and Anthrosols.

Types:	Subtypes:	Varieties:
Colluvium (Kolluvisol)	carbonate free C.	gleyic pseudogleyic
	carbonate containing C.	gleyic pseudogleyic
Cultivated raw soil (Kultur-Rohboden)	carbonate free C.r.s.	possible
	carbonate containing C.r.s.	possible
Hortisol (Gartenboden)	carbonate free H.	possible
	carbonate containing H.	possible
Trenching soil (Rigolboden)	carbonate free T.s.	possible
	carbonate containing T.s.	possible
Shipping soil (Schüttungsboden)	levelled soil (Planieboden)	carbonate containing carbonate free pseudogleyic gleyic
	slag-heap soil (Haldenboden)	carbonate containing carbonate free pseudogleyic gleyic
Depot soil (Deponieboden)	carbonate free	possible
	carbonate containing	possible

The soil type **Cultivated raw soil** is characterized by a humus-poor horizon of fine-clastic material of no more than 30 cm thickness with clear signs of tillage and erosion. Humus is present mostly in the form of mull and transition to the C-horizon is clearly visible. At varying carbonate content the supply with the nutrients is generally of medium level. This type is found on hillsides in association with chernozems and cambisols.

In terms of agricultural use, these are mostly sites of medium to low quality (which may be used as cropland or as grassland), but well-suited for wine-growing. Dry turf sites should be protected by law.

A further sub-classification is made depending on the carbonate content.

The next soil type to be discussed is **Hortisol**. It is marked by long-lasting and intensive cultivation and the site can be clearly distinguished from is surrounding area. Soils of this type are usually characterized by an increased content of organic matter. If the soil type from which the Hortisol has developed can still be identified, it is specified, e.g. hortisol from Chernozem, from Cambisol or from Fluvisol.

The amelioration of these soils is a consequence of long-lasting horticultural use with supply of organic matter (compost, peat), intensive deep tillage and, frequently, of irrigation. Theses soils are to be found also in suburban areas (horticultural enterprises, home gardens).

There are high-quality sites with a very high supply of nutrients and hence susceptible to nitrate wash-out.

A further sub-classification of this type of soil can be made depending on is carbonate content.

Another soil type in their class is the **Trenching soil** (Rigosol). Is shows signs of deep tillage, and the minimum depth must be at least 40 cm resulting from subsoiling and not from deep-ploughing. This subsoiling work is carried out usually prior to the planting of vineyards, and frequently nests of former genetic soil horizons can be identified in the soil profile. If the type of soil from which the subsoil has originated can still be recognized, it is included in the description and is then referred to as „Rigosol from the respective soil type“.

These soils are mostly used as vineyards, occasionally also for other crops or plantations (tree nurseries, orchards, horticultural enterprises).

Another differentiation is made based on carbonate content.

Another soil type in this class is **Shipping soil**. This is a type of soil where natural soil material and/or rock has been transported by technical means from a different place and deposited up to a thickness of more than 40 cm. This material has usually undergone mechanical but hardly any chemical change and may be earth or rubbish excavated during mining and tunnel-driving as well as material stemming from road or building constructions from a distance of a few meters only. Soils that have formed in and from flush areas are also included in this category.

This soil type is characterized by the following features:

1.) The sequence of horizons typical of natural soil is absent.

2.) An initial A-horizon at least can be identified.

3.) Heavily compacted zones can frequently be found in the profile as a consequence of levelling.

Depending on the type and quality of the material medium - to even high-grade soils may develop.

This type has two subtypes: We talk about **Levelled soil** if the site is characterized by primary rock from layers close to the surface or underlying strata that has been piled up or rearranged. Frequently the soil profile shows inhomogeneities in material, e.g. allochthonous rocks, allochthonous organic matter.

Soils on an from building pit excavations are assigned to this subtype. Additional varieties can be differentiated based on carbonate content and on gleyification or pseudogleyification.

The second subtype is a **Slag-heap soil**. It consists chiefly of material from originally deeper layers that has been excavated during mining activities and deposited.

Additional varieties can be differentiated based on cabonate content and on gleyification or pseudo-gleyification.

The fifth and last soil type is **Depot soil**.

This soil type includes soils whose common feature is their origin from technogenic material. This material determines also the properties of the actual soil, whereby this material must have a thickness of at least 20 cm. The source may be urban, commercial or industrial waste, such as building rubbish, ash, sludge, slag, garbage, industrial residues of various kinds as well as compost.

These soils are characterized by a high degree of inhomogeneity, and soil formation is hardly site-specific. Typically, soil of this type may be found in all regions, however, they are most frequent close to urban and (existing and abandoned) industrial sites. Due to their highly imbalanced chemical compostion caution in advised it they are to be used since toxic substances contained in the initial material may still be effective.

The topmost 70 cm are decisive as to whether soils can be classified as terrestrial (the material has already undergone change) or as soils with „technogenic material“ (the technogenic layers within the topmost 70 cm have a thickness lower than 20 cm).

Subtypes are differentiated depending on their carbonate content.

Conclusions

I believe that the working group within the Austrian Soil Science Society has succeeded in defining and systematizing as precisely as possible these classes, types, subtypes and varieties, which have often been neglected so far over natural soils.

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A Comparative Analysis of Approaches to Anthropogenic Soils Classification in Slovakia and Russia

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Abstract

A conceptual background concerning the position of anthropogenic soils in classification systems in Slovakia (SCS) and Russia (RCS) was analysed. The human-modified soils are integrated into both systems, although some differences are recognized. Anthropogenic diagnostic horizons commonly serve as major criteria for soil categorization. Soils with minor anthropogenic modifications (diagnostic features) are included in the systems at the level of anthropogenic subtypes within the natural types, or anthropogenic soils with incipient natural features. The basic difference in approaches concerns the priorities of criteria – soil properties versus type of impact. Anthrozems (i.e., soils) in SCS are not regarded as soils in the RCS, where they are qualified as technogenic surface formation, or non-soils.

Introduction

One of the obvious reasons of differences in soil classification systems may be the difference in geographical diversity of soils along with prominent differences in human economic activities and technologies. Nevertheless, the attitude to human-modified soils in Slovakia and Russia has much in common, and a comparative analysis was made for the anthropogenic soil diagnostic horizons and soil units.

In accordance with the principles of soil classification systems in Slovakia (SCS) – morphogenetic and in Russia (RCS) – substantive-genetic, human-modified soils are regarded as ingredients of the entity of classified soils, and are included as such in both systems. In many cases anthropogenic soils are incorporated as new soil group. However, since both systems are open ones, some changes are not prohibited.

Results and Discussion

Comparison of anthropogenic soil diagnostic horizons

The SCS (Sobocká et al., 2000) distinguishes three anthropogenic diagnostic horizons:

Cultizemic Ak-horizon is a the top horizon transformed by agricultural practices, manure addition, or other cultivation human impacts with various properties, which has: thickness > 10 cm, organic carbon content > 0.3 %, admixture of subsoil horizons or artifacts, and at least one of the following properties:

1. cultivation indices (homogeneization, distinct transition or sharp boundaries, lighter colour than subsoil, compaction on the horizon’s lower part);
2. admixture of agricultural chemicals, limestone, manure and other organo-mineral fertilizer components.

Varieties of the horizon: *Cultizemic ploughed Akp-horizon:* has at least one of the properties 1, 2 in thickness 10 - 35 cm; and *Cultizemic ameliorated Akm-horizon*: has at least one of the properties 1, 2 in thickness > 35 cm. The presence of Cultizemic ploughed Akp-horizon may be used to any soil type in the arable land to form its Cultizemic-subtype.

Anthrozemic Ad-horizon is a top horizon developed from heterogeneous removed materials which can be of natural, natural-technogenic, or technogenic origin (Sobocká, 2000) with various properties, and which has: thickness > 1 cm, organic carbon content > 0.3 %, artifacts (brick fragments, glass, plastic materials, iron, slag, coal, etc.) may be present.

Varieties of the horizon: *Anthrozemic initial Adi-horizon:* initial stage of soil development (1-10 cm – thick horizon) from anthropogenic materials with thickness > 35 cm; *Anthrozemic recultivated Adr-horizon*: indications of soil reclamation or rehabilitation measures aimed at the improvement of plant growth conditions are recognizable in the upper horizon. It is a biological rehabilitation (humification of anthropogenic materials) on technical flat-levelled areas.

Contaminated Ax-horizon is a top horizon with changed (aberration) chemical properties owing to anthropically or geogenically introduced substances, which has: thickness > 1 cm, excessive content of risk toxic and emission elements (at present over B-limit).

Varieties of the horizon: *Contaminated toxic Axt-horizon* is identified by means of special analyses, indicating that different toxicants (heavy metals, oil and oil products, organic pollutants, etc.) exceeded the permissible limit at least in part of the horizon. Simultaneously the names of contaminants are given. *Contaminated emission Axi-horizon*: is contaminated predominantly by solid emissions, their deposition being visible on, or in the soil body, they are significantly affecting soil chemical properties. Simultaneously, the names of contaminants are given. Contaminated Ax-horizon can be used for classification of any soil unit at the level of soil variety.

All anthropogenic horizons can be characterized by subvarietes: o - ochric, u - umbric, m - mollic, a - melanic.

In the RCS (Shishov et al., 2001), *Agrogenically transformed horizons*, are identified; they have been formed owning to regular ploughing and to other artificial displacements (mechanical turbations) of one or several natural horizons, application of organic and mineral fertilizers, or other chemicals. These human-modified horizons differ from their natural analogues by the soil mass arrangement, and some physical and chemical parameters.

These are: *PT Agro-peat horizon* - formed from the material of a natural peat horizon after artificial drainage and reclamation; *PAT Agro-peat-mineral horizon* - formed from natural peat soil material, or agro-peat horizon in the course of farming practices comprising application of sand, clay, mineral fertilizers, liming. The *PY Agro-light-humus horizon* results from mixing (with subsequent homogeneization) of any natural organic, light-humus horizons with podzolic or eluvial ones; the *PU Agro-dark humus horizon* is usually formed by ploughing of the natural dark-humus horizon, dark stratified horizons, very rare are the cases of the light-humus horizon progradation.

The *PB (PC) Abraded horizon* originates by modification of middle-profile horizons or parent material in abraded (wind- or water eroded) soils.

The *X Chemically polluted horizon* is any horizon(s) within the upper 30 cm layer containing any chemical pollutant(s) in concentrations above the accepted permissible levels.

Anthropogenic soil horizons may have diagnostic features. The group of natural-anthropogenic features comprises the following ones: tr - top-turbated, o - organic material, r - mineral admixtures in peat, rh - humus-enriched mineral deposit on the soil surface, a – accumulation of unusual natural chemicals, etc. The following features are human-produced: hr - topsoil heterogeneity, d - density, ab - abrasion, hi - humus illuviation, rr - artificial non-toxic sediments, rt – artificial toxic sediments, x - chemical pollution.

We have used for comparison only those horizons of the RCS that have analogues in the SCS. Criteria to categorize anthropogenic soils comprise types of horizon sequences (system of horizons) produced by the anthropogenic impact and types of impacts. Although in RCS the former is of primary importance, and in the SCS the priority is given to impacts, the results appear to be the same: anthropogenic diagnostic horizons serve as major criteria to categorize soils. Moreover, there are many common features inherent to horizons, e.g. Contaminated horizon (SCS) is equivalent to Chemically polluted (RCS), Cultizemic horizon (SCS) is rather close to the agro-humus horizons in RCS. Further research and correlation may complete the Table 1.

Table 1. Comparison of anthropogenic diagnostic soil horizons (topsoils).

SCS	RCS (NOT ALL HORIZONS)
CULTIZEMIC PLOUGHED HORIZON < 35 cm thick (as intergrades to natural soil units at the soil subtype level diagnostics)	**AGRO-LIGHT-HUMUS AND AGRO-DARK-HUMUS HORIZONS** (depth parameter is not diagnostic, it is reflected at the species level)
CULTIZEMIC AMELIORATED HORIZON > 35 cm thick (for Cultizems diagnostics)	**AGRO-HORIZON** (dark-, light-humus, or peat horizons) > 40 cm thick (deeply turbated at lower level)
CONTAMINATED HORIZON (toxic, emission, also natural contamination)	**CHEMICALLY POLLUTED HORIZON**
ANTHROZEMIC HORIZON	**NO HORIZON IN RUSSIAN SYSTEM,** it might be "stratified horizon" + layers
taxonomic level - **EROSION FORM** (it may be not necessary anthropogenic)	**ABRADED HORIZON** (it may be not necessary anthropogenic)

Comparison of anthropogenic soil units

In the SCS as anthropogenic soils were defined as Cultizem (Cultisol) KT and Anthrozem (Anthrosol) AN.

Cultizems (KT) are soil types with Cultizemic ameliorated A-horizon > 35 cm deep, and/or also with remnants of original topsoil or subsoil diagnostic horizons which thickness is > 10 cm. The group consists of 10 soil subtypes.

Soil varieties: saturated (n), acid (a), calcareous (c), alkaline (z), contaminated (x).

Soil forms: gardening (g), trenching (r), terraced (t).

Anthrozems (AN) are soil types with Anthrozemic A-horizon developed from transported (removed) anthropogenic materials with various origin having thickness >

35 cm. Subtypes of Anthrozems: *Modal Anthrozem*: without any other diagnostic horizons or indications, *Initial Anthrozem*: with Anthrozemic initial Adi-horizon, *Recultivated Anthrozem*: with Anthrozem recultivated Adr-horizon, and *Covered Anthrozem:* with artificial cover of natural soils by significantly different anthropogenic material (peat, humolit, compost, humus, etc.).

Soil varieties: saturated (n), acid (a), calcareous (c), alkaline (z), contaminated (x).

Soil forms: urban (u), dumping (d), spoil bank (b).

Urban form is defined as a heap of organo-mineral material on artificially levelled, or waste areas in urban, or industrial areas, along traffic communications, etc. *Dumping form* is defined as a heap of organo-mineral material on waste dumping areas which is prevailingly chemically active material. *Spoil bank form* is defined as an initial development of soils from natural-technogenic or technogenic substrates (excavated, dredged material or industrial spoil banks, fill, ramparts, etc.).

In the RCS the strongly human-modified soils are presented at the high taxonomic level – orders. Thus, the *Agrozems* order (with 13 soil types) comprises soils which profile has an agro-dark-humus, or agro-light-humus underlain by any natural subsoil. The natural component may be also gley or cryptogley horizon, or parent material.

All soils of the *Agroabrazems* order (8 soil types) have a surface post-abraded horizon, poor in humus and composed of the subsoil or parent material, instead of argo-humus horizons inherent to Agrozems. The post-abraded horizon is underlain by any kind of natural subsoil horizon, or parent material.

Alluvial Agrozems are soils with a profile comprising agro-dark-humus, agro-light-humus, or peaty-mineral horizon underlain by non-gleyed, gleyed or crypto-gleyed alluvium. The order comprises 5 soil types.

Chemodegrazems belong to human-modified soil, all soil are contaminated with toxic chemicals: heavy metals, pesticides or herbicides, hydrocarbons, radio-nuclides, etc. The degree of contamination is qualified as very dangerous according to criteria accepted. The morphological properties of soils may remain unchanged versus the natural soils, or some modifications of morphological features may be observed. Two soil types are now identified. In *Chemozems* chemical pollution causes drastic changes in the composition of soil solutes and soil exchange complex, strongly affects soil biota. Diagnostics requires analytical methods. Chemical pollution in *Chemically modified soils* is accompanied by changes in soil morphology caused by aggressive chemicals and/or by deposition of technogenic material in the soil body. Genetic horizons are strongly modified, new horizons may appear.

Aquazems - soils formed under the influence of periodical prolonged flooding required for rice cultivation. Gley processes, Fe-Mn neoformations, and bleached horizon are the main characteristics.

The difference in approaches concerns the priorities of criteria – soil properties versus type of impact, and the emphasis is put on the latter in SCS, while it is “concealed” in the RCS. Cultizems of SCS being somewhat similar to Russian Agrozems comprise a smaller set of soils, corresponding to Russian Agrozems properly (soil type). The preservation of the initial subsoil is taken into account in the SCS, like different subsoils produce different Agrozems in RCS. In accordance with the SCS taxonomic levels (soil group, soil type, soil subtype, variety, form, texture, parent material), the following full soil name may be produced: Cultizem Chernozemic, gardening form, carbonatic variety, loamy, from loess.

The problem of eroded soils remains but partially solved in both systems, although eroded ("abraded") soils are introduced irrespectively of the soil erosion origin.

Table 2. Comparison of Anthropogenic soil units.

SCS	RCS
CULTIZEMIC … (as an intergrade to natural soil types)	**AGRO-** (as an intergrade to natural soil types)
CULTIZEMS: 10 SUBTYPES (sub-division based on subsoil characteristics)	**AGROZEMS: 13 SOIL TYPES** (sub-division based on human-modified horizon properties and subsoil characteristics)
only the level **EROSION FORM** (for any natural or anthropogenic soil unit)	**AGROABRAZEMS: 8 SOIL TYPES** (sub-division based on human-modified horizon properties and subsoil)
included **IN CULTIZEMS** (as Modal Cultizems or Cultizemic Fluvizems)	**ALLUVIAL AGROZEMS: 5 SOIL TYPES** (sub-division based on subsoil characteristics)
only the level **CONTAMINATED VARIETY** (for any natural or anthropogenic soil unit)	**CHEMODEGRAZEMS** (sub-division based on intensity of pollution and morphology changes)
ANTHROZEMS (sub-division based on developing process and kind of impact)	like **TECHNOGENIC SURFACE FORMATIONS** (non-soils in Russian perception)

Totally different is a perception of specific objects developed from artificial substrates – part of Anthrozems (i.e., *soils*) in SCS, which are not regarded as soils in the RCS, and are qualified as technogenic surface formation (TSF), or *non-soils*. TSFs are not real soils in view of the Dokuchaev pedogenetic paradigm, and are, therefore, not included in the same genetic soil classification as natural or semi-natural soils Nevertheless, TSFs being a recognizable block of surface bodies (e.g. mapping units in detailed soil surveys), need to be diagnosed and classified separately with a following tentative criteria: composition of material, morphology, origin and toxicity.

At present, the following groups and subgroups of TSFs may be identified:

<u>*Quasizems,*</u> which are similar to natural soils with humus-enriched surface layer, or other fertile material purposefully for plant growth providing. As subgroups, there are: *Replantozems* - soil-like bodies created purposefully for farming by heaping of humus-enriches layer on the levelled surface or landfills, and *Urbiquasizems* - below the fertile surface layer, there is a mixture of mineral material with specific urban artifacts like remnants of construction material, wires, municipal garbage, etc.

<u>*Naturfabricats*</u> have no humus-enriched surface layer, they consist of any material of natural provenance, that has been translocated and mixed by humans. Several subgroups are identified: *Abraliths* (outcrops of hard rocks and/or unconsolidated materials of quarries, etc.), *Lithostrats* (landfills composed of wastes produced by mining or building activities), *Organostrats* (heaped peat or other natural organic material), *Organolithostrats* (mixed, non-sorted organo-mineral material).

<u>*Artifabricats*</u> consist of artificial substrates occurring in towns, industrial areas. They are subdivided into subgroups: *Artiindustrats* (non-toxic waste material produced by industrial processing of natural material as slag, ash, etc.), *Atriurbistrats* (material

from municipal garbage in dumps), *Artifimostrats* (material of liquid and hard organic sludges as faecal slurries from livestock farming, etc.)

Toxifabricats consist of toxic chemically active materials, which are unsuitable for agricultural and silvicultural practices. They may be sediments of toxic slime and dump tailings of factories, poisonous wastes, dumps of toxic chemicals or mineral fertilizers, etc. Presence of toxic substance is indicated by the prefix “toxi”.

Table 3. Comparison of Technogenic surface formations (RSC) with Anthrozem subtypes (SCS).

TECHNOGENIC SURFACE FORMATION (BODIES)	ANTHROZEMS
1. QUAZIZEMS	Anthrozem modal or recultivated
a) Replantozems	Anthrozem recultivated
b) Urbikvazizems	Anthrozem modal, urbic form
2. NATURFABRICATS	Anthrozem modal or initial
a) Abralits	Anthrozem initial
b) Litostrats	Anthrozem initial or modal, form spoil bank
c) Organostrats	Anthrozem covered (only partly)
d) Organolitostrats	Anthrozem recultivated
3. ARTIFABRICATS	Anthrozem initial or modal, urbic form
a) Artiindustrats	Anthrozem initial or modal, spoil bank form
b) Artiurbistrats	Anthrozem initial or modal, dumping form
c) Artifimostrats	Anthrozem, not specified
4. TOXIFABRICATS	Anthrozem (whatever), contaminated variety

Conclusions

The comparison made permits to deduce that cultivated soils are not a real problem in the sphere of anthropogenic soils classification. Diagnostic horizons of both soil systems quite well correspond. Similar comparative analysis could be done also with other classification systems (German, Polish, and other international systems).

The real problem is how to classify Anthrozems or technogenic surface bodies in Russian perception. These are totally new soil bodies, practically unknown for many soil scientists. Their main characteristics are: initial development from transported material of natural or technogenic provenance, extremely weak soil properties and strong environmental significance. The Russian approach (although totally different of the SCS) presumes elaboration of individual classification criteria for them as solid-phase bodies (non-soils); however, some common criteria with soils may be preserved only in terms of functioning. In the SCS, one soil type is not sufficient to cover the multi-forming character of these soils.

We feel, that there will be yet a lot of hardworking to summarize all characteristics of soil bodies occurring in urban, industrial, traffic and mining areas. We suppose that in future many new soil types, or soil-like bodies will emerge in this group. Joint efforts in correlating approaches may give a good result in future.

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New Trends in Anthropogenic Soil Groups Formation

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Abstract

New ideas on anthropogenic soil groups formation as managering systems are presented. We try to divide the group of known anthropogenic soils into managering systems according following criteria: the main human-induced impact, the main function and from that definition of soil quality, frequent occurrence and soil resource involving. The main reason for such study is to provide a scientific orientation in up-to-date not well-known soils laying stress upon environmental functions of these soils. As soil managering groups have been considered: cultivated soils, urban soils and mining soils. The division differs of a large amount anthropogenic soils classification systems appeared in the last time, but in general features can be find some common characteristics.

Introduction

There are revealed a large amount of anthropogenic soil classification systems in the last time. Many questions have been emerged regarding definition of these soils, their diagnostic horizons determination, problems of anthropedogenesis, or geogenesis definition, anthropogenic substrates classification, etc. Most of classification systems are not comparable or have very difficult correlation. Many soil units cannot be comparable world-widely due to problematic or not well-known soil characteristics, morphology, physical and chemical properties. It means, a lack of general conception in anthropogenic soil classification is recognized. In nomenclature there is a confused situation, many anthropogenic soil units revealed with totally new and sometimes strange names, general anthropogenic soil terminology is not developed.

Nevertheless, we mention, that problem of the anthropogenic soils classification will be prolonged for a long time, when all, in many cases heterogeneous anthropogenic soils will be registered, described, analysed and at the appropriate level classified.

In order to find the right orientation in this scientific field we have tried to divide the group of known anthropogenic soils into managering systems. Managering system of anthropogenic soils present practical management of soils - how to manage soils which are deeply influenced and/or modified by human activities. Due to strong human impact most of anthropogenic soils occur in risk areas, therefore it is laying stress upon their environmental functions. A system results in guidelines for soil management (manual for description, methodology, analysis, use proposals and monitoring).

It should be noted, that managering systems do not correspondent with anthropogenic soil classification systems, but generally it is reflected.

The main division was made according following criteria: the main human-induced impact, the main function and definition of soil quality, involving frequent occurrence and soil resource.

Identification of three main anthropogenic soil managering systems will be given involving soils with specific diagnostic characteristics defined in the latest Morphogenetic Soil Classification System of Slovakia (2000). As a part of this assessment some examples of soil units will be given to illustrate differences between individual managering groups.

Results and Discussion

Here are proposed anthropogenic soil managering systems:

Managering group of Cultivated soils includes soils with significant cultivation practices features, they are distinguished prevailingly according to cultivation impact in soil profile. In the WRB system are very good recognizable soils with establishing of several soil types like Hortisols, Plaggen, Teric soils, etc. Quality of these soils may be high and depends upon their productivity. Cultivated soils are part of agriculture soil resource.

Characteristics:

- *Main human-impact*: agricultural practices like deep ploughing, manure or organo-mineral compound addition, or other cultivation practices (trenching, terracing, etc.)
- *Main function:* productive and environmental.
- *Diagnostic features (according to MSCS of Slovakia, 2000):*

  Cultizemic Ameliorated Akm-horizon is top humus horizon more than 35 cm thick with possible presence of subsoil horizons or artefacts, and it has at least one of the following properties like cultivation signs (layer homogenization, distinct or sharp transition, lighter colour than subsoil horizon, soil compaction on the horizon bottom, etc.); admixture of agro-chemical materials, limestone addition, manure and other organo-mineral fertilizer compounds.
- *Quality of soil:* like nutrient medium for plant growing, depends on its ability for plants production.
- *Occurrence:* deep ploughing, trenching and terraces farmland (gardens, vineyards, hop gardens, orchards).
- *Soil resource:* part of agriculture soil resources.
- *Managering system:* guidelines for soil fertilization and reclamation are well-known in our conditions.
- *Soil unit example:* Cultizems with their subtypes, varieties and gardening, terracing, trenching forms indication.

Managering group of Urban soils includes soils of urbanized, industrial, traffic areas with occurrence of many new soil types with very different soil features. Human-impact is very variable (soil types like Liquid Intrusols, Carbonatosols, Nekrosols according German proposal, in FAO system as Urbic Anthrosols, etc.). A quality of these soils depends upon their urban site use. They are a part of urban soil resource.

- *Main human-impact:* very variable and different human impact occurred in urbanized, industrial and traffic areas
- *Main function:* environmental, partly productive.
- *Diagnostic features (according to MSCS of Slovakia, 2000):*

Anthrozem Ad-horizon is prevailingly initial topsoil horizon developed from heterogeneous removed materials which can be natural, natural-technogenic, or technogenic origin, with thickness > 1 cm; organic carbon content > 0.3 %; often presence of artefacts (brick fragments, glass, plastic materials, iron, slag, coal, etc.).

- *Quality of soil:* is variable by different urban site use, depends on real or planned urban site use.
- *Occurrence:* urban, industrial and traffic areas.
- *Soil resource:* urban soil resource.
- *Managering system:* not well developed in our conditions, practically unknown.
- *Examples:* Anthrozems with urbic and deposit form. Many soil types have very heterogeneous and variable morphological, physical and chemical properties which are not precisely characterized in the present soil classification system of Slovakia.

Managering group of Mining soils presents a specific part of Anthrosols with different features of initial or recultivation processes in soil profile. Soils are developed from spoil heaps, dumpsites with occurrence of some soil types (like Regosol, Recultivated Anthrosol). Their quality depends upon successful recultivation or remediation process. They could be a part of forest, agriculture or urban soil resources. Several examples of representative soil groups occurring in Slovakia will be presented.

- *Main human-impact:* mining excavation and deposit activities.
- *Main function:* environmental and productive.
- *Diagnostic features (according to MSCS of Slovakia, 2000):*

Anthrozemic Ad-horizon as above defined. Note, that Sulphuric horizon defined in the USDA Soil Taxonomy can be used, too.

- *Quality of soil:* depends on successful recultivation or remediation processes.
- *Occurrence:* in mining or quarries landscape strongly deteriorated by mining excavation activities.
- *Soil resource:* forest and agricultural soil resource.
- *Managering system*: guidelines for recultivation and remediation measures for mining areas, as technical or biological recultivation are well-known.
- *Examples:* Anthrozems recultivated or initial with spoil bank form.

Conclusions

The general division of anthropogenic soils into managering systems was made according following criteria: the main human-induced impact, the main function and from that definition of soil quality, occurrence, soil resource and existing guidelines involving. Apart of cultivated and mining soils, which managering system guidelines and practical utilization is well-known, urban soil management system is presented as totally new soil science field laying stress upon significant environmental functions. Quality of urban soils depends on various site use in urban, industrial and traffic areas. As specific characteristics of urban soils are recognizable: initial soil-forming process (low age), so-called substrate soils according their anthropogenic substrate composition, often cultural layer, buried horizons and artefacts presence, heterogeneity in vertical and horizontal directions, extreme morphological, physical and biological characteristics.

We suppose that this part of soil science will be quickly developed and bring new achievements mainly in knowledge of urban soils.

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Growth of Colluvial Bodies and Rise of Bottoms of Linear Depressed Landforms as Example of Soil Anthropization

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Abstract

The article presents the investigation of "new soil bodies" in colluvial and linear depressed landforms. It deals with some methodological remarks about the relationship between the development and spatial distribution of landforms and soil bodies. As the examples where erosion-accumulation processes caused the development of the above mentioned anthropogenic soil bodies the selected localities of Myjava hilly land in western Slovakia, where network of dells on the slopes and valley side slopes with inclination of ca. 8° are prevailing, have been investigated. The Luvisols and Cambisols have been analysed from the point of view of the soil horizonation i. e. thickness and layering of accumulated horizon, soil colour differentiation, humus (% Cox) and particle size (< 0,01 mm) content. The work presents two examples of formation of "accumulative soil forms" and together with results gained by other cited works gives the image about the development of specific soil bodies in depressed landforms.

Introduction

The human impact on soil manifests in different forms and dimensions. Reflection of this diversity can be also found in the nature of approaches analysing this relation. Their products are represented by a sum of knowledge which is, in pedology like in other sciences, gradually classified and eventually formulated in a form of new taxons enriching the basic system. The basis of the classifying system of anthropized soils is represented by their morphological features in the pedon (topic) level. They represent diagnostic horizons, their arrangement in soil profile and their basic properties.

The anthropic soils are classified directly in two types within the Morphogenetic Soil Classification System of Slovakia (MSCS): Kultizem and Antrozem and in one form: anthropogenic form. Kultizem is defined as soil with the kultizemic Ak-horizon, its full recreation to the minimum depth of 35 cm, or with remnants of some of the diagnostic horizons thicker than 10 cm. Antrozem is characterised by the anthrozemic Ad-horizon, which originated on a parent rock artificially created from moved material of different origin over 10 cm thick. Anthropogenic form is according to MSCS, the soil type solum of which remained untouched by anthropic intervention in thickness and/or intensity allowing for diagnosis of the Kultizem Ak-horizon. Another common property of anthropogenic soils is their origin in situ (Sobocká 1999).

The above said suggests that the MSCS obviously ran into problem how to asses the soils containing the kultizemic Ak-horizon, which did not origin in situ and in the development of which natural forces (though caused by man, such as the runoff process) participated. The runoff processes with water as the agent transporting the solid soil phase and soil solutions determined the change of dynamic properties of soils and their regimes. Spatial differentiation and intensity of these processes is determined first of all by relief properties. The authors of the MSCS took this fact into account by assessing eroded, accumulated or overlapped-form and thus fulfilled the condition of the origin of anthropic soils in situ. Accumulated and overlapped soil forms are called

Colluvisols in German and Austrian soil classifying systems, they are denoted as Cumulic Anthrosols in the FAO soil classification and Terric Anthrosols in the WRB (Sobocká 1999). Although considerable areas of our arable land fall under these soil forms, it seems that this classification is more suitable for the localities where the runoff erosion-accumulation processes take place only in natural and by man intact or very scarcely human-influenced environment.

The aim of the presentation is to discuss about the development of the soil bodies in depression landscape positions due to large scale farming i. e. anthropogenic impact. For the investigation of ”new soil bodies - Anthrosols” in colluvial and linear depressed landforms the soil horizonation analysis (thickness and layering of accumulated horizon, soil colour detection, humus content (% Cox) and particle size analysis (<0,01 mm)) has been applied. The selected localities of Myjava hilly land in western Slovakia, where network of dells on the slopes and valley side slopes with inclination of ca. 8° are prevailing, have been concerned as the examples where erosion-accumulation processes caused the development of the above mentioned anthropogenic soil bodies. The Luvisols and Cambisols have been analysed in these localities.

Relief and soils – ideas of integrity

Ideas on integrated development of relief and soil originated in time of the 1930´ and were further developed in the 1940´ and 1950´. Only later the authors of soil development models took in consideration the factor and age of parent rock properties and age, eventually the development of landform when studying the soil development. Soil catena (Milne 1936) and toposequence (Bushnell 1942) as soil sequences related to relief have been defined (in Gerrard 1992). The interaction of geomorphic and pedologic approaches at the integrated level constitutes a new geoscientific discipline so called pedogeomorphology (Conacher, Dalrymple 1977). Finally the result of these efforts was comprehension of progressive, static and regressive pedogenesis. Progressive pedogenesis is understood as a development of soils in the conditions of correlated development with landforms. Contrary to it, regressive pedogenesis is interpreted as a development of soils in changed conditions of the landform development. As static are defined such processes during which the soils develop little but they do not degrade either (Johnson, Watson-Stegner 1987).The most distinct area where the interaction of the quoted two scientific disciplines was reinforced is the one of accelerated soil erosion, eventually runoff processes. The interaction of the two geosciences enriches the physical-hydrologic defined process of runoff formation, water and material movement along the slope and the aspects of spatiality and of the evolution changes of the soil and its properties. It simultaneously enables the investigate and estimate the origin of new landforms and soil (Ruhe 1975, Fridland 1984, Hole, Campbell 1985, Jungerius 1985).

This approach gains its application also at the level of formulation of principles of sustainable development of regions. The integrity is here presented in a interrelated position with landscape use, element migration, acidification of environment, as well as at the position of overall strategy of management and resource use of the regions, when the relief and soil appear as an integrated part of environment - as "accumulator , transformer and distributor" of a number of phenomena and materials of interaction between man's activity and various types of environment (Greenland, Szabolcs, 1994). In Slovakia the integrated pedogeomorphic approach at the research of recent landforms and soil bodies was applied mainly in works of Bedrna (1962), Bedrna, Džatko (1963), Bedrna, Račko (2000), Fulajtár (1994, 1998, 1999), Hraško (1974), Lehotský et. al. (1989, 1992, 1993, 2000), Lehotský (1995, 1999), Mičian (1965), Šúri, Lehotský (1995). Generally they deal with soil bodies related to the relief and influenced by both the human impact (tillage) as well as by natural erosion-accumulation processes.

Methods

In our case they are based on:

– the detailed geomorphic field investigation of the selected localities where the most suitable conditions are for the study of the soil accumulation,
– digging pits in some selected localities and determining soil horizonation (accumulation) by the visual detection and by Munsell soil colour charts,
– taking soil samples (only in selected localities) in soil horizons for the analysis as follows - particle size and humus content. Analysis of the soil properties was realised by current methods used in oil science.

Results

Bottoms of linear depressed landforms (Fig. 1)

The locality No. 1 is a dry valley. The upper reaches of the valley are now used as one large co-operative field with eroded Eutric Cambisols created by merging the previous small contour fields in 1959 - 1960, while the last marked intervention was levelling of the remaining agricultural terraces and ploughing the meadow at the bottom of the valley in 1978. These land use changes prepared good conditions for the effective operation of the fluvial slope processes overgrowing in the middle and lower valley reaches in the flash muddy floods generation during heavy rainfall events. The muddy floods caused layering accumulation of carried sediment due to its slowing down on the buffer zone represented by grassland and orchard and downwards also by barriers represented by some buildings and low dike of a local road partially crossing the valley bottom. The result of repeated accumulation is a horizonation of young sediments. Their thickening downwards reached approximately 70 - 75 cm just below the contact of co-operative field and the orchard (assessed by the dendro-geomorphic method) and 105 cm at the bottom of valley. The excavated probe revealed 9 sediment layers corresponding to 9 erosion-accumulation events which occurred after 1961 when the telephone pole was erected.

The locality No 2 represents a similar case to the previous one. The only difference is in soil and absence of a barrier. The valley bottom passes from the upper situated co-operative field with Albo-gleyic Luvisol to the lower situated meadow with bush and a little further even to the forest. Just at the contact of the field and overgrown meadow, representing here the buffer zone, is the anthropically remodelled head of the Holocene cut situated in the thalweg position. The cut is filled to a considerable degree by young sediments. Excavating a probe we managed to find the previous flat bottom of the cut from years 1926 - 1928 in the depth of 233 cm. The authenticity of the cut bottom level from mentioned period was proved by a local resident on the basis of identification of stones and broken pottery and his antecedent knowledge of the shape and depth of the cut in the past. The mentioned 233 cm thick sediment layer, buried the previous cut bottom from the second half of the 1920s, had been deposited in the period of the last approximately 70 years.

Examples of the growth of colluvial bodies (Fig. 2)

A marked, flat, gently inclined colluvial body lies on the flood plain below the slope valley reaching almost the left channel bank (locality No. 1) A large co-operative field which originated by merging the former small contour plots in 1959 - 1960, runs continuously from the slope valley through foot-slope colluvial body up to the narrow strip of alluvial forest following the channel. There is no barrier or buffer zone there. The probe was excavated in the colluvium in the site situated 15 m from the foot of the valley slope and approximately 90 m from the channel.

On the basis of interpretation of this probe it is possible to state that Albo-gleyic Luvisols was buried by an approximately 70 cm thick layer coming from the upper part of the slope. The locality No. 2 is slope not continuously running to the valley floor with Stagno-gleyic Cambisol. It is undercut by a former brook and today adjusted and artificially shifted. The co-operative field on slope was originated in 1959 - 1960 by ploughing former meadow. The agricultural activities are continued by downwards tilling to the edge of the lowermost, undercut slope portion. This short and steeper slope part is covered by young alluvial forest together with an adjacent, narrow marginal part of flood plain. The colluvial fan was deposited here due to the operation of fluvial slope processes. The colluvium thickness was assessed by investigating buried fence posts and also by the dendro-geomorphic method. The maximum thickness of the quasi homogenous brighter (in comparison with non eroded soil) horizon of accumulation is 52 cm proved by both methods.

Conclusions

In Slovakia the most sensitive areas susceptible to the operation of erosion-accumulation processes are those localised in hilly landscape type with arable land. The material washed down from slopes conditioned by human impact (tillage, crop rotation) i. e. accelerated soil erosion remains on foot-slopes or on flood plain margins. After reaching those localities the carried soil material is partially deposited in the form of various colluvial soil bodies with thickness of approximately 0,5 m which covers original soil. The accumulation of those soils exhibit specific kind of soil layering (horizonation). Accumulated soil horizons as far as humus content and colour in the depth usually exhibit inversion. This phenomenon is clearly developed in the localities where the origin of accumulated material is the deeper, brighter or other colour horizon of strongly eroded soil in rectilinear part of slope catena. Soils eroded by linear erosion and carried by concentrated flow along the thalwegs of different linear landscape depressions (dell-like depressions, dells, gullies) is in the case of presence of barriers or active buffer zones accumulated in their bottoms and forms there specific soil body

The work presents only two examples of the formation of ”accumulative soil forms”, but together with results gained by other above cited works gives the image about the development of specific soil bodies in depressed landforms. In the same time it exposes the problem of their classification and shows the way how to join and combine pedology and geomorphology and how it is possible to apply pedogeomorpgic approach in the research of soil anthropization. This approach in the context of the soil anthropization also finds application in formulation of principles of sustainable development and life of regions, where the subject of integrity of relief and soils becomes important in connection with approach to soil as natural resource.

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MULTI-FUNCTIONAL USE OF ANTHROPOGENIC SOILS, CHARACTERISTICS AND LANDSCAPE PLANNING

Anthropogenic Soils of the Ancient Russian Monasteries

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Abstract

Unique anthropogenic, soils created 300 - 500 years on the territories of island ancient monasteries, have been investigated. Four types of their profiles, related to the land use kinds, were distinguished and characterized as well as some physico-chemical soil properities. Accumulation of humus is thought to be the primary process of soil formation. Due to continuous cultivation the humus-modified soils are characterized by increased content of humus and exchangeable bases and lower acidity. The soil properties can't be considered as resistant to anthropogenic impact, except soils of the Iverskiy monastery.

Introduction

Presently, the problem of anthropogenic modification of soils is in the center of attention of the researchers. A great number of studies were done on the changes in soil and soil cover parameters due to anthropogenic influence. However, in most cases the objects of the studies are the soils of the vast intercontinental zones with the anthropogenic factors limited to the traditional agricultural influence (plowing, melioration and addition of mineral and organic fertilizers).

Monastic culture agriculture in the island conditions was hardly studied at all. Remoteness of the monasteries, extended supply lines and limited territory available for argriculture dictated the intensity of soil transformation. Human-modified soils of monasteries are the convenient model for studying of character and tendency of different forms of anthropogenic influence on soils and soil cover and also for evaluation of the stability of such artificial modifications depending on environmental conditions and main genetic properties of the soils.

The main aim of this study was to analyse the morphological and physico-chemical properties of the main types of anthropogenically modified soils of ancient island Russian monasteries as well as the evaluate the resistance of such soils under different anthropogenic load.

Material and Methods

The study was performed on the fields of three island monasteries: the Solovetzkiy, the Valaamskiy, the Iverskiy monasteries.

The Solovetzkiy monastery is located on the islands in the White sea (Arhangelskiy region). The territory of the islands is heterogeneous. The central area is mostly monticulate morainic relief, littoral part is the series of marine terraces. The main soil forming rocks are glacial sands with high boulder content, marine sands and clays. Coniferous forest of the northern taiga take about 88 % of the forest territory.Sphagnum bogs are widespread. In the island's soil cover on tops of the hills and slopes podzols are predominant; on flat plains and in depressions – complex of Podzol-gleyed soils and Histosols. Since 1492 year when monastery was founded, the monks constantly have reclaimed ground. They have built unique system of the drain canals which diminished area of swamps and hydromorphic soils. Some small gardens were grown up around monastic buildings. In 1822 year the Botanical gardens was laid down in 4 km of monastery. There cedars, larches, poplars are preserved up to now. In 1920 year the monks left monastery and all agriculture fields were neglected. During the last years agriculture works were revived.

The Valaamskiy monastery is located on an island in the north-east part of the Ladoga lake (Karelia). The island relief is very dissected. High gabbro-diabases rocky ridges are separated by waterlogged depressions and ravines composed by limnoglacial and lacustrine deposits. Soil cover is diverse and consists mostly of Brown forest, bog Podzol and Soddy gley soils. The Brown forest soils are occurred on the tops and slopes of rock ridges. They are formed on a shallow eluvium of massive-crystalline gabbro-diabases. Half boggy soils are more typical for depressions and formed on the loam or sandy loam-sand deposits in poor drained conditions. Pine and spruce forests of central taiga with some maple, lime and elm trees predominate. The Valaamskiy island agricultural development is tied up with the activities of the monks from the men monastery that opened on the island in the 14-th century. Its peak of activity falls on 19th century. Temple complexes supported growing fruit trees, vegetables and medical herbs. The monks cultivated the grains, implemented soil melioration, introduced new plant breeds. Since 1940 when the monastery was closed, its land is deteriorated. In 1998 the monks returned to the Valium.

Iverskiy monastery was built in 1656 year on a island in the Valday lake (Novgorod region). Island's terrain is esker ridge with a number of terraces oriented towards the lake Ridge's composition is predominantly calcareous fluvioglacial and limnoglacial sands. Natural flora consists of coniferous and broad-leaved forests. After the monastery was closed in 1918, its territory was assigned to different institutions. Orchards were chopped down and fields let fallow. 1991 year saw a restoration of monastery.

We studies the soils of monastery's garden and orchards. We used virgin forest soils as the undisturbed background. In all genetic horizons of the investigated soils we determined the soils texture, physical-chemical properties and composition by methods used in Russia. "Soil classification of Russia" (1997) with some additions was accepted as the base for the human-modified soils classification.

Results and Discussion

Beside the traditional agricultural influence on soils monasteries on their fields used development by adding humus and solid-phase materials on the surface.

Four main groups of anthropogenic soils (Agro-natural soils, Agrozems typical, Stratified Agrozems, Agrostratozems) were established depending on the degree and character of the anthropogenic influence on the native soils. In the agro-natural soils the system of soil horizons is practically undisturbed. Human-modified humus horizon is created by plowing and fertilizing. It is underlain by some diagnostic horizons (eluvial, illuvial) allowing to recognize of original natural soil (Fig. 1).

Typical Agrozems have a homogeneous human-transformed humus horizon that is situated on the illuvial horizon or directly on the soil forming rocks. Such deep transformation of the upper soil horizons leads to obliteration of its natural typical signs.

Stratified Agrozems unify the soils where the humus horizon was formed by the mixing of different horizons as well as by the addition of external solid phase material. The middle-profile horizons lay under humus horizon.

In Agrostratozems humus horizon forms in added material that has thickness of over 40 cm. Buried natural soils are often observed inside the Agrostratozem.

Forms of anthropogenic influence on the soils depend on the character of agricultural usage, nature conditions and basic soil's properties.

Monks of the Solovetzkiy monastery have been obliged using infertile Podzols. Transformation of these soils was achieved mostly by the addition of the mineral substrates (that often contain anthropomorthic inclusions - i.e. glass, broken bricks) and by humus horizon development. Such artificially created horizons can reach up to 38 - 45 cm in thickness. They overlay the native horizons of Podzol. Such neoformed soils are classified as Agrostratozems with buried soils.

Agrostratozems of the Solovetzkiy monastery have strong acid reaction, a very low content of potassium and high content of phosphorus compounds. In comparison with native soils (Podzols) poured horizon of Agrostratozem is enriched in organic matter content (Table1, Profile 6). The upper part of plow horizon (0 - 8 cm) is distinguished by high content of exchangeable base cations and humus (3,5 %). Qualitative humus composition is fulvic-humate (Ch.a.: Cf.a.=1,1). However from 8 - 10 cm plow layer is marked by lowering of humus content in third time and mobile aggressive fulvoacids prevail in organic matter composition. The Ch.a.:Cf.a ratio drops to 0,6. The low resistance of the Solovetzskiy islands to anthropogenic impact is connected with natural conditions: severe climate, short growing period and small plant biomass and fruitfulness. Here small grain crops don't ripen, orchards are absent. Agrostratozem are spread by local spots and used as truck garden for vegetables and greens.

Wide agricultural areas (arable fields, meadows, and orchards) of the Valaamskiy monastery are situated in the level downs that show sand or loam-sand deposits of various thickness (0,5 - 1,0 m). Moreover the shallow Brown soils on massive-crystalline rocks (gabbro-diabases) were also used for agriculture on the sides of the fields and in the areas nearby cathedrals and small churches. Soils of arable fields and meadows are sod or Bog-Gley and Bog-Podzol soils. Plowing, fertilizing and draining of these soils resulted in the development of the agronatural soils.

These soils have dark homogeneous arable P-horizon 20 - 28 cm in thickness, containing 3,0 - 4,5 % humus of fulvic-humate composition, weak acid reaction and are provided by the available forms of phosphorus and potassium (Table 1, Profile 1).

Intense human intervention brought about the formation of Agrozems, Stratified Agrozems, Agrostratozems. They concentrate around cathedrals mainly in the gardens.

Typical Agrozems are formed, as a rule, on considerable thickness of earthly material (1,5 - 2,5 m). Stratified Agrozems and Agrostratozems were formed in cases if thin original fine earth material and massive-crystalline rocks located near the soil surface. Humus horizon of these soils could be either artificially added or it could consist of the fully mixed native soil horizons with the addition of mineral and organic components.

These soils differ from the initial Brown forest or Podzolic soils by considerable thickness of humus horizons (40 - 50 cm and more), good developed structure, high content humus (10 % and more) and exchangeable bases, weak acid or near to neutral reaction, higher supply of nutrients (Table 1, Profiles 2, 3).

Anthropogenic soil transformation is unstable. Micromorphological investigations have shown that migration processes of organic matter and clay, characteristic for natural soils in humid climate, don't crease in human-modified soils of the Valaam. Clay-humus cutans - the signs of podzolization are found in subhumus horizons in some Agrozems.

Soil maintenance in cultivated condition needs constantly efforts for creation of soil function in optimal regime. Degradation processes such as reduction of humus content, acidification, deterioration of structure and agrochemical properties are revealed in some antropogenic soils of the Valaamskiy monastery.

In the Iverskiy monastery the arable areas are located mostly outside the monastery itself. They are artificially modified to a much smaller extent and consist predominantly of the Agro-natural soils. On the monastery territory itself, beside the cathedral, in the small orchard and vegetable garden, the soils are mostly "poured" soils - Agrostratozem Typical with buried humus horizons or soils and Stratified Agrozems.

Soils of the Iverskiy monastery are enriched in construction debris and wastes (brick debris, lime, cement, nails) that influence on soil properties. Agrohumus horizons have reaction from weak acid to neutral. Values pH increase in the lower part of soil profile where calcareous soil forming rocks occur. Soils are characterized by an increased humus content (2,1 - 4,3 %) in comparison with native podzols. Humic acids portion is considerable in humus composition and ratio Ch.a:C f.a. alters from 1,1 to 0,8 - 0,9. Agrostratozems and Stratified Agrozems also have elevated concentration of phosphorus and low content of potassium mobile compounds.

Morphological and analytical signs of podzolization weren’t discovered in anthropogenic soils of Iverskiy monastery. Its absence is caused by presence of carbonate rocks and input of waste containing a lot of lime.

Conclusions

According to morphological characteristics four types of anthropogenically transformed soils are distinguished and classified Agro-natural soils, Typical Agrozem, Stratified Agrozem, Agrostratozem on the territories of ancient monasteries. In contrast to the native soils, all types of anthropogenic soils exhibit a new artificially created homogenized humus horizon that could be from 20 to 55 cm thick. Anthropogenic soils are characterized by increased humus and exchangeable bases content and lower acidity. In humus composition humic acid often predominate.

The main elemental soils forming process is the humus accumulation. Anthropogenic soil modifications are unstable and must be artificially supported by men. The only exception is the soils of the Iverskiy monastery. They are enriched in lime containing construction waste and overlay the soil forming calcareous rock

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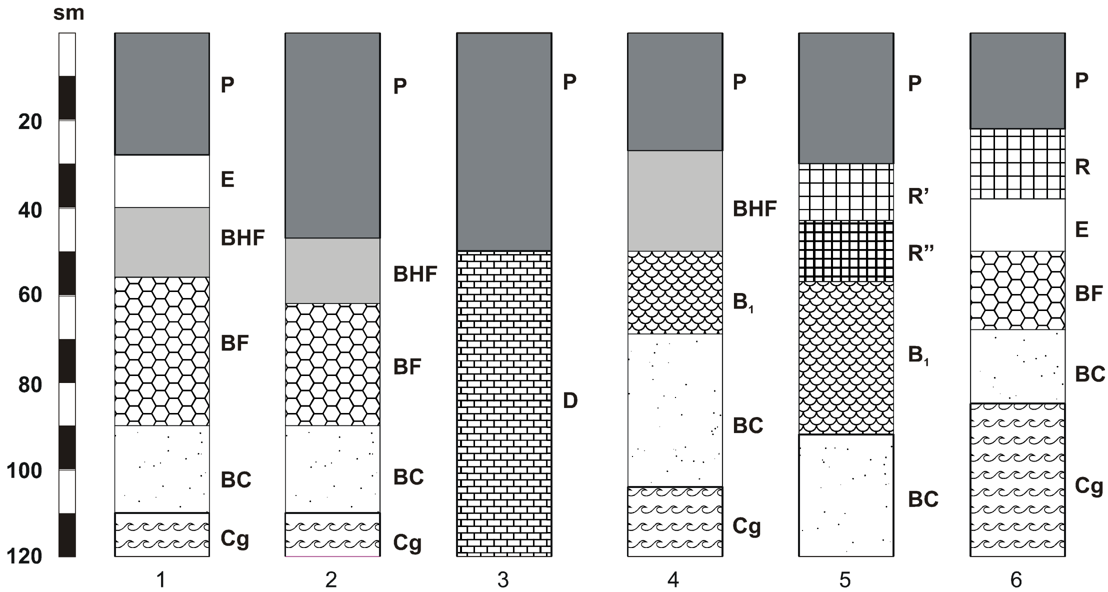

Fig. 1. Main types of anthropogenic soil profiles
1 — agropodzol on sands, 2 — agrozem on sands, 3 — stratified agrozem on gabbro-diabases, 4 — stratified agrozem on sands, 5-6 — agrostratozem on sands

Table 1. Some characteristics of anthropogenic soils.

Soil profile	Horizon	Depth (cm)	pH		Humus (%)	C h.a. / C f.a.	Hydrol acid	Sum Ca^2+Mg^2	Clay (%)	Mobile forms mg/100gr	
			H_20	KCl			mlq/100gr			P_20_5	K_20
The Solovetzkiy monastery											
Agrostratozem (Profile 6)	P	0-8	6,0	4,5	3,5	1,06	3,2	15,8	12	21	5
	P	8-22	5,9	4,3	1,3	0,57	2,5	6,4	19	20	3
	R	22-38	6,0	4,3	1,0	0,32	2,5	6,0	12	31	3
	E	38-50	6,3	4,6	0,7	0,12	1,4	4,7	7	14	2
	BHF	50-68	6,0	4,4	1,0	0,15	2,5	7,5	12	14	4
	BC	69-54	6,3	4,8	0,4	0,07	1,3	6,7	12	13	3
	Cg	84-102	6,5	5,4	0,2	0,06	0,3	7,1	11	14	3
The Valaamskiy monastery											
Agropodzol (Profile 1)	P	0-28	6,5	5,3	4,5	1,4	6,1	16,6	10	18	14
	E	28-37	5,9	4,6	0,34	0,5	1,7	9,2	7	6	9,0
	BHF	37-54	6,1	4,7	0,72	0,62	1,9	10,5	6	7	4,0
	BF	60-70	6,6	4,8	0,32	0,21	1,4	11,4	8	8	4,0
	BC	100-110	7,0	5,2	0,18	0,12	1,2	12,1	8	9	5,0
Agrozem Typical (Profile 2)	P	0-15	7,0	5,8	6,91	1,5	4,0	29,7	11	17	16
	P	15-29	7,0	5,6	4,20	1,0	2,0	20,4	11	10	6
	P	29-47	6,8	5,5	3,48	1,0	2,2	18,4	11	8	7
	BHF	47-60	6,8	4,9	0,74	0,5	1,4	11,4	7	10	7
	BF	60-90	6,8	4,9	0,60	0,2	0,9	11,4	5	3	2
	BCG	100-120	6,9	4,9	0,34	0,2	0,9	13,4	8	3	5,2
Stratified Agrozem (Profile 4)	P	0-16	6,6	5,6	10,5	1,6	3,4	39,4	13	40	22
	P	16-28	6,7	6,0	10,5	1,5	2,4	35,3	14	32	10
	P	28-50	6,9	6,1	7,2	1,4	1,7	27,9	10	10	9
The Iverskiy monastery											
	P1	0-15	6,3	5,5	2,2	1,17	3,4	6,5	9	30	10
Stratified Agrozem (Profile 4)	P1	15-27	6,5	5,7	1,9	0,98	2,3	3,3	9	33	15
	BHF	30-50	6,8	6,0	0,2	0,30	0,6	2,0	4	32	3
	B1	52-69	6,9	6,3	0,1	0,24	0,5	1,0	2	36	4
	BC	69-104	7,1	6,5	0,1	0,21	0,3	1,0	2	34	6
	C	104-120	7,2	6,2	0,1	0,12	0,3	1,0	4	34	7
Agrostratozem (Profile5)	P1	0-15	6.9	no	4,3	0,90	no	*0,6	10	24	11
	P1	15-30	7,2		3,1	0,69		2,7	9	16	11
	R1	30-43	7,8		1,4	0,83		2,8	5	12	8
	R2	43-57	7,6		0,9	0,64		1,0	5	15	6
	B	57-80	7,6		0,7	0,39		0,8	4	10	7
	BC	80-120	7,2		0,3	0,2	0,6		5	11	5

* Content of $CaCO_3$ (%).

Anthrosols Developed on Reclaimed Dumpsites

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Abstract

Soils from eight localities on reclaimed dumpsites with different reclamation were studied. The composition and nature of deposited material, relief, planted vegetation, enrichment with organic matter, and dumpsite age showed to be the principal factors contributing to the development of these soils. Vulnerability of soil structure to different aggregate breakdown mechanisms as an indicator of soil development and quality was assessed. Fast wetting was more dangerous than swelling and shrinkage or mechanical desaggregation. Stability of fossil structural elements of exposed marls exposed was very low, compared to loess or natural topsoil. Amendments of some organic wastes were efficient in increasing soil structure stability.

Introduction

These Anthrosols, that develop on the reclaimed dumpsites on former brown-coal mining territories, differ in their properties according to deposited materials, reclamation measures, management and exploitation, etc. Different ways of technical reclamation are used (Balon et al. 1999). These include covering with natural topsoil, combination of natural topsoil and marls with different covering and/or mixing treatment, covering or incorporating of marls alone or of loess and loess-like materials, and others. Amendments of organic matter of different origin are used either separately or in combination with other reclamation practices. Some areas were also left without any reclamation treatment. The technical reclamation is often followed by agricultural or forest biological reclamation, depending on the properties of the soils.

Soil structure stability characterises well the development of soil quality. Forming stable aggregates, i.e. creation of strong bonds among soil particles, is in our conditions dependent mainly on fine textural elements (silt, clay) and soil organic matter. Organic matter according to its quality makes the soil mineral particles hydrophobe, which slows down wetting and consequently decreases the danger of aggregate destruction. The stability of structural elements increases also with forming bonds in clay and silt. The nature of destructive mechanisms is determined by initial soil moisture and the way of wetting.

The aim of this study was to assess the properties of reclaimed soils from different materials, under different way of reclamation and of different age. The survey was carried on permanent areas of the reclaimed dumpsites of Doly Bílina Company. Another aim consisted in the evaluation of soil structure stability of the Anthrosols as a result of the reclamation method.

Materials and Methods

Several different soils were described in the field, including way of reclamation, state of vegetation etc. Soil profile characteristics (depth of each layer, colour, structure, and other morphological features) were observed and samples for analyses were collected from all the layers.

Soil properties were determined using common methods (Valla M. et al. 1983): Textural composition was determined areometrically. pH_{H2O} was measured in water suspension (1 : 2 w/v), pH_{KCl} in soil in suspension with 1M KCl (1 : 2.5 w/v)

. Soil carbonates ($CaCO_3$) were determined by volumetric method. Bower method using Na as the index cation was used for cation exchange capacity (CEC) determination

. Organic carbon was determined oxidimetrically using $K_2Cr_2O_7$. Humus quality was described by the ratio of absorbances of 0.05 M $Na_4P_2O_7$ extract of soil (1 : 20 w/v) at wavelengths 400 and 600 nm, respectively (A_{400}/A_{600}).

Structure stability was determined by the method proposed by Le Bissonnais and Le Souder (1999) and Le Bissonnais (1996). Aggregates 2 to 5 mm in diameter were separated from the samples and subjected to three different tests for evaluation of the effect of the aggregate breakdown mechanisms: test 1 enables an assessment of aggregate resistance to rapid wetting, test 2 enables an assessment of aggregate resistance to desaggregation caused by progressive wetting and drying, test 3 enables an assessment of aggregate resistance to mechanical influences (e.g. raindrop impact) on attractive forces among textural elements. The degree of aggregate stability and vulnerability was assessed by the vulnerability coefficient (K_v) (Kozák et al. 2000). Its calculation is based on weighted average size of the aggregates and it determines how many times the aggregate size is decreased in comparison to the initial aggregates taken for the analysis. Optimal value equals 1.0, increasing values indicate higher vulnerability.

Results and Discussion

Soil properties and development

Several soil profiles showing different conditions for the development of soils were selected (Table 1). Presented data are combined from several technical reports (Kozák et al. 1996, 1997, 1998, 1999). The most favourable conditions were found on soils were a combination of marls and natural topsoil was used (profiles No. 1 and 2). No significant difference was found between the treatments when the surface was simply covered with separate layers and the treatment when the layers are mixed. These soils showed good textural composition, carbonate content, and also organic matter of medium quality. However, a similar treatment on Anthrosol No. 6 led to worse conditions, mainly due to high clay content, so that this way of reclamation cannot be generally proclaimed to be the best. Anthrosols No. 3 and 4 showed medium conditions for development of suitable soil profiles. Here, a layer of loess-like materials was put. Absence of carbonates and slightly more acid reaction makes the conditions less favourable compared to No. 1 and 2. Paper-mill wastes amendment as the source of organic matter on the soil No. 4 increased organic carbon content and consequently also the cation exchange capacity. Though a gradual decrease of the humus content through mineralization during the time can be expected, the importance of organic matter amendments is apparent. Less favourable conditions for good soil profile development are caused mainly by high clay content leading to worse physical properties of the soil (No. 5 and 6). The worst conditions were found at the profile No. 7, where a layer of marls alone was put.

In spite of the fact that the properties are not bad currently, weathering of the marls on the surface is expected in a long-term perspective, which will inevitably lead to very high clay content and unfavourable physical state of the soil. Characteristics of a profile where no reclamation was used is presented for comparison (No. 8). These characteristics are relatively good. However, it cannot be generalized since it strongly depends on the deposited dumpsite material. On the Anthrosols No. 3 and 6, two separate samples were collected from the same layers. The variability in these two pairs of samples illustrates high heterogeneity of the Anthrosols in a small scale.

Tab. 1. Soil characteristics of selected reclaimed Anthrosols.

No.	Site (profile)	Reclamation	Depth (cm)	Particles < 0.01 mm (%)	$CaCO_3$ (%)	pH[a]	CEC ($mmol.kg^{-1}$)	C_{ox} (%)	A_{400}/ A_{600}	Condi-tions[b]
1	Radove-sice II (R1)	marls + topsoil (cover)	0-25	43.2	7.0	ND[c]	325	1.08	5.4	***
			25-46	63.3	41.0	ND	250	ND	ND	
			46-80	11.2	0.2	7.6	ND	ND	ND	
2	Radove-sice III (R2)	marls + topsoil (ploughed)	0-25	40.9	8.9	ND	275	1.26	4.7	***
			25-50	56.0	20.0	ND	225	ND	ND	
			50-70	25.3	0	8.0	ND	ND	ND	
3	Braňany (S12)	60cm layer loess-like materials	0-40	43.7	0	6.9	200	0.66	5.07	**
			40-100[d]	29.9	0	6.0	150	ND	ND	
			40-100[d]	65.2	0	ND	200	ND	ND	
4	Braňany (S9)	60cm layer loess-like materials + paper-mill wastes (10cm)	0-15	NS	0	6.9	1000	4.27	5.03	**
			15-90	34.0	0	7.0	100	ND	ND	
			90-110	82.8	0	7.3	175	ND	ND	
5	Braňany (S11)	60cm layer loess-like materials	0-30	66.0	0.8	ND	300	0.98	5.03	
			30-80	44.1	1.1	ND	175	ND	ND	
			80-110	55.7	0	5.1	205	ND	ND	
6	Radove-sice III (S1)	30cm marls + 30cm topsoil (ploughed)	0-30	67.9	2.8	7.5	175	1.09	7.89	*
			30-70	75.2	3.6	7.7	175	ND	ND	
			70-125[d]	38.0	0	7.6	100	ND	ND	
			70-125[d]	62.7	0.2	7.6	175	ND	ND	
7	Radove-sice IV (S2)	60cm layer of marls	0-60	57.4	10.7	7.8	150	ND	ND	0
			60-95	47.5	0	7.5	150	ND	ND	
8	Braňany II (S13)	no reclamation	0-45	47.4	0	7.2	175	1.05	5.48	-
			45-105	38.3	0	7.4	75	ND	ND	

[a] For No. 1 to 5, and 8 pH_{KCl} is given, for No. 6 and 7 pH_{H2O}
[b] Suitability of the conditions for a good soil profile development:
*** - most favourable conditions,
0 - the worst conditions
[c] ND - not determined
[d] Two samples from the same layer.

Soil structure stability

Soil structure stability analysis showed that the aggregates are the most vulnerable to destruction by fast wetting which is more dangerous than swelling and shrinkage or mechanical desaggregation (Table 2). Therefore, good vegetation cover can be efficient in decreasing aggregate breakdown. The stability was especially low in case of fossil structural elements of marls exposed to weather influence. These earths should be covered by or mixed with some more suitable materials like loess or natural topsoil.

The best structural state was found in samples from the localities with the oldest reclamation (Větrák, Křinec, Fučík), while the aggregates from newer localities were usually the most labile (Radovesice I and III, Braňany) (Kozák, et al. 2000). Similarly, Haynes (2000) showed an increasing aggregate stability in permanent pasture soils with longer time of utilization. This trend in our results can be explained by increasing content of organic matter in the Anthrosols under study and by building stronger bonds with mineral particles. At the same time, organic matter in the formed more stable aggregates is protected from mineralization (there is a slow turnover), which was confirmed by a number of authors (e.g. Aoyama et al. 1999, Angers et al. 1999).

Tab. 2. Vulnerability coefficients of soil structure stability in the dumpsite earths (average values) and in Chernozem for comparison.

Test	Desaggregation factor	Dumpsite earths	Chernozem
Test 1	rapid wetting	4.4	1.4
Test 2	progressive wetting and drying	1.9	1.1
Test 3	mechanical influences	1.9	1.2

Organic matter (C_{org}) showed in all the three tests positive effect on structure stability, the vulnerability coefficient decreased with its augmentation. Structure stability of the Anthrosols was therefore increased by amendments of some organic wastes, e.g. from paper-mills. Increasing content of clay and silt particles as the textural fractions important for structure building was negatively correlated with structure stability. An opposite phenomenon was reported by Angers (1998), however, that was in soils with long-lasting pedogenesis and with clayic epipedons saturated with organic matter. Our finding is most probably caused by the organic matter, that is deficient in the Anthrosols under study and the bonds in pure clay and silt are not strong enough. When the bonding agent (microbial organic matter) is missing, the aggregates formed are very vulnerable and are easily broken down to the microaggregates, especially during a sudden wetting. The vulnerability coefficient increased also at higher pH values.

Conclusions

The Anthrosols can be characterised by strong heterogeneity. Their development is influenced mainly by deposited material, way of reclamation, vegetation, organic matter content and quality, and reclamation age. Organic matter proved to be an important factor improving the development of Anthrosols. From this point of view older Anthrosols were better than the new ones, thanks to plant growing which enriched the surface layer with organic matter. These effects were well shown in the stability of soil structure.

Expected long-term development of the reclaimed Anthrosols depends mainly on the deposited material. Development of soils of Cambisol type is expected from non-calcareous materials. Calcareous materials could develop towards Rendzinas. Development of Chernozem-like soils is less probable. Soils, where a layer of clayey materials was put in the profile, can develop towards Luvisol-like soils. However, it would never be real Luvisol since profile stratification is artificial and did not result from natural pedogenetic processes. On limited areas close to water bodies some Gleys could develop and soils with an impermeable layer under higher precipitations could locally provide Stagnosols. Generally, the development of the Anthrosols in a long-term perspective is expected towards soils similar to the original soils of the region. Agricultural and/or forest utilization of these Anthrosols is and will be possible and desirable.

This research should further continue, studying the effects of different reclamation and long-term development of the reclaimed soils.

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Anthropization Process in the Soils from Farmstead Area

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Abstract

Anthropization is defined as appearance of features and properties in some natural creation resulting from human activities. In the light of above definition, exceeding accumulation (overacumulation) of nutrients in soils from the rural farmstead and its vicinity could be one of examples of anthropization processes resulting from the whole human activities in compassing farmstead. Produced and stored animal wastes, silage effluents, domestic waste water and solids are accumulating in soil (ground) of farmstead and its vicinity. The aim of the paper is the identification of places in farmstead, where this overaccumulation occurs and its quantitative evaluation as some examples, soil samples taken from farmsteads of 12 demonstration farms of BAAP project. The soil samples were taken from each 20 cm layer up to the 200 cm depth, and some places from 0-10 and 10-20 cm layers. The content of N-NO_3, N-NH_4 and P-PO_4 in 1 % K_2SO_4 extract as well as P, K, Na, Mg, Mn and Zn in 0.5 m .dm^{-3} HCl extract were determined. The accumulation of mineral forms of N and P as well as K reached the highest values in soils situated near the manure storage places, in soil that had contact with silage effluent as well as on the way of water runoff from farmstead area. Significant N, P, K as well as Mn and Zn accumulations were observed in poultry paddocks. Soils oversaturated with nutrient loss their ability to further its bounding that results in leaching of N and P compounds as well as K down the soil profile and a risk of water pollution and eutrophication is producing. In this way, a new soils are created that have undergone an anthropogenic chemical degradation.

Introduction

Anthropization is defined as appearance of features and properties in some natural creation resulting from human activities (Prusinkiewicz 1999). In the light of above definition, exceeding accumulation (overacumulation) of nutrients in soils from the rural farmstead and its vicinity could be one of examples of anthropization processes resulting from the whole human activities in compassing farmstead. Produced and stored animal wastes, silage effluents, domestic waste water and solids are accumulating in soil (ground) of farmstead and its vicinity. The aim of this investigations ware the identification and presentation of places in farmstead, where the overaccumulation of nutrients in soils from the rural farmstead and its vicinity occurs and its quantitative evaluation on the example of soil samples taken from farmsteads of demonstration farms.

Material and methods

The soil samples were taken from the farmsteads and its vicinity on demonstration farms situated in north Poland during spring. The farms were selected within the programs “Poland agriculture and water quality protection” (PAWQP), which was implemented in cooperation with the Environmental Protection Agency of the United States in 1992 - 1996 (Sapek et al. 1995) and “Baltic Agricultural Run-off Action Program” (BAAP) sponsored by the Swedish government and accomplished in 1995 - 1997 (Sapek 1997) and continued up to now. The soil samples were taken from each 20 cm layer up to the 200 cm depth, and some places from 0-10 and 10-20 cm layers. The content of N-NO_3, N-NH_4 and P-PO_4 in 1 % K_2SO_4 extract as well as P, K, Na, Mg and Zn in 0,5m.dm^{-3} HCl extract were determined. The accumulation of mineral forms of N and P as well as K expressed in mg.dm^{3} of fresh soil as well as in kg of nutrient per hectare.

Results

To comparison of mineral nitrogen content, especially nitrate, as well as phosphorus and potassium in different places in farm and its vicinity, the boundary values of this nutrients in grassland soils were citated (Table 1.) (Sapek & Sapek, 1992). The considerable higher content of its were confirmed in the investigated places, named the „hot spots".

Nitrogen

The content of two form of mineral nitrogen depending of red-ox potential in the soil profile can change from about 100 % of $N\text{-}NH_4$ to $N\text{-}NO_3$ and vice versa (Fig. 1). The very high content of $N\text{-}NH_4$ appeared in the soil layers on the depth where condition favoured reduction processes. Remarkable amounts of $N\text{-}NH_4$ in the soil profile from these places are, when conditions permit nitrification, transformed into soluble, non-sorbed nitrates, which move down the soil profile and finally to groundwater. In the higher distance from animal waste storage the mineral nitrogen content considerable decrease and nitrate-nitrogen appears mostly. Analysis of the soil samples from 0 - 20 cm soil layer in different places on farmstead and its vicinity were shown the $N\text{-}NH_4$, $N\text{-}NO_3$ content in the 1 % K_2SO_4 soil extract, P and K content in the 0.5 0,5m.dm^{-3} HCl soil extract content between 2 and 369 kg N.ha^{-1}.

Table 1. Ranges of nitrate nitrogen, phosphorus and potassium content in grassland soil.

Estimation of N- NO_3, P and K content	**$N\text{-}NO_3$**	**P**	**K**
	mg.dm^{-3}, (kg.ha^{-1} in 10 cm soil layer)		
very low	0-5		
low	5-10	< 53	<133
medium	10-20	53 - 106	133-233
high	20-40	> 106	>233
very high	> 40		

In the same soil layer the $N\text{-}NO_3$ content was from 6 to 502 kg N.ha^{-1}. The highest mineral nitrogen content originated from the soil by the animal wastes storage (Table 2). This values were considerably higher than the highest content of $N\text{-}NO_3$ in grassland soils (Table 1 and 2, Fig. 1). The high nitrogen content was observed also in the vicinity of silage storage, and in the place by non-used sewage tank. High $N\text{-}NO_3$ content (206-215 kg N/ha) occurred also on further distance (about 150 m) from described places. This places was situated on the water flow from the farmstead area. The mineral nitrogen content can exceeded 2000 kg/ha in the soil profile up to 200 cm depth, especially close to the manure storage places, by the barn or slurry tank. The big nitrogen enrichment of soil profiles occurred also in the monitoring points removed from this places. The biggest $N\text{-}NH_4$ as well as $N\text{-}NO_3$ content was appeared in the place by the non-used sewage tank (Table 2). An important source of mineral nitrogen in the soil on farmstead also could be poultry paddocks (Table 3). Particularly high content of $N\text{-}NO_3$ has occurred. It exceeded about three time such content in the soil of farm garden. The highest $N\text{-}NO_3$ content on poultry paddock in 0-20 cm soil layer was about 280 kg N/ha.

Phosphorus

The phosphorus content in the extracts of 1% K_2SO_4, just as in the water extract represent the most labile forms of phosphate in the soil. As in the case of mineral nitrogen, the biggest phosphorus content in 0 - 20 cm soil layer appeared in the places by the animal wastes storage. Its content in the vicinity of manure heap is mostly, but not only, concentrated in the surface soil layers as a result of decreasing of soil permeability caused by the accumulation of organic matter. As we could consider, the phosphorus was moved in the deeper layers in the soil profiles remote from the manure heap (Fig. 1). The P-PO_4 content in the soil profile down to 200 cm, depending on the place, was in the range from 2 to 1083 kg P/ha (Table 3). When the distance from the source of pollution increased (with the direction of water flow) the phosphorus can be transported in to the deeper layers of soil profile (Fig. 1). The ground surrounding the places of animal waste storage is most enriched in phosphorus, also in the form strongly bonded with the soil (extracted in to the solution 0,5 m.dm^{-3} HCl). The determined P contents are from several up to hundred times higher than occurred in the grassland soils (Table 1 and 4). The important source of soil pollution in phosphorus can be also poultry paddock, like as manure heap. The maximum content of labile form of phosphorus in the soil surface layer 0 - 20 cm could be up to 200 kg P/ha. It is a hundred time more in the comparison to such a soil in farm's garden. The potential soil enrichment with phosphorus in this layer could attain about 2 tons (Table 3).

Potassium

The amount of 0.5 0,5m.dm^{-3} HCl soluble potassium in the upper 0 - 20 cm soil layer the place of silage storage was 5760 kg K. ha^{-1}, from near the animal waste storage - in the range from 1940 to 7900 kg K.ha^{-1} (Table 5). Its content in such a soil layer in the place removed from the source of pollution was in the range from 420 to 3000 kg K.ha^{-1}. The potassium content in the 0,5m.dm^{-3} HCl extract from grassland soils, after recalculation to the soil volume, equal 233 mg K.ha^{-1} is considered as a high content (Table 1).

As in the case of nitrogen and phosphorus, the important source of soil pollution in potassium can be also poultry paddock. The potassium content 1600 kg K/ha, that is about seven time more than in the soil from farm's garden (Table 3). This value correspond the 466 kg K.ha^{-1} in 0 - 20 cm layer of fresh soil. Amounts of potassium in the soil profile down to 200 cm near the animal waste storage reached 63240 kg K.ha^{-1}, while in places at a higher distance - only 1320 - 33780 kg K.ha^{-1}. Noteworthy, similar amounts were found in the soil close to the arable field (Table 5). Excessive amounts of potassium accumulated in soil near the manure heap can easily penetrate down the soil profile.

Zinc

The enrichment of soil from poultry paddock with zinc was observed also (Table 2). The concentrate using in poultry feeding includes zinc, among the other micro-elements. Depending on the management this element could be also the important source of soil pollution. The zinc content in 0.5 M HCl extract from the surface soil layer 0 - 20 cm on poultry paddock was about 300 kg Zn/ha and was about eight time higher in comparison from such content in soil from farm's garden. The maximum Zn content in the soil from poultry paddock occurred 600 kg Zn/ha (Table 3).

Table 2. The content of ammonium ($N\text{-}NH_4^+$) and nitrate ($N\text{-}NO_3^-$) nitrogen (kg/ha) in surface layer (0-20 cm) as well as in the soil profile (0- 200 cm) from the demonstration farms in different regions of Poland.

No	Monitoring point	Layer cm	1% K_2SO_4 extract; kg N/ha									
			I		II		III		IV		V	
			NH_4	NO_3	NH_4	NO_3	NH_4	NO_3	NH_4	NO_3	NH_4	NO_3
1.	In the previous place of silage storage	0-20	23	131	68	68	-	-	-	-	-	-
		0-200	700	255	797	797	-	-	-	-	-	-
2.	In the vicinity of manure storage, by the barn or slurry tank	0-20	369	8	22	22	254	7	2	53	47	502
		0-200	2107	71	567	567	1650	70	1072	259	381	1710
3.	About 150 from the manure storage, on the flow by the road	0-20	11	206	6	6	-	-	6	91	2	215
		0-200	47	622	64	64	-	-	46	820	1530	1354
4.	Place by the non-used sewage tank	0-20	-	-	-	-	-	-	-	-	12	389
		0-200	-	-	-	-	-	-	-	-	5194	2326

Farms from the regions:
I- Kujawsko-Pomorskie, II- Warminsko-Mazurskie, III-IV Mazowieckie, V- Podlaskie

Table 3. Nutrient content in soil surface layers in the farm's gardens and poultry paddocks from the demonstration farms in different regions of Poland.

Nutrient	Soil extract	Layer cm	n	kg.ha^{-1}					
				Farm's garden			Poultry paddock		
				mean	min.	max.	mean	min.	max.
$N\text{-}NH_4^+$	1% K_2SO_4	0-10	15	1.6	0.16	3.2	4.9	0,20	37.7
		10-20		1.6	0.36	4.9	9,1	0.44	106.8
$N\text{-}NO_3^-$	1% K_2SO_4	0-10	15	16.8	7,5	44.4	53.1	2.16	147.6
		10-20		15.7	6.2	31.7	47.4	12.6	137.6
$P\text{-}PO_4^{3-}$	1% K_2SO_4	0-10	15	4.8	0.66	10,7	22.1	3.8	118.0
		10-20		6.3	0.76	17.0	15.9	2.5	80.0
$P\text{-}PO_4^{3-}$	0,5m.dm^{-3} HCl	0-10	4	273	250	310	923	510	1400
		10-20		320	160	590	623	200	990
K^+	0,5m.dm^{-3} HCl	0-10	4	348	280	400	828	560	1060
		10-20		305	210	370	773	480	1050
Zn^{2+}	0,5m.dm^{-3} HCl	0-10	4	49.8	21.9	99.1	172.1	87.0	337.6
		10-20		35.2	13.4	70.4	151.9	68.0	321.6
pH	1m.dm^{-3} KCl	0-10	15	7.19	6.43	7.70	7.15	6.44	7.63
		10-20	15	7.20	6.53	7.69	7.20	5.93	7.65

Discussion

The high enrichment of soil in nitrogen, phosphorus, potassium and zinc in the vicinity of animal waste storage as manure heap, barn, poultry paddock can be confirmed in many farmsteads**.** The soil profiles in the places situated in larger distance from the pollution sources by nutrients, especially those located in direction of water flow, are mostly enriched with this nutrients. Soil enrichment with nitrogen may pose a threat for waters for a long time since liquidation of the manure heap. Instead of that, Dewes and Schmitt (1994) studying, among the others, nitrogen accumulation in soil from under the long-term stored manure heap found that, only $N\text{-}NH_4$ content differed significantly (by 4.2 mg/100 g of soil) between the 0 - 15 cm soil from under the hill and that from the field. Additionally, they showed higher nitrate-nitrogen content in the deeper soil layers in some cases.

The highest concentration of labile phosphorus (extracted in 1 % K_2SO_4 solution) was confirmed down to 40 - 60 cm and more of soil depth (Figure 1, 2). The phosphorus contents found in the profiles were about several tons per hectare and were higher than the soil capacity to bound the phosphate. The high content of labile form of phosphorus in the soil profile situated in the vicinity of farm wells have to be taken into consideration (Sapek B. 1998). A threat of the excessive soil enrichment with phosphorus in places of animal wastes storage is confirmed by the analysis of this element in soils from farms, where manure or animal slurry is used frequently and in large doses (Smith et al. 1998, Richards, Coxon, Ryan 1998). In Smith et al studies (1998), phosphorus content analyzed by the method of Olsen in soil fertilized with poultry manure was 100 - 240 mg dm^{-3} in the layers 0 - 15 cm to 45 - 60 cm, which makes 360 - 150 kg P/ha. It can confirm that the mean source of increased content of phosphorus in the soil profiles from the farmstead area - a „hot spots" are animal wastes dispersed in different forms on the farmstead. The surplus of phosphorus compounds caused its leaching into the groundwater. According to Dewes (1997) the mean concentration of phosphorus in the leakage from the manure heap is equal 337 mg P/dm^3**.** Soils from the "hot spots" within the farmstead being the threat of soil pollution with nitrogen and phosphorus show also a remarkable enrichment in potassium (Table 2 - 5). Similarly high accumulation of potassium in soil from under the manure heap stored for a long time was presented by Dewes and Schmitt (1994). The difference in K content of 0 - 15 cm soil layer from under the heap and from field was 92.7 mg.100 g^{-1} of soil.

Table 4. The content of phosphorus (P-PO_4^{-3}) in surface layer (0 - 20 cm) as well as in the soil profile (0 - 200 cm) from the demonstration farms in different regions of Poland.

No	Monitoring point	Layer cm	1% K_2SO_4 extract				0,5m.dm^{-3} HCl extract	
			kg P.ha^{-1}				kg Pha^{-1}	
			I	II	III	IV	I	II
1.	In the previous place of silage storage	0-20	128	-	-	-	2180	-
		0-200	230	-	-	-	8660	-
2.	In the vicinity of manure storage, by the barn or slurry tank	0-20	279	4	0.1	40	1840	2060
		0-200	665	1083	2	15	9340	16560
3.	About 150 from the manure storage, on the flow by the road	0-20	56	4	0.1	50	2120	820
		0-200	496	120	7	37	10680	3000
4.	Place by the non- used sewage tank	0-20	24	-	-	-	-	-
		0-200	39	-	-	-	-	-

Farms from the regions:
I- Kujawsko-Pomorskie, II- Warminsko-Mazurskie, III Mazowieckie, IV- Podlaskie

The excessive nutrient enrichment of soil from the "hot spots" in the farmstead and its vicinity is reflected by the pollution of groundwater from these places. Water monitoring in demonstration farms from EPA Project in 1993-1996 demonstrated the highest N-NO_3 concentration in groundwater from a wells installed near the place of the manure storage (Table 6). Mean concentration of N-NO_3 was 25.1 mg.l^{-1}, but maximum concetration was 312 mg.l^{-1}, respectively (Sapek B. 1998). Water from the used farm wells in the area exceeded the standard (11.3 mg N-NO_3 .l^{-1}; 50 mg .l^{-1} NO_3). Concentration of N-NH_4 in groundwater near the manure heap exceeded several times the limit of 0.5 mg.l-1 and water from the farm well was close to that limit. Groundwater from under meadows, pastures and arable field contained on average only 2.9 - 5.0 mg $N\text{-}NO_3$ .l^-, though maximum concentrations were very high (Sapek B. 1998). Mean $N\text{-}NH_4$ concentrations in the groundwater from this area were in the range 0.1 - 0.6 mg.l^{-1}. (Table 6.)**.** A problem of groundwater pollution from places of animal waste storage is illustrated by the results of Dewes (1996) that shown the concentrations in leachate on the level 1139 mg.l^{-1} with 66 % being .l^{-1} $N\text{-}NH_4$ and only 4 % $N\text{-}NO_3$. As in the case of N, groundwater from places near manure storage contained P, K and Cl in concentrations markedly exceeding permissible values (Table 6). The consequence of nutrient losses from the farmstead and its vicinity as well as its dispersion into the environment is the pollution of soil and water that confirmed the obtained results and observations.

Table 5. The content of potassium (K^+) in surface layer (0 - 20 cm) as well as in the soil profile (0 - 200 cm) from the demonstration farms in different regions of Poland.

No	Monitoring point	Layer cm	0.5 M HCl extract, kg K.ha^{-1}					
			I	II	III	IV	V	VI
1.	In the previous place of silage storage	0-20	5760	-	800	-	1840	-
		0-200	41700	-	2500	-	9920	-
2.	In the vicinity of manure storage, by the barn or slurry tank	0-20	2440	3740	7900	1940	2060	-
		0-200	63240	62200	46540	29240	24300	-
3.	About 10 m from the manure storage (direction of water flow)	0-20	1460	1800	720	-	3120	2100
		0-200	21100	21520	5280	-	25400	20400
4.	About 150 from the manure storage (direction of water flow)	0-20	680	3000	420	700	640	580
		0-200	5120	33780	1440	1320	4540	2060

Farms from the voivodships: I- III- Kujawsko-Pomorskie, IV- VI- Warminsko-Mazurskie

Table 6. Mean values of nutrients concentration in groundwater from different places in demonstration farms in Mazowieckie voivodship in 10.1993 - 05.1996.

No	Monitoring point	No of samples	mg.l^{-1}				
			$N\text{-}NO_3$	$N\text{-}NH_4$	P	K	Cl
1.	Meadows	541	2.91	0.61	0.61	9.0	25.7
2.	Pastures	462	4.99	0.39	0.48	11.2	31.0
3.	Arable land	37	4.54	0.1	0.09	2.7	16.2
4.	By the manure storage	342	25.1	8.13	3.5	397	371
5.	By the barn	212	18.4	0.40	0.68	91.9	36.9
6.	Farm wells	282	10.6	0.50	0.23	35.0	36.6

Standards for drinking water and for management using water: $N\text{-}NO_3$ - 11,39 (50 - $N0_3$) mg.l^{-1} , $N\text{-}NH_4$ - 0.5 mg.l^{-1}, Cl- 300 mg.l^{-1}; according to EU Directive: P- 2.2 mg.l^{-1}, K- 12.0 mg.l^{-1}

Conclusions

- The agricultural operations and domestic activities concentrated on farmstead and its vicinity results in accumulation of different pollutants in soil profile.
- In this way, a new soils are created (rural farmstead soil) that have undergone an anthropogenic chemical degradation.
- Soils oversaturated with nutrient loss their ability to further its bounding that results in leaching of N and P compounds as well as K down the soil profile and a risk of water pollution and eutrophication is producing.

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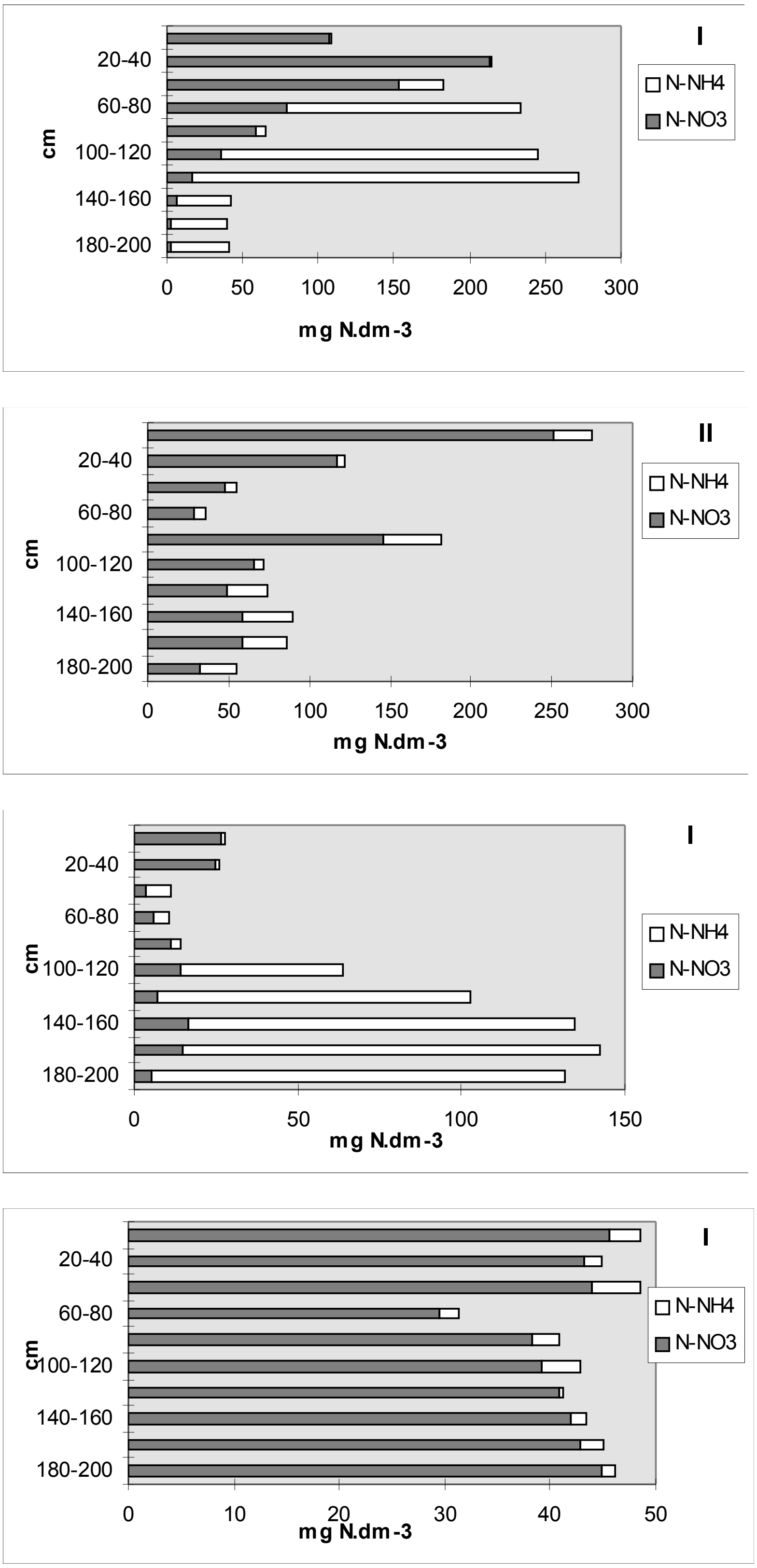

Fig. 1: Content of nitrate (N-NO3) and ammonium (N-NH4) nitrogen in 1% K2SO4 soil extract in the samples from soil profiles in different places on farmstead and its vicinity; I - by the urine tank, II - over the manure pad and urine tank, (Podlaskie voivodship), III - by the barn and slurry tank, IV - on the water flow, by the road (Mazowieckie voivodship).

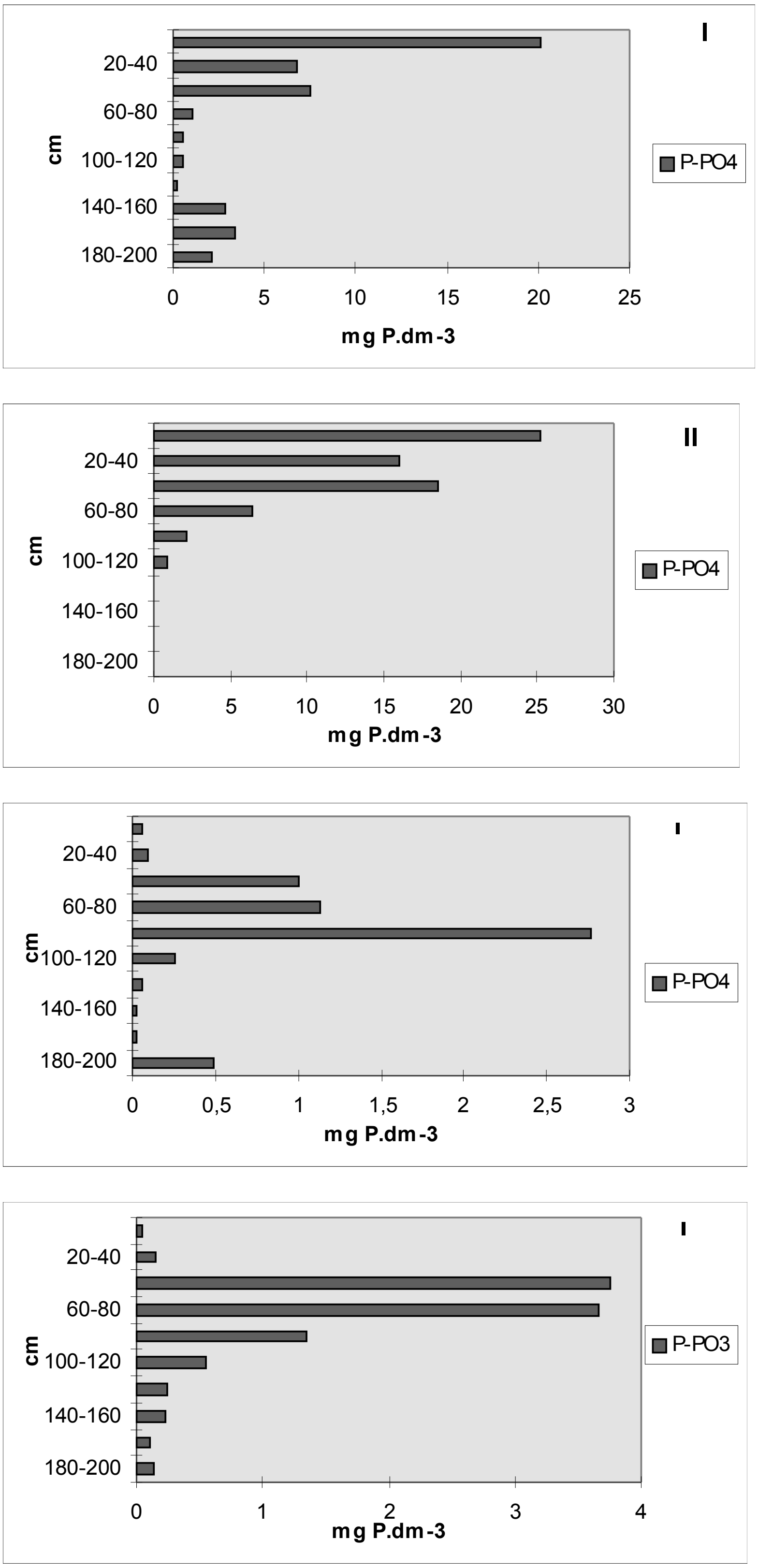

Fig. 2: Content of phosphorus in 1% K2SO4 soil extract in the samples from soil profiles in different places on farmstead and its vicinity; I - by the urine tank, II - over the manure pad and urine tank, (Podlaskie voivodship), III - by the barn and slurry tank, IV - on the water flow, by the road (Mazowieckie voivodship).

"Reconstituted Anthroposoils" for Landscaped Areas: Morphological Characteristics and Physical Properties

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Abstract

In landscape projects, soils are currently reconstructed from the arable earth layer of agricultural earth recovered during the installation and the construction of industrial and commercial zones. These materials undergo a series of operations from excavation at the initial site to the placement at the final site: the different operations are the excavation and the storage in piles over a short or long time, followed by transport and placement. Each operation could be the origin of physical property degradation of the material, such as the compaction or formation of blocks of soil. It is necessary to foresee the evaluation of the soil's physical properties to verify the quality of the earth placement and its further evolution. The controls, listed below, should allow the evaluation of physical properties to determine whether or not the soil is suitable for rooting and draining. These different controls are carried out by destructive and qualitative methods, like the pit observation or macroporosity by image analysis and also by non-destructive and quantitative methods like bulk-density measurements, penetrometry or infiltrometry.

Introduction

Nowadays, country-dwellers are moving to and concentrating in our cities and towns. These centres are dominated by concrete buildings and asphalt roads; it is an environment where hard landscaping dominates. The inhabitants need some contact with nature, and this can be supplied via gardens, parks and green areas. These zones provide a natural aspect, changing and softening the geometric dimension of our cities. In order to provide for these social needs, municipalities are developing green areas where the planting presents an immediately mature look.

In these new landscape projects, soils, for the most part, are reconstructed from the arable earth layer of agricultural soils, recuperated during new construction. These materials undergo constraints which can be considerable, from excavation at the initial site to placement at the final site. Plants and trees which are installed are generally in bad health and they have difficulty in getting established. At present, professionals are showing great interest in installing plants in soils which present physical properties adapted for quick recovery and quick root colonisation. This new awareness of professionals requires the control of the different earth placement operations: from the excavation of the arable earth to its deposit on the final site. Soil moisture during these different works is an essential factor for planting success.

The soils are reconstructed, taking as a model, fertile natural soils, whose physical and chemical characteristics are known; the soil's physical fertility can be determined by destructive methods such as the description of horizons and profiles at different scales, and by non-destructive methods such as measures of bulk density, permeability and penetrometry. Chemical fertility is normally determined by earth-sample analysis and controlled by current interpretation standards.

Material and Methods

The Reconstituted Anthroposoils in green areas, parks and gardens are built from the topsoil of arable agricultural soils when these areas are nominated as future industrial, commercial or living zones.

Different reconstituted anthropic soils are designed in accordance with the vegetation and the type of green area proposed. For lawns and small shrubs, the reconstituted soils should be 30 cm deep; at this depth, the plant roots do not suffer any serious constraints. On the other hand, for tree plantations, the soil must be at least one metre deep. Using the fertile natural soil model, two types of layer can be reconstituted: the earth used on the superficial horizon, with a depth of 30 cm is enriched by organic substances and if necessary with chemical fertilisers, which are mixed before or after placement; the earth used for deep horizons are modified only a little, except if there is a chemical imbalance.

Before using the earth it is necessary to know the principal physical and chemical characteristics of the topsoil: its texture, mechanical properties (plastic and liquid limits), water reserve, structural stability, aggregate bulk density, chemical characteristics (pH, CEC, exchangeable cations, easily assimilated phosphorus).

The earth placement conditions are fundamental to obtain a soil which presents physical properties suitable for quick root colonisation; the material moisture is one of the essential factors for success: a low moisture level, inferior to the plastic limit, avoids aggregate destructuration due to soil mixing or soil compaction The machines used for the transport and the handling of earth are also an important factor of success; the reconstructed soil compaction risks are considerable if no precautions are taken.

After placement, the soils can be studied using the classic pedological methods to characterise the physical properties suitable for the plant root development.

These different studies are carried out by destructive and qualitative methods, like the observation pit and also by non-destructive and quantitative methods like bulk-density measurements, penetrometry, infiltrometry and image analysis.

Results

1 – description of soil profiles

We can apply to reconstituted anthropic soils the observation pit method; it is a destructive method which requires digging a pit in order to describe the characteristics of different soil layers; this method uses the pedological description of horizons and the agronomic interpretation of these characteristics. For each layer or horizon the described characteristics are: texture and stones, colour and oxide-reduction marks, moisture, structure, calcilinity, organic matter, porosity, roots, soil consistence, biologic activity. Porosity and rooting are two important variables to characterise the aeration and drainage of soils. A soil profile characteristic for tree plantations has two types of layer, superficial and deep. These descriptions give prominence to the restricting factors for root colonisation and water circulation.

2 – Bulk density and moisture measurements

These descriptive data are verified by soil measurements. The total bulk density allows one to determine the degree of soil compaction by using the value of total porosity. The use of depth gamma densitometer allows one to measure the moist bulk density every 10 cm; the earth sample taking during the installation of the measurement tube allows one to determine the value of soil moisture. These profiles (figure n°1) show the bulk density some months after soil placement. The figure n°2 shows the bulk density evolution over time. It is stabilised after two or three years.

3 – Penetration resistance measurements

Penetration resistance is a soil composition property: various physical properties of soil are at the origin of this soil resistance measured by pushing a spike into the ground; we can cite principally mechanical properties and bulk density. The soil consistence goes through various states when the moisture changes, from dry soil to very wet soil: the consistence is rigid when the soil is dry and the material breaks without deformation, the consistence is malleable when the soil is wet and the material is easily bent, the consistence is pasty when the soil is very wet and the material can slide due to gravity. These different states are separated by limits: plastic and liquid limits. The penetration resistance is sensitive at these state variations: it is high for rigid and coherent soil, it decreases for malleable and plastic soils, it becomes very low for pasty and liquid soils. The curves obtained in figure n°3a and 3b were obtained from wet soil. For the same range of moisture, the penetration resistance increases with the bulk density, though the results are difficult to give prominence in the field. The penetrometer used is the Panda®, dynamic penetrometer.

4 – Hydraulic conductivity measurements in situ

One important property of soil, especially for drainage and irrigation, is its aptitude for water infiltration; it can be measured in situ using the Guelph permeameter which allows one to take hydraulic conductivity measurements on the surface and at depth. In the field, considerable variations have been observed on small surfaces and for homogeneous soils: the measurements have been taken at two depths (35 and 65 cm): its varies from more than 10 cm/h to less than 2 cm/h, for measurements at the same depth (figure n°4). These considerable variations depend of the macroporosity and in particular the macroporosity created by biological activity.

5 – Porosity study by image analysis

This technique allows one to observe the soil's macroporosity with samples taken in situ; it is solidified with resin which contains a fluorescent pigment which, in ultraviolet light, shows the voids; after the sample has been cut, the polished face is studied by image analysis. Some software allows one to obtain macroporosity information, such as pore repartition, dimension, orientation and form. Samples have been taken from three year old reconstituted Anthroposoil. The total macroporosity of the superficial layers is very high: 23 %. At depth, the soils are less porous (19 - 14 %). In soils where placement takes place with dry topsoil, we can see greater macroporosity (20%) than in soil placement with wet earth (8 – 12 %) (figure n°5).

Discussion

An assessment of physical properties of reconstituted Anthroposoils

These different methods of approach to analyse Reconstituted Anthroposoils approach allows one to learn more of their functioning and their behaviour besides water and root colonisation.

The use of different methods allows one to evaluate the soil's physical properties which have influence on physical fertility of constructed soils: the compaction, the drainage and aeration capacities. Thresholds have been defined following the study of Anthroposoils by the French Lyons International Centre:

- The compaction is determined by bulk densities (da):

da < 1.5 : is considered as low compaction: the roots penetrate easily in the soil and drainage water flows quickly;
1.5 < da < 1.7: is considered as average compaction;
da > 1.7: indicates high compaction: the majority of roots cannot penetrate the soil.

- The drainage capacity is determined by hydraulic conductivity (Kfs):
Kfs > 5cm/h: is considered as high drainage capacity;
2 cm/h < Kfs < 5 cm/h is considered the average drainage capacity;
Kfs > 5 cm/h: is considered as low drainage capacity.

- The aeration capacity is determined by macroporosity (Mp):
Mp > 20% indicates high aeration capacity;
10 < Mp < 20 % is the average aeration capacity;
Mp < 10 % indicates low aeration capacity.

These thresholds are obviously valuable only in the scope of the Lyons study, but it is possible to refine it if complementary studies are carried out. The penetration resistance did not given thresholds because of the low differences obtained between the penetrometrical profiles.

Conclusions

The study and the follow up of the physical properties of soil underlines the importance of careful methods employed during the placement of reconstituted Anthroposoils. The adopted reconstitution model and the recommended soil implementation modality allows one to create favourable edaphical conditions for plant recovery. The diagnostics on soil physical fertility may continue for confirm the reconstituted Anthroposoil quality. On the other hand, it is necessary to continue penetrometry validation as a simple method for the characterisation of physical soil properties.

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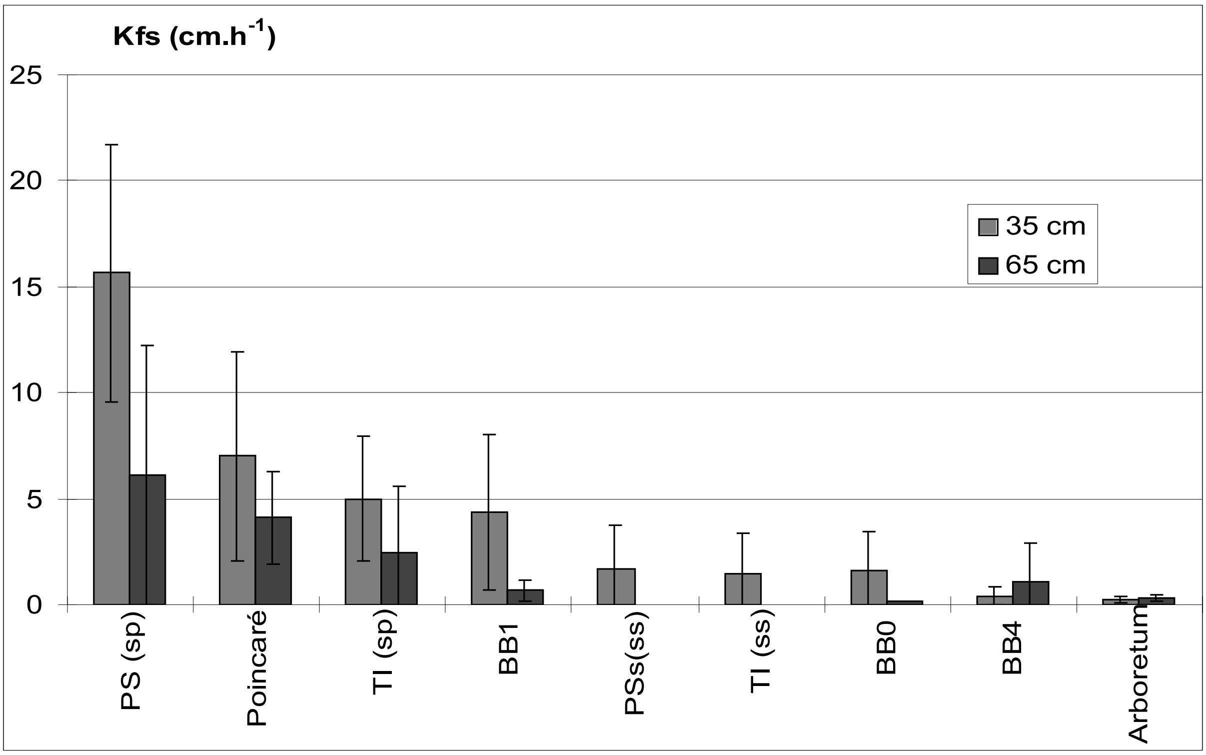

Figure n° 4: Soil permeability mean coefficients in different green areas, Lyons.
(sp: deep soils; ss: superficial soils).

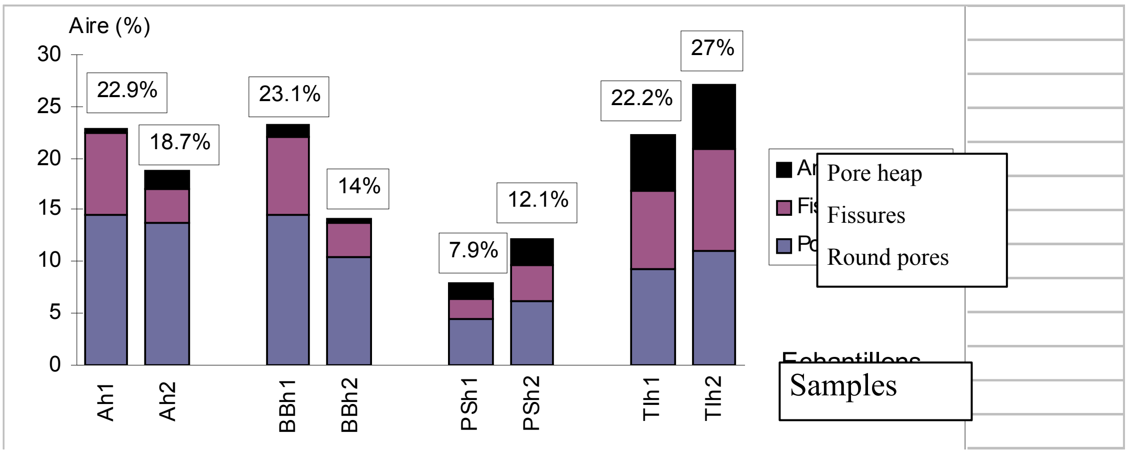

Figure n°5: Macroporosity and pore form.

Some Properties of Roadside Soils in the Environs of Olsztyn, NE Poland

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Abstract

Soils situated near the Olsztyn – Warsaw road were analysed to assess the effects of traffic on soil properties. The heavy metals content was determined by the AAS technique after hot digestion in concentrated acids of HNO_3 and $HClO_4$, and in 1 M HCl (soluble forms). The soils sampled from the 5 m belt closest to the road have sorption properties modified by salinization due to frequent use of NaCl as road de-icer (BS > 90 %, exchangeable Na > 5 % of CEC, pH(H_2O) 7.1-7.8).
Soils sampled 2-3 m from the road have Cd content above 1.0 $mg.kg^{-1}$, and Pb content above 70 $mg.kg^{-1}$. They are regarded as slightly contaminated (second degree of contamination). The increased level of Pb was recorded in soils sampled 18 - 30 m from the road. The soils from this 5-metre belt could be classified as Urbic Anthrosols because they have disturbed soil profiles and accumulation of alien substances. In the case of the studied road, the width of land on which cultivation of crops designed for direct consumption (e.g. vegetables) should be eliminated is ca. 20 - 30 m.

Introduction

In Poland in recent years, especially in the 1990s, a rapid increase of road traffic has been observed. This causes contamination of soils adjacent to busy roads. Because of possible environmental problems, the concentration of heavy metals in such soils should be recorded and studied. In soils in the immediate vicinity of the road, the mechanical disturbance of soil profile is also noted as well as soil salinization due to frequent use of NaCl as road de-icer.

The aim of this paper is to determine the extent of anthropogenic transformation of roadside soils in the environs of Olsztyn. This is part of a wider research project focused on soils modified by human influence in the urban and suburban environs of Olsztyn. Soils within Olsztyn city limits have not been previously studied. Olsztyn is a city of ca. 180 thousand inhabitants, located in north-eastern Poland. This part of Poland is considered to be rather unpolluted, as it is far from major sources of air pollutants.

Material and Methods

The investigated soil profiles were distributed in a perpendicular transect near the Olsztyn – Warsaw road, outside the built-up area of Olsztyn but within the administrative boundary of the city. The study area is covered by grassland (lawn and pasture) vegetation. The estimated traffic intensity in the year 2000 was ca. 10,000 vehicles per 24 hours. In recent years there has been an increase in traffic volumes of 8 % annually on this stretch of road. For example in 1995 the average traffic intensity was only 6,400 vehicles per 24 hours.

The soils were sampled 2, 3, 5, 18, 25, 30, 46, 60, and 110 metres from the road's edge. The heavy metals content was determined by the AAS technique with the Pye Unicam SOLAAR 969 apparatus after hot digestion in concentrated acids of HNO_3 and $HClO_4$ (Ostrowska at al. 1991). The content of elements in 1 M HCl (relatively easy soluble forms) were determined using the method developed in the Institute of Soil Science and Plant Cultivation in Puławy (Gembarzewski, Korzeniowska 1996). Exchangeable basic cations were determined in 1 M ammonium acetate at pH 7.0 by the AAS method after rinsing of the water-soluble ions. The content of hydrogen was determined after extraction by a $BaCl_2$ – triethanolamine buffer solution at pH 8.2. Grain size distribution was determined by Prószyński's hydrometer method. Loss on ignition at a temperature of 550ş C was regarded as an approximation of organic matter content.

Results and Discussion

The soils studied are mostly light soils, as the content of particles < 0.002 mm in diameter is from 1 to 5 %. Only soils sampled 46 m and 110 m from the road are loamy in texture (Table 1). The exchangeable cation content is typical for soils of sandy and loamy texture (Table 2). But the soils sampled within the 5-metre belt closest to the road have sorptive properties modified by salinization. Their base saturation is above 90 %, and exchangeable sodium occupies from 2.3 % to 7.7 % of the total exchangeable capacity. Downwards leaching of salts is observed, because the deeper layer (30 - 35 cm) has higher sodium saturation than the top layer (5 - 10 cm). Soil reaction also indicates chemical modification of the soil as pH(H_2O) values are within the range 7.1 -7.8. Soils sampled from further distances have acid reaction and base saturation around 50 %.

It can be concluded that soils from the 5-metre belt closest to the road are modified by salinization, which is due to frequent use of NaCl on the road surface to eliminate snow cover. Salt accumulation is in spite of moist climatic conditions which favour leaching of salts. The possibility of the build-up of soluble salts during dry summers should be taken into consideration because of the toxic effect on roadside trees and shrubs (Czerwiński 1987).

The effects of traffic on adjacent soils is also manifested in the form of accumulation of heavy metals (Table 3). Soils sampled 2 - 3 metres from the road have Cd content slightly above 1.0 $mg \cdot kg^{-1}$, and Pb content above 70 $mg \cdot kg^{-1}$. According to the threshold values used in Poland (Kabata-Pendias at al. 1993), these soils belong to the "slightly contaminated" category (second degree of contamination). The effect of traffic on lead concentration is still apparent in soils sampled 18 - 30 m from the road. These soils have increased levels of Pb (first degree of contamination). Accumulation of Zn, Cu, and Ni in the soils closest to the road (2 - 5 m) is also noted. This spatial distribution of heavy metals indicates that road traffic is the main source of pollutants in the soils studied. This is also recorded in the literature, e.g. Kabata-Pendias, Pendias 1992, Rodrignez-Flores, Rodrignez-Castellón 1982. Soils from points more distant from the road display natural amounts of heavy metals and can be regarded as uncontaminated soils (Czarnowska 1996, Czarnowska, Gworek 1987, Dudka 1992, Terelak et al. 1997). Heavy metals have built up mostly in the surface layer of soil, but where the highest levels were found in the surface layer, an increased concentration was also observed in the layer 30 - 35 cm. Probably this vertical distribution of metals was partly caused by mechanical disturbance of the area adjacent to the road during road renovation.

The amounts of heavy metals occurring in relatively weak bound forms is significantly higher in soils close to the road than sampled from further locations. Copper soluble in 1 M HCl constitutes from 39.3 to 55.5 % of the total copper content in the top layer of the soils closest to the road, but only ca. 8 % in the deeper layer of investigated soils. A similar trend is observed in the case of Zn and Cd. Forms of lead soluble in 1 M HCl constitute from 38.5 to 72.8 % of the total amounts of this metal. The lead solubility was slightly lower than reported by Tuin and Teis (1990). Also in this case samples from the top layer and taken from places close to the road demonstrate higher solubility. This indicates that increased amounts of heavy metals in the investigated soils are from road traffic and occur in non-silicate forms.

Conclusions

Based on soil properties, the soils from the 5 m belt closest to the road could be classified as Urbic Anthrosols (FAO-Unesco 1988). According to the Systematics of Polish Soils (1989) these soils are Anthropogenic soils. The main reason for this classification is mechanical disturbance (mixing) of soil profiles up to 50 cm, and accumulation of soluble salts and heavy metals. Soils from further locations were classified as Cambic Arenosols or Haplic Arenosols when of sandy texture, and as Eutric Cambisols when of loamy texture.

The results obtained indicate that emissions from traffic have caused degradation of a rather narrow belt of soils close to the road. In the case of the studied road, the width of land on which cultivation of crops designed for direct consumption (e.g. vegetables) should be eliminated is ca. 20 - 30 m. Properties of roadside soils should be under constant inspection because there is ongoing accumulation of pollutants.

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Table 1. Basic properties of investigated soils.

Distance from the road's edge (m)	Depth of sampling (cm)	Per cent of particles of diameter in mm				Loss on ignition (%)	pH		Soil classification according to:	
		1-0.1	0.1-0.02	<0.02	<0.002		H_2O	KCl	**Systematics of Polish Soils (1989)**	**FAO – UNESCO (1988)**
2	5-10 30-35	67 75	24 17	9 8	5 3	3.08 1.57	7.4 7.8	7.2 7.6	Anthropogenic soil (saline) with unformed profile	Urbic Anthrosols
3	5-10 30-35	63 78	29 15	8 7	5 5	3.89 1.63	7.1 7.5	6.8 7.4	Anthropogenic humous soil (saline)	Urbic(?) Anthrosols
5	5-10 30-35 50-55	69 60 75	25 33 21	6 7 4	3 3 2	3.31 2.64 1.42	7.1 7.3 7.7	6.8 7.1 7.5	Anthropogenic humous soil	Urbic(?) Anthrosols
18	5-10 30-35 65-70	59 57 60	35 35 37	6 8 3	3 4 1	1.91 1.87 —	5.8 5.9 5.5	4.8 5.2 4.7	Proper rusty soil	Cambic Arenosols
25	5-10 30-35	64 67	32 30	4 3	2 1	1.41 0.89	6.0 6.2	5.1 5.3	Proper rusty soil	Cambic Arenosols
30	5-10 35-40	70 77	27 21	3 2	2 1	1.02 0.63	6.1 6.3	4.9 4.9	Proper arenosol (rusty)	Haplic Arenosols
46	5-10 35-40 50-55	29 29 89	35 37 4	36 34 7	12 14 5	5.80 3.16 —	5.4 5.8 5.9	5.0 5.5 5.3	Brown soil (typical)	Eutric Cambisols
60	5-10 45-50	65 69	29 27	6 4	4 3	1.44 0.93	5.6 5.9	4.4 4.3	Proper rusty soil	Cambic Arenosols
110	5-10 35-40	38 20	38 38	24 42	12 17	4.25 2.97	5.8 6.0	5.2 4.8	Brown soil (typical)	Eutric Cambisols

Table 2. Cation exchange capacity of investigated soils.

Distance from the road's edge (m)	Depth of sampling (cm)	Exchangeable cations (cmol(+)· kg^{-1})							BS (%)	Na/CEC × 100 (%)
		Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	H^{+}	SBC	CEC		
2	5-10	6.3	0.5	0.20	0.30	0.3	7.3	7.6	96.0	3.9
	30-35	3.6	0.6	0.15	0.35	0.1	4.7	4.8	97.9	7.3
3	5-10	6.8	0.4	0.15	0.25	0.8	7.6	8.4	90.5	3.0
	30-35	2.8	0.4	0.20	0.30	0.2	3.7	3.9	94.9	7.7
5	5-10	6.6	0.5	0.20	0.20	1.3	7.5	8.8	85.2	2.3
	30-35	3.2	0.3	0.10	0.20	0.3	3.8	4.1	92.7	4.9
	50-55	2.3	0.3	0.15	0.15	0.3	2.9	3.2	90.6	4.7
18	5-10	1.8	0.3	0.37	0.03	3.3	2.5	5.8	43.1	0.5
	30-35	1.3	0.2	0.27	0.03	2.8	1.8	4.6	39.1	0.6
	65-70	0.9	0.1	0.08	0.02	1.8	1.1	2.9	37.9	0.6
30	5-10	1.6	0.2	0.09	0.01	2.0	1.9	3.9	48.7	0.3
	35-40	1.8	0.1	0.09	0.01	1.8	1.6	3.4	47.1	0.4
46	5-10	7.3	1.0	0.28	0.12	8.1	8.7	16.8	51.8	0.7
	35-40	5.5	0.5	0.30	0.10	5.7	6.4	12.1	52.9	0.8
	50-55	2.2	0.3	0.07	0.03	1.6	2.6	4.2	61.9	0.7
60	5-10	1.5	0.1	0.09	0.01	3.1	1.7	4.8	35.4	0.3
	45-50	0.9	0.1	0.09	0.01	2.8	1.1	3.9	28.2	0.3
110	5-10	4.4	0.6	0.15	0.05	4.7	5.2	9.9	52.5	0.5
	35-40	6.7	0.8	0.12	0.08	4.0	7.7	11.7	65.8	0.7

Explanations:
SBC – sum of basic cations
CEC – cation exchange capacity
BS – base saturation

Table 3. Total content of heavy metals in investigated soils (mg · kg^{-1}).

Distance from the road's edge (m)	Depth of sampling (cm)	Fe	Mn	Cu	Zn	Pb	Cd	Cr	Ni
2	5-10	11575.0	192.9	13.73	75.07*	45.07*	1.15**	20.87	7.85
	30-35	9031.7	143.0	1.67	15.93	21.33	0.83*	10.53	6.80
3	5-10	8429.4	172.9	8.33	57.54*	74.94**	0.35*	19.27	7.00
	30-35	6642.0	113.8	1.00	15.27	30.67*	0.40*	6.35	3.53
5	5-10	7676.7	204.7	8.07	41.04	48.67*	0.33*	10.33	4.87
	30-35	8027.4	249.9	3.80	26.73	36.87*	0.13	12.13	4.67
	50-55	6443.4	113.4	0.52	11.07	29.87	0.13	6.33	2.60
18	5-10	6721.4	283.0	2.20	22.13	31.73*	0.09	25.07	3.67
	30-35	7428.0	333.1	1.93	14.67	27.13	0.07	31.27	2.13
	65-70	5174.7	209.2	0.52	16.13	22.87	0.05	15.00	2.27
25	5-10	15810.0	187.5	3.53	35.14	20.60	0.40	27.33	9.73
	30-35	10290.0	111.6	2.13	32.27	17.73	0.33	13.40	7.60
30	5-10	7394.7	95.9	0.51	16.40	34.67*	0.20	11.87	3.00
	35-40	6212.0	31.9	0.32	14.73	28.67	0.27	8.93	2.13
46	5-10	23783.3	274.4	5.93	48.20	23.73	0.53	52.20	15.13
	35-40	22280.0	322.1	5.40	32.60	23.60	0.53	53.87	14.13
	50-55	13126.7	81.8	0.60	9.53	20.27	0.60	16.07	7.13
60	5-10	8778.4	178.5	2.33	27.33	26.20	0.20	32.07	2.15
	45-50	3734.7	141.8	0.93	9.67	25.07	0.20	16.40	2.05
110	5-10	17680.0	318.6	4.27	34.94	31.53	0.53	45.40	10.00
	35-40	27753.3	235.7	8.07	46.20	27.87	0.53	82.93	19.53

** slightly contaminated soils (II degree of contamination)
* increased level of heavy metals (I degree of contamination)

Anthropization of Eolian Sands in Slovakia

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Abstract

Human-induced impact on sands occurred in Slovakia is presented. Extent and location of sands is characterized according their significant soil properties, soil types or subtypes determination, respectively. There are three important regions of sands: Borská lowland, Danubian lowland and East-Slovakian lowland, which present only 1,2 % of the total Slovakia extent. As the main human influence on Slovakian sands can be involved: changes of native vegetation cover (like wood cutting, meadow ploughing, pine monoculture planting), strong devastation of landscape (like sand quarries, military training explosion activities, etc.), nevertheless many cases of well-managed sandy soil are presented, like deep trenched soils of vineyards, orchards or gardens enriched by organic matter and fertilizers.

Introduction

The eolic sands in Slovakia arose by blowing up of thick-grainy particles from alluvial sediments of adjacent river flows. The larger areas of eolic sands are situated mainly on larger alluvia, which were formed by the rivers Danube, Nitra, Žitava, Morava, Myjava, Rudava, Bodrog, Tisa, Latorica and Ondava. A character and qualities of single sandy dunes have its specialities in dependence on river and territory on which they are situated. A chemical and mineralogical characteristics of blown sands are similar like characteristics of alluvial sediments, of which they originated. The results of geological recognition dealing with the Quarternary and before-Quarternary substrates (1950-1980) in the scale 1:50 000, complex recognition of agricultural soils (1960-1970) in the scale 1:10 000, survey of forest soils (1960-1980) in the scale 1:10 000 and itself research in the all areas of eolian sands and their soils, enable to evaluate in a detail widening of sandy dunes and blown sands in single regions of Slovakia.

Material and Methods

The soil profiles have been described by Čurlik et Šurina (1998). The soils were classified according to the Morphogenetic Soil Classification System of Slovakia (Sobocká [ed.] 2000). The soil samples have been analysed for following properties:

- pH/KCl (0.2 M KCl)
- pH/H_2O (the soil - water ratio of 1:2.5)
- humus content (according to Walkey-Black)
- total nitrogen (according to Kjehdal-Jodlbauer)
- available nutrients (P and K by Mehlich II).

Results and Discussion

The eolic sands are according to their share less occurred soil-forming substrate in Slovakia. The total extent of blown sands does not reach 600 km^2 and it represents only 1.2 % of the total extent of Slovakia. An occurrence of blown sands is concentrated to three regions of Slovakia: the Borska lowland (the northern part of the Vienna basin), the Danubian lowland (the northern part of the Kiss Alföld) and the East-Slovakian lowland (the northern part of the Nagy Alföld). The largest areas of blown sands are situated on the Borska lowland, where the most of them are covered by forest (Table 1). A majority (75 %) of eolic sands on the Danubian lowland are utilized in agriculture, at which up to 30 % of its are vineyards. On the East-Slovakian lowland blown sands represent only arable landscape like agroecosystems.

Table 1. Widening and extent (km^2) of the eolic sands in Slovakia.

Utilizing	*Borska lowland*	*Danubian*	*East-Slovakian lowland*	*Total*
Forestry	284	35	0	319
Agriculture	126	105	50	281
Total	410	140	50	600

The main part of eolic sands is covered by forest (53 %) and less one is utilized in agriculture (47 %) in Slovakia. A really insignificant part (to 1 %) is built up, or areas used as cemeteries, or unmanaged agricultural land, eventually just a sand quarries.

The eolic sands of the **Borska lowland** present substrates with the lowest mineral power in Slovakia. It means, that they content lowest potential nutrients from all substrates. Under the original oak-pine forests and secondary pine monocultures were formed soils of Podzol type developed from eolic non-carbonate sands. These soils have an extreme acid soil reaction (pH in KCl = 3.3). On isolated dunes of moveable non-carbonate sand occurred only Arenosols. Such conditions did not enable to create a continuous area stand of plants. On the Borska lowland are 27,522 ha of protected areas, which of 33 % are eolic and alluvial sands. In the military training space (260 km^2) where also prevails forest landscape is mostly preserved a natural character of the original landscape in opposite to agriculturally utilized landscape (Valachovič 2000).

A human-influence on eolic sands is not only by change of plant communities (cutting of forests, ploughing of meadows, planting of pine monocultures) but also by fertilizing, or respectively devastation. On the Borska lowland are recognizable fertilizing and utilizing of eolic sands for cultivation of field crops and less of grape-vine. Anthropic influence has appeared in lower humus and total nitrogen content in arable land more than in forest sandy soils with low humus content (Table 2). Acid sandy soils does not change in pH and available soil potassium and phosphorus content is not increasing (Bedrna 2000), with exception of localities Malacky in the military training space. It is a result of plant production intensification by military properties (Paračková 2001). Devastation of blown sands is caused by grubbing of stems and laying them to belts after clear-cutting and fires, by excavation of a sand, building of houses and traffic network and also by breaking of sands by explosion of military bullets, grenades and bombs.

The carbonate sands of the **Danubian lowland** are mineralogically the richest material from the all eolic sands in Slovakia. They content carbonates (up to 10 % $CaCO_3$), which causes a weak alkaline reaction with pH in KCl = 7.2 - 7.8 (Table 2). The higher contents of carbonates in the low layers of blown sands (to 20 %) are a consequence of pedogenetic processes, mainly leaching from upper layers of sand to the down. After leaching of carbonates it comes to weathering of primary minerals (spars, micas) and to loosening of iron and aluminium in soil material. Oxidised iron compounds conditioned brown colour of a sand in soil type Cambisol. Mostly anthropically influenced are sandy dunes of the Danubian lowland which are utilized for cultivation of grape-vine. Soils for this purpose are trenched to the depth 0.6 m with enriching by organic materials and fertilizers. Such a way a soil type Aric Anthrosol is formed. A human influenced a development of eolic sands in Danubian lowland, mainly by its managering (arable land, vineyards), but also by planting of black locust forests. Such a way the wind erosion is limited. Only small enclaves were destroyed by excavation of sands.

Because silica sands are not occurred on the **East-Slovakian lowland** like on Borska lowland, non-carbonate sands without any content of carbonates also prevail. Presence of limestone in the Zemplinske vrchy mountains creates numerous dunes on its foothill after weathering of background rocks. It is appeared in single layers of blown sands also in a lower content of carbonates. Rocks were rolled from top of mountains to the down and after its weathering eolic sands were enriched with carbonates and mineral nutrients. Soil reaction of eolic sands ranges from weak acid up to weak alkaline (pH in KCl = 5.3 - 7.9). The eolic sands have a high presence of a fine sand up to coarse loam_fraction. Secondary clay minerals in eolic sands created by weathering of primary minerals, usually submitted by vertical transport of water. We have intensive transport of colloids in a sand, which were accumulated in thin horizontal layers. Thin lamellar accumulation of colloids in sands was called by Hungarian soil scientists (Stefanovits 1963) as "kovárvany". This soil type - Orthic Luvisol is very widened in eolic sands of the East-Slovakian lowland. More rarer there were developed also soil types as Arenosol, Cambisol and Aric Anthrosol. Up to 75 % of blown sands extent present vineyards and orchards in the East-Slovakian lowland. Numerous areas are utilized in agriculture for field crops cultivation. Isolated small mounds of sandy dunes represent a specific landscape element, where they encompass clayey fluvial sediments, often wetted or flooded by flowing rivers. People often established on its smaller vineyards or orchards, eventually they were utilized its as cemeteries. Elevated dry places were also good building areas on the plane and therefore a part of sands is sealed by smaller villages.

Conclusions

The total extent of blown sands does not reach 600 km^2 and it represents only 1.2 % from the total extent of Slovakia. An occurrence of blown sands is concentrated to three region: the Borska, Danubian and East Slovakian lowlands. The largest areas of blown sands are on the Borska lowland, how the most of their are covered by forests. Man influences eolic sands not only by a change of plant communities (cutting of forests, ploughing of meadows, planting of pine monocultures), but also by fertilizing, respectively devastation (excavation of a sand, breaking after explosion of military bullets). A majority of eolic sands on the Danubian lowland are utilized in agriculture, at which up to 30 % of its are vineyards. Soil for this purpose are trenched to the depth 0.6 m with enriching by organic materials and industrial fertilizers. On the East Slovakian lowland represent blown sands only arable landscape with agroecosystems. Up to 75 % extent are vineyards and orchards. A really insignificant part is built up, or there are fallows (cemeteries, unmanaged agricultural land) eventually a forbidden sand excavation.

Acknowledgement

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Table 2. Chemical properties of soils of eolian sands in Slovakia.

Horizon	Samples (cm)	pH		N_t (%)	C_{ox} (%)	C : N	Humus (%)	Available nutrients ($mg.kg^{-1}$)	
		H_2O	KCl					P	K
Borska lowland, Studienka, forest, Ferro-orthic Podzol									
Om	1 - 2	4.1	3.3	0.49	22.0	44.9	37.9	8	14
A/E	6 - 8	4.1	3.4	0.21	2.40	11.4	4.1	6	8
Bsv	35 - 45	4.2	4.2	0.10	0.31	3.1	0.5	5	11
Borska lowland, Gajary, forest, Leptic Arenosol									
Ao	10 - 20	5.2	4.2	0.17	1.05	6.2	1.8	10	20
C	50 - 60	6.5	4.9	0.06	0.18	3.0	0.3	6	10
Borska lowland, Gajary, arable land, Leptic (anthropic) Arenosol									
Ap	10 - 20	5.1	4.2	0.11	0.81	7.4	1.4	15	63
C	50 - 60	5.9	4.8	0.10	0.17	1.7	0.3	7	12
Borska lowland, Malacky, forest, Spodic haplic Arenosol									
Au/E	5 - 10	4.2	3.5	0.11	2.79	26.6	4.8	11	15
A/Bsv	10 - 20	4.9	4.1	0.10	1.53	15.3	2.6	13	9
Borska lowland, Malacky, arable land, Ari-Anthropic Arenosol									
Ap_1	5 - 15	6.3	5.9	0.16	2.31	14.4	4.0	104	113
Ap_2	25 - 35	6.5	5.9	0.17	2.05	12.0	3.5	102	42
Borska lowland, Malacky, garden, Hortic Anthrosol									
Akm_1	5 - 15	7.3	6.9	0.26	3.05	11.8	5.3	125	51
Akm_2	30 - 40	7.6	7.2	0.12	0.52	4.4	0.9	105	16
Danubian lowland, Chotin, forest, Haplic Arenosol									
Ao	5 - 15	6.3	5.8	0.29	3.15	10.8	5.4	31	59
Bv/C	30 - 40	6.8	6.2	0.15	0.35	2.3	0.6	20	45
C_{Ca}	80 - 90	8.3	7.6	0.10	0.16	1.6	0.3	12	40
Danubian lowland, Radvaň, vineyard, Ari-Anthropic calcaric Arenosol									
Akm_1	5 - 15	8.3	7.7	0.20	1.82	9.1	3.1	88	95
Akm_2	40 - 50	8.4	7.8	0.16	0.86	5.4	1.5	65	71
East Slovakian lowland, Maly Kamenec, unmanaged agricultural soil, Orthic Luvisol									
Ao_{Ca}	5 - 15	8.4	7.9	0.31	0.09	3.4	0.5	2	40
A/Bt_{Ca}	30 - 40	8.5	7.9	0.07	0.09	1.3	0.2	2	31
Bt	50 - 60	7.7	6.4	0.04	0.11	2.8	0.1	1	20
East Slovakian lowland, Malý Kamenec, vineyard, Ari-Anthropic Arenosol									
Akm_1	5 - 15	7.5	6.8	0.08	0.48	6.0	0.8	35	197
Akm_2	30 - 40	7.6	6.8	0.07	0.51	7.3	0.9	28	86
East Slovakian lowland, Sirnik, arable land, Haplic (anthropic) Arenosol									
Ap	5 - 15	7.2	6.2	0.07	1.02	14.6	1.8	20	45

Anthropogenic Soils of Little Carpathians Vineyard Area

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Abstract

Some characteristics of vineyard soils in the Little Carpathians mountain are presented. Anthropogenic soils of the Little Carpathians vineyards can be classified as Cambic Cultisol or Modal Cambisol (MSCS 2000) and as Ari-Anthropic Regosol (WRB 1994). Water erosion in past caused total deterioration of soil on convex slopes also due to fields shaped down the slope. In recent time it can be observed shifting of vineyards down to the less steep slopes and also terraces construction which decreases water erosion intensity. On the contrary, unification of small vineyards into large-scale vineyards has increased soil erosion. There was found marked diversification in chemical properties of these soils. On old constructed terraces there is very low pH values, on yang terraces is observed weakly acid till neutral soil reaction, sometimes carbonate presence due to intensive amelioration liming

Introduction

Grapevine cultivation in the region of Little Carpathians is known according some archaeological findings since 7th - 6th century BC Later, in the Roman time, in the 3rd century AD, army of Emperor Marcus Aurelius Probus established several vineyards in Little Carpathians mountain. Also during the Great Moravian Kingdom time vine was cultivated, as it is known from conserved vineyards prays.

The first written documents concerning vineyards is from the beginning of 13th century, but in the half of the 13th century vineyards were destroyed by Tatars (Mongolian). After this period "German colonisation" started to renew growing of grapevine.

In the 17th century, so called "30 years war" (1618 - 1648) has negatively influenced further development of vineyards. A new development has started during the 18th century in the time of emperors Marie Theresa and Joseph II. Further development even with wine export has started in the second half of the 19th century after the land bondage cancel.

End of the 19th century was influenced by grapevine diseases (like fyloxera and others) which nearly destroyed European vine growing. Further development becomes at the beginning of the 20th century, but mainly in thirties.

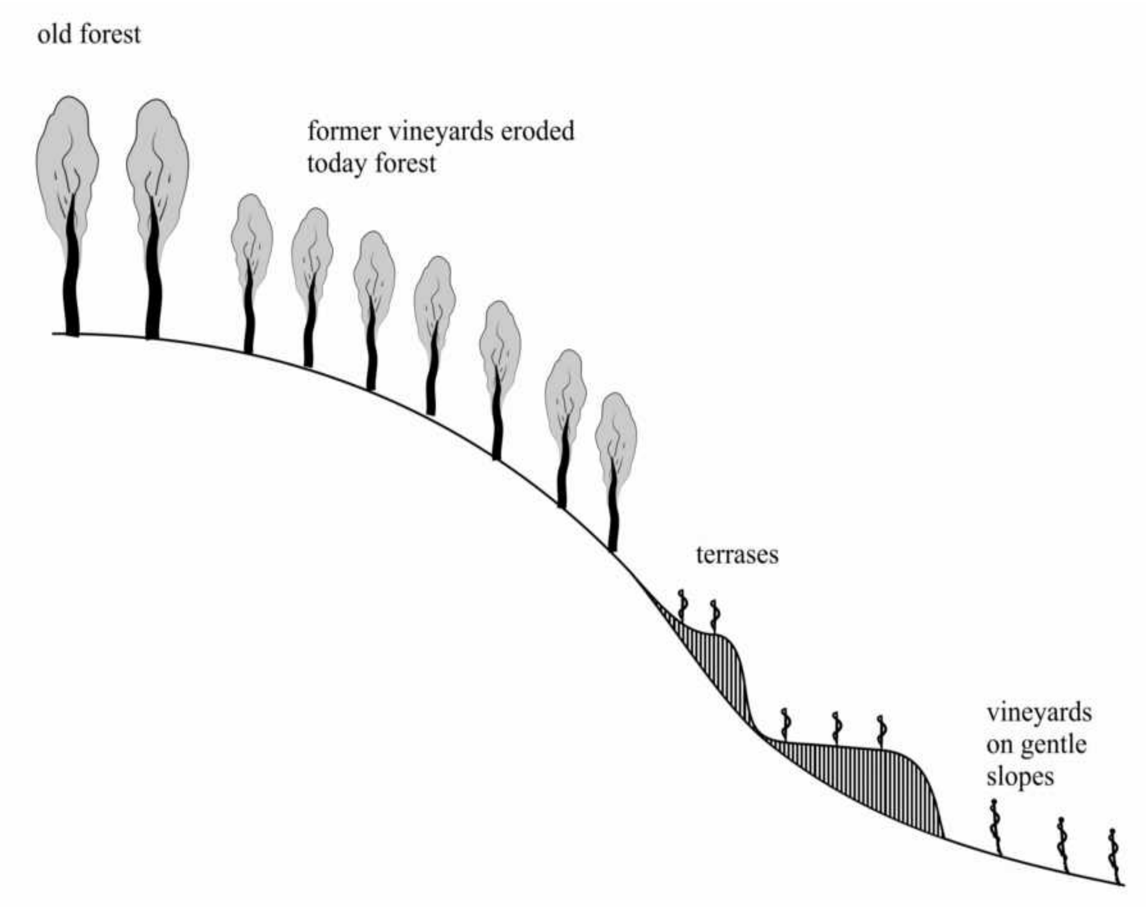
In the seventieth and eighties of 20th century large vineyards and new terraces on slopes were created. Generally vineyards has moved to gentle slopes. Regular liming of vineyards.

Original soil conditions in Little Carpathians vineyard area

Before creation of the Little Carpathians vineyard area in this territory, Cambisols from acid rocks has prevailed, in upper parts of steep slopes also Rankers. In some areas of the Little Carpathians vineyard also some Rendzinas from limestone in small extend has occurred.

On gentle slopes on the foot of the mountains Pseudogleyic Cambisols or even Pseudogleys had occurred.

Picture 1. Situation of vineyards on slopes of Little Carpathians.

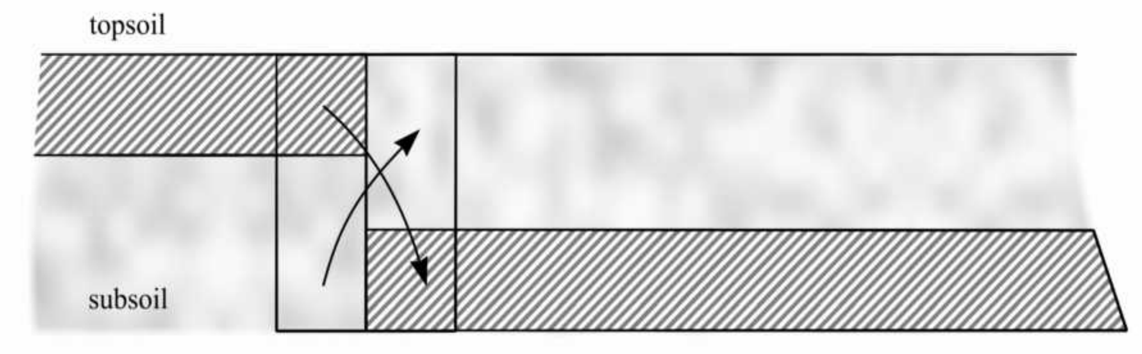


Today soil conditions

Due to needs of grapevine plants, having rather deep located root system, vineyards soil has been improved by man by deep digging, or deep tillage, so called "trenching". Picture 2 is showing this process.

The Morphogenetic Soil Classification System of Slovakia (2000) (further MSCS) classifies such soil as "Kultizem kambizemná" (Cambic Cultisol), with mainly "acid" variety and trenching form, having usually lighter texture, or "Kultizem modálna" (Modal Cultisol). WRB 1994 classifies these soils as Ari-Anthropic Regosols.

Picture 2. Trenching of vineyards soil.



Large parts of Little Carpathians vineyard area were also improved in seventies and eighties of the 20th century by terraces formation. In such conditions prevails dominantly "Kultizem kambizemná" (Cambic Cultisol), originally acid, but in many cases due to ameliorative liming also carbonatic, eventually "Antrozem modálna" (Modal Anthrosol), in upper parts of terraces also with "Kultizem modálna" (Modal Cultisol) and "Kultizem kambizemná" (Cambic Cultisol).

Specific features of Little Carpathians anthropogenic vineyard soils

There are two main phenomena dominantly influencing Little Carpathians vineyard soils:

1. Strong influence of water erosion.
2. Diversification of soil pH.
3. Low organic matter content.

Strong influence of water erosion

There are several causes influencing strong water erosion performance. The most important is of course sloping of vineyards. Especially older vineyards are situated on rather steep slopes. Also shape of fields were traditionally situated "down-slope" that make since very old time serious erosion risk. Also absence of plant cover on soil with rather wide lines of vines is an accelerating factor. Soil organic matter balance in vineyards is increasing erosion risk. Deep digging or tillage, so called trenching increased erosion risk, due to low organic matter content in present topsoil. In past time, on convex parts of slopes, water erosion has taken all fine soil material down, on the spot remain just stones. Such places were naturally or artificially reforested on the end of 19th or beginning of 20th century.

During the history several anti-erosion actions were realised. In the middle age just small anti-erosion actions were performed. Generally gradual movement of vineyards to more gentle slopes can be observed. This tendency has significantly increased during last decades. In the seventieth and eightieth of the 20th century large soil terraces has been formed.

Diversification of soil pH

In the area of Little Carpathians vineyards soil pH has diversified according following rules A):

- gradual acidification of soil of old vineyards "down the slope" on steep slopes due to
- long time use as vineyards with water erosion transporting fine soil fraction down - slope

– low organic matter content in soil due to trenching and open OM balance.

In this part liming is not common ameliorative action.

Lowest soil pH can be found on oldest vineyards as well as on natural shallow soil under forest:

Kultizem kambizemná (Cambic Cultisol) - former vineyard field

Horizon	sampling (cm)	pH_{H2O}	pH_{KCl}
A_{km}	5 - 15	4,68	3,82
A_{km}/B	30 - 40	4,77	3,87
B/C	60 - 70	6,01	4,98
B/C	110 - 120	6,48	5,54

Kambizem modálna (Modal Cambisol) - with natural forest

Horizon	sampling (cm)	pH_{H2O}	pH_{KCl}
A_o	0 - 5	4,79	3,68
A/B	5 - 12	4,32	3,36
Bv	15 - 25	4,21	3,48
B/C	65 - 75	6,02	4,72

B) Rest of the vineyard area of Little Carpathians with large soil terraces is rather recently recultivated and also large ameliorative doses of lime has been used here. That is main reason why soil pH of this area is much higher, on some places soil is containing also calcium carbonates. Example of such soil will be shown on excursion.

Low organic matter content

Due to deep digging/ploughing (trenching) soil organic matter (OM) is occurred in subsoil in the depth of 40 - 60 cm, having 1 - 2 % of OM. Topsoil is humus-arm usually with less than 1 % of OM.

Conclusions

1. In the Little Carpathians vineyards anthropogenic soils can be classified:
– according to the MSCS (2000) as Kultizem kambizemná, and/or Antrozem modálna;
– according to the WRB (1994) as Ari-Anthropic Regosol.

2. Main influence of soil water erosion, causing in past time complete soil deterioration, is due to convex slopes and field shapes "down-slopes".
Terraces formation in the second part of 20th century decreased soil erosion.
On the contrary, creation of large fields has increased soil erosion.

3. Soil acidity
– on former old fields very low pH;
– on new, young terraces soil reaction slightly acid to neutral, on some places even calcareous soil.

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Anthropogenic Soils of Quarry Ground Compositions in Roztochia Region (Ukraine)

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Abstract

The place, which the dominant types of anthropogenic soils occupy in modern soil covering in Roztochia region (Western Ukraine), their distribution, peculiarities of formation and functioning are established. The soil-formation process in technogenic compositions discussed takes place on the rocky dumps without fertile layer or potentially fertile substrates drifting on their surface. Depending on origin and substrate condition, we have marked out the refused, quarry and alluvial techno-grounds. The initial functional condition of techno-grounds, basing on their physical, chemical and biotic parameters has been estimated.

Introduction

Changes in the main components of natural landscapes during technogenesis cause the appearance of specific technogenic modifications and new formations in the place of natural soils. The anthropogenic soils are forming and equally with natural and natural-anthropogenic ones determine the present state of soil covering in the region. According to the level of technogenic transformation the ecological functions of soil are modified as well. The more intensity and duration of anthropogenic effect on soil, the more the balance in its functions is disturbed and more slowly the renewal of soil system proceeds.

Material and Methods

Roztochia (the north-western part of Podillian Hills in the west of Ukraine) is a part of a large industrial region, specialized in output and processing of local raw materials. Quarries of useful minerals and adjacent to them technological areas cover about 13 % of the whole Roztochia territory.

The objective of our work was the ascertainment of place the anthropogenic soils of dominant type occupy in modern soil covering in the region, their distribution, peculiarities of forming and functioning, taking as a model the quarry of building materials with dumpless system of production (Potelytch vill.) and adjacent technogenic formations connected with sulphur output: hydro-dumping and sections of underground sulphur smelting (Yavoriv PU "Sulphur").

In estimating characteristics of anthropogenic soils, some parameters were used, which reflect the intensity of soil transformation (in comparison with natural soils) and permit to trace back their initial functional condition. The determination of physical-chemical indices and values of biotic activity in anthropogenic soils was carried out. The sampling was accomplished 0 - 10 cm deep in five fold repetition. The laboratory work was carried out according to pedological and biogeocenotic methods adapted to the peculiarities of the object investigated.

Results and Discussion

The anthropogenic soils include artificial soils (techno-soils) and bare soil-formative, under-laying rocks (rocky substrate) located in zones of maximum technogenic transformation and represented by techno-grounds (Fig.1). Being guided by the basic works on soil anthropogenesis (Lebedeva et al., 1993) we try to give the regional ecological-functional estimation of the most widely-distributed anthropogenic soils as techno-grounds are.

In technogenic compositions considered the soil-formation process takes place on the rocky dumps, without fertile layer or potentially fertile substrate (loess-form loam and sandy loam) drifting on the surface. In the present case we deal exclusively with techno-grounds which differ only in the way of forming and in duration of the self-renewal process.

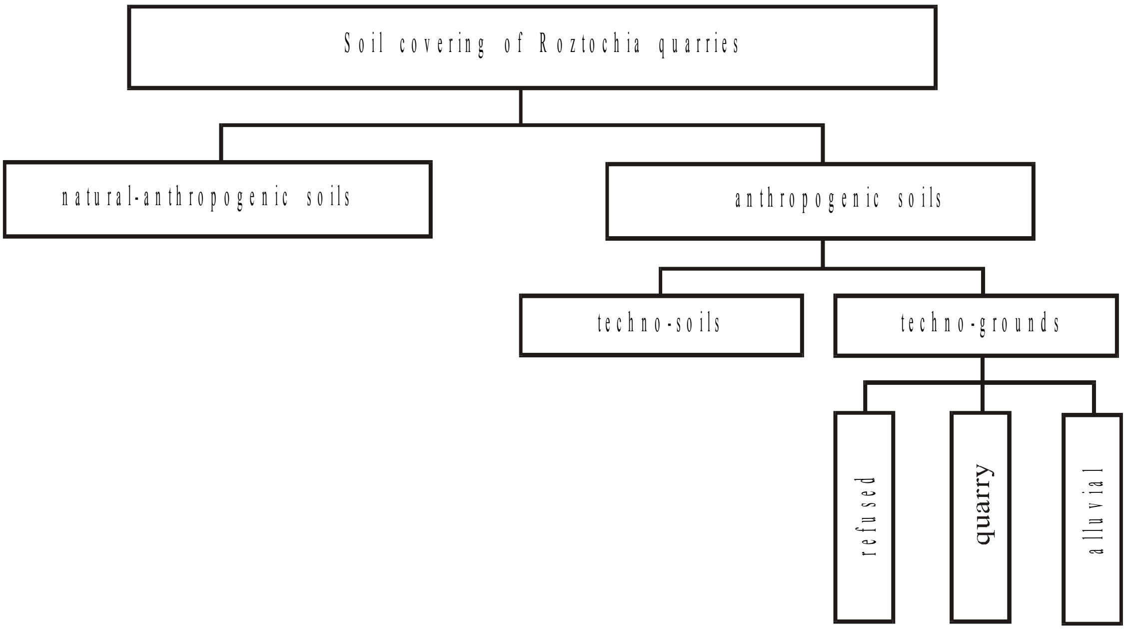

Fig. 1. The structure of soil covering of quarries in Roztochia.

Techno-grounds are the separate type of anthropogenic soils which include the soil formations developing spontaneously owing to interaction of the natural environmental components with soil-formative (refused) rock or another substrate. In most cases such a substrate is alien to zonal soil-formations, sometimes a toxic one, slowing down the process of biota inhabiting. The soil profile differentiated by genetic horizons is lacking, and available streaks are of an artificial origin and were formed in the process of pouring the heterogeneous rock into dump. Generally these rocks are of heavy mechanical structure, strongly thickened with small reserve of organic matter and other nutrients. They are littered by minerals quarried.

Within the industrial quarries investigated we have marked out the refused, quarry and alluvial techno-grounds, according to the origin and substrate condition. In the case, when the technogenic soil-formative factor dominates, under the “origin” we understand such a type of technological process which caused the formation of the available rocky substrate.

Refused techno-grounds apply to the top limit of quarry and are forming on a rocky substrate transferred at some distance and are often mixed with lower horizons of natural soils. The including of natural soil material favour the soil-formation process, owing to which the refused techno-ground becomes similar to recultivated techno-soil. Further evolution of refused techno-grounds is determined by the available soil-formative potential of refused rock (age and physical-chemical characteristics), by orographic conditions of dump (steepness and exposition of slopes) and by degree of disturbance of surrounding landscape. The refused techno-ground of a quarry develops on loess-form loam with poured humus horizon of dark-grey podsol and its functional condition conforms to the natural soils of a kind.

The extension of area, occupied by **quarry techno-grounds** clearly correlates with size of a quarry's pit of dumpless type and with a quarry's bottom of dumping type of output. At the first stage of soil-formation the quarry techno-ground is almost like crushed rock quarried. Thus, the initial substrate for quarry techno-ground is the rock alien to zonal type of soil-formations. During its environmental adaptation, at first the process of weathering takes place and its speed depends on the type and characteristics of rock. The substrate for soil-formations in the quarry of building materials near Potelych vill. consists of crashed rock mixed with loam. Being based on the minimum nutrient potential, the soil-formation process is stable and its speed depends on the duration of self-overgrowing period (besides the climatic features in the region). The longer the self-overgrowing period, the quicker techno-ground parameters reach the optimum. If the soil-formative rock is unusual for zonal soil-formation (tertiary loam of sulphur quarry) the adaptation of rock to the soil-formation process must be long-lasting.

Alluvial techno-grounds are technogenic formations on repeatedly redeposit rocky substrates of different age. Such substrates are typical for industrial areas adjacent to sulphur quarry. These are sandy substrates of hydro-damping and loamy-sandy mixtures forming the sections of underground sulphur smelting. According to the technological requirements of sulphur production, the rock is washed by powerful spurt of water, sometimes hot, washing away organic and mineral combinations which could provide the minimum initial fertility. Alluvial techno-grounds are characterized by considerable density and superfluous humidity. The process of inhabiting such kind of substrates by biota becomes complicated also on account of pollution by waste of sulphur industry and by toxicants.

The modern soil covering in quarries is formed by anthropogenic soils represented by refused, quarry and alluvial techno-grounds side by side with some fragments of natural-anthropogenic soils. The availability of either soil formation in soil covering composition depends on a series of natural and technogenic factors. The duration of self-renewal period and successional changes in edaphotope, based on the different types of substrate, determine the considerable heterogeneity of soil surface. Thus, the structure stated can be supplemented by new soil formations and additional descriptions of existing ones.

Among soil-ecological indices of techno-grounds the leading part belongs to water-physical parameters. Just those very parameters determine the trends of future soil evolution.

The comparison of spatial changes in physical characteristics of techno-grounds in the quarry's profile near Potelytch vill. showed that the most condensation of upper layer was observed at the bottom and in the sections of permanent operation with initial soil substrate available (Table). While the period of self-renewal in separate sections of the quarry increases, the density of techno-ground structure decreases and reaches the optimum only in the sections of insignificant operation, where at present the refused techno-ground is forming. The reserve of humidity depending on the physical parameters of techno-ground also decreases as the intensity of technogenic pressure increases. That is accompanied by forming xerophytic plant associations. The present functioning of techno-grounds surrounded by less disturbed landscapes lays down the ecological potential of future soil.

Table 1. Comparison of characters of natural soils and techno-grounds in Roztochia.

Main indices of soil condition	Natural soils	Techno-grounds		
		refusal	quarry	alluvial
Sampling depth, cm	0-10	0-10	0-10	0-10
Field humidity, %	30.4	10.3	12.9	14.4
Total humidity content, %	75.8	46.3	56.2	25.0
Structural density, g/cm^3	0.9	1.2	1.1	1.6
Solid structural density, g/cm^3	2.5	2.6	2.5	2.6
Porosity, %	65.6	54.8	58.3	39.8
Humus content, %	3.4	1.6	1.1	0.8
pH value	4.0	6.5	7.7	1.3
Metabolic coefficient	0.04	0.20	0.04	- 0.03
Overground phytomass ,	21.9	6.1	3.8	–
Underground phytomass,	7.2	9.7	2.4	–

According to conditions of self-renewal and type of substrate the reserve of organic matter in soil changes. The general content of humus in techno-grounds forming on quaternary crashed rock is determined by the initial nutrient potential of rock. The first morphological indications of humus horizon formation can be observed in sections being out of use during 5 - 10 years. Within alluvial techno-grounds of hydro-dumping, where the rocky substrate completely devoid of potential fertility, the accumulation of organic matter occurs slowly. In sections where the destruction of soil covering was accompanied by toxic sulphur pollution (alluvial techno-grounds of underground sulphur smelting) and plant cover is absent, the accumulation of organic matter and, thus, soil renewal is impossible. In general, for techno-grounds investigated the alkaline reaction (pH from 7.0 to 8.0) is typical, causing deterioration of soil absorption and, as a result, washing away the organic substances. The alluvial techno-grounds should be distinguished, in which strong acidic medium is formed (pH not over 2.0) owing to pollution by waste of sulphur production. In such case any biotic process is impossible.

Unfavourable environmental conditions (small humus reserve, strong alkaline or acidic reaction in medium, limitative effect of water-physical indices) reduce assimilation of nutrients and depress microbiotic activity in soil.

Thus, basing on the material stated above the total diversity of techno-grounds investigated should be divided into two groups, according to the perspectives of optimum functional renewal:

1. techno-grounds (refused and partially quarry ones), forming on soil-formative rocks of zonal type with initial nutrient potential available. As functional parameters show, in conditions of limited anthropogenic pressure and self-overgrowing, these techno-

grounds evolve in young weak soils of zonal type. The renewal of their ecological functions by natural means is quite possible;

2. techno-grounds (alluvial and partially quarry ones), forming on rocks, which are not soil-formative in present climatic conditions, or on rocks of zonal type, being modified by intensive physical and chemical anthropogenic processes. Natural renewal of ecological functions is possible only in quarry techno-grounds formed by non-toxic rocks. It is necessary to take into consideration the long-lasting renewal period, which is complicated by adaptation of alien rock to soil-formation process. The further evolution of soil profile is possible only after the complete cycle of recultivative and phyto-meliorative works.

Conclusions

It is necessary to lay stress on the continuity of soil formations considered, on the lack of sharp differences between natural and natural-anthropogenic soils, and between techno-soils and techno-grounds. In this connection, within the whole community of soils and new soil-formations one can distinguish the consecutive increase of anthropogenic transformation in accordance with main trends of technogenesis.

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Anthropogenic Soils of Modra Town

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Abstract

We bring our opinions to man-induced impact to soils. We solve question, if it is soil factor, condition or process. We created and realized conception of soil cover mapping in a part of Modra town terrain in three hierarchical categories. The main category divided the area into 5 anthropomakropedochors, which are distinguished in 9 anthropomezopedochors in lower category and 10 soil types and 15 soil subtypes of pedotops with diverse man impact in the lowest one. We also bring specification of soil cover objects and their classification, which are not mentioned in the work Šály et al. (2000). Conceptional mapping is based on conception of strong relations between soil and other components of land with using real and late character of land use.

Introduction

The reason for elaborate of this paper was that there are still only a few works focused on Slovak anthropopenic soils mapping including our publications (Kolény 1994a, 1994b, 1994c, 1996, 1998a,1998b). This article has relations to our fieldwork in 2 gardens in Modra and wood near the observatory Tisove skaly (Kolény 1996, 1998b).

We have several aims of work: to analyse man-induced impact to soil, if a man is considered as soil factor or process. Another aim concerns to draft mapping of area with strong relations between soil cover and other land components. The last aim is to specify objects of soil cover and their nomenclature. The aims number 1st and 3rd have considerable theoretical meaning.

Material and Methods

First group of the methods represents this one, which comes out from definitions of terms and logical qualitative and quantitative analysis of essence and appearance points of objects (soils with man impact). We analyse problem, when is man impact soil process and when it is only soil factor or condition.

The main methods are conceptional, because model area is large and specific (e. g. a lot of private areas). Added and verifying by pits digging (Čurlík, Šurina 1998, Kolény 1996, 1998b) is suitable for extrapolation on model area. We use also other methodical publications (Bedrna 1995). With soil problems in towns works also in foreign countries (Billwitz, Breuste 1980, Blume 1982, Blume 1989, Cordsen et al. 1990 and many others).

Base for last group of methods is criterion evaluation of soils with man impact and its classification (Smolík 1957, Hroššo 1961, Bedrna, Hraško, Sotáková 1968, Mičian 1977, Hynek 1984, Hraško et al. 1987, Hraško, Bedrna 1988, Němeček, Smolíková, Kutílek 1990, Hraško et al. 1991, Kolény 1994a, Sobocká 1999, Šály et al. 2000). We prefer type of man impact in soil subtypes taxonomy.

Results and Discussion

We bring only results to 1st aim for publications range reasons. If man does material input to soil and output from soils, man impact is soil factor. But in this case man does not agree with use real and relict structure of soil cover and interaction with its using. We create preliminary 5 main types of soil use in accordance with man impact. Wood soils are relatively least anthropic areas without places with tree cutting, where we can see changes of soil profile. Wood sub-area, which was once used for wine growing, has substantial soil changes and its structure is relict. Vineyards areas are strong affected by trenching, plantation and processes of collection of skeleton in two phases.

The first one, approximately to beginning of eighties years was built vineyards with anti-erosion constructions, skeleton was collected on the sides and create skeleton ramparts (local name Rúny) or man used ascents of very resistant granodiorities. There arose anthropogenic Rankers in both cases, Lithosols were only locally. These areas are covered by shrubs and xerotermic oaks. These places are also often used as dump sites. There is only a few localities with natural structure (e.g. localities Plázle, Ohnavy, Firigle). This type of vineyards was manually trenched to the depth of 60 cm. Mould horizon was invert (protect from freezing of vine). Majority areas of vineyards was created by terraces constructed from 1975 to 1989. Scuffling of native rampart of skeleton was mistake.

Type of arable land areas is divided in two forms: meliorate (with depth scuppering) in Modranský šúr and non-meliorate in hilly land (locality Hliny). One part of Modranský šúr has native woodland character. We can see derelict arable land and vineyards caused by spreading of sealing by urbanization. Gardens have specify soil condition in dependency on resources of owners. Hortisols are immediately intensive cultivated, manured and irrigated, with minimum of skeleton and often with highest amount of chemicals. Gardens arrangement were locally generous (Kolény 1996). Main part of Hortisols soil qualities are close to natural soils. They have a little bit more mould and low skeleton. Cambisols are dominated, there is lower Fluvisols and Phäozems. Old plots in central town and upper and lower suburbs belongs to this category. Rigol-Cambisols and Kultisols are dominated in new urban parts of Modra town in Vineyards zone. Technical surfaces have only few small areas with Technosols. Differences are noticeable in the map.

We have several comments to different types of man impact to soils and latest soil terminology (Šály et al. 2000). There is not possible to place Kultisols subtypes in the same hierarchical level with others process subtypes. What can we do, if everyone of non-modal type of soil is ploughed. All others subtypes can be only under meadows in this case. If man impact is process, it is good to use it in Kultisols subtypes taxonomy. Degradation processes are not respected in this case. There fail some marked soil types, such as Anthropo-Ranker, Hydrosols and nearer specifying of Fluvisols (to Rambla, Paternia, allochtone Vega and Borowina). There is only initial Anthrosol in Technosol category of this thesis.

We have conceptional entrance to anthropic impact on soils of Modra town. We suppress natural qualities of site. In case of indirect anthropic impact is man like soil condition, he also does not suppress natural qualities of site. If man has direct impact on soil formation or methamorphoses of soil profile or visual non-identified principal change of soil quality is man impact very specify soil–forming or soil-disturbing process. We made this result after reflection about global man impact to the Earth. Result is that all soil cover is anthropic soil, which is diverse only by quantitative parameters of man impact. Not everyone is ready to.

Conclusion

In this paper we specify, in what case is man impact considered as soil factor, or condition or process. We created and realized conception of soil cover mapping in a part of Modra town terrain in three hierarchical categories. The main category divided the area into 5 antropo-makropedochors, there are occurred 9 antropomezopedochors in lower category and 10 soil types and 15 soil subtypes of pedotops with diverse man impact in the lowest one. We also bring specification of soil cover objects and their classification, which are not mentioned in work Šály et al. (2000). Conceptional mapping is based on conception of strong relations between soil and other components of land with using of real and late character of land use.

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Example of Intensive Anthropization of Sandy Soils

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Abstract

A detailed soil investigation was realised in the Borská nížina Lowland (northern part of the Viedenská Panva Basin) in 1999 - 2000. The localities under impact of intensive cultivation and neighbouring forest stand with planted pine monoculture were studied. The analysis of soil samples (35 probes) - pH, content and quality of humus, content of nutrients available for plants and content of water soluble salts were done by actual analysis methods.
The results of study of intensive influence on sandy soils showed, that livestock yard soils were, compared to forest acid soils (pH H_2O = 4.2 – 5.4), strongly alkalised (pH H_2O = 7.9-10.1) as consequence of indirect human impact. These soils contained also considerable bulk of water soluble salts. Increasing content and higher quality of the organic matter were found in the livestock yard soils in comparison to forest soils.
Concerning arable soils, the successive compaction of subsoil (as a negative anthropic factor) is evident. The content of nutrients was substantially higher than in the forest soils. Also the soil acidity was partially affected by liming. A positive anthropization was manifested in higher quality of humus and also by an increase.
In this paper, two different levels of human influence on soils (positive as well as negative) are presented. The parameters, characteristics and soil quality indexes determine an impact on agricultural land soils. A negative impact on sandy soils can result into their degradation and contamination.

Introduction

A detailed soil investigation was realised in the Borská Nížina Lowland (northern part of the Viedenská Panva Basin) in 1999 - 2000. From the point of anthropization the Borská Nížina Lowland is interesting mainly for its contrast structure with ecosystems, not or minimally intervened by human and also with intensively used agricultural land. Recent status of anthropic influence to pedosphere is in certain phase of evolution, it reflects in a sum of soil changes, evoked by man who indicates some trends of evolution in human influence to soils (Račko 1994).

The aim of our research of soil was to evaluate recent situation of agricultural land-use in landscape of the Borská Nížina Lowland and the determination of the anthropic influence intensity. The level rates of anthropic influences on soils in conditions of sandy soils at the Borská Nížina Lowland in locality Táborisko were determined by their morphological, physical and chemical characteristics in different ecosystems.

Material and Methods

The soils and their profiles were selected from following ecosystems: forest soil, meadows used as pastures, livestock yard soil (high density of cattle, time of usage was 20 years), extensively used garden (vineyard, vegetable), and arable soil ecosystem (area under permanent crops).

Morphological records and soil classifications were done according to the Morphogenetic Soil Classification System of Slovakia (Collective 2000). Soil colour was determined by Munsell charts (Oyama, Takahara 1967). Soil samples from humus horizon were used for agrochemical soil characteristics determination. Chemical characteristics of soil samples were determinated by standard methods (Hanes et al. 1995):

– total content of organic carbon, Tyurin`s method, modified by Nikitin
– total content of nitrogen (Nt), method by Kjeldhal,
– content of potassium, method by Schachtschabel,
– soil reaction in water, 1 M KCl and 0,01 M $CaCl_2$ solutions by pH-meter,
– fractional composition of humus – from short fractionation by Konovová-Belčiková.

In the soil samples from soil profile of livestock yard the content of water soluble salts was analysed. Physical characteristics of soil profiles in observed soils were characterised by selected parameters (indicators): bulk density, soil particles density, porosity, maximal capillary water capacity, minimal air capacity

On the base of analytically determined values and their comparison were made conclusions about level of anthropic influence on soil development and environment in region Borská Nížina Lowland.

Results and Discussion

The Borská Nížina Lowland represents a higher degree of anthropogenically influenced landscape. From a relatively intact up to disturbed devastated landscape. The soil anthropization at the Borská Nížina Lowland is divided into two different levels (positive and negative) (Paračková 2001a, 2001b).

Morphological properties

The shallow humus horizon under the forest litter is typical for forest ecosystem. The arable soils were intensively cultivated in last years. In the seventieth years amelioration tillage was done. Difference occurred in consistency: subsoil horizon at the arable soil was cohesive and in the forest mellow. The highest differences of morphologic characteristics were observed between soil profiles of livestock yard soil and the forest soil. Unfinished decomposed excrements together with plant roots were found in 0.0-0.4 m layer of soil profile in livestock yard.

From the listed issues at the Borská Nížina Lowland we defined an intensive human influence on morphological soil characteristics, mainly:

– Deepening of A-horizon at arable soil, in garden by tillage. In cultivated meadow ecosystem there was only slight A-horizon deepening. In the livestock yard in one case the A-horizon was deepened in 0.6 m, in the other case wasn't. In this case a sod hydromorphic horizon originated to 0.18 m.
– Forest profile was darker than profile at arable soil, but compared to others the colour was identical, differed only by chroma.
– In several cases there were differences in consistency. Forest soil was more mellow.

Comparing by Škoda (1999), who described low and medium anthropization of soils at the Borská Nížina Lowland, we recognised a stronger soil cultivation. Soil anthropization considerably relates with land utilisation as intensive soil cultivation, livestock breeding, etc. It was confirmed that anthropization caused A-horizon deepening and also the soil type change as mentioned Kolény (1994).

Physical properties

More significant changes of physical characteristics were in bulk density and total porosity (Paračková, Zaujec in press). The values of bulk densities in livestock yard soil were strongly decreased (1,176.7 $kg.m^{-3}$ and 601.7 $kg.m^{-3}$) due to the accumulation of organic matter in comparison to soil from the forest ecosystem. Compaction of subsoil was clearly determined in arable soil, what is documented by higher values of bulk densities in Akm_2 horizon (1,804.5 -1,808.7 $kg.m^{-3}$) than in Akm_1 horizon (1,566.4 – 1,674.5 $kg.m^{-3}$). Different development was in the garden, because the bulk density in humus horizon was optimal for sandy soils and towards deep it gradually mounted up. Other it was in case of meadow ecosystem, where the bulk density values in humus horizon were very close to the critical value. These high numbers are results of soil compaction by animals.

We determined also differences in porosity. In livestock yard the porosity is high in humus horizon and sod hydromorphic horizons (55.34 – 77.16 %) due to high volume of organic matter. It is very mellow soil, but because of high concentration of animals in the livestock yard the consistency is cohesive. In the garden there are optimal values of porosity. On the arable soil the porosity is low due to compaction of subsoil.

On sandy soils the aggregates are missing in elementary structure, the soil is compressed with a lack of air, because capillary pores absent. By total pore space can be stated that at the arable soil, meadow and in the livestock yard on the soil type alkalic-Anthropic Regosols (ANô) these values are critical. Similar it is in garden soils. Other situation is in the livestock yard on the soil type Eutric Hortic Anthrosols, where in humus horizon the values are optimal but towards depth the total pore space is critical. This statue is caused by influence of gleyic oxic-reducing horizon, where the consistency is cohesive.

Soil reaction

The highest soil acidity and low values of soil reaction from very strongly acid to strongly acid soil (pH H_2O 4.2-5.4) in forest soil were determined. It was created by conditions to podzolization in this soil environment, poor to minerals and soil colloids. The arable soil after intensive liming and fertilization which caused a strong neutralization of soil acidity from very strongly acid to slightly acid and very slightly alkaline soil reaction (pH H_2O 5.6-7.3). Soil reaction in livestock yard soil was strongly alkaline (pH H_2O 7.9-10.1) by intensive accumulation water-soluble salts and organic substances from cattle excrements.

It is evident that cultivation, fertilisation and liming of observed agroecosystems markedly improved soil reaction (soil acidity reduction) not only in humus, but also in subsoil horizons.

Comparing with Škoda (1999), who determined minor improvement of soil reaction in humus horizon on sandy soils, our results shows strong change of soil reaction by liming.

Comparing with Bedrna (2000), i.e. low intensity of positive anthropization due to lower effective fertilisation and liming, we determined strong soil anthropization in military forests and plots neighbouring to Malacky. In observed soils the soil acidity was strongly neutralised and high intensity of anthropization was confirmed.

Humus

Comparison of the humus content in soils from selected land showed that different level of anthropization caused its increase or decrease. Values of soil organic matter show that humus contents (%) of forest and meadow soils in surface humus horizons are approximately equal. Due to soil cultivation we registered a great fall of humus content in humus horizon at the arable soil and in the garden with vegetable patches. This humus loss is a result of organic matter and humus mineralisation, which is stronger than humification. Higher percentage we determined in livestock yard and vineyard soils. It can be explained by accumulation of livestock excrements in the livestock yard and more frequent fertilisation with higher batches of organic manure in vineyard.

In calculated total humus in soil ($t.ha^{-1}$) – concerning thickness of humus horizon, humus content and bulk density – it is shown that Eutric Regosols in meadow ecosystem contain 16 – 126 $t.ha^{-1}$ more humus than in the forest. Alkalic-Anthropic Regosols in livestock yard contain 64 – 106 $t.ha^{-1}$ more humus than in the forest. Histi-Mollic Gleysols contain 16 $t.ha^{-1}$ less humus than in the forest. Eutric Hortic Anthrosols had slightly more humus. Other situation is on the Ari-Anthropic Regosols on the arable soil, where due to cultivation, the humus content slightly decreased and also increased.

Humus quality also can be evaluated from ratio C_{ox} : N_t. In studied humus horizons the humus quality was considerably different. We can document it on soil profiles from forest and arable soils, where on the arable soil the humus is better (C:N = 13.4 –14.3) compared with the forest (C:N = 15.3 – 26.6). Similar situation was also in the garden under the vine, where the humus quality (C:N = 11.8 – 12.8) was slightly better than at the arable soil. The garden soil under vegetable patch (C:N = 14.2 – 10.4) was slightly worse than soil under the vine. In livestock yard soils compared with forest we recorded rich and very rich humus (C:N =10.7 – 12.6) depending on the soil type.

Humus quality was determined by short fractionation according to Kononová – Belčiková in humus horizons, where we determined low degree of extractionability of humus matter from total organic carbon content and also low content of humic and fulvic acids. Interesting situation occurred in humic and fulvic acids ratio (HA/FA) in soil type Eutric Regosols, where in meadow ecosystem the ratio HA/FA was 1.14 and 1.182, the humic acids prevail, so the humus quality is better. Other situation is in livestock yard soils, where the HA/FA ratio is 0.75 and 0.86, the fulvic acids prevail, and the humus quality is lower. In garden soils determined values vary according to gardening plant species, while in vineyard soils the content of humic acids (HA/FA = 1.15) means high and higher quality of humus. In soils under vegetable patch fulvic acids prevail (HA/FA = 0.85) i.e. lower humus quality. In soils of type Ari-Anthropic Regosols at the arable soil fulvic acids prevail (HA/FA = 0.94 and 0.89). The relatively higher values of the colour coefficient Q4/6 HA (5.20 and 2.36) and low values of proportional representation HA/FA (0.96 and 0.64) correspond with the humus substances with low degree of condensation and quantitative predominance of fulvic acids over humic acids in Umbric Podzols and spodic Eutric Regosols in forest. Colour coefficient shows to similar relationships.

Total nitrogen content in surface horizon of examined profiles was various (0.04 – 0.33 %). Extremely high nitrogen content is in livestock yard soils. High nitrogen content is also in meadow soils and in the garden under the vineyard. Reverse trend was in soil profiles of Eutric Hortic Anthrosols and in the garden on vegetable patch, where the nitrogen content was low.

Nutrients available to plants

Content of phosphorus and potassium available to plants was determined only in humus horizons of soil profiles in all ecosystems. Content of phosphorus available to plants is often considered as a criteria of positive soil anthropization. Following anthropization the nutrient (phosphorus, potassium) reserve in soil increased. In general, these soils are strongly cultivated, what is visible in good and medium content of available phosphorus in soil. In most of cases the reserve of available potassium was small and good. In livestock yard we must notice extremely high content of potassium and phosphorus.

On the other side Škoda (1999) states that there was no stronger increase of plant available nutrients in arable soil following its cultivation. Compared with Bedrna (2000), who also described small and medium intensity of positive soil anthropization, our results show strong intensity of human influence onto soils. We can confirm, comparing with Kobza (1999), that in observed pedological parameters the cultivation effect at arable soil it has been seen, for example higher values of available nutrients – phosphorus and potassium.

In livestock yard the soil was extremely alkalised due to soil salinisation with water soluble salts from livestock excrements. It is a bicarbonate salinisation. The most occurred ions were HCO_3^-, K^+, NH_4^+. In the livestock yard we determined salinisation without any analogue in literature.

Because, the evaluated soils are light, have sandy texture, there is real danger of eluviation of water soluble salts to underground water and contamination of the environment.

Soil classification

When comparing degree of anthropization also classification of soil types and subtypes is important. We used the Morphogenetic Soil Classification System of Slovakia (Collective, 2000). Soils of the meadow ecosystem we determined as Eutric Regosols. Soils of the garden locality we determined as Eutric Hortic Anthrosols, at the arable soils as Ari-Anthropic Regosols. In livestock yard soils, one was classified as Alkalic-Anthropic Regosols and second as Histi-Mollic Gleysols according to classification. In classification (Hraško et al. 1991) strong degree of anthropization in livestock yard soils as a separate soil type was not considerated. Also Bedrna (1999) noticed this failure. Anthropic Regosols is according to Hraško et al. (1991) only a soil on anthropogenic substrate. According to Račko (1999) if on anthropogenic substrates natural soils developed it is not necessary to call like Anthropic Regosols.

Very important is, that Slovak soil classification (Collective, 2000) specified characteristics of particular soil horizons and also enlarged the number of soil subtypes. Substantial is the subtype "kultizemná" as an influence of soil anthropization, also radical changes in subtype classification of Anthrosols and Anthropic Regosols. Controversial was the name of the livestock yard soils: the first one was determined as Alkalic-Anthropic Regosols, but better name would be Gleyic –Anthropic Regosols.

Conclusions

1. Different level of intensity of anthropization is represented by a high influence of man on the soils by positive and also negative way in observed area (Borská Nížina Lowland). The intensity of anthropization has been increased by forest soil across garden, meadow and arable land to soil in livestock yard in the Borská Nížina Lowland.
2. Anthropization, first level, was morphologically represented by deeper humus horizon. Extreme degree was showed on creation of humus horizon in livestock yard soils in soil type Alkalic-Anthropic Regosols.
3. Anthropization caused stronger changes in physical characteristics (bulk density, porosity) mainly in the livestock yard and at the arable soil, but also in the cultivated meadow ecosystem. In the livestock yard due to organic matter accumulation the bulk density value strongly decreased, so far in the forest ecosystem it is naturally compacted. In the arable soil, compaction of subsoil was clearly determined as

a result of negative human influence. In meadow ecosystem the animal grazing also caused gradual soil compaction, shown in high bulk density values and reduced porosity.

4. Anthropic influences on soil chemical properties: the soil acidity was reduced due to liming. We determined a great humus content decrease, because of stronger mineralization by soil cultivation in Ari-Anthropic Regosols at the arable land and in the garden on vegetable patches. In observed soils with higher humus content ($t.ha^{-1}$) it was slightly decreased, but also increased. Interesting it was in the meadow ecosystem: the humus content in $t.ha^{-1}$ strongly increased. In the soil type Histi-Mollic Gleysols the humus content in $t.ha^{-1}$ decreased. Humus quality in observed soils following anthropization strongly changed. The availability of phosphorus, nitrogen and potassium for plants was increased. In livestock yard the soil was extremely alkalised with water soluble salts from livestock excrements. These light sandy soils can endanger groundwater and environment with salt washout.
5. The effects of evaluation of human impacts on soils and different land-use on the quality and quantity of soil organic matter were studied at the Borská nížina lowland, location Táborisko where the soil generally was classified as Regosols. The short fractional composition of soil organic matter was done by Konovová-Belčiková method in humus horizons, where we determined low degree of extractionability of humus matter from total organic carbon content and also low content of humic and fulvic acids.
6. Anthropic soils were classified generally as Anthropic Regosols: in the garden locality it was Eutric-Hortic Anthrosols, at the arable soil as Ari-Anthropic Regosols. Controversial was the name of the livestock yard soils: the first one was determined as Alkalic-Anthropic Regosols, but better name would be Gleyic-Anthropic Regosols. The second one is Histi-Mollic Gleysols. A lot of authors intend that classification of anthropogenic soils should content all soil types and subtypes changed or created by man. We also recommend to the Pedological society to include this into update of new basal soil classification.
7. In this case study are presented two different levels of anthropic influence on soils (positive and negative). Parameters and characteristics or indicators of soil quality define impact on soil in the agricultural landscape. Negative influence at sandy soils can cause a danger of soil degradation and contamination. Trend of our soil development is up to all of us.

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Anthropogenic Soils - Some Physical Properties and Characteristics

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Abstract

Anthropogenic soils (man-made soils) have very often different properties in connection to surrounding environment as soils which arise in such environment in natural way. Such different properties, it means properties which are not in equilibrium with natural environment can cause a lot of problems, e.g. erosion processes (water, wind), not suitable air and water regimes, pollution of ground water, health problems for people and biota. Two possibilities can be considered: plants can or cannot grow on these soils. The first case is positive action in soil and the second fact causes degradation of soil as a place for plants growth. Therefore there is a need to monitor all their properties. Especially physical properties are part of the anthropogenic soils monitoring. We have observed some physical features to manifest and present some pecularities of anthropogenic soils which are not typical for natural soils. Finally it is necessary to manage man-made soils in such a way which leads to closer equilibrium with natural environment.

Introduction

Anthropogenic -“man made“ soils have very often different properties as natural soils. For natural soils is typical characteristics close equilibrium with surrounding environment. Anthropogenic soils in dependence of their formation process are in more or less close connection with surrounding environment. This is one of reasons why such soils need monitoring. Especially soils with completely different properties as natural ones can be potential risk for environment. Soil monitoring is necessary also for knowledge of development such soil’s properties. Physical properties belong to basis and influence the other soil properties. They have to be part of soil monitoring.
For anthropogenic soils some typical physical properties are characteristic:

– soil profile with extreme horizon;
– soil profile with layers with extreme texture;
– alternation of layers with high (very high) and low (very low) water and air permeability;
– extreme particle density (r_s› 3,0 g.cm^{-3});
– extreme basic physical properties.

Material and methods

Localities in study were from two types of soil anthropization process. On one side it was process of degradation of soil properties, on the other side it was process of positive intensive cultivation. For soil types description we have used the Morphogenetic Soil Classification System of Slovakia (2000). Followed localities were recognized and analysed in this study:

Degradation process

Banská Bystrica site:

- Anthrozem Modal, spoil heap form, from building waste material
- Anthrozem Modal, dumping form, from municipal waste material

Galanta site:

- Anthrozem Modal, spoil bank form, from nickel metallurgy waste material.

Intensive cultivation

Soblahov site - Cultizem Modal, trenched form, hop garden;
Dolné Vestenice site - Cultizem Modal, trenched form, intensive orchard.

From investigated soils we taken core samples for basic physical properties determination into steel cylinders with volume 100 cm^3: bulk density (r_d), particle density (r_s), total porosity (P), non-capillary porosity (PN), capillary porosity (PC), maximal capillary capacity (MCC), retention water capacity (RWC).

Results and Discussion

Anthrozem Modal, spoil heap form, locality Banská Bystrica

The first investigated locality is building waste.

Table 1. Basic physical properties.

Depth (m)	moisture content (Q)	rd ($g.cm^{-3}$)	rs ($g.cm^{-3}$)	Q P	Q MCC	Q RWC	Q PN	Q PS	Q AC
0-0,2	21,25	0,89	2,77	67,8	43,4	34,1	12,8	21,0	24,4
>0,2	12,41	1,36	2,82	51,7	22,1	17,9	25,0	8,7	29,5

This soil was in building area. Deposit from different soil is on the top. For basic physical properties we can see that on the top investigated soil has low bulk density and high total porosity. Maximal capillary capacity is very high (limit value is 35 % of volume). In deeper layer MCC decreases very rapidly. In natural conditions such rapid decrease is not obvious. In both investigated layers soil has very high volume of air.

Anthrozem Modal, dumping form, locality Banská Bystrica

The second investigated locality is municipal waste deposit.

Table 2. Basic physical properties.

Depth (m)	moisture content (Q)	rd ($g.cm^{-3}$)	rs ($g.cm^{-3}$)	Q P	Q MCC	Q RWC	Q PN	Q PS	Q AC
0-0,2	27,76	1,11	2,68	58,6	37,5	34,2	17,4	7,00	21,1
>0,2	34,62	1,46	2,66	45,0	41,5	40,3	2,0	2,7	3,6

Soil has high porosity in upper horizon. In deeper layer total porosity decreases rapidly due to non-capillary porosity and MCC increases. Because of low porosity, high MCC and low air capacity (below 10 % of volume) soil is compacted in deeper layer.

Anthrozem Modal, spoil bank form, locality Galanta

Second investigated locality is nickel metallurgy spoil bank.

Table 3. Basic physical properties.

Depth (m)	moisture content (Q)	rd (g.cm^{-3})	rs (g.cm^{-3})	Q P	Q MCC	Q RWC	Q PN	Q PS	Q AC
0-0,2	20,38	1,21	3,94	69,4	39,9	34,9	24,2	10,4	29,5
>0,2	29,7	1,42	4,29	66,9	48,4	44,4	13,2	9,3	18,4

This is typical spoil soil. Soil has typical non-natural character from most physical point of view. Particle density is very high (3,94 - 4,29 g.cm^{-3}). Natural soils do not have such high particle density (normal is about 2,60 g.cm^{-3}). Such high particle density is due to man made cumulation of one type of material. Total porosity as well as MCC is very high. Non-capillary porosity of upper horizon is very high, which is not typical for natural soil.

Cultizem Modal, trenched form, locality Soblahov

Table 4. Basic physical properties.

Depth (m)	moisture content (Q)	rd (g.cm^{-3})	rs (g.cm^{-3})	Q P	Q MCC	Q RWC	Q PN	Q PS	Q AC
0-0,12	29,14	1,40	2,66	47,6	34,6	31,6	10,1	5,9	13,1
0,12-0,32	16,0	1,32	2,68	50,8	35,1	31,1	10,1	9,6	15,7
0,32-0,39	24,22	1,45	2,66	45,7	35,8	33,2	6,7	5,8	9,9
>0,39	25,8	1,55	2,69	42,1	37,3	35,1	5,82	4,5	4,9

This soil is utilised for hop production and is trenched. It is medium heavy soil. Two upper layers have suitable physical properties. From layer 0,32 cm the soil is compacted because of total porosity value which is lower than limit value for this textural category ((P=47 % of volume). From 39 cm soil compaction is more intensive. Bulk density is higher than limit value 1,45 g.cm^{-3} for this textural category.

Cultizem Modal, trenched form, locality Dolné Vestenice

Table 5. Basic physical properties.

Depth (m)	moisture content (Q)	rd (g.cm^{-3})	rs (g.cm^{-3})	Q P	Q MCC	Q KN	Q RWC	Q PN	Q PS	Q AC
0-0,24	22,94	1,15	2,62	56,0	47,9	40,5	37,8	12,7	5,6	15,5
0,24-0,4	23,2	1,65	2,68	38,3	41,8	38,4	36,7	0,0	3,7	0,0

According to most values this soil is extremely compacted in lower layer. Especially bulk density, total porosity and air capacity are unsuitable from soil compaction point of view. In natural conditions such intensive compaction is not present.

Conslusions

Soils which arise from anthropogenic activities can have such physical properties which are similar to properties of natural soils. They also can have completely different physical properties in dependence of type of process of their development.

Soils which are used for agricultural purposes have less different properties as natural ones in comparing with, e.g. spoil soils.

For anthropogenic soils is very often typical compaction or extreme change of texture as well as basic physical properties in different layers. Their horizon is very heterogeneous.

Soils which arise on materials extremely cumulated on one area can have completely different properties as natural soils, e.g. extremely high particle density, which arises “non-soil typical” values.

More close equilibrium of such soils with environment less risk for this environment.

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SPECIFIC PROBLEMS OF ANTHROPOGENIC SOILS, THEIR QUALITY AND CONSERVATION

Content of Macroelements and Some Trace Elements in Dust Fallout within Szczecin Urban Area

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Abstract

The results of the studies indicate that the surface layer of park soils, adjacent to the streets of Szczecin centre, is characterised by a relatively small accumulation of heavy metals (e.g. lead content does not exceed 100 mg $\times$ kg^{-1} d.m.) a considerably higher content of heavy metals, mainly Cd, Pb, Zn, was found in the dust fallout on some of eight chosen objects, important for functioning of the city. The content of macroelements in the fallout under study is decreasing as follows: Ca > Mg = K > Na.

Introduction

Many authors in Poland e.g. Łukaszewicz (1989), Czerwiński and Pracz (1990), Zimny (1993), Chmielewski (1996), Niedźwiecki et al. (2000) point to specific environmental, microclimatic and soil conditions in expanding, at a great pace, urban agglomerations. The distinctness of urban environment, industrial – urban in particular, is evident in the dust and gas pollution of atmospheric air, which has been quite common phenomenon so far. Particulate pollutants containing trace elements are extremely harmful both to the health of inhabitants and plants and animals (Wixson, Davies 1994, Górka et al. 1998, Kabata – Pendias and Pendias 2000).

Due to the installation of dust collection devices in industrial plants and greater popularity of gas heating, the dust emission in Szczecin (population 430 000) is clearly decreasing in comparison with 1991. Despite the decrease in the amount of total dust fallout, the measurements taken by the State Sanitary Inspectorate from several places in Szczecin show that the permissible amount of lead fallout (100 mg Pb / m^2 / year – WIOŚ, 1997) has been exceeded.

This is the result of the more and more intensive car transport and secondary emission of dust fallout from the streets moved up into atmosphere as a result of traffic.

The range of secondary dust emission, according to Kwapuliński et al. (1991, 1999) and Górka et al. (1998) can be observed even 100 m from the emitter and depends on the car traffic intensity, the diameter of particles, wind velocity and direction, air temperature and humidity and municipal infrastructure of street surroundings.

This paper is the continuation of the research presented by Niedźwiecki et al. (2000) during the „First International Conference on Soils of Urban, Industrial, Traffic and Mining Areas" (University of Essen, Germany). Its main purpose is to illustrate the content of macroelements and certain trace elements in the dust fallout from the flat surfaces and other objects located near the streets with heavy traffic. Besides, there will be some information about the harmful effects of those elements on the natural environment including the health of Szczecin inhabitants.

Material and Methods

The samples of the dust fallout were collected from the following places: inside living spaces (window sills, balconies, stairs, furniture), outside building walls of the shops, gas station areas, road sides (sidewalks), children's playground, buildings in the vicinity of Grain Silo „Ewa" (quay), the road to the municipal landfill in Sieraków and the machinery there.

The material was collected in summer (June – August) 1998 in the sunny and windless period. In the case of the surfaces outside and inside of living spaces and outside the shop buildings the material was collected many times to obtain composite samples. The same was done for the gas station area and children's playgrounds. The samples from the Grain Silo „Ewa" (rooms for workers, cloakroom, store–room and repair–shop) were collected only once. Forty one samples were collected altogether. They were representative of eight chosen elements important for functioning of the city. The material collected from the road to the municipal landfill site and the road side and city squares was sifted through a plastic sieve with 0.1 mm openings to eliminate coarse –grained sand.

In collected dust samples the content of organic matter was determined. Atomic absorption spectrometry by means of Solaar 929 spectrophotometr was used for analyzing macroelements and some trace elements after treating the samples with the solution of concentrated HNO_3 + $HClO_4$. The accuracy and precision of the method were tested on the basis of the determination of the above mentioned heavy metals in the referential material MESS – 2.

Results and Discussion

In the years 1947 - 1960 Szczecin was called the city of parks, diversity of trees and shrubs, mostly of parks, diversity of trees and shrubs, mostly of foreign origin, the location of the city among the primeval forests – Bukowa, Wkrzańska and the nearness of Goleniów Primeval Forest, favoured the name.

In recent years within the city the decrease in vitality of trees is being observed, especially along the streets with intensive car traffic. Mazur (1993) reports that in 1979 305 dried trees were cut down and 686 in 1981 (mostly lime-trees and ash trees). Among the reasons for such a state of trees, except for using salt to remove snow from the streets, intensive car transport and connected with it the amount and quality of fumes as well as secondary dust emission, are also mentioned.

Chemical composition of the dust fallout within Szczecin, is presented in Table 1, 2. The data in Table 1 show that the content of potassium in the dust collected from the roads and road side objects, is similar to the amount found in the surface layer of the soils near the streets (Niedźwiecki et al. 2000). Increased amount of potassium in the dust collected from the buildings near "Ewa" Grain Silo results from different properties of the dust since it contained 69.6 - 76.0 of organic matter. There was more magnesium than potassium on the objects situated near the streets, whereas the organic dust of the Grain Silo had two times lower amount of magnesium in comparison with potassium. Average values of potassium and magnesium, calculated on the basis of 8 chosen elements of city functioning, prove that the content of those chemical elements in the dust is similar. The concentration of calcium and sodium is several times higher in the dust fallout in comparison with the soil.

The obtained amounts of iron, manganese, cobalt, lithium and vanadium (Table 1) in the dust fallout near the streets, corresponded with the amounts of those elements in the surface layer of Szczecin soils. The concentration of Cd, Pb, Zn and Cu (Table 2) in the examined material may be the reason for concern. In the case of the dust from road sides, the concentration of cadmium amounted to 2.25 $mg{\cdot}kg^{-1}$ dry matter, and even 5.7 $mg{\cdot}kg^{-1}$ dry matter in the dust inside the buildings (I, II floor) located along the build-up area without any trees. The highest level of cadmium 31.6 $mg{\cdot}kg^{-1}$ dry matter was found in the dust of repair shops of “Ewa” Grain Silo. The distribution of copper (Table 2) is similar.

All in all, the observed level of lead and zinc in the dust can be considered to be high and typical of urban environment. A particularly high concentration of those elements were accumulated in the dust collected from the exterior surface of the buildings (952.1 mg Pb $\cdot kg^{-1}$ dry matter and 2970.2 mg $Zn{\cdot}kg^{-1}$ dry matter) and in the dust from the surface of machinery working at municipal landfill site (1029.3 mg $Pb{\cdot}kg^{-1}$ dry matter and 3389.3 mg $Zn{\cdot}kg^{-1}$ dry matter) and from the repair shop of “Ewa” Grain Silo (763.0 mg $Pb{\cdot}kg^{-1}$ dry matter and 3708.7 mg $Zn{\cdot}kg^{-1}$ dry matter). This state in some parts of the city may be a threat to the vegetation and health of the inhabitants.

Conclusions

The chemical composition of the dust fallout of Szczecin agglomeration was characterized by:

1. the highest amount of calcium and the smallest amount of sodium, with the average content of magnesium and potassium maintained at a similar level,
2. the contents of iron, manganese, cobalt, lithium and vanadium corresponded, in general, with the amount of those elements in the surface layer of the city soils,
3. a high concentration of heavy metals (Cd, Pb, Zn, Cu) which in some parts of the city may be a threat to the vegetation and health of the inhabitants.

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Table 1. Content of macro and some trace elements in dust fallout collected in 1998 with surface of different sampling sites of Szczecin urban area (mg×kg^{-1} d.m.).

Sampling sites	K	Mg	Ca	Na	Al	Fe	Mn	Co	Li	V
Gas station areas	2077 1596-2915	3203 2265-4526	27423 15820-57015	628 440-865	11298 6900-15655	22262 14045-27750	352 305-453	8.4 6.8-11.8	9.3 6.6-14.3	35.5 15.9-57.3
Road sides (sidewalks)	1674 1310-2097	4304 3302-5007	21959 16665-30090	676 578-741	11018 8705-13230	26272 24220-28575	366 315-425	7.6 6.1-8.6	10.8 7.8-14.1	20.6 25.6-35.3
Outside building walls	3508 3024-4320	9705 3106-21120	146745 28570-337700	2374 1868-2971	9992 8705-11335	21652 14550-26775	318 243-403	7.7 7.1-8.3	9.6 7.8-11.8	29.8 24.6-35.9
Inside living spaces	4395 3537-5094	5829 2170-14580	90918 20200-272900	5360 3000-9120	9635 2736-12850	13346 9536-19350	204 104-335	7.3 4.2-9.2	8.4 2.1-11.7	29.2 6.2-42.8
Children's playground (20-25 m from road)	2319 2208-2430	2391 2219-2564	6634 2053-11215	390 389-390	13435 10625-16245	16027 13435-18620	241 209-273	6.4 5.7-6.9	12.9 9.4-16.4	30.5 21.6-39.4
Road to landfill site of municipal wastes	1763 1270-2825	7108 2624-29950	78941 22565-327700	817 470-1805	11269 8460-13165	23369 15360-29825	398 319-456	9.2 7.3-11.7	10.8 7.2-13.2	31.2 26.1-34.5
Machinery and devices on municipal wastes	2573 2147-3028	4288 2627-5796	79894 59363-104480	1155 706-1574	19973 9670-37875	38391 12860-74850	517 260-837	38.4 14.7-71.4	23.9 10.1-51.1	17.9 3.4-28.4
Buildings in the vicinity of Grain Silo „Ewa”	16885 14490-19280	6013 5058-6969	13520 9045-17995	632 326-805	5205 3435-6975	12192 10260-14124	180 171-190	5.5 2.4-11.4	10.4 7.3-14.8	14.8 11.2-18.4
Warehouses in the vicinity of Grain Silo „Ewa”	10137 5379-14895	6120 5163-7077	70000 14345-125655	1948 1283-2614	6335 6245-6425	8298 8225-8372	174 160-188	3.4 3.2-3.4	8.0 7.2-8.7	20.0 19.8-20.1
Metal and repair shops of Grain Silo „Ewa”	6113 2632-9595	3689 2369-5009	19317 10215-28420	1009 655-1364	6699 4934-8465	276650 121550-431750	2029 1068-2991	44.0 20.9-67.2	15.4 7.4-23.5	46.8 34.6-59.0

Table 2. Content of Cd, Pb, Zn, Cu, Ni (mean values) in dust fallout collected in 1998 with surface of different sampling sites of Szczecin urban area (Niedźwiecki et. al., 2000).

Sampling sites	**Losses on ignition (%)**	**Content - mg×kg^{-1} d.m.**				
		Cd	Pb	Zn	Cu	Ni
Gas station areas	23.2	3.97	271.8	1134.5	160.8	30.3
Road sides (sidewalks)	4.6	2.25	365.8	597.5	193.9	33.0
Outside building walls	5.7	3.08	952.1	2970.2	138.9	31.4
Inside living spaces	11.3	5.74	284.7	2124.1	267.2	37.9
Children's playground (20-25 m from road)	2.9	0.98	214.0	485.5	50.2	18.5
Road to landfill site of municipal wastes	10.7	1.50	272.0	1072.8	192.1	27.1
Machinery and devices on municipal wastes	3.3	7.15	1029.3	3389.3	213.8	38.4
Buildings in the vicinity of Grain Silo „Ewa"	69.6	0.72	46.0	894.2	69.0	20.2
Warehouses in the vicinity of Grain Silo „Ewa"	76.9	13.56	178.9	388.6	60.1	22.6
Metal and repair shops of Grain Silo „Ewa"	31.6	31.00	763.0	3708.7	864.0	351.7

Acidification and Contamination of Soils Influenced by Former Polymetalic Ore Mining Activities

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Abstract

The results of research conducted in the surroundings of a former polymetallic mine near the town of Zlaté Hory, northern Moravia, Czech Republic are presented. Mining in the area dates from the Middle Ages, but the modern era of mining activities began in the 50's and ended in 1993. A by-product of the ore flotation technique was 6.8 million tonnes of metalliferous tailings. The adjacent forest area is contaminated by wind blown pyritic dust particles. The experimental profile was located in a spruce monoculture down wind of the tailings. Samples of both soil and plants were taken at 50 m intervals. Eleven soil probes (3 samples each) were dug and soil samples from the artificial top layer of deposited metalliferous dust, as well as from the organic and mineral horizon, were taken. In addition, samples of both Norway Spruce (*Picea abies*) branches and birch (*Betula pendula*) seedlings were collected for analysis. Soil samples were analyzed using AAS (1GBC AAS Avanta Ó) to obtain total heavy metal content for Cu, Zn, Pb, Cd and active forms of Al and Fe. The contents of accessible nutrients (Mg, Ca and K) were measured, as well as the content of organic carbon and the ratio of phosphorus retention. Both the active and exchangeable soil pH were measured. Five categories of plant tissue were distinguished: Norway Spruce samples were divided into branches and needles while the birch seedlings were divided into roots, stems, and leaves. These samples were analyzed for both heavy metal content and absorbed nutrients.

Our results show that the main problem is not heavy metal contamination *per se*, but rather severe acidification. The oxidization of pyrite has resulted in a profound decrease in pH (pH_{H2O} ranging from 3.09 – 4.12). The final values for Al and Fe fall within either the aluminium or iron buffering range. Such severe acidification has led to increased toxic Al and Fe, heavy metal mobilization, the serious leaching of mineral nutrients (Mg: 0-34.3 mg/kg, Ca: 0.55-244mg/kg and K: 0-107.5mg/kg) and a high degree of irreversible retention of phosphorus (90-95 %).

Introduction

Mining activities are often connected with various environmental problems. The extent of burden depends on the mining and processing techniques used and on the nature of the mined material. A major difficulty linked to ore mining is heavy metal pollution of the adjacent area. Interest continues in the fate of metals in polluted soils due both to their direct toxicities to biota and indirect threats to human health from contaminated groundwater and bio-accumulation in food crops (Martinez and Motto1999).

Mining of various ores has a long tradition in the area under study. Intense mining and a flotation technique used to obtain polymetallic concentrates began in the 1950's when an ore processing factory was built 5 km south of Zlaté Hory, Northern Moravia. Sulphide ores generally contain a large proportion of valueless gangue minerals, meaning that the ores need to be processed in order to extract the minerals. During processing, ores are first finely ground and the material is mixed with chemicals leaching out the metal particles.

The mill tailings normally contain a variety of residual sulphides (e.g. pyrite FeS_2), heavy metal particles and various chemicals used during the flotation process. When the tailings are exposed to air, the sulphide minerals oxidise which in turn causes acidic mine drainage resulting in contaminated soil and deteriorated water quality (Lin 1997). During the last four decades of ore processing in the area under study, about 6.8 million tonnes of metalliferous tailing by-product was stored in a tailings deposit constructed adjacent to the mill. The location of the deposit is in a narrow mountain valley that copies the prevailing wind direction coming from the south and south-west towards the town of Zlaté Hory. Wind is, in this case, one of the major vectors of pollution. Wind-borne particles have accumulated in a neighbouring Norway spruce monoculture. Here, the oxidation of sulphide minerals connected with the various ore-processing chemicals affected soil and vegetation.

Material and Methods

Research goals. The main goals of our research were to describe the area from the point of view of soil characteristics, especially the level of presumed contamination. We looked for trends in heavy metal contamination of the soil both in the vertical and horizontal direction. Because of sulphide particles' presence in the tailings deposit we also concentrated on the processes and consequences of soil acidification.

Sample collection. An experimental profile was designed in order to cover the consequences of eolic contamination from the till deposit surface. The sample point of the profile was situated near the base of the tailings dam. From there the profile was directed northwards, following the prevailing wind direction, into the forest. Soil samples were collected every 50 meters. Three different samples were taken from each soil probe: samples from the artificial top layer of deposited metalliferous tailings, the original surface A horizon, and subsurface B horizon. A total 10 soil probes were dug and 30 soil samples were collected.

Analytical procedures. Soil samples were dried at room temperature, homogenized and then sieved in order to get fine soil. To measure the total content of heavy metals (Pb, Cu, Zn CD), 0.2 g of the soil sample was digested in a mixture of mineral acids (3ml HNO_3, 2ml HCl, 1ml H_2SO_4). A Plazmatronika microwave digestion unit was used for this purpose. The obtained mineralizate was then analysed. As for active Al and Fe contents, samples were treated overnight with 0.01M $CaCl_2$, were filtered, and the filtrate was then analysed. To determine the concentrations of accessible nutrients (Mg, Ca, K), we followed the Mehlich II method (Zbíral 1995). All samples were analysed with the use of AAS (1GBC AAS Avanta Ó).

To obtain more detailed information on the soil samples' nutritional status we also measured the percentage of P retention. 5 gr. of soil were shaken with 25ml of 1000-ppm P-retention solution for 24 hours at room temperature. Samples were then filtered and diluted with nitric vanadomolybdate acid reagent (NVAR). Using a spectrophotometer the per cent transmittance of the solution is read at 466nm. The percentage of P retained is calculated using constructed calibrated curve (Soil Survey Laboratory Methods Manual, 1996).

Soil reaction was measured as both active and exchangeable. Soil samples were diluted in distilled water or $CaCl_2$, well shaken, and left overnight at room temperature. Solutions were filtered and pH was measured.

Statistical analyses. All data obtained on the soil characteristics and the contents of the studied elements were statistically calculated (StatGraphics) in order to determine general statistical parameters and significant correlations among the studied elements and anticipated soil processes.

Results and Discussion

Samples of three different soil layers were taken: the artificial top layer (P) made up of wind blown tailings consisting of grounded rock dust particles, the original surface A horizon and the subsurface B horizon. All results are given in the following table:

Table 1: Soil characteristics and element contents in individual soil layers.

	pH_{H2O}	pH_{CaCl2}	act. Al	act. Fe	Pb	Zn	Cu	Cd	K	Mg	Ca
P	3.48* 0.04**	3.15 0.08	335.82 204.89	1117.26 1465.6 9	68.53 11.39	55.66 8.80	74.3 17.07	0.56 0.59	19.53 18.49	1.56 2.62	34.15 24.50
A	3.37 0.11	2.95 0.06	469.1 378.76	11030.9 1853.8 9	54.53 21.16	28.76 9.62	91.8 26.70	0.86 0.84	53.20 27.90	13.2 8.12	120.7 1 49.58
B	3.61 0.38	3.33 0.39	1263.3 583.39	4730.6 3159.5 9	55.82 11.17	44.38 7.17	75.78 25.69	1.03 0.66	13.21 7.89	2.47 1.99	27.34 15.33

* average values, ** standard deviation

General trends in both the vertical and horizontal distribution within the study profile are visible from the graphs (Fig. 1 and 2). As can be seen, the total amount of wind-borne particles decreases with increasing distance from the dike. To the contrary, the concentration of heavy metals per unit weight (mg/kg) increases. Such results are in agreement with findings of Lee and Touray (1998) in the finest size fraction of a polluted artificial soil. Figure 2 shows the distribution of lead as a typical example of strong metal enrichment. The opposing trends result in a decreasing concentration of the studied heavy metals *per se*, because the amount of deposited tailings decreases rapidly with the distance.

Soil sample extracts in 0,01M $CaCl_2$ has shown that soil acidification caused by sulphide weathering is the main degrading process. One of the products of this oxidation is H_2SO_4 reacting with the soil leading to an extreme decrease in pH.

In the organic horizon the acidification has stopped in the iron buffering barrier (Ulrich 1991; Dlapa1997); at pH values around 3, where the main neutralization process is represented by hydrated iron oxides dissolution. The A horizons of all soil probes are in this buffer range.

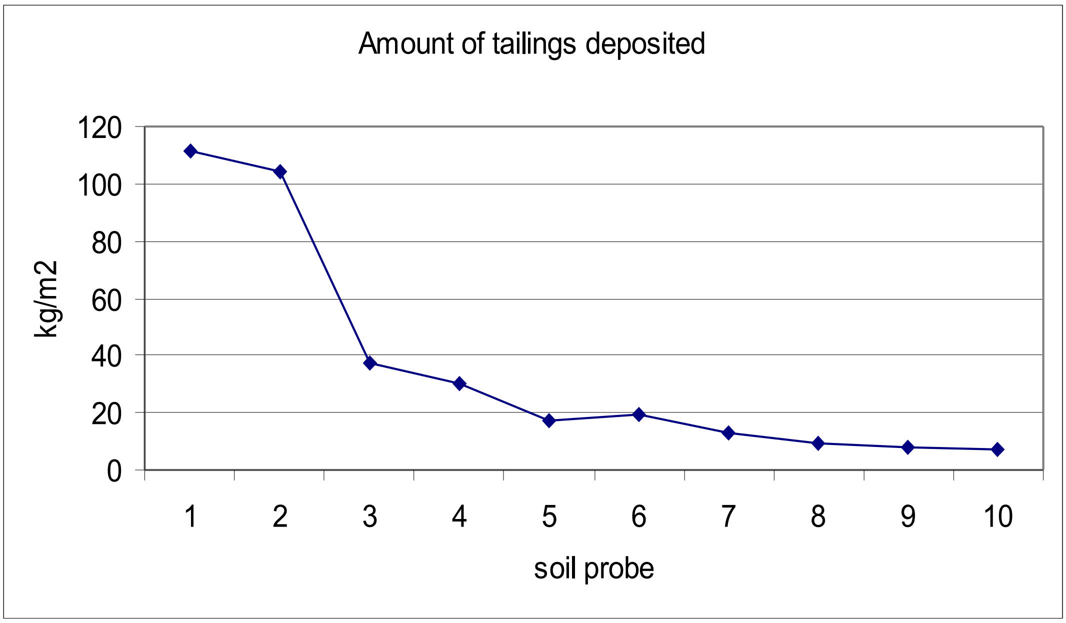
The situation is a bit different in the B horizons. In the less degraded soils of the B horizon the aluminium buffering range occurs. This is where the main neutralization process, the dissolution of hydrated aluminium oxides, takes place. As the degradation increases towards the tailings deposit even the subsurface horizons enter the iron buffering range. This fact is characterized by an exponential increase in Fe dissolution with simultaneous Al leaching.

In contrast to the effects of acid rain the sulphides weathering results in such an extreme acidification pressure that the soil pH drops to values around 3 in the iron buffering range. This severe acidification results in a crucial increase in Al toxicity, as well as in heavy metal mobility and toxicity and nutrient deficiencies.

The retention of P in the A horizons of all soil probes exceeds 90 %; P retention over 85 % can be described as extreme. In the B horizons the P retention increases with increasing soil degradation and increasing Fe solubility. The main mechanism for P fixation is the creation of insoluble Fe compounds (Golez and Kyuma 1997).

The situation with the analysed nutrients contents is similar. The acidification which caused them to be leached from the soil is connected with the extreme Fe^{3+} and Al^{3+} concentration increase in the soil solution and subsequent basic cation displacement from the sorption complex. Complete deficit of Mg^{2+} and K^{+} ions can be observed in all soil profiles.

Fig.1: Amount of tailings deposited at individual soil probes.



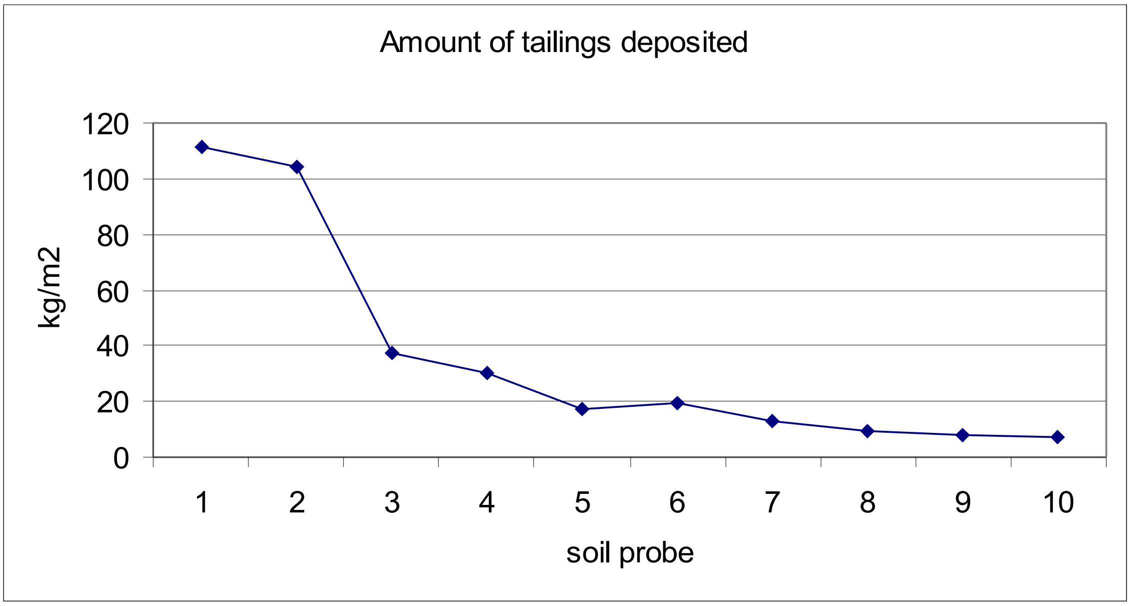


Fig. 2: Trends in vertical and horizontal distribution of Pb at individual soil probes.

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The Effect of the Solid Municipal Wastes' Polygons on the Soil Cover of Adjoining Territories

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Abstract

The monitoring of the environmental state on the SMW polygon "Zapadniy" had been carried out since 1988 The geochemical investigation of the snow cover, soils, surface waters and ground layers of atmosphere was carried out in 2000. Soil samples of the top part of the investigated soils were collected for the soil-geochemical analyses. The SMW polygons influence the adjoining landscapes. The present safety measures of the landfill's use provide a rather high level for the environment protection against the contamination. As a result the significant increasing the maximum permissible concentrations of heavy metals and other pollutants in the underground water and soils were not obtained during the investigation. At the same time there is the landfill's effect on soils and their properties and, the first of all, on morphological, physical and chemical ones. According to our opinion, the use of SMW polygons is the constrained measure, which should be considered as a temporary means for the salvaging of municipal wastes. And the landfill's use should be accompanied with the soil-geochemical monitoring of the environment state.

Introduction

According to the nature protection law of Russia, polygons of solid municipal wastes (SMW) are facilities ensuring the protection of atmosphere, soils, surface and underground waters from the pollution and pathogenic micro-organisms. At the present time the landfill is the most widespread kind in the utilizing of SMW. However, this way for the salvaging of urban wastes demands the permanent control for the environmental state.

Materials and Methods

Rostov-on-Don is the largest city in the Southern European part of Russia with the population more than one million that don't still has the wasteplex. So, the landfill is also being made on the SMW's polygons. In this case, the warehousing of the A-waste, toxic substances and materials with ability to an auto-ignition and to an explosion on these polygons is prohibited. There are several SMW's polygons around the city, but the most of them are closed at the present time. The new plots for the SMW "Zapadniy" are established on the periphery of the Rostov-city, i.e. in Northwest industrial zone. A number of enterprises such as the chemical plant "Alkid", beer plant, car building and building plants and other ones are closely located to this polygon. Between the industrial zone and the SMW polygon passes the Rostov-on-Don – Taganrog railway. In the south this territory is cut with the unnamed gully with confluent streams collecting from different parts of the zone. In the western part of the polygon this brook flow into the gully Suhoi Chaltyr that accumulates surface waters. In the eastern part of the landfill a territory are located that has been reserved for the future spread of the industrial zone. In the north the SMW polygon borders with agricultural lands of the

Myasnikovsky region. Between the landfill and the gully Suhoi Chaltyr, on the flat slope, citizens were formerly cultivating their kitchen gardens.

The monitoring of the environmental state on the SMW polygon "Zapadniy" had been carried out since 1988. The data are included in the ecologo-geochemical database of the environmental monitoring of the polygon and adjoining landscapes.

The geochemical investigation of the snow cover, soils, surface waters and ground

layers of atmosphere was carried out in 2000. Soil samples of the top part of the investigated soils (i.e., 10-15 sm) were collected for the soil-geochemical analyses. That is the part of/ soils where the maximum activity of geochemical processes is usually observed. For that reason, the full soil profiles were pitted and after that additional soil samples were collected from the each pedogenic horizon. Moreover, for the study of the pollutants' distribution in the soil profile 10 probe geochemical holes with the depth in 3-5 m were pitted on the investigated territory. In stationary observational hydrological holes, pitted on the SMW polygon "Zapadniy", seasonal tests of the underground water were carried out.

Full soil profiles were pitted for the same purpose on the polygon "Severniy" too, which was closed in 1992, and adjoining landscapes.

Results and Discussion

The geochemical observation of the territory allow to make some preliminary conclusions that are going to be detailed during the further investigation of the all landscape's components. The assessment of the atmospheric chemical load observed around the SMW polygon "Zapadniy" has shown that the dust content was increased in 20-55 times in comparison with the background value. In the spring-summer period these values were raised over than 100 times (Tab. 1).

Table 1. Average weight and composition of the dust flowing down on the SMW polygon "Zapadniy" (in $kg \cdot km^{-2}$ per a day).

Plots for the dust control	The insoluble inorganic dust	The unsolvable organic dust	The soluble salts
1998, summer	1045	313	240
1999, spring	832	193	151
1999, summer	1548	281	222
2000, spring	1440	355	162
2000, summer	1977	377	199
Conditional summer background	**46**	**87**	**60**
1998, winter	179	59	154
2000, winter	401	58	90
Conditional winter background	**13**	**13**	**42**

But, the dust content outside of the investigated polygon was more in 5-10 times than on the background territory. In this study the dust content in Rostov-on-Don we are considering as the atmospheric chemical load's background. Even in comparatively pure parts of the city the dust content in winter was 70-100 $kg \cdot km^{-2}$ per a day and in summer – 200-500 $kg \cdot km^{-2}$ per a day according to the investigations carried out in

1989-2000. In other parts of the city this values are very high. For example, on a plot for the atmospheric chemical monitoring, i.e. nearby the Car Market, the dust content in 2000 was 3669 $kg{\cdot}km^{-2}$ per a day. This value was even more than the dust content in summer around the SMW polygon.

In 2000 on the SMW polygon and adjoining landscapes the winter dust load did not exceed the 750 $kg{\cdot}km^{-2}$ per a day. The maximum value was detected nearby the lodge-gate of the landfill, where dust was stirring up the air by the wheels of the dump trucks as well as in places of their dumping. In spring and summer an average concentration of dust in the air around the polygon in a dry period exceeded the maximum permissible concentration (MPC) in 1.5-2.5 times. But nearby the inside part of the sanitation-protected zone the dust content decreased to the normal value. In comparison with 1998-1999 the chemical load on the ground layers of atmosphere around the investigated territory did not increase.

Overall, for Rostov-on-Don the predominance of zinc (e.g., as a result of the pollutants' emission from chemical enterprises), lead (e.g., as a result of the emission of the vehicles' gas) and copper is a characteristic of the dust chemical content. Frequently, the chromium is one of the prevailing chemical elements of the atmospheric dust. The household garbage, especially after the burning of polymeric films, packages, plastic bottles, leaf age of trees and bushes, becomes a most dangerous source of the environmental pollutants such as heavy metals, dioxins and other toxicants that have been made by men and not occur in the nature.

The chemical content of dust inside of the investigated polygon is shown in the Table 2. The average concentration of vanadium, chromium, molybdenum, lead, zinc, strontium and barium was below in comparison with the concentration of these metals calculated for the whole territory of the city. In summer period the part of technogenic components in the atmospheric sediments was decreased. Therefore, in the dry season the concentration of the most part of heavy metals is a little bit lower than winter.

In the dust samples that have been collected from the distillate surface in traps around the SMW polygon "Zapadniy", abnormal concentrations of copper, lead, chromium, argentum, vanadium were established. But these anomalies are localized in the limits of this polygon or adjoin to the industrial zone of the city.

Thus, the observance of the technology for the utilizing of municipal wastes and the well-timed extinguishing of fires on the polygon decrease the air migration of heavy metals.

The control for the underground waters was carried out with probe geochemical holes that have been pitted on the SMW polygon and adjoining landscapes. The data showed that the quality of underground and surface waters did not degrade due to the deficient infiltration of the polluting substances from the landfill's body into the brook.

The pollution level of soil cover on the investigated territory did not also have the dangerous value. On a working plot of the SMW polygon the lithochemical anomalies of nickel, cobalt and vanadium are obtained. At the same time, the anomalies of manganese and chromium do not have the spatial dependence with this polygon.

The zones of the higher concentrations of copper, lead and zinc are located in the limits of the landfill's part that has been filled and covered. This fact shows the potential danger of the buried municipal wastes. The same lithochemical anomalies were obtained nearby to the industrial zone of the city. The concentration of pollutants can be significantly raise after increasing the enterprises' technological capacity.

The index of the total soil pollution with heavy metals was calculated according to the Y. Sayet [1]: Zc=Summ Kc - (n-1). The zones of a maximum soil pollution are located not in the limits of the polygon, but closely to the industrial zone of the city (i.e., to the east from the covered part of buried wastes and nearby to the lodge-gate of the landfill. On the most part of the polygon the low (Zc=2-5) or medium (Zc=5-10) levels of the contamination of the topsoil horizon was obtained.

Table 2. The average content of heavy metals in the atmospheric dust around of the SMW polygon "Zapadniy" (in $mg \cdot kg^{-1}$ of dust).

The period for the samples' collecting		Mn	Ni	Co	V	Ńr	Mo	Cu	Pb	Ag	Zn	Sn	Sr	Ba
Year	**Month**													
1998	**February**	750	47	17	107	290	2	300	365	2.6	860	104	643	926
	July	750	47	17	107	290	2	300	365	2.6	860	104	225	380
1999	**May**	840	160	24	260	210	1.6	255	210	1.3	355	90	470	970
	July	1080	165	30	175	190	1.7	200	210	0.8	430	80	500	810
2000	**February**	971	111	29	148	264	2.5	260	300	2.2	1129	117	829	1171
	May	922	159	40	244	228	1.5	198	182	1.4	467	102	544	867
	August	1089	178	43	256	311	1.6	261	244	0.8	811	126	456	778

Table 3. Physic-chemical properties of soils in territories adjoining to the SMW polygon.

Soil profile, №	Horizon and the depth of the sampling, cm		The total humus content, %	The catalase activity, ml $O_2 \cdot g^{-1}$ per 1 min	$CaCO_3$, %	$MgCO_3$, %	The structure coefficient
001	U1	0-10	1.76	1.5	4.9	0.2	0.8
	U2	10-38	4.03	5.1	1.9	0.2	0.2
	U3	38-75	3.61	3.3	2.7	0.1	-
	B_2	75-96	1.68	2.8	7.6	0.8	3.0
	BC	96-117	1.09	not analyzed	8.0	1.2	1.8
	C_{ca}	117-bottom	0.70	not analyzed	7.7	1.8	1.3
005	Ad	0-15	5.85	5.8	9.0	0.4	1.5
	A_{arable}	15-32	4.51	3.7	2.4	1.2	1.9
	$A_{u/arable}$	32-50	3.72	3.2	2.0	0.2	3.3
	B_1	50-70	2.55	2.5	1.8	0.2	4.9
	B_2	70-85	1.82	3.0	4.1	0.6	3.9
	BC	85-115	1.30	not analyzed	8.9	0.1	3.3
	C_{ca}	115-bottom	1.06	not analyzed	8.8	0.5	2.0
006	Ad	0-6	9.11	3.8	9.3	1.2	3.0
	A_1	6-16	5.68	2.2	8.3	2.0	3.0
	$A_{buried-}$	16-55	4.66	4.7	2.2	0.2	1.7
	AB	55-95	4.21	6.0	2.1	0.6	2.3
	B_1	95-110 (bottom)	2.97	4.9	3.1	0.6	3.1
007	Ad	0-8	6.14	4.6	4.9	0.6	0.4
	A1	8-16	3.05	4.5	5.9	0.6	0.9
	AB	16-30	2.55	3.8	2.8	0.4	0.7
	B1	30-42	3.02	4.5	3.7	0.9	0.3
	A_{buried}	42-65	3.55	3.8	3.9	0.5	1.0
	Cg	65-bottom (W)	1.42	not analyzed	8.8	0.9	-
008	Ad	0-6	1.47	3.6	5.9	1.2	1.8
	$C_{covered}$	6-20	0.80	2.6	7.5	1.1	7.1

Nevertheless, the influence of such a multiple engineering construction as the SMW polygon on the soil cover consists not only in the possible pollution of the territory with decomposing wastes. This effect is observed due to the excavating of grounds, planning works, waste transportation and other technological operations. In this case are detected the disturbance of soil cover in adjoining territory such as the soil compaction, cutting off and mixing some surface soil horizons, the dusting off soils with excavated ground and as a result the burial of humus layers, etc. Moreover, in the west part of the landfill on the flat slope (profile 001) was observed the mocharic soil (i.e., hydromorphic soil). The crossing of the underground water's flow by the dumpsite' body and the attenuation of it on the surface may cause the formation of this soil. Altogether, construction of the transport traffic to the ground resulted in the humus layer burial. As a result, soil water-physical qualities, humus state and biological activity of soils declined.

The analysis of soil samples from the profiles 005-007, which have been pitted on the bottom of the landfill's slope in the SMW polygon, has shown that the chemical, physical and biological properties of soils was significantly changed. Thus, the content of carbonates in the topsoil horizons was increased due to the erosion processes, i.e. the flowing down and the air erosion of clay material that was used for the burial of municipal wastes in 1992 (Tab. 3).

The deterioration of water-physical properties of soils and decreasing the biological activity were established. For example, the humus total content in the top layer of agricultural soils around the landfill was 4.33 % with the gradual decreasing in the soil profile. The activity of catalase also was much higher than in the landfill's soils: 6.0 ml $O_2 \cdot g^{-1}$ per 1 minute. The disturbance of soil profile as a result of planning of the polygon's surface or any technologic processes on the landfill influence the humus state. In this case there is the changing not only the humus total content, but also the humus state in generally.

Conclusions

Thus, the SMW polygons influence the adjoining landscapes. The present safety measures of the landfill's use provide a rather high level for the environment protection against the contamination. As a result the significant increasing the maximum permissible concentrations of heavy metals and other pollutants in the underground water and soils were not obtained during the investigation. At the same time there is the landfill's effect on soils and their properties and, the first of all, on morphological, physical and chemical ones. According to our opinion, the use of SMW polygons is the constrained measure, which should be considered as a temporary means for the salvaging of municipal wastes. And the landfill's use should be accompanied with the soil-geochemical monitoring of the environment state.

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Secondary Salinization of Soils after Oil Production

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Abstract

Agricultural production has to be beware of amount of limitating factors. They can strongly reduce the gain of field production. Among these limitating factors at South Moravia in the districts of Břeclav and Hodonín is also placed bad influence of rock oil mining, the activity of "Moravské naftové doly Hodonín" enterprise. This is not at large areas, but it can have intense impact on the arable soil.
Noticeable is mainly the process of secondary salinization of soils due to crash defect of the piping and leak of salt brine to soil surface. On superior arable soils, largely Chernozem, we can find series of localities with long-term degradation and accordingly outage fromagrarian production because of secondary salinization. The field enquiry has been done near to village Hrušky. After that the actual affection was described, in the extent and in the depth. Subsequently has been processed the proposal of improvement and fertilization of these areas.Handicaped area have had greater alkality than close area without impact of the salt brine.Chemical analyses demonstrated salinization by high mineralized water of Na-Cl type, NaHCO3 subtype. Also the physical properties were worsened. Some methods of recultivation were recommended, above all those with combination of loess, gypsum, manure and green manuring.

Introduction

Soil according to definitions tends to be understand as a basic means of production in agriculture which does not wear in the process of production but usually improves thereby soil becomes both the object and the product of human labour. In an ideal case, this should correspond to the fact mentioned above, however, reality is usually different. Negative effects particularly in emphasizing short-term economic aspects often prevail. With the increasing knowledge of man an endeavour should arrive not only to reduce the negative effects but also to remedy the previous impacts. From the long-term point of view production potentials of soil are actually damaged. Secondary salinization of soils is one of the limiting factors (Červenka 1958). It refers to the Moravské naftové doly Hodonín Company activities during oil production. The extent of damaged areas is not too large, however, we cannot omit the intensity of salinization impacts on arable soil. It concerns particularly salinization in case of the pipeline crash and leakage of brine – heavily mineralized salt waste water which remains after separation of oil matters and returns to oil wells.

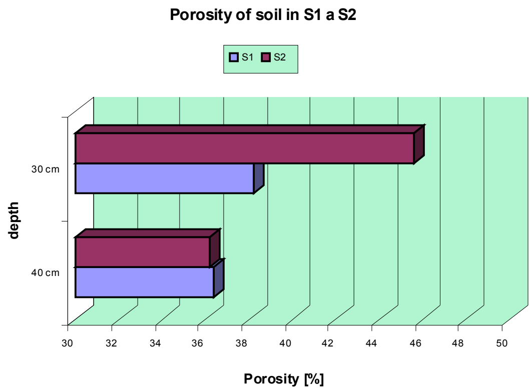
Material and Methods

Chernozems appear to be a typical representative of soils in this area. Parent materials are formed largely by calcic drift sands with clayey subsoil. The whole region is very poor in water, climate is warm and dry with mild winters. Annual precipitation amounts to 570 mm, annual mean temperatures do not fall below 9°C.

The area under study is situated in the cadaster of Hrušky at an altitude of 160 – 180 m, about 15 km NE of Břeclav. Four soil pits were dug to the depth of 90 cm, 2 pits were dug in areas of 10 to 20 m^2 showing clear evidence of salinization: thin crop with changed plant habit, different colouring of soil and crop surface; other two ones served as a control in a nearby place but without evident changes. Tracts are ordinarily treated, however, these places give minimum production and weed vegetation predominates. Analyses of physical and chemical properties of soils were carried out to evaluate the present condition of both area and depth range of secondary salinization of agricultural soils.

Results

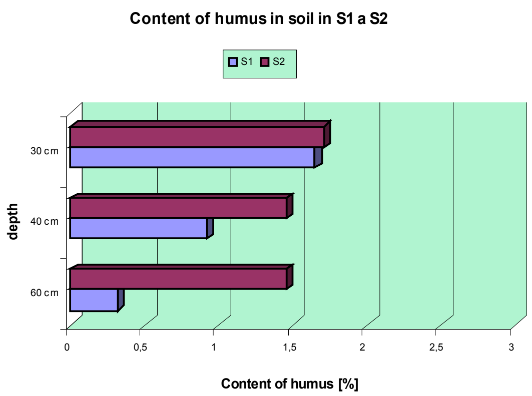
Physical properties in the saline soil were mostly different. For example, actual moisture in S1 and S2 was on average 33.4 and 16.2 % (i.e. about half), respectively, retention water capacity in the plough layer was 1.6-times higher in S1 as compared to S2, porosity was 7.4 % lower, reduced volume weight 1.67 g.cm^{-3} (in S2 1.44 g.cm^{-3}) which indicates damage to soil structure, higher compaction and effects of osmotic phenomena. Differences between S3 and S4 soil pits are not so marked.



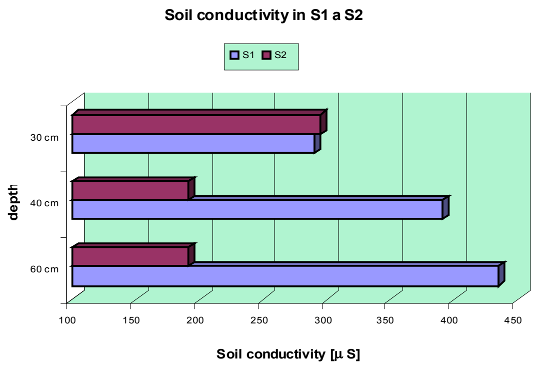
In studying chemical properties, the following results were obtained:

In comparing soil reactions S1 shows more alkaline pH than S2 (in S1, pH/H_2O ranges from 8.5 in the plough layer to 9.1 at a depth of 60 cm mean value of the whole profile being 8.8). The value of pH increases from the soil surface to lower layers. Values of pH/KCl show slightly alkaline reactions (7.4 – 8) increasing again towards lower layers. In S3, salinization did not become evident to such an extent as in S1 although a larger area was affected. The content of $CaCO_3$ was very low in all four soil pits or was not found at all. The fact shows that an alkaline reaction found in the pits is caused by other salts than calcareous ones.

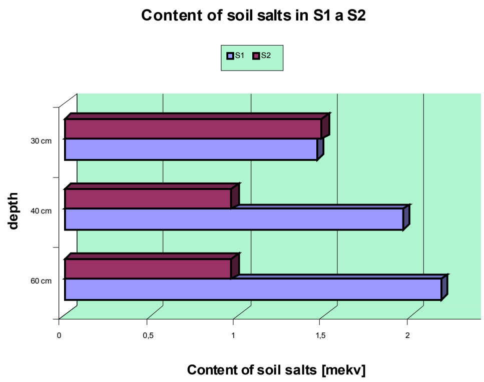
The content of humus in S1 and S2 is approximately the same (1.65 and 1.71 %) in the plough layer, in S1, however, more than fivefold decrease with depth occurs. The condition can be evaluated as a medium supply of humus. In S3 a S4, soil is medium-supplied by humus in the plough layer and in the subsoil, however, at a depth of 60 cm humus reserves are low.



Soil conductivity is related to the content of salts in the soil environment. In S1, the course of soil conductivity in particular depths was as follows: the plough layer showed the lowest value (290.3 $_{\mathrm{M}}$S), at a depth of 40 cm the value of conductivity increased (by 100.3 $_{\mathrm{M}}$S to 390.6 $_{\mathrm{M}}$S), at a depth of 60 cm even to 434.6 $_{\mathrm{M}}$S (by 144.3 $_{\mathrm{M}}$S more than in the topsoil).



The course of the content of soil salts corresponded also to the condition. In the plough layer, the content of salts was lowest, 1.45 mval.100g^{-1}, at a depth of 40 and 60 cm the value was already 1.95 and 2.17 mval.100g^{-1}. In comparing with S2 where the value of conductivity in the topsoil was roughly the same 295.0 $_{\mathrm{M}}$S as in S1, decrease



in conductivity to 191.0 $_{\mathrm{M}}$S occurred with increasing depth. The same situation in S2 was also as for the content of salts. In the topsoil, the value of 1.48 mval.100g^{-1} was found but at a depth of 40 cm, the value was only 0.96 mval.100g^{-1}. Thus, a marked decrease occurred.

It is evident that conductivity in the saline locality increases from lower layers towards the topsoil. In S3, we can observe gradual increasing both of soil conductivity and the content of salts. In S4, however, at a depth of 60 cm an intense increase in conductivity and salt concentration occurs. Thus, it is possible to suppose that salinization occurred here. It is not possible to say with certainty whether the salinization manifests itself or retreats.

Discussion

For reclamation of the soils we recommend to use loess in combination with gypsum, manure or lignite dust and green manure. With respect to the fact that localities of secondarily salinized soils largely of Chernozem types have not been successfully reclaimed so far it is possible to tackle the situation by a methodical instruction for pilot trial reclamation. The localities under study show similar chemical properties as some saline soils of southern Slovakia and Hungary and according to literature (Armstrong, Pearce, Rycroft, Tanton 1990, Zahow, Amrhein 1992) there are practical procedures for reclamation of these soils. An important precondition for reclamation of these soils is either a soil profile without the presence of groundwater table or a plot with a functional drainage system. For the given situation the following procedures for reclamation of these soils appear to be optimal:

Solution No. 1: In an area of 100 m^2 to spread and incorporate 10 m^3 loess, 300 – 400 kg gypsum and 300 kg manure. To sow the area by a crop serving as a green manure.

Solution No. 2: In an area of 100 m^2 to spread and incorporate 10 m^3 loess and 300 – 400 kg lignite dust. To sow the area by a crop serving as a green manure.

The most suitable months for reclamation measures are winter months or dry autumn when the smallest damage to the plough horizon by agricultural technology occurs.

Conclusions

In saline localities, mostly weed vegetation grows and agricultural use is virtually zero although these areas are treated from agronomical aspects which only increases costs. As for the extent of the area it refers to dispersed localities in the middle of tracts. Based on the pedological survey of two localities it is possible to say that these localities contain increased amounts of salts as compared with their vicinity. Salt concentration mostly increases with soil depth, samplings were carried out to a depth of 90 cm. Chemical analyses of groundwater prove that it is a case of salinization by highly mineralized water of Na-Cl type, $NaHCO_3$ subtype showing (according to Rozov) the most harmful effects. The saline soils demonstrate here also worsened physical properties, viz. lower soil porosity, higher values of $ń_d$ (reduced volume weight) and lower aeration. Soil reaction is not also favourable here the plants being usually not too tolerant to alkaline pH.

Acknowledgement

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Simultaneous Testing of Phytotoxicity and Mutageneity of Anthropic Soil Samples Collected in the Vicinity of Oil Refinery

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Abstract

Soil properties in the vicinity of oil refinery plant, which was constructed at the beginning of 50-ties were the main object of our investigation. The research interest was focused on toxicological effects of anthropogenically influenced soils. Besides of routine chemical analyses as amount and kind of pollutants we have tested phytotoxic and mutagenic properties of contaminated samples. Laboratory results of soil leaching screening testing proved a negative effect of polluted soils involved by chemical factors influence.

Introduction

The study site is located in the upper part of the Žitný ostrov at the point where the Danube and Little Danube rivers drain the underground waters. At the beginning of the 1950's oil refinery was started and was later expanded to a large petrochemical agglomeration. Environs of the structure was exposed to industrial pressure during its 50 year existence, while atmosphere, hydrosphere and pedosphere, (the later represents the natural linkage between the first two mentioned) were the most affected components of the natural sphere. Our aim was identifying the basic properties of the locality, particularly assessing those of the local soil. Relying on the gathered data we applied the most recent knowledge in the field of bio-indication of phytotoxicity and genotoxicity by model plants.

Material and Methods

The first phase of the reconnaissance of the terrain consisted in its exploration using the soil drill for observation of changes of soil profile. The recognised area stretched next the seepage canal of the Danube along the southern edge of the Slovnaft comp. Areas representing the typical soil types of the study territory were selected. Probes size 50 cm (width) x 150 cm (length) were dug out at the selected points, the depth of the probe oscillated according to the underground water between 40 cm and 130 cm. The proper fieldwork consisted in diagnostics and description of horizons, while the limits of horizons and the type of transition were noted down. Colour was identified by means or charts (Munsell Revised Colour Charts). Moisture, consistency, granularity, and structure were determined according to the Manual of Field Research and Mapping of Soils (Čurlík and Šurina 1998). Soil types were classified according to the Morphogenetic Soil Classification System of ČSFR (Hraško et al. 1991). Samples (weighing approx. 1 - 2 kg) to be evaluated as analytical and testing samples were collected from the individual horizons according to the layer. Identified samples of earth were transported in plastic bags; soils suspected of organic contamination were stored in aluminium foil. The laboratory processing of the samples consisted in drying them on filtration paper at room temperature, homogenisation and sieving through a 2 mm mesh.

Selection of the analytical methods included assessment of the basic soil characteristics commonly used for characterisation of soil types. For the laboratory analyses, the methods of assessment of active soil reaction, carbonate content in soil (Hraško et al. 1962), assessment of carbon by the Walkey-Black method modified by Novák - Pelíšek (Kliha et al. 1954), and assessment of the total content of soluble salts in saturated soil extract were used. Special analyses for detection of pollutants (polyaromatic hydrocarbons, polychlorinated biphenyls, petroleum substances and heavy metals) were analysed at the SSCRI laboratory.

Preparation of soil extract also plays an important role for cultivation of plants destined to testing of toxic substances. No particular directive clearly and exactly defines the procedure of extract preparation. However, the US EPA recommends using the individual procedures accompanied by description of preparation (Kapustka 1991). Preparation of the testing medium for our purpose was carried out following the definition of the technological standard STN from one weight amount of soil and one volume amount of water. The corresponding of 1:2, 1:4, and 1:8 solutions of the original soil extract were also tested.

In terms of selection of appropriate methodology for assessment of toxicological effects our criteria were focused to the following conditions: the closest possible linkage between soil and plant, selection of species according to the recommendations of the international legislation (Directive No. 208/OECD 1994), acceptability of the test covering standardisation of the data, and also financial and temporal aspects of the test. After fulfilling all above-mentioned criteria finally the simultaneous test of toxicity and mutageneity of waste waters, soil extracts and other pollutants (Mičieta, Murín 1998) was selected. The test is being developed and improved at the Department of Botany of the Comenius University. The proper cultivation of the prepared medium was carried out in Petri dishes (diameter 23.4 cm) after previous of treatment in extract during 24h. 5x5 imbibed seeds are placed at one Petri dish (because of high oxygen consumption of the germinating seeds and seedlings) and after 72h of cultivation the roots are measured while the degree of growth inhibition is assessed. Distilled water (d H_2O) was used as control and 0,1 mM solution of malein hydrazide (MH) known as klastogene was used as negative control. The roots inhibited up to 25, 50 and 75 % were used for determination of chromosome or genome mutageneity. In order to reach the required statistically significant number of observed cells (300 ana-telophases) it is necessary to check 5 - 6 preparations out of 18 - 20 individuals. The level of statistical significance of the difference between the mean root lengths of the individual solutions was calculated by the ANOVA analysis.

Results

Fluvisols, Gleysols, and Anthrosols are the three principal soil types, which characterise the soil composition of the study locality. Typical Fluvisol, carbonate variety (FMm^c) is the most spread soil type in the area, one of the youngest characterised by considerable oscillation of the humus content and granularity along the whole profile. Depending on the depth of groundwater the mentioned soil type gradually changes into the Gleyic subtypes and eventually Gleysols. Typical carbonate Gleysol (GLm^c) is another soil type typical for the study area. The dominant agent participating in the origin of the Gleysols is the high table of groundwater, occurrence of which is linked to depressed areas of the former arms, the Holocene depressions or old silted arms of the river. Occurrence of the Gleysols is much less frequent than that of Fluvisols as it is discontinuous, isolated and separated. Occurrence of degradation Anthrosols (ANd) is determined above all by the presence of the petrochemical agglomeration, which contributes to the pollution of atmosphere and hydrosphere and secondarily to contamination of pedosphere, on the one side and primary contamination of soil in case of emergency situations/crashes or spontaneous tipping on the other. Table 1 contains the results of basic soil analyses while those of the principal pollutants are summarised in Table 2.

Table 1: Results of basic analyses.

PROBE No.	HORIZON	pH (H_2O)	RCO_3^{2-} (%)	Cox (%)	Conductivity ($uS.cm^{-1}$)	TDS (mg/l)
Probe no.1 (FMm^c)	A	7,9	20	2,3	466	222
	C_1	8,2	18	1,32	-	-
	C_2	8,7	20	0,23	-	-
Probe no.2 (GLm^c)	A	7,6	24	4,2	-	-
	Gr	8,1	24	0,5	-	-
Probe no.3 (FMm^c)	A	7,8	22	1,5	564	269
	C_1	8,3	23	0,5	-	-
	C_2	8,6	22	0,15	-	-
Probe no.4 (ANd^j)	A	7,9	14	2,55	912	440
	C	8,3	16	0,7	-	-
s.Slovnaft	A	6,8	15	12	-	-

Table 2: Assessment of the pollutant contents in samples of the study locality (SSCRI 1999).

PROBE No.	PAH	PCB	RL-NEL	HEAVY METALS (mg/ kg)			
	(mg/kg)	(ug/kg)	(mg/kg)	Pb	Cu	Cr	Hg
Probe no.2	9,13	1,38	30	42,0	41,5	61,0	0,938
Probe no.3	8,58	2,79	30	48,7	63,75	51,5	0,206
Probe no.4	11,27	5,94	1055	20,8	23,3	46,5	0,248
s. Slovnaft	1867,8	3,9	5090	245,0	64,8	87	0,238

Results of the screening phytotoxic test applied to soil extracts of surface A horizons of soils produced the picture of anthropization of the localities in the upper part of the locality Žitný ostrov. The roots, cultivated on soil extracts (FMm, GLm) free from the primary contact with contamination showed stimulation of growth of sprouts compared with the control (distilled water). On the other side, roots cultivated on extracts of the ANd and a sample from the interior of Slovnaft, as well as their following solutions displayed inhibition of growth of the sprouts (Table 3).

The level of significance of the difference between the mean length of roots of the individual solutions was calculated by the ANOVA analysis (one-way analysis of variance), which in case of the 2-element test is identical with the non-pair t-test. The differences in these following samples were statistically significant ($p<0.05$): s. Slovnaft (1:1), s. Anthrosol (1:1), s. Slovnaft (1:2) and malein hydrazid sample. The remaining differences between the mean lengths were statistically not significant ($p>0.05$).

The level of significance of the difference between the mean values of the aberrant cells of the individual variants compared to the control was calculated by the non-pair t-test. Differences in these following samples were statistically significant ($p<0.05$): malein hydrazide s. ($p<0.0001$) extreme significance, s. Anthrosol (1:1), s. Slovnaft (1:1) and Slovnaft (1:2). Differences in the remaining samples were statistically insignificant (p>0.05).

Table 3: Results of the simultaneous test of phytotoxicity and genotoxicity on *Vicia sativa* L.

Sample no. (extract, earth: water ratio)	Length of roots (mm)	IC % (inhibition index)	Number of cells evaluated	Number of chromozome aberrations (CHA)	Frequency of CHA
FMm	44	-23,3	300	0	0
GLm	47,6	-1,5	250	1	0,4
ANd (1:1)	39,8*	5,2	280	4	1,43*
ANd (1:2)	55,7	-32,9	-	-	-
Slovnaft (1:1)	23,2**	43,3	280	6	1,9*
Slovnaft (1:2)	33,4*	18,9	300	4	1,3*
control **MH**	27,8*	15	300	25	8,3**
control **d H_2O**	41,9	0	290	0	0

** extreme significance
* significant difference

Discussion

The results presented in table 1 show that soil reaction oscillates between 7.6 and 8.7 pH. The soils are classified as alkaline to highly alkaline. The cause of high pH is the high content of carbonates, which moves between 14 and 24 %. Distribution of carbonates is irregular; nevertheless always high enough to secure the pH of the carbonate buffer area. Their origin should be sought in the water of the Danube, which contains a high proportion of these soluble compounds. As mentioned before, humus content of such a young soil is variable in horizontal as well as vertical directions while the amount of natural carbon moves from 1.5 to 4.2 % in A horizon and from 0.15 to 1.32 in subsurface horizons. Summarised results of analyses (Table 2) reveal that the territory is polluted by heavy metals. It is the point type of pollution. Oil substance pollution was detected in the sample of Anthrosol as the result of remains of spontaneous dumping, as well as the sample from the interior of the chemical plant Slovnaft, stricken by oil leak in 1993. This sample also contains considerable contamination by polyaromatic hydrocarbons.

Use of vascular plants for determination of toxic and mutagenic substances boasts history and significant position. Plants are used as indicators of phytotoxicity or mutageneity in case when pollutants, which enter the biological circle from soil, water or air, are involved (Murín 1984). Results of such preliminary screening tests allow for focusing on the investigated part of the damaged environment and widening the battery of the toxicological tests for more details/effects of toxicity and mutageneity. In our case we used soil extracts in the tests and the solvent was distilled water, which as the natural solvent best models the natural conditions. However, not all pollutants are extracted from the sample, for instance, the majority of heavy metals remains immobile in pH solution. Likewise, organic pollutants are not solved in such a polar solvent. In spite of it, significant inhibition of the sprouts in case of degradation Anthrosol (5.2 %) and the Slovnaft (43.3 %) samples was detected event after its dilution to a half (18.9 %). Significantly increased level of chromosome aberrations which moved from 1.3 to 1.9 % (Figs. 1 and 2, Table 3) was also observed.

Figure 1: Root length inhibition of *Vicia sativa L.*

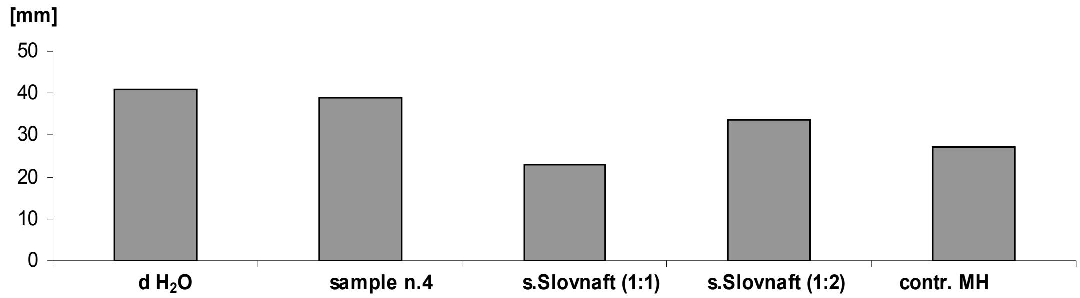
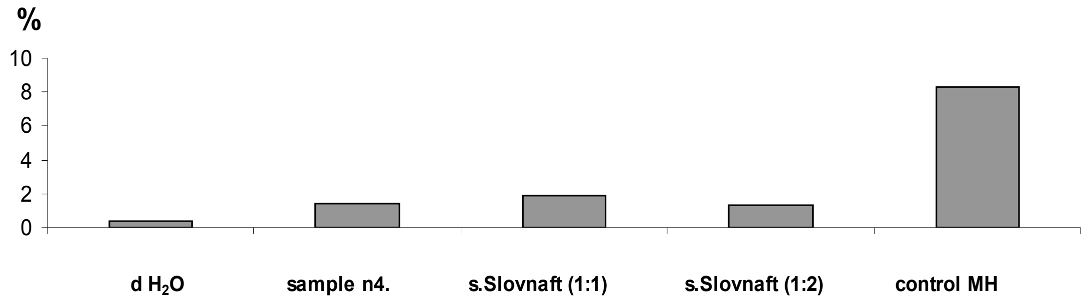


Figure 2: Frequency of chromozome aberrations of inhibited roots in *Vicia sativa L.*



Conclusions

The research showed that the study territory, environs of the petrochemical agglomerations are under the stress caused by chemical factors. The results have proved significantly increased level of phytotoxic and mutagenic effects of primarily contaminated soils. The simple, low-cost and generally accessible test used in this research can be widely applied in the methods of assessment of negative environmental impact along with the standard chemical analyses. Taking into consideration the complexity of the study area the preliminary test must be followed by a more complex approach, which will focus attention to a particular component (for example, soil air, solution, organic part).

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Technogenic Salinization of West Siberian Forest-Tundra and Upper Taiga Soils within the Limits of Hydrocarbon Exploration and Production Fields

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Abstract

Spatial and temporal regularities of the migration of technogenic salts in different soils of forest-tundra and northern taiga ecosystems of Western Siberia polluted in the course of oil and gas mining are examined. It is shown that the accumulation of salts takes place not only in mineral, but also in hydromorphic organic and organo-mineral soils (peaty and peaty-gley soils and peat bog soils). Thus, technogenic halogenesis can be considered a typomorphic process that affects soil properties in vast areas.

Introduction

Discharge of anthropogenic mineralized wastewaters generated from hydrocarbon exploration and production is one of the most widespread causes of soil human-induced salinization within all the Russia's native zones. It has been revealed that oil fields toxic pollution is mostly associated not only with bituminous substances of petroleum and its products, but with water-soluble salts as well (Solntseva 1998). Sodium chlorides are of first importance in the oil field saline pollution. Technogenic salts may even outperform bituminous substances in severity of negative environmental responses (De Jong 1980, Pikovskii 1981, Solntseva 1998). Because of this, the soil technogenic salinization problem can be currently central even for overmoistured landscapes.

Oil fields and condensed gas deposits located in the northern part of the Western Siberia are environmentally the safest in comparison with oil and gas fields of any other Russia's territories. The reason is that the Siberian hydrocarbon production sites have relatively low salt levels in stratal waters containing generally 15 to 19 g/l of salts. Therewith, native overmoistening of northern Western Siberia landscapes keeps the soils from intensive accumulation of technogenic salts. At the same time, poor drainage slows down the outflow of solutions and dictates wide spreading of peat bogs and fens having increased salt-carrying capacity (Bolyshev1972). As a result, strong and rather sustainable salt accumulations (up to 10 %) of salts present a severe environmental issue for Western Siberia oil fields.

The peculiarity of soil technogenic salinization within West-Siberian forest-tundra and tundra landscapes is discussed by the example of Urengoy oil and condensed gas field, Sutorma, Muravlenkovo and Krayniy oil fields situated at Nadym-Pur interfluve.

Material and Methods

Parallel description of both polluted soils and corresponding background ones was conducted. Process of soil salinization after discharges of crude oil, condensate, drilling fluids, and mineralized wastewaters was studied. To evaluate lateral distribution of salts in polluted soil cover, base soil pits were sited at various distances from the source of salt inputs with some pits being beyond the morphologically visible boundaries of pollution. Pit location was regulated by size and configuration of polluted area. Presence of oil products or technogenic deposits on the soil surface and evidences of vegetation damage or disturbance were selected as criteria of oiled areas. Soil profiles were morphologically analyzed in field. Collected soil samples were analyzed according to standard techniques (Arinushkina 1970).

Results

Collection sites are located within naturally overmoistened landscapes with ultra-fresh surface and subsoil waters, and predominance of acid parent rocks amongst which sands have a significant place. Such conditions dictate extremely low natural water-soluble salt content in soils ($n*10^{-3}$ %). Insignificant height variations along with poor drainage, ubiquitous gleyization and active frozen processes result in high complexity of soil cover and, in many cases, great differences between soils of adjacent contours. Soils with peaty horizons of various thickness including tundra mucks, peat bogs, peaty, peaty gley, peaty gley podzolic, and gley soddy soils are of widespread occurrence throughout the northern part of the Western Siberia.

Salt-containing wastewater intrusions in landscapes are responsible for soil and subsoil water salinization. As a result, water-soluble salt levels in soils increase by a factor of 100 to 1000 (Table 1). In extreme cases, salt concentrations may far exceed 1 %. Technogenic salinization of soils is often associated with accumulation of bituminous substances. The formation of saline bituminous soil variants including so-called bituminous solontchaks presents one of the manifestations of soil technogenic salinization within West Siberian oil and gas production areas.

The following types of soil salinization are ranked according to anion composition: predominantly chloride (Fig. 1A,B), hydrocarbonate-chloride (Fig. 1B), hydrocarbonate-chloride-sulphate (Table 1, pedon 58a-94), chloride-sulphate (Table 1, pedon Ur-KP). According to cation composition: predominantly sodium (Fig. 1, A to C), magnesium-calcium-sodium (Table 1, pedon Ur-KP). Saline peaty soils are characterized by specific cation composition: the contribution of water-soluble salts of iron and aluminium is 0,3 to 2,0 and 0,2 to 1,0 meq, respectively (Fig. 1D).

The types of soils' saline profiles are extremely varied even for short distances. The main body of salts may accumulate in upper horizons with pronounced decrease in their content downwards (Fig. 1A,B; Table 1, pedon 5b-94). Almost uniform salt distribution in profile may occur too (Table 1, pedon Ur-KP). On occasion, maximal salinity levels are observed within the middle (Fig 1C) or even lower horizons. Both the character of soil saline profiles and salt composition reflect not only the make-up of technogenic flows but also depend on type of pollutant attack (input with surface runoff or intrasoil input), the elapsed time from the start of pollution, and soils natural properties, especially soil selective power to retain ions.

Table 1. Content of water-soluble salts and bituminous substances in soils of oil and condensed gas fields within the northern part of the Western Siberia.

Native zone, soil type	Type of the technogenic impact (pedon No.)	Horizon	Depth, cm	Total salinity, %	Salt composition, equiv.-%	Bituminous substances, g/kg
Forest-tundra, tundra peaty gley soils (Urengoy oil field)	Crude oil (5b-94)	O	0-13	1,130	Cl^- 46 SO_4^{2-} 44 HCO_3^- 10 Na^+ 91,9 Ca^{2+} 7	75,5
		Cg	13-40	0,100	SO_4^{2-} 47,3 Cl^- 33 HCO_3^- 19,3 Na^+ 83,2 Ca^{2+} 12,9	1,25
	Oiled wastewaters (5m-10)	O	0-5	0,484	Cl^- 57,5 HCO_3^- 37,5 Na^+ 92,4 Ca^{2+} 7,0	17,78
		Bg	21-48	0,046	Cl^- 45,0 HCO_3^- 25,0 Na^+ 82,5 Mg^{2+} 12,7 Ca^{2+} 3,1	1,11
Forest-tundra, peaty and peaty gley soils, peat bogs (Urengoy oil field)	Stratal waters (A0-1)	O1	0-10	0,740	SO_4^{2-} 93,1 Cl^- 6,9 Ca^{2+} 43,6 Na^+ 34,5 Mg^{2+} 21,8	Not determined
		O2	10-29	0,890	SO_4^{2-} 91,2 Cl^- 8,8 Ca^{2+} 36,7 Na^+ 32,3 Mg^{2+} 30,9	Not determined
	Crude condensate (Ur-КП)	O1	0-10	0,220	SO_4^{2-} 68,6 Cl^- 20,3 HCO_3^- 11,1 Na^+ 60,0 Mg^{2+} 22,8 Ca^{2+} 17,2	3,20
		O2	10-20	0,180	SO_4^{2-} 60,5 Cl^- 23,8 HCO_3^- 15,7 Mg^{2+} 45,2 Ca^{2+} 38,7 Na^+ 16,1	21,50
		O3	20-30	0,230	SO_4^{2-} 69,1 Cl^- 12,4 HCO_3^- 18,4 Na^+ 66,8 Ca^{2+} 16,6 Mg^{2+} 16,6	81,70
	Drilling fluids (58a-94)	O1	0-7	0,250	SO_4^{2-} 59,9 Cl^- 24,5 HCO_3^- 15,6 Na^+ 73,8 Ca^{2+} 21,0 Mg^{2+} 5,2	Not determined
		O2	7-19	0,180	SO_4^{2-} 55,8 Cl^- 27,8 HCO_3^- 16,4 Na^+ 51,7 Ca^{2+} 27,6 Mg^{2+} 20,7	Not determined
		O3	19-32	0,140	Cl^- 45,8 HCO_3^- 28,4 SO_4^{2-} 25,8 Mg^{2+} 48,0 Na^+ 28,0 Ca^{2+} 24,0	Not determined
Upper taiga, Illuvial-ferroginous podzols (Sutorma oil field)	Crude oil (29-11)	EB	15-40	0,006	SO_4^{2-} 100,0 Na^+ 59,7 Ca^{2+} 40,3	31,7
		Bhg	40-64	0,250	Cl^- 98,7 HCO_3^- 1,3 Na^+ 87,9 Ca^{2+} 8,3 Mg^{2+} 3,0	Not determined
		BCg	64-111	0,747	Cl^- 100,0 Na^+ 91,7 Ca^{2+} 6,6 Mg^{2+} 1,0	0,04

Fig. 1. Variations of water-soluble salts profile distribution in West Siberian forest-tundra and upper taiga soils after elapse of various time from salt water discharge.
A – upper taiga, peaty soils within 6 months of drilling fluids discharge (Pedon No. 27-1);
B – forest-tundra, tundra peaty gley soils within 12 months of mineralized wastewater discharge (Pedon No. 5м-4);
C – upper taiga, peaty soils within 12 months of crude oil discharge (Pedon No. 93-1);
D – upper taiga, peaty soils within 3 months of crude oil discharge, (Pedon No. 0-3). Water-soluble salts: 1 - SO_4^{2-}; 2 - Cl^-; 3 - HCO_3^-; 4 - Mg^{2+}; 5 - Ca^{2+}; 6 - Na^+; 7 - Fe^{3+}; 8 - Al^{3+}.
"

Discussion

There are specific regularities of salt behaviour in soils of various types within forest-tundra and upper taiga landscapes of Western Siberia. In terms of the type of interrelations between soils and salts the soils are differentiated over typically into two basic groups. The first consists of soils with well-defined peaty horizons (tundra peat bogs, peaty gley and peaty soils of mineralizing peat bogs). Their saline profiles are of great variety due to high ion- and water-retaining capacity of peat. The second group is made up by mineral soils such as podzols and tundra gley soils which widely disparate from those of the first group according to their ion- and water-retaining power as well as hydrothermal regime and water permeability. Being exposed to technogenic discharges of equal salt levels and composition, peaty soils demonstrate higher salinity. For instance, when salt levels of wastewaters is slightly more than 15 %, their concentrations in peats are within the range of 2 to 4,5 % while sandy soils are able to retain at most 0,3 % of salts under the same conditions of exposure. The lowest salt levels have been observed in mineral, especially gley horizons poorly drained due to higher clay content. When drying the surface layers of both salinized mineral soils and technogenic deposits their surface are covered by salt crystals forming a crust with 10 % of salts or even more.

Fig. 2. Field of distribution of water-soluble salts within gley horizons of tundra peaty gley soils polluted by mineralized wastewaters:
1 - interpedon boundaries;
2 - boundaries of soil horizons;
3 - solid residual value (%);
4 - directions of oil products movement.
Particle-size composition: 5 - loamy sand; 6 - sandy loam; 7 - silt loam; 8 - loam and silt loam.

Patterns of salt migration vary not only from horizon to horizon but within horizons, especially mineral, as well. Phase irregularity inherent in most of parent materials of West Siberian landscapes determines complicated profile distribution of salts (Fig. 2). For instance, mineral gley horizons of tundra peaty gley soils are characterized by salt accumulations in layers, tongues and lens of relatively coarse material playing a role of migration ways for flows moving by gravity. For loamy soils, salt levels are lower by an order and not exceed 0,005 %. It is only about twice what the background soils contain. Where the migration ways becomes narrow (i.e., the thickness of the coarse layers decreases or sandy tongues narrow), solutions slow down and salts obeying the equalizing of capillary-sorption pressures begin to penetrate into adjacent soil mass having relatively fine texture. As a result, soil mass immediately adjacent to the migration ways increases its salinity, and salt levels within the horizon as a whole tend to equalizate (Fig. 2).

The regularities of salt vertical migration in soils relate to soil genetic properties, but the real form of separate ions profile distribution depends also on time elapsed from the discharge. Immediately after indiscriminate discharge of mineralized wastewaters the overwhelming bulk of salts concentrates in soil upper layers. In the course of migration chlorides surpass less labile calcium carbonates, so the fractionating of salts accompany their vertical movement. It can be traced by change of Cl^-/HCO_3^- and Na^+/Ca^{2+} ratios from one soil horizon to another (Table 2). Such distribution of salts is roughly consistent with their solubility.

Table 2. Profile rearrangement of salt composition in tundra peaty gley soils polluted with mineralized wastewaters (forest-tundra).

Pedon No.	Horizon	Depth, cm	Cl^-/HCO_3^-	Na^+/Ca^{2+}	Total salinity, %
5_M-56	O	1-24	1,9	13,2	0,50
	Cg3	45-74	3,3	26,0	0,03

As time elapses, significant vertical rearrangements of the initial saline profile go on affecting water soluble salt concentrations and composition. In all instances the upper layers lose some salts and the lower ones are enriched by them (Table 3). For example, a year after crude oil effluent the upper horizons of peaty soil demonstrate desalinization while the main body of salts are found in lower part of the profile (Table 3).

Table 3. Salt profile distribution dynamics in oiled peaty soils (upper taiga).

Pedon No., Time elapsed from the discharge	Horizon	Depth, cm	Na^+/Ca^{2+}	Total salinity, %
X-53, 6 months	O1	0-10	-	0,25
	O2	10-20	1,0	0,12
	O3	20-25	8,45	0,02
M-93-1a, 12 months	O1	30-54	0,6	0,02
	O2	54-74	10,8	0,90

At the same time, vertical distribution of salts shows further regular trends of differentiation which is well represented by ion ratios (Table 3).

In spite of soil high moistening and relatively low concentrations of salts in technogenic flows, overmoistened tundra peaty gley, peaty soils and peat bogs demonstrate high degree of sustainability of the salt accumulations. It is connected with poor drainage and high salt-carrying capacity of soils.

Maximal sustainability of salt accumulations characterizes peat bogs and peaty soils which are reputed to keep salt accumulations at 0,74 to 0,89 % level, i.e. 148 to 178 times higher than background values, even 13 years after emergency input of stratal water (Table 1, pedon A0-1). It enables to classify the soils as those of middle salinity level according to new Russian soil classification (Classification… 1997). Not only do salt redistribution in profile of the soils, but also processes of post-technogenic transformation of soil composition due to forming of sulphates under anaerobic conditions. Such a reaction is likely to be produced by carbothionic bacteria having an ability to oxidize sulphur of peat's plant residues (Glazovskaya and Dobrovol'skaya 1984). This microbiological process may occur under neutral soil reaction which is a common secondary response of technogenic salinization (Solntseva 1998). Observations for dynamics have shown that SO_4^{2-} ion content in water soluble salts gradually increases 3 to 17,5 times or even more in the wake of pH growth. Table 4 contains information about the case of three-year increasing of SO_4^{2-} levels. The most intensive changes of salt composition occur in lower horizons which have often been affected by great sodium input.

Table 4. Dynamics of salt qualitative characteristics in peaty soils polluted with crude condensate (forest-tundra).

Pedon No., Time elapsed from the discharge	Horizon	Total salinity, %	SO_4^{2-}/Cl^-	Na^+/Ca^{2+}	pH
K-65, P3 months	O1	0,33	0,02	6,25	4,0
	O2	0,17	0,06	6,38	3,6
K-68, 3 years	O1	0,10	1,50	2,16	6,0
	O2	0,38	1,20	19,0	5,8

Conclusion

Intensive salinization peaking at a concentration of 1 % or even more and covering both mineral and overmoistened peaty and peaty gley soils is a specific peculiarity of soil human-induced salinization within forest-tundra and upper taiga landscapes. As a result, soils of hydromorphic and semi-hydromorphic landscapes dominating here take on the properties of saline peaty gley soils or bituminous solontchaks. Salt accumulations under such conditions are often accompanied by forming of sulphate or, sometimes, hydrosulfide conditions.

The sustainability of salt accumulations in overmoistened forest-tundra and upper taiga landscapes is maintained by the soil hydrological regime whose features are: (i) poor drainage, and (ii) presence of peat with high retaining power with respect to some ions and solutions as a whole. In terms of salt conservation in soils the salinization becomes a typomorphic process dictating the progress of a number of salt-geochemical phenomena in landscapes of the region.

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Selected Soil Types as Pollution Barriers in Slovak and Croatian Karst Areas

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Abstract

Carbonate rock aquifers are composed of water-soluble rocks where fractures can be widespread by karsting to sinkholes, caves or tunnels causing that water and any accompanying pollutants move very rapidly. Therefore, groundwater is very susceptible to pollution in karst areas. Even some heavy metals can migrate to the considerable distances through karst channels despite of the buffering capacity of surrounding carbonates. Soils are often the only cover of the carbonate rocks and in that case, the thickness, permeability and sorption properties of the soil control the migration velocity of contaminants. Under certain conditions, fine-grained soils could prevent an accidental groundwater contamination leaving time for remedial action.

An international research project was started in summer 2000 in order to investigate the permeability and sorption properties of fine-grained soils in karst areas of Brezovske Karpaty Mts. and Slovensky Kras (Slovakia) and Istrian Peninsula (Croatia).

It is an interdisciplinary attempt to the characterisation of the Quaternary soil cover in karst areas. Pedological, mineralogical, engineering-geological, and geochemical methods were used to obtain complex information of some typical soil types of estimated areas. In order to observe changes in the soil properties due to contamination or other recognised anthropization, soils from both uncontaminated sites and sites affected by different source of pollution were investigated. Contamination sources were agriculture (fields and vineyard), road traffic and a coal power station.

Introduction

A lot of experience has been achieved in the evaluation of the sealing and retention properties of mineral liners of waste disposal sites in last years in order to prevent the groundwater pollution. These could be used in the evaluation of the groundwater-protective effect of the Quaternary soil cover on highly permeable hydrogeological structures like carbonate karst areas, as well, which is the main research question of the project, expressed also in the title. Testing some typical soils and giving their complete characteristic, results of such an evaluation could be extrapolated over larger areas with analogical soil cover.

Carbonate rock aquifers are composed of water-soluble rocks where fractures can be widened by karsting to sinkholes, caves or tunnels causing that water and any accompanying pollutants move very rapidly. Therefore, groundwater is very susceptible to pollution in karst areas. Even some heavy metals can migrate to considerable distances through karst channels despite of the buffering capacity of surrounding carbonates. Soils are often the only cover of the carbonate rocks and in that case, the thickness, permeability and sorption properties of the soil control the migration velocity of contaminants. Under certain conditions, fine-grained soils could prevent an accidental groundwater contamination leaving time for remedial action.

An international research project was started in summer 2000 in order to investigate the permeability and sorption properties of fine-grained soils in karst areas of Brezovske Karpaty Mts. and Slovensky Kras (Slovakia) and Istrian Peninsula (Croatia).

Material and methods

For project aims, areas with relatively thick fine-grained soils covering carbonate rocks were selected in karst areas of Brezovske Karpaty Mts. and Slovensky Kras (Slovakia) and Istrian Peninsula (Croatia). Location of soil profiles are in picture 1 and 2. Detailed site selection was determined using auger pits.

By the recognition, attention was paid also to possible anthropogenic influences, like pollution sources (intensive agriculture, road traffic, industry, landfills), erosion/accumulation or other strong anthropogenic influences on soils (pipeline areas, destroying of soil cover etc.). In terms of this, we tried to select sites with native soils (excepting eroded or accumulated soils in arable land) and soils potentially contaminated (most of profiles are situated in agricultural land or near contamination sources). Soils destroyed by anthropogenic influences are not representative and such sites were avoided.

In order to compare properties of contaminated and uncontaminated soils, pairs of similar soils were investigated. Assignation of profiles is A for uncontaminated soil and B for contaminated soils. No contamination was assumed in Dobra Voda 1 and 2 and these soils were chosen for the assessment of the buffer function of soils in protective zones of groundwater resources (Table 1.).

The samples for pedochemical analyses were air-dried and crushed in a jaw-mill to dis-aggregate the soil. Then, the samples were dry-sieved below 2 mm. Analyses of basic chemical properties (pH, $CaCO_3$, Cox) were done according standard laboratory methods for soil monitoring of Slovakia (Fiala et. al. 1999). Analysis of CEC were done according Van Reeuwijk (1995).

For analyses of microelements the dry soil samples were sieved to the 2 mm fraction pulverized and were analyzed by ICP-AES. Major element concentrations were obtained after $LiBO_3$ fusion and ICP-AES. Trace element analysis was performed after near total hot acid digestion: $HClO_4$-HNO_3-HCl-HF at 200° C for 35 elements by ICP-AES. The following elements were analyzed: Ag, Al, As, Au, Ba, Bi, Be, Ca, Cd, Co, Cr, Cu, Fe, La, K, Na, Nb, Ni, Mg, Mn, Mo, P, Pb, Sc, Sb, Sn, Sr, Ti, Th, U, V, W, Y, Zn, and Zr. The analyses for Ag, Au, Bi, Be, Mo, Sb, Sn, U and W were not used since more than 80 % of the samples contained concentrations of these elements below the instrumental detection limits. Accuracy of analyses was controlled using certified geological reference materials i.e. soils from the USGS; GXR-2, GXR 5, and SJS-1, and for most elements analyzed in reference soil materials is in the range of +/-10 % of the certified values. The list of analyzed samples is shown in the Table 3.

Results and Discussion

According to the World Reference Base for Soil Resources (ISSS-ISRIC-FAO 1994), most of the studied soils are preliminarily classified as Cambisols (6 profiles), 5 profiles as Luvisols and only 1 profile as Rendzic Leptosol (Table 2). The average depth of studied soils is 78 cm, and the depth ranges from 35 cm (profile Silica B) and 40 cm (profile Plomin B) to more than 100 cm. Lithic contact was detected only in four of the pedological dug pits. Most of the soil profiles are located in an accumulation position and therefore, the actual thickness of these soils is probably several meters.

There are only traces of calcite and/or dolomite in analysed soils, except of the Rendzic Leptosol. However, soils range from strongly acid to weakly alkaline ones. Exchange pH is lower than active pH in all samples, i. e. negatively charged colloids may prevail. Humus content is varying considerably (2,95-12,83 % in the A-horizon, 0,78-6,7 % in the B-horizon). The sample with the highest humus content showed also the highest CEC 37,10 mmol/100g, the lowest values were approximately 20 mmol/100g. Basic pedochemical properties and total content of macro-elements of studied profiles are shown in the Table 4 and 5.

From the summary data in the Table 6 and 7, it is apparent that some of the elements (Al, As, Cd, Co, Cu, Fe, La, Ni, Mn, Th, V, Sr and Cr) have higher mean values in Croatian soil profiles while Na, K, Ba, P, Mg, and Ti manifest a similar range of contents in both regions. The trace elements show large variability in soils in some profiles (Pb and Zn in Silica, Ardovo; Mo and Cd in Plomin and Pekići). The highest contents of Cd, Co, Cr, Cu, Mn, and V were determined in the profiles near Plomin, Mo contents are the highest at Pekići and Pb and Zn at Silica and Ardovo. While the concentrations of Cd, Co and Mn increase towards the surface in Plomin, concentrations of Zn, Pb and Ag are increasing with the depth in the profile Silica A that was assumed as uncontaminated. This is the evidence of two different contamination sources: serious anthropogenic pollution in Plomin (fly ash from the coal firing power plant) and geogeneous source in Silica A (probably some ore veins).

The Mn content in Plomin is so high that it became already a macro-element. It is also evident, that the soil profile Plomin A that was considered as uncontaminated, was also contaminated by the fly ash. On the other hand, no considerably elevated values were found at some of the B profiles. But, the high content of As in the surface samples from the whole Slovak Karst indicates also an eolian contamination even in A profiles, from the ore processing plant in Nižná Slaná. However, in general, Slovak soil profiles contain less amounts of potentially toxic elements than the Croatian ones which is due to absence of serious hazards. Both studied areas, in the Brezovské Karpaty Mts. and Slovenský Kras, are natural preserves.

Conclusions

Only a very first assessment of studied soils is presented. It showed that previous opinion about the soil contamination must be corrected. Due to chemical results of bulk chemistry, the selection of samples for planned sequential analyses will be changed to those with highest heavy metal contents. As soon as the permeability tests, as well as all sequential analyses are finished and all morphological and chemical data collected and interpreted, a complex assessment of the function of studied soils as pollution barriers will be possible, which is the main objective of the presented research project.

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Table 3. List of samples.

sample	*profile*	*horizon*	*depth*	*sample*	*profile*	*horizon*	*depth*
1	***PLOMIN-A***	***Ao***	1-5	**18**	***DOBRÁ VODA-1***	***Ao***	2-12
2	***PLOMIN-A***	***Bv***	5-15	**19**	***DOBRÁ VODA-1***	***E***	20-30
3	***PLOMIN-A***	***Bv***	35-45	**20**	***DOBRÁ VODA-1***	***Btg***	60-70
4	***PLOMIN-B***	***Ao***	0-5	**21**	***DOBRÁ VODA-2***	***Au***	2-12
5	***PLOMIN-B***	***Bv***	15-25	**22**	***DOBRÁ VODA-2***	***E***	25-35
				23	***DOBRÁ VODA-2***	***Bt***	60-70
6	***PEKIĆI-A***	***Akp***	2-12				
7	***PEKIĆI-A***	***Bv***	25-35	**24**	***ARDOVO***	***Au***	5-15
8	***PEKIĆI-A***	***Bv***	50-60	**25**	***ARDOVO***	***Bt***	35-45
				26	***ARDOVO***	***Cr***	60-70
9	***PEKIĆI-B***	***Akp***	2-12				
10	***PEKIĆI-B***	***Bv***	20-30	**27**	***SILICKÁ BREZOVÁ***	***Ak***	20-30
11	***PEKIĆI-B***	***Bv***	60-70	**28**	***SILICKÁ BREZOVÁ***	***Bv(t)***	60-70
12	***MEDULIN-A***	***Bt(g)***	60-70	**29**	***SILICA-A***	***Am***	20-30
13	***MEDULIN-A***	***Bt(g)***	35-45	**30**	***SILICA-A***	***Am/Btg***	45-55
14	***MEDULIN-A***	***Akp+E***	2-12	**31**	***SILICA-A***	***Btg***	70-80
15	***MEDULIN-B***	***Akp***	0-10	**32**	***SILICA B***	***Akpc***	0-10
16	***MEDULIN-B***	***Bt(g)***	20-30	**33**	***SILICA B***	***Akpc***	20-30
17	***MEDULIN-B***	***Bt(g)***	50-60				

Table 1. Location of soil profiles and assumed contamination sources.

Locality	*Profile*	*Site*	*assumed contamination sources*
Plomin	Plomin A	*grassland, on the slope, lokal deprestion*	not contaminated
	Plomin B	*grasland (abandoned arable land), on the footlope*	thermal power station, contamination by ash
Pekići	Pekići A	*grassland (abandoned arable land), sinkhole bottom*	not contaminated, potentialy negative influence of agriculture
	Pekići B	*arable land (shalow), sinkhole bottom*	main road, contamination by traffic,
Medulin	Medulin A	*arable land, medium slope*	not contaminated, potentialy negative influence of agriculture
	Medulin B	*vineyard, medium slope*	intensive agriculture, contaminated by Cu - based pesticides
Dobrá Voda	Dobrá Voda 1	*forest, medium slope*	not contaminated
	Dobrá Voda 2	*grassland, on the slope*	not contaminated
Ardovo	Ardovo A	*grassland, medium slope*	not contaminated
Silická Brezová	Silická Brezová B	*arable land, medium slope*	intensive agriculture
Silica	Silica A	*grasland, footslope (in sinkhole)*	not contaminated
	Silica B	*arable land, plane*	intensive agriculture, main road

Table 2. Preliminary classiffication of soil profiles (according to the WRB, 1994).

CROATIA			***SLOVAKIA***		
Locality	**Profile**	**Classiffication unit**	**Locality**	**Profile**	**Classiffication unit**
Plomin	Plomin A	Eutric Cambisol	**Dobrá Voda**	Dobrá Voda 1	Stagni-Albic Luvisol
	Plomin B	Eutri-Cromic Cambisol		Dobrá Voda 2	Albic Luvisol
Pekići	Pekići A	stagnic Eutri-Chromic Cambisol	**Ardovo**	Ardovo A	Hapli-Chromic Luvisol
	Pekići B	Eutric Cambisol	**Silická Brezová**	Silická Brezová B	Luvi-Eutric Cambisol
Medulin	Medulin A	stagnic Albi-Chromic luvisol	**Silica**	Silica A	Stagni-Haplic Cambisol
	Medulin B	Stagni-Haplic Luvisol		Silica B	Rendzic Leptosol

Table 4. Basic chemical properties and total content of macroelements in Croatian soils.

sample	pH_{H2O}	pH_{KCl}	$CaCO_3$ [%]	CEC pot. [cmol.kg^{-1}]	Cox [%]	humus [%]	SiO_2 [%]	Al_2O_3 [%]	Fe_2O_3 [%]	MgO [%]	CaO [%]	Na_2O [%]	K_2O [%]	TiO_2 [%]	P_2O_5 [%]	LOI [%]	C [%]	S [%]
1	-	5,09	1,02	31,665	5,63	9,71	54,16	13,46	5,7	1,08	1,02	0,64	1,87	1,06	0,15	20,1	6,92	0,07
2	6,09	4,71	0,86	24,785	2,41	4,15	59,38	14,92	6,58	1,15	0,86	0,67	1,45	1,17	0,11	13,1	2,29	0,02
3	7,15	5,41	0,94	24,06	1,29	2,22	58,75	15,78	7,01	1,2	0,94	0,65	1,78	1,18	0,12	11,5	1,3	0,01
4	-	5,84	1,3	36,375	7,44	12,83	43,28	16,58	7,56	1,23	1,3	0,43	1,5	0,93	0,16	26,4	10,1	0,5
5	7,07	5,53	1,08	30,575	3,93	6,78	47	19,51	9,17	1,33	1,08	0,44	1,62	1,05	0,15	18,2	4,12	0,07
6	6,39	5,26	1,25	26,96	2,14	3,69	57,22	16,16	6,75	1,51	1,28	0,98	2,17	0,99	0,11	12,4	2,16	0,01
7	7,37	5,75	1,15	27,685	1,11	1,91	56,39	17,48	7,29	1,54	1,25	0,9	1,84	0,99	0,09	11,9	1,22	< ,01
8	7,38	5,72	1,21	26,235	1,10	1,90	57,53	16,82	6,97	1,51	1,22	0,95	2,08	1,02	0,1	11,4	1,22	< ,01
9	6,96	6,28	1,28	28,41	2,45	4,22	58,22	15,44	6,27	1,36	1,25	0,87	2,03	1,03	0,13	13	2,53	0,01
10	7,89	6,29	1,25	26,235	1,35	2,33	60,14	15,96	6,6	1,38	1,15	0,9	2,09	1,07	0,08	10,2	1,23	< ,01
11	7,70	6,08	1,22	24,06	1,13	1,95	59,09	16,47	6,8	1,43	1,21	0,85	1,54	1,05	0,13	11,1	1,4	< ,01
12	7,24	5,63	0,93	24,06	0,68	1,17	59,53	16,31	6,7	0,86	0,93	1,02	1,73	1,03	0,2	11,3	1,92	0,02
13	6,98	5,5	0,83	22,61	0,68	1,17	51,53	21,61	8,62	0,96	0,83	0,58	1,84	0,93	0,07	12,7	0,85	< ,01
14	5,68	4,36	0,93	19,71	1,94	3,34	50,63	21,61	8,47	1,04	0,93	0,61	2,05	0,88	0,13	13,2	0,78	< ,01
15	5,88	4,61	1,04	16,81	1,50	2,59	63,66	14,98	5,83	0,93	1,04	1,29	1,56	1,05	0,16	9,2	1,69	0,01
16	6,93	5,32	1,04	16,81	0,65	1,12	59,04	17,1	6,99	1,1	1,04	1,15	2,11	1,01	0,09	10,1	0,82	< ,01
17	7,29	5,63	1,06	17,465	0,57	0,98	56,8	18,32	7,43	1,22	1,06	1,03	2,35	0,98	0,11	10,4	0,75	< ,01

Table 5. Basic chemical properties and total content of macroelements in Slovak soils.

sample	pH_{H2O}	pH_{KCl}	$CaCO_3$ [%]	CEC pot. [cmol.kg^{-1}]	Cox [%]	humus [%]	SiO_2 [%]	Al_2O_3 [%]	Fe_2O_3 [%]	MgO [%]	CaO [%]	Na_2O [%]	K_2O [%]	TiO_2 [%]	P_2O_5 [%]	LOI [%]	C [%]	S [%]
18	4,65	3,22	0,49	14,925	1,70	2,93	72,3	10,57	3,3	0,94	0,49	1,12	1,93	0,94	0,1	8	2	< ,01
19	6,15	3,88	0,61	12,825	0,65	1,12	74,5	10,97	3,45	1	0,61	1,17	1,91	0,97	0,05	5,1	0,75	< ,01
20	6,18	4,38	0,8	18,84	0,45	0,78	66,16	13,24	5,6	1,48	0,8	0,97	2,55	0,87	0,13	7,7	0,46	< ,01
21	7,74	6,94	2,78	33,48	5,54	9,55	60,98	10,02	3,62	2,64	2,78	0,86	1,78	0,82	0,18	16	5,21	0,05
22	7,59	6,32	0,82	19,345	1,35	2,33	71,62	11,01	3,71	1,38	0,82	1,03	2,03	0,95	0,07	7,1	1,23	< ,01
23	7,94	6,23	0,81	24,055	0,61	1,05	68,3	12,43	4,84	1,59	0,81	0,93	2,09	0,88	0,04	7,8	0,66	< ,01
24	6,05	5,04	0,86	27,755	3,06	5,28	62,6	13,03	5,47	0,93	0,86	0,57	2	1,01	0,15	13	3,08	0,03
25	6,43	4,97	0,91	28,19	1,96	3,38	62,13	14,07	5,85	0,98	0,91	0,54	1,98	1,03	0,12	12	2,16	< ,01
26	6,87	4,5	1,01	32,46	0,99	1,71	51,25	19,87	8,43	1,25	1,01	0,25	1,64	0,77	0,07	15,2	1	< ,01
27	7,33	6,32	0,71	21,45	2,35	4,05	68,19	11,23	4,67	0,78	0,71	0,49	1,69	1,18	0,15	10,5	2,35	0,02
28	7,56	6,23	0,6	17,39	0,94	1,62	70,25	11,62	4,63	0,79	0,6	0,49	1,68	1,21	0,11	8,2	1,02	< ,01
29	6,73	5,94	1,11	32,39	3,45	5,95	57,78	14,09	5,99	1,74	1,11	0,61	2,26	0,93	0,17	14,9	3,66	0,04
30	7,28	5,97	0,94	29,06	2,53	4,36	59,89	13,82	6,09	1,63	0,94	0,64	2,46	0,97	0,13	12,4	2,46	0,01
31	7,38	5,73	0,79	24,93	1,17	2,02	62,53	14,31	5,99	1,59	0,79	0,62	2,61	1,01	0,1	10	1,3	< ,01
32	7,89	7,15	7,17	26,16	3,44	5,93	48,46	13,79	5,6	2,11	7,17	0,48	3,35	0,77	0,35	17,5	4,84	0,02
33	7,70	7,09	4,82	27,68	2,49	4,29	50,87	15,64	6,44	2,03	4,82	0,49	3,12	0,81	0,3	15,2	3,66	0,03

Table 6. Total content of microelements in Croatian soils.

sample	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppm	Co ppm	Mn ppm	As ppm	U ppm	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm	W ppm	Li ppm	Cr_2O_3 %	Ba ppm	Ni ppm	Zr ppm	Y ppm	Nb ppm	Sc ppm
1	4.2	42	49	110	< .2	41	2856	20	2	14	76	2.0	1	< 1	161	2	55	.025	346	85	320	42	24	14
2	4.3	55	51	107	< .2	46	3305	23	2	19	79	2.2	1	< 1	176	2	62	.029	387	83	324	45	< 10	15
3	4.6	42	48	108	< .2	44	###	24	2	19	81	2.1	1	< 1	198	2	70	.032	376	106	332	47	20	16
4	5.9	45	55	147	< .2	24	1425	33	5	15	107	2.3	1	< 1	309	2	74	.036	298	129	247	49	20	15
5	7.8	45	42	130	< .2	25	1358	32	1	17	89	2.4	1	1	332	2	84	.044	327	145	264	55	17	18
6	7.2	36	35	115	< .2	22	1091	24	2	14	89	.5	< 1	< 1	177	2	62	.025	410	80	301	43	24	16
7	8.6	33	33	116	< .2	21	974	25	2	17	85	.3	1	< 1	195	2	69	.027	419	93	273	44	18	17
8	8.0	29	31	108	< .2	20	973	29	2	15	87	.2	< 1	< 1	178	2	65	.027	431	87	268	41	15	17
9	7.3	34	39	118	< .2	21	1069	26	2	15	84	.2	1	< 1	163	2	59	.022	391	65	302	40	24	15
10	6.9	30	32	101	< .2	23	1150	21	2	17	91	< .2	< 1	< 1	174	2	64	.031	398	74	323	41	24	16
11	7.7	31	33	106	< .2	23	1145	26	2	14	88	< .2	1	< 1	186	2	68	.028	404	86	261	41	< 10	16
12	2.8	32	42	91	< .2	21	939	21	2	21	82	.2	2	< 1	161	3	62	.028	310	98	400	45	19	16
13	3.7	37	42	118	< .2	22	841	30	< 1	24	60	< .2	2	2	219	3	94	.028	334	125	265	36	19	17
14	3.8	36	41	118	< .2	21	845	31	< 1	19	59	< .2	< 1	2	210	3	93	.033	332	123	270	44	24	19
15	2.2	52	41	88	< .2	17	791	18	1	15	93	.2	1	< 1	128	2	50	.027	351	58	395	43	< 10	13

16	2.5	29	50	86	< .2	19	853	28	3	20	96	< .2	< 1	< 1	151	3	67	.023	386	97	369	39	14	15
17	2.9	31	50	97	< .2	21	982	32	4	20	89	< .2	< 1	< 1	175	3	75	.027	407	104	306	43	10	19

Table 7. Total content of microelements in Slovak soils.

sample	*Mo ppm*	*Cu ppm*	*Pb ppm*	*Zn ppm*	*Ag ppm*	*Co ppm*	*Mn ppm*	*As ppm*	*U ppm*	*Th ppm*	*Sr ppm*	*Cd ppm*	*Sb ppm*	*Bi ppm*	*V ppm*	*W ppm*	*Li ppm*	*Cr_2O_3 %*	*Ba ppm*	*Ni ppm*	*Zr ppm*	*Y ppm*	*Nb ppm*	*Sc ppm*
18	1.1	12	48	76	< .2	12	882	10	< 1	11	82	.3	< 1	< 1	72	< 2	32	.020	410	110	398	34	10	9
19	1.1	10	37	70	< .2	14	813	8	< 1	13	86	.3	1	< 1	73	< 2	34	.019	430	25	399	33	12	9
20	1.7	26	38	106	< .2	15	768	14	< 1	11	82	.4	< 1	< 1	112	< 2	48	.038	415	539	330	38	23	12
21	1.2	11	40	93	< .2	11	702	9	1	11	75	.6	< 1	< 1	67	< 2	31	.021	353	42	349	32	18	9
22	1.2	9	29	80	< .2	14	575	7	< 1	11	78	.2	< 1	< 1	77	< 2	35	.016	391	< 20	422	34	23	9
23	1.3	14	27	88	< .2	15	747	9	< 1	13	73	.2	< 1	< 1	91	< 2	39	.026	555	32	343	36	17	10
24	2.2	24	82	162	< .2	19	1263	19	1	13	65	.5	3	< 1	111	2	56	.020	382	52	375	45	20	12
25	2.2	25	82	163	< .2	19	1282	22	1	13	66	.2	4	< 1	128	< 2	65	.024	400	49	317	46	18	13
26	2.5	32	51	217	< .2	14	686	32	< 1	11	43	.2	2	< 1	181	2	104	.022	360	71	199	38	11	17
27	1.5	21	43	83	< .2	26	1552	13	2	15	79	< .2	2	< 1	97	< 2	42	.018	381	37	461	38	22	10
28	1.6	18	38	77	< .2	28	1528	16	2	15	64	< .2	2	< 1	101	2	43	.023	379	53	482	37	20	11
29	2.2	27	155	384	.3	16	1266	47	2	14	67	1.0	3	< 1	128	2	67	.021	408	74	282	36	16	13

30	2.5	30	158	392	.3	18	1331	47	2	14	69	.9	3	< 1	140	2	70	.024	416	54	313	38	23	13
31	2.2	27	126	309	.2	19	1147	46	2	14	71	.6	2	< 1	132	< 2	70	.017	420	35	333	38	29	13
32	1.8	36	50	156	.4	16	1037	18	1	12	206	.5	1	1	103	2	92	.012	316	38	224	27	33	13
33	1.6	36	45	148	.2	17	1022	18	3	12	175	.2	< 1	< 1	106	2	98	.018	333	49	150	28	< 10	13

Some Problems of Contaminated Soils Assessment and Evaluation

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Abstract

The problem of contaminated soils, as a result of their anthropogenic influence, is investigated relating to their classification, assessment and use. Specific problem is soil contamination by imission, which has their delimited existence according type and intensity of its action and does not change soil characteristics by substantial way. Presented problem was pursued in the part of contaminated soil fund in some selected imission areas of Slovakia. For this contamination type it seems to be sufficient the approach of present valid Morphogenetic Soils Classification System of Slovak Republic, where the contaminated diagnostic horizon is characterized at the taxonomic level - variety.

Introduction

The problem of contaminated soils, as a result of anthropogenic impact, includes scientific fields of classification, assessment and use. The complexity and seriousness of this situation is indicated by the fact that due to non-clarified basic postulates extents of contaminated agricultural soils in Slovak Republic are very variable, just declared in the range from 4,120 hectares by imission contaminated soils (Ilavská, Lazúr 2000), through 30 thousand hectares (VÚPOP 2000) to 120 thousand hectares (Kol. 1997). Besides of insufficient mapping of the present state, despite of partial soil monitoring system realization (VÚPOP Bratislava), this situation is complicated by absence of terminology unification in the present soil classification and by soil hygienic limits complication, too. A system of productive (economic) evaluation of contaminated soils and method of their exploitation depends upon explicitly explaining of these terms.

Material and Methods

Presented problem was pursued as a the part of contaminated soil fund in the chosen imission areas of Slovakia – Orava´s Ferro-alloy Work (OFW) in Istebné and Non-ferrous Metal Work (NMW) in Krompachy (Kalúz 1989, 2000). From the view of contamination type, it deals with inorganic pollutants from the category of heavy metals with accumulation ability and with the long-term persistence in a soil.

Methodically it has been accepted aberration soil technique (Bedrna 1999), its intensity (Svedrup et al. 1990, cit. Čurlík 1998) and taxation (Holobradý 1998). In the part of productive soils use it has been examined process of crop production quality assessment (Kalúz 1988).

Results and Discussion

By application of mentioned processes there were evaluated the imission areas of Orava´s Ferro-alloy Work in Istebné (Istebné and Široká plants) and Non-ferrous Metal Work Krompachy in two time periods: 1985 (1989) and 1997. Results of contaminated soils categorization with specification of their use are shown in Table 1.

Table 1. Categories of soil contamination and their use.

CATEGORY OF SOIL CONTAMINATION	SOIL USE	ACREAGE (hectares)	
		OFW Istebné*	NMW Krompachy**
I.	Without imitation	9 162	788
II.	Delimited	3 893	170
III.	Temporary unavailable	1 268	130
Together		14 323	1 088

* 1985
** 1989

Comparison of these results with year 1997, total soil contamination (investigated according to the contents of dominant contaminants in a soil) has been not decreased considerably, the influence in the territory OFW Istebné are not exceeded human and animal consumption norms. It means that the soil use is not restricted. In the case of NMW Krompachy (acreages are presented in Table 1) are considerably decreased, while soil use in III contamination category has been changed to the restricted category. New status was emerged due to work recession and technology restructuring – OFW Istebné territory, in period 1990 – 91, in Krompachy territory, in period 1992 and 1995.

Presented example indirectly interferes in the discussion about classification of anthropogenic-affected soils (Bedrna 1999, Račko 1999, Sobocká 2000). Unambiguous soils classification determines their use, productive–economical assessment and soil taxa itself. On the other hand, mainly in the case of imission contaminated soils is external contamination consequence temporal and a soil use has been changed. Besides of natural soil development there are possibilities to acceletate these processes by appropriate form of chemical or biological decontamination.

Conclusions

Classification of contaminated soils with their consequences on assessment and use, is more complicated than it seems to be. As a specific problem is considered contamination by imission, which has delimited existence according type and intensity of action and does not change substantially soil characteristics. For this contamination type it seems to be sufficient an approach of the present valid Morphogenetic Soils Classification System of Slovak Republic, in which a contaminated diagnostic horizon is characterized at the taxonomic level - soil variety. Assuming to be fulfill hygienic limit conditions, a partial soil monitoring system can assure data upgrading.

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Soil Organic Matter as Indicator of Soil Quality and Human Influences on Agroecosystem and Natural Forest Ecosystem

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Abstract

The measurements of soil organic matter (SOM) changes under various forms of land use are needed for the development of sustainable systems. Soil organic matter quality was assessed by HA:FA ratios determined by fractional method Tyurin´s in modification Ponomareva-Plotnikova and by the calculation of lability of soil organic matter. These parameters were determined and assessed in arable soil and in forest soil in locality Cabaj-Čápor. Analyses of paired samples (cropped and uncropped soil) have shown high difference in total and labile carbon content, and in quality of SOM caused by intensive cultivation. We observed a decline in total carbon content as influence of erosion processes and cultivation. Labile carbon can be used effectively to monitor the rate of change in soil carbon.

Introduction

Soil carbon is a major determinant of sustainability of agricultural systems and changes can occur in both total and active or labile C pools. Mainly in the past century, human perturbations of the environment have affected the biogeochemical behaviour of the global carbon cycle and that of the other three nutrient elements closely coupled to carbon: nitrogen, phosphorus, and sulphur.

Human activities on land caused an enhanced loss of mass from terrestrial organic matter reservoirs (phytomass and humus) mainly through deforestation and consequently increased humus mineralization, erosion and transport to the coastal margins by rivers and runoff.

Soil organic matter (SOM) is considered as a key indicator of sustainability, therefore measurements of SOM changes under various forms of management are needed for the development of sustainable systems. Because the measurement of total SOM is not sensitive enough to monitor short and medium term changes, techniques that measure meaningful fractions of SOM should be use.

Agricultural activity has generally involved exploitation of soil organic matter reserves as a source of nutrients. Small changes in total SOM or C are difficult to detect because of the generally high background levels and natural soil variability. For this reason many attempts have been made to use sub-pools of SOM or C as more sensitive indicators of changes in pool size. Changes in the lability of soil carbon have been proposed as a measure of sustainability.

The overall influence of accumulating organic matter usually leads to higher soil fertility, with the resultant higher humus content often serving as the first indication of a fertile soil. In addition to changes in soil properties, components of humus and the level of productivity can have a direct physiological influence on plants as well as on the biological activity of the soil. Agricultural activity has generally involved exploitation of soil organic matter reserves as a source of nutrients.

Material and Methods

The study area was located in Cabaj-Čápor, 10 km from Nitra and included forest soil and nearby arable soils (planted maize). The parent material is calcareous loess and formed soils were classified as Haplic Luvisols and Albi-Haplic Luvisols. Soil samples were taken from soil horizons and parent material. For soil organic matter analyses were used followed methods:

- total soil organic carbon (Ct) - by Tyurin method;
- HA:FA ratios, quality of SOM were determined by fractionation Tyurin´s method modified by Ponomareva-Plotnikova (Orlov, Grišina 1981);
- content of labile carbon (C_L) (Loginow et al., 1987, 1993).

Form labile carbon content (C_L) in arable soil and in reference site (natural forest ecosystem), a Lability Index (LI) was determined. These two indices were used to calculate a Carbon Management Index (CMI) (Blair et al. 1995, Szombathová 1999a, 1999b).

Results and Discussion

Soil organic matter is considered as a key indicator of sustainability, therefore measurements of SOM changes under various forms of management and land use are needed for development of sustainable systems (Lacko-Bartošová, Zaujec, Szombathová 2000). The total content of organic carbon was different in arable and forest soil in soil profile, but high difference was determined in SOM quality by used method of fractionation (Table 1). Higher quality of SOM was in humus horizon of arable soil than in forest ecosystem. The content of SOM was very low in arable in comparison to forest soil, where was determined and calculated the highest content of SOM (forest soil) in observed area, with significant difference in quality (Table 1).

Analyses of labile carbon in paired samples (arable and forest soils, Table 2, 3) have shown a decline in CPI as influence of erosion processes and long time cultivation. The decline of lability index (LI) and hence strong decline in carbon management index (CMI) in upper layers with cropping and erosion processes was caused. Labile carbon and the CMI can be use effectively to monitor the rate of change in soil carbon.

Obtained results confirmed knowledge, that agriculture and other human activities were accelerating soil erosion and other forms of soil degradation. The problems of soil degradation and soil destruction are caused by the competition existing between these different forms of land use. Therefore, new perceptions and concepts for sustainable land use should be developed, which are conditioned in the bounds of nature. Sustainable land use and protection of soil can be defined as the spatial and temporal harmonisation of all main uses of soil and land, minimizing irreversible ones, which is not a scientific but rather a political issue.

Monitoring of trends is a way of quantifying change in soil quality over time, this requires establishing baseline values for various indicators and measuring change in the indicators over time. Changes in the indicators reflect the combined effects of land use and climate.

Conclusions

Because the measurement of total SOM is not often sensitive enough to monitor short and medium term changes, techniques that measure meaningful fractions of

SOM should be use. From presented results we can conclude, that in the soil under forest was a higher content, but lower quality of SOM than in the arable soil. SOM changes under different ecosystems reflect human influence, intensity of cultivation and forms of management, but also the influence of erosion processes. Changes in the lability of soil carbon have been proposed as a measure of sustainability.

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Table 1. Humus composition by Tyurin method.

Sample	Depth m)	% C_{ox}	Humus fraction composition									HA:FA
			1	2	3	ΣHA	1a	1	2	3	ÓFA	
Forest Soil	0-0.25	2.55	7.30	9.38	6.63	23.31	7.03	2.51	21.35	5.06	35.95	0.648
	0.25-0.55	1.24	5.39	13.02	8.04	26.45	8.52	3.77	15.51	5.55	33.35	0.793
	0.6-0.8	0.77	6.14	3.0	8.62	17.76	7.05	3.39	14.62	7.31	32.37	0.549
Arable soil	0-0.18	1.15	3.12	14.92	13.27	31.31	4.68	10.14	11.27	8.07	34.16	0.917
	0.18-0.35	0.90	2.99	12.51	14.95	30.45	4.76	9.41	8.53	6.76	29.46	1.034
	0.35-0.51	0.49	4.10	3.07	18.24	25.41	8.61	3.48	15.95	2.66	30.72	0.827

Table 2. Observed parameters in forest soil profile.

Depth (m)	%Ct	C_L (mg/kg)	% C_L from Ct	L (C_L/C_{NL})
0-0.1	4.82	6 430.5	13.3	0.1540
0.1-0.2	2.46	3 465.5	14.1	0.1640
0.2-0.3	1.60	1 841.0	11.5	0.1300
0.3-0.4	1.66	2 237.9	13.4	0.1558
0.4-0.5	1.07	1 386.0	13.0	0.1488
0.5-0.6	0.78	1 102.1	14.2	0.1645
0.6-0.7	0.60	601.9	10.1	0.1115
0.7-0.8	0.67	427.5	7.5	0.0682

Table 3. Observed parameters in arable soil profile

Depth (m)	%Ct	C_L (mg/kg)	% C_L from Ct	L (C_L/C_{NL})	LI	CPI	CMI
0-0.1	1.30	1 703.7	13.1	0.1508	97.92	0.2697	26.41
0.1-0.2	1.31	1 440.7	11.0	0.1236	75.37	0.5325	40.13
0.2-0.3	1.12	1 421.8	12.7	0.1454	111.85	0.7000	78.30
0.3-0.4	0.68	619.0	9.1	0.1001	64.25	0.4096	26.32
0.4-0.5	0.67	386.1	5.8	0.0612	41.13	0.6262	25.76
0.5-0.6	0.53	261.0	4.9	0.0518	31.49	0.6795	21.40
0.6-0.7	0.48	164.5	3.4	0.0355	31.84	0.8000	25.47
0.7-0.8	0.33	147.6	4.5	0.0318	46.63	0.7925	36.95

Influence of Fertilization Measures on Soil Parameters

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Abstract

Fertilization measures significantly influence especially soil sorption complex quality (CEC), pH, soil structure, available nutrient supply and microbial biomass and its activity. Soil parameters differ in their significance as for crop production and manure management as well as for evaluation of soil quality and soil classification. The stability of parameters partly explains difference between set of parameters for evaluation of soil quality and soil classification where rather more stabile parameters are used. Anthropic soils according to Slovakian classification system are represented by two soil types: Cultizems and Anthrozems. From important agrochemical parameters $CaCO_3$ or pH, as well as soil sorption complex saturation are directly used at the soil classification. Position of nutrient content as classification parameter is actual especially in the case of Cultizems (horticulture, terraced and trenched forms). Cultivated horizon (topsoil or ameliorative) is characterised by admixture of (agro)chemicals that seems very generally. From available soil nutrients (P, K, Mg) only phosphorus is clearly related to anthropic activity because K and Mg usually occurs in high content also in natural conditions (carbonates, primary and secondary clay minerals etc.). Preliminary limits of Mehlich II & III phosphorus for all three forms of Cultizems are proposed.

Introduction

Human activity belongs to the most important factors that accelerate soil quality changes, especially in last decades. Many findings document the decrease soil quality as consequence of agricultural practices and such degradation processes as water erosion, compaction, acidification, problems of negative influence of excessive or insufficient fertilization intensity inclusive (e.g. Bielek et al., 1991). As introduce Pouyat and Effland (1998) human influence of soils is manifested in soil disturbance or soil stress. Humanly caused stress effects are typically chemical in nature. Fertilization practices belong to the group with direct and often also significant influence.

In correspondence with concept of sustainable development (e.g. Francis et al., 1990; Collective, 2000b), the role of fertilizers and manures use is oriented on stabilisation and optimisation of production process conditions in crop production in correspondence with stabilisation of qualitative soil parameters and preservation of other environment constituents against pollution. Nevertheless rapid improvement of soil fertility status through high rate of fertilizer may be considered as soil stress as mentioned above.

Material and Methods

In submitted paper attention is oriented on analysing of manure application goals, examination of relationship fertilisation/soil parameters analysing and explanation of significance of agrochemical soil parameters at soil classification. Mentioned evaluation is presented in general form when available knowledge were discussed and revised.

Significance of influence of manure application on soil parameters was expressed in positive and negative direction at 3 levels expressed as low, medium, and strong (e.g. +, ++, +++).

Results and Discussion

Manure application, from view-point of nutrient and organic matter input, belongs to intensive human activities primarily oriented on achievement of cropper goals. At manure application soil accumulates temporarily or long-term the applied nutrients and subsequently releases them into soil solution. The idea “By nitrogen is fertilized plant and by P, K, Ca, Mg the soil” stress especially fact that nitrogen rate, in comparison with other nutrients, can not exceed the crop demand and then increase the available soil N-pool that may pollute the water issues. Besides the covering nutrient demands regular manure application should to contribute to reaching or maintenance of optimal soil parameters, first of all agrochemical ones.

Strategy of nutrient rate determination is based on balance principle that is starting from normative need of given nutrient on assumed yield at considering the available nutrient supply from soil or utilizable nutrient supply from applied organic manures and crop residues (Bujnovský, 2000). Adjustment of available soil nutrient supply (as a rule phosphorus, potassium and magnesium) is also constituent of “fertilisation on yield”. Categories of nutrient supply have more close relation to regulating of nutrient rates on assumed yield than to regulation of available soil nutrient supply. In correspondence with mentioned, within regular fertilization is very low and low nutrient supply adjusted by higher rates than crop demand with goal to build up soil nutrient content gradually during longer period (e.g. Bujnovský, 2000; Sims, 2000). When soil nutrient supply exceeds the optimal level, nutrient rates are lower that crop demands or negligible. Rapid adjustment of soil nutrient content during short period is matter of ameliorative fertilization at substantially higher rates and financial costs. Special case of fertilizers represents limestone as Ca and Mg source that are applied in rate many time exceeding the crop demand. In this case we can directly speak about soil fertilization, because goal of mentioned measure is soil pH adjustment. In is necessary to mention that long-term input of excessive manure rates in gardens (especially P, K, Mg fertilizers) often leads to creating of very high available soil nutrient supply.

Application of organic manure (e.g. FYM, compost, slurry) is connected with maintenance of SOM as well as with nutrient inputs mainly N, that in last period represents crucial parameter from view-point farm-manure rate in sensitive areas. So organic manure has influence as on soil quality parameters as well as on soil productivity expressed by crop yields. Goals of mentioned types of manure application are summarised in Table 1.

Influence of manure application on soil parameters (see Table 2) may be as positive as well as negative. For example physiologically acid fertilizers influence the pH values in negative sense while lime application in positive way. Similarly, application of phosphates is usually connected with heavy metal input and increase of available supply and lime (containing Ca and Mg respectively) decrease mobility of them.

From classification of the influence of several types of fertilization on soil parameters (see Table 2) is possible to conclude that most significant are soil sorption complex quality (or base saturation in simplified sense), pH, soil structure, available nutrient supply and microbial biomass and its activity. In principle above mentioned parameters belong to basic parameters also for soil quality evaluation (e.g. Bujnovský, Juráni 1999; Singer, Ewing, 2000) but not each of them has place the same importance at soil classification. It is necessary to mention that soil parameters differ in their significance as for crop production and manure management as well as for evaluation of soil quality and soil classification. The stability of parameters partly explains difference between set of parameters for evaluation of soil quality and soil classification where rather more stabile parameters are used. Mentioned indirectly confirm also opinion of Galbraith and Bryant (1998).

Table 1. Standard types and goals of manure application.

Type of measure	Description of primary goal
N fertilizer application	covering crop demands
P,K, Mg, Ca fertilizer application in low rates	covering crop demands, long-term improvement of available soil nutrient supply for covering plant demands
P, K, Mg fertilizer application in high (ameliorative) rates	rapid improvement of available soil nutrient supply for stabilising crop demand for long period
Ca fertilizer (limestone etc.) application in low (maintenance) rates	maintenance of pH level with respect to stabilisation of crop production, stabilisation of soil quality
Ca fertilizer (limestone etc.) application in high (ameliorative) rates	rapid adjustment of low pH for crop yield stabilisation, rapid improvement of soil quality
FYM & composts application	maintenance of soil carbon balance, covering crop demands, vitalisation of soil micro-flora
Liquid manure (slurry, dung water) application	covering crop demands on nutrients, vitalisation of soil micro-flora

To the frequent chemical parameters of soil classification belong $CaCO_3$ content, pH, CEC/base saturation, soluble salt concentration. In generally, heavy metal content as well as excessive nutrient content have no fixed place in soil classification. As introduce Pouyat and Effland (1998) there is the need of introduction the new soil chemical parameters.

Direct and significant influence of soil (agro)chemical parameters is assumed at ameliorative liming on arable land and application of high P, K, (Mg) rates with aim to increase of available soil nutrient supply in 0 to 0.6 m to desirable level before planting of permanent cultures especially vine-yards or in 0 to 0.4 m before planting hop-gardens and orchards. High content of available soil nutrient supply may also occur in gardens due to long-term cumulative effect. Long term balanced fertilization does not create the preconditions for arising of excessive soil fertility.

Anthropic soils in recent Slovak soil classification system (Collective, 2000a) are represented by two soil types: Cultizems and Anthrozems. From important agrochemical parameters $CaCO_3$ or pH as well as soil sorption complex saturation are directly used at soil classification. In agreement with opinion of Sobocká (2000) position of nutrient content as classification criterion is opened and actual especially in the case of Cultizems (horticulture, terraced and trenched forms). According to the Slovakian soil classification system (Collective, 2000a) cultic horizon (topsoil or ameliorative) is characterised by admixture of (agro)chemicals (limestone, FYM, fertilizers etc.). This definition is general enough. From available soil nutrients (P, K, Mg) only phosphorus is clearly related to anthropic activity because K and Mg usually occurs in high content also in natural conditions (carbonates, primary and secondary clay minerals etc.).

Table 2. Influence of manure application on soil parameters.

Soil parameter	N fertilizer application	P, K, Mg, Ca fertilizer applied in low rates	P, K, Mg fertilizer applied in high rates	Ca fertilizer applied in low rates	Ca fertilizer applied in high rates	solid organic manure application	liquid organic manure application
organic carbon (SOM)	– to 0	0	0	0	+	+ to ++	0
soil sorption complex quality	0	– to 0	+ to ++	+	+++	0 to +	0
pH	– to 0	– to 0	– to +	+	+++	0 to +	0
soil structure	– to 0	0 to +	0 to +	0 to +	+ to ++	+ to ++	0 to +
available nutrient supply	0	+	+++	+	+++	0 to +	0 to +
available heavy metal supply	0	0 to +	0 to ++	– to 0	– –	– to 0	0
mineralisable N	0 to +	0	0	0	0	+	0 to +
microbial biomass & activity	0 to +	0	0	0	0	+++	++

By USDA taxonomy (Anonym, 1999) anthropic horizon is characteristic also by citric acid soluble phosphorus exceeding 660 mg/kg. Respecting existing calibration scheme of Mehlich II & III methods for determination of available P within regular soil agrochemical testing in Slovak Republic (Collective, 1995; Collective, 2000c) we may propose the limits for all three forms of Cultizems as follows:

- texturally light soils 240 mg P/kg
- medium soils 200 mg P/kg
- heavy soils 175 mg P/kg.

Introduced values were derived as average top range of good P supply level for hop-gardens, vineyards and orchards. It is necessary to mention that between limits Mehlich II and III methods were observed minimal differences. Mehlich methods extract the highest available P amount from soil in comparison to other ones (e.g. Olsen and DL method). Above mentioned citric acid is not used at soil fertility monitoring and as results from paper of Collins and Budden (1998) this method extracts 2 and 3 times higher amount of P than DL method. Above mentioned may serve as good arguments for using of available P by Mehlich methods (II or III) at classification of soils (Cultizems).

Conclusions

Human influence of soils is manifested in soil disturbance or soil stress. Humanly caused stress effects are typically chemical in nature. Fertilization practices belong to the group with direct and often also significant influence.

Manure application, that includes nutrient and organic matter input, belongs to intensive human activities primarily oriented on achievement of cropper goals. Rapid application of very high rates of P, K, Mg fertilizers on arable land and especially before planting of permanent cultures (vine-yards, hop-gardens, orchards) as well as ameliorative rates of Ca fertilizers (limestone, lime, etc.) directly and significantly influence the soil parameters. High content of available soil nutrient supply may also occur in gardens due to long-term cumulative effect of excessive manure rates.

Fertilization measures significantly influence especially soil sorption complex quality (or base saturation in simplified sense), pH, soil structure, available nutrient supply and microbial biomass and its activity.

Anthropic soils by the Slovakian classification system are represented by two soil types: Cultizems and Anthrozems. From important agrochemical parameters $CaCO_3$ or pH as well as soil sorption complex saturation are directly used at soil classification. Position of nutrient content as classification parameter is actual especially in the case of Cultizems (horticulture, terraced and trenched forms). From available soil nutrients (P, K, Mg) only phosphorus is clearly related to anthropic activity. Proposed limits of Mehlich II & III phosphorus is necessary consider as provisional.

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Changes of Soil Sorptive Complex in Consequence of Interaction of Soil Particles and Steel Rotary Motion

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Abstract

Dependence of the adsorption complex parameters of six plough layers from southern Moravia (Czech Republic) on the period of the rotary motion of steel prisms were investigated.
Due to the effect of steel prism rotation decrease in CEC values of fine and clay particles of the studied plough layer occurs. After 30 minutes of rotation, the decrease is markedly reduced. Owing to the effect of steel prism rotation decrease in the content of soil skeleton occurs resulting in the marked increase of CEC of all particles during the first 15 minutes of rotation in samples of a topsoil Leptosol developed from limestone and Cambisol developed from amphibolite and in samples of Cambisol developed from syenite and Cambisol developed from phyllite to the CEC increase of all particles during the first minute of rotation. Due to the effect of steel prism rotation increased base saturation values occur in a topsoil Cambisol developed from amphibolite and Cambisol developed from gneiss and, on the contrary, marked decrease occurs in a topsoil Cambisol developed from syenite.

Introduction

The most typical anthropic effect on soil made by man already for several millennia is soil cultivation. Intensity of mechanical interference in the soil environment increased with the application of machines using the rotary motion of working elements (rotovators, rotary cultivators, some sowing exactors). Therefore, we have decided to define the dependence of the adsorption complex parameters of plough layers on the period of the rotary motion of steel prisms.

Material and Methods

Six plough layers from southern Moravia (Czech Republic) were tested:

1. Ap – Eutric Cambisol (ISSS-ISRIC-FAO 1994) developed from granite (the Mrákotín locality).
2. Ap – Eutric Cambisol developed from syenite (the Nové Město na Moravě locality).
3. Ap – Eutric Cambisol developed from gneiss (the Krahulov locality).
4. Ap – Eutric Cambisol developed from phyllite (the Javůrek locality).
5. Ap – Eutric Cambisol developed from amphibolite (the Slavětice locality).
6. Ap – Rendzic Leptosol developed from limestone (the Klentnice locality).

The rotary motion of working parts of agricultural machines on soil particles was simulated in a drum apparatus designed by Bond. Testing bodies were fixed in a rotor. Peripheral speed of testing bodies was 438 $m.min^{-1}$. The testing drum contained 1300 cm^3 of tested soil samples.

Testing bodies were made of high-grade, low-alloy steel 14 260 (the ČSN EN 10020 (420002) Standard) showing the following chemical composition: C – 0.55%, Mn – 0.6 %, Si – 1.4 % and Cr – 0.6 %. Steel was normalized for 2 hours at a temperature of 850°C and then cooled by air. The testing body was manufactured by milling and grinding. It was of the prism shape with the following dimensions: 76 x 25.4 x 6.3 mm. The roughness of its surface was R_a = 0.4 μm and the hardness was expressed as 250

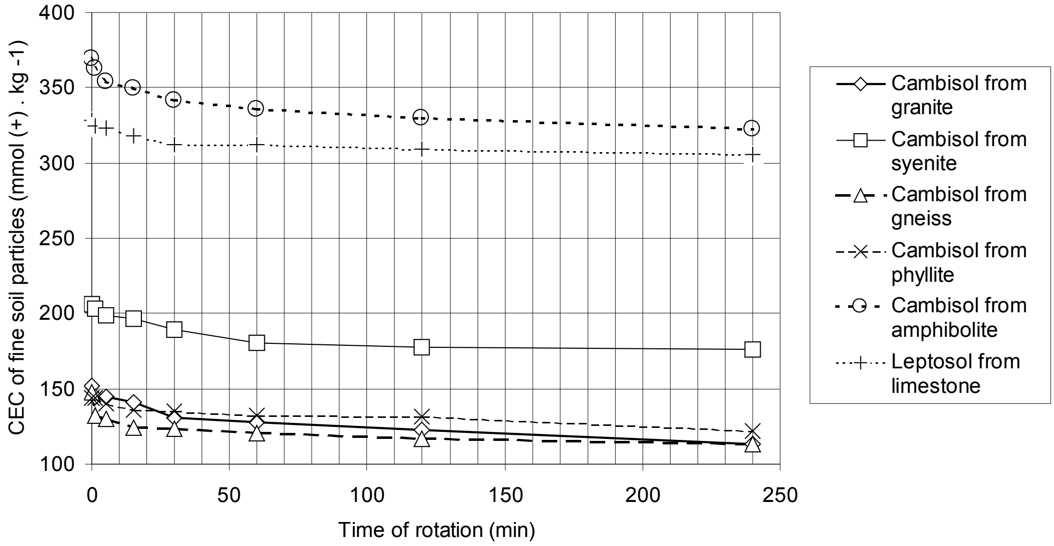
HV. Regarding the design of the drum testing apparatus it was necessary to remove the soil skeleton of a diameter > 10 mm. The following periods of rotation were used: 1, 5, 15, 30, 60, 120, and 240 min.

Parameters of the adsorption complex were determined according to the method of Mehlich used in the large-scale mapping of agricultural soils in Czechoslovakia (Facek et al. 1967). The soil texture was analysed using the pipette method.

Results

Changes in cation exchange capacity (CEC) of fine particles of the plough layer under study as affected by various intervals of the rotary motion of steel prisms are presented in Figure 1. In all the samples, decrease in CEC values of fine soil particles occurred and the most marked decrease could be observed in the first time

Figure 1: Changes in CEC of fine soil particles as dependent on period of rotation of steel prisms.



Intervals of the experiment. The decrease can be expressed by polynomial equations :

Cambisol from granite:
$y = -0.00001x^3 + 0.005x^2 – 0.6317x + 148.39$; $R^2 = 0.9705$.

Cambisol from syenite:
$y = -0.00001x^3 + 0.0047x^2 – 0.6364x + 204.37$; $R^2 = 0.9877$.

Cambisol from gneiss:
$y = -0.00001x^3 + 0.0055x^2 – 0.6143x + 136,82$; $R^2 = 0.7598$.

Cambisol from phyllite:
$y = -0.00001x^3 + 0.0035x^2 – 0.374x + 143.03$; $R^2 = 0.9790$.

Cambisol from amphibolite:
$y = -0.00002x^3 + 0.0071x^2 – 0.8773x + 363.28$; $R^2 = 0.9571$.

Leptosol from limestone:
$y = -0.00001x^3 + 0.0044x^2 – 0.4987x + 325.76$; $R^2 = 0.9495$.

Five of six equations show the very high coefficient of determination. After that, changes were calculated in CEC of fine soil particles after 10 seconds roughly corresponding to one passage of a rotovator (Table 1). The most marked decrease after 10 seconds of rotation could be observed in the plough layer of Cambisol from gneiss: 2.62 mmol (+) .kg^{-1}. Marked changes were observed in the plough layer of Cambisol from granite and Cambisol from amphibolite: 1.19 and 0.98 mmol (+).kg^{-1}, respectively.

The root system of plants is undoubtedly affected by the adsorption complex of topsoil as a whole and not only by the adsorption complex of fine earth. In case of soils containing skeleton, it is necessary, therefore, to evaluate CEC of all particles of the plough layer and not only CEC of fine soil particles. Changes in CEC of all particles of the plough layer under study as affected by various intervals of the rotary motion of steel prisms are presented in Figure 2.

Table 1: Decrease CEC of fine soil particles after 1 application of rotovator**.**

Soil	CEC fine soil particles		Decrease CEC fine soil particles
	basic soil sample	after 1 passage of a rotovator	
	(mmol (+) . kg^{-1})		
Cambisol from granite	152.14	150.95	1,19
Cambisol from syenite	206.37	205.85	0,52
Cambisol from gneiss	147.60	144.98	2,62
Cambisol from phyllite	144.01	143.94	0,07
Cambisol from amphibolite	368.94	367.96	0,98
Leptosol from limestone	328.46	327.78	0,68

In samples of a topsoil Leptosol developed from limestone and Cambisol developed from amphibolite we can observe a marked increase in CEC during the first 15 minutes of rotation. In samples of Cambisol developed from syenite and Cambisol developed from phyllite there is an evident increase in CEC of all particles only during the first minute of rotation. In case of the plough layer of Cambisol developed from gneiss the value is constant. CEC of all particles of the plough layer of Cambisol developed from granite decreases very slowly. Changes mentioned above are related to the decrease in the content of skeleton owing to the rotation of steel prisms as shown in Table 2. Changes in CEC of fine soil particles after 10 seconds in the topsoil Leptosol developed from limestone amount to +12.91 mmol (+) . kg^{-1}, in the topsoil Cambisol developed from amphibolite +8.13 mmol (+) . kg^{-1}, in the topsoil Cambisol developed from syenite +5.24 mmol (+) .kg^{-1} and in the topsoil Cambisol developed from phyllite +3.78 mmol (+) .kg^{-1}. In remaining two samples, the changes are negligible.

Figure 3 illustrates changes in CEC of clay particles of studied topsoil as affected by various intervals of the rotary motion of steel prisms. The highest values are shown by the initial sample of a topsoil Cambisol developed from amphibolite, see 3638 mmol (+) .kg^{-1}, slightly less values exhibit the initial sample of a topsoil.

Figure 2: Changes in CEC of all particles as dependent on period of rotation of steel prisms.

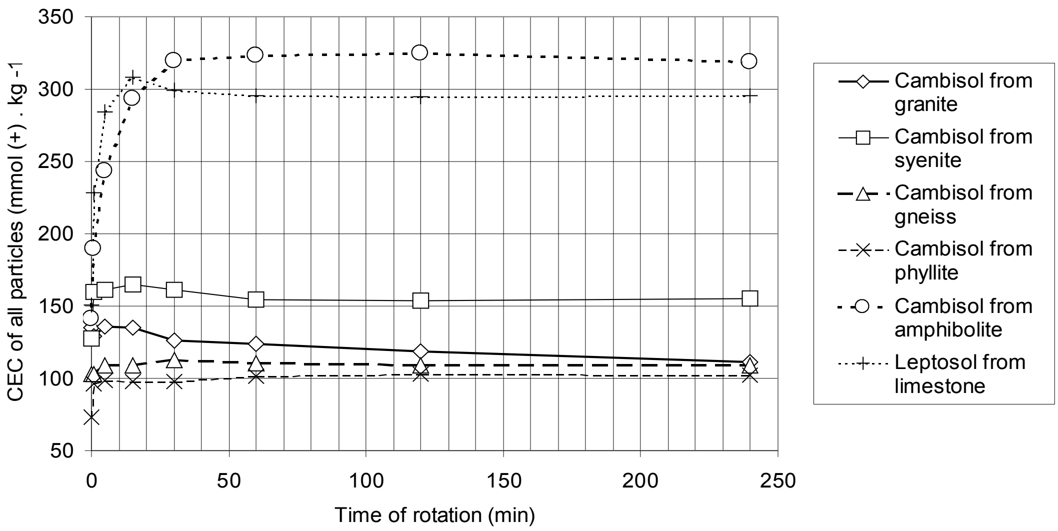
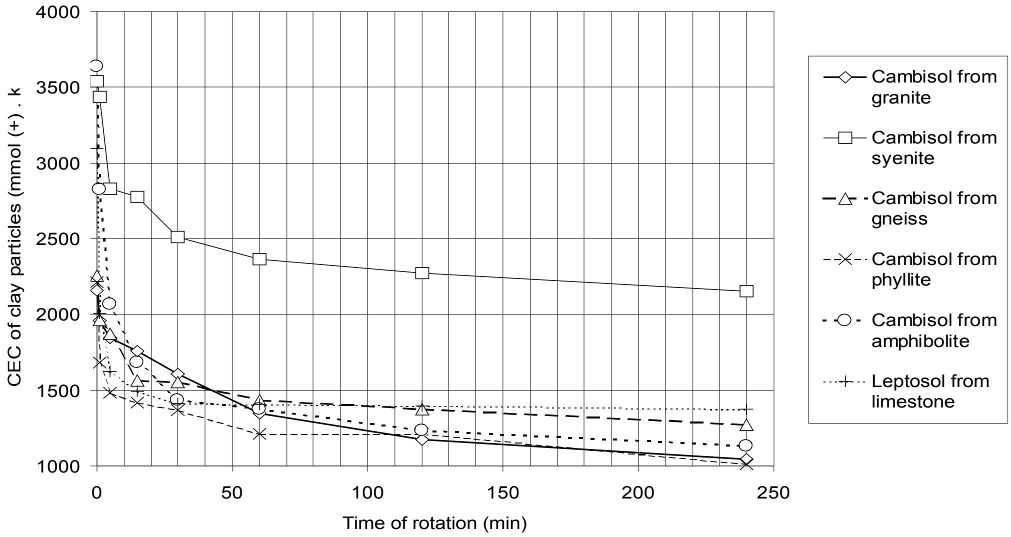


Table 2: Contents of skeleton particles.

Soil	Cambisol from granite	Cambisol from syenite	Cambisol from gneiss	Cambisol from phyllite	Cambisol f. amphibolite	Leptosol from limestone
Time of rotation						
	Contents of skeleton particles (> 2 mm)					
(min)	(% w./w.)					
0	11.45	37.99	30.15	49.04	61.77	54.12
1	10.80	21.57	21.80	33.10	47.71	29.66
5	5.97	18.86	16.02	29.66	31.14	11.88
15	4.19	16.21	12.08	28.07	15.98	5.27
30	3.88	14.80	8.70	27.43	6.42	4.73
60	3.15	14.40	8.27	23.16	3.83	4.04
120	2.98	13.43	6.65	21.85	1.37	3.24
240	2.14	12.08	3.97	16.12	1.15	3.21

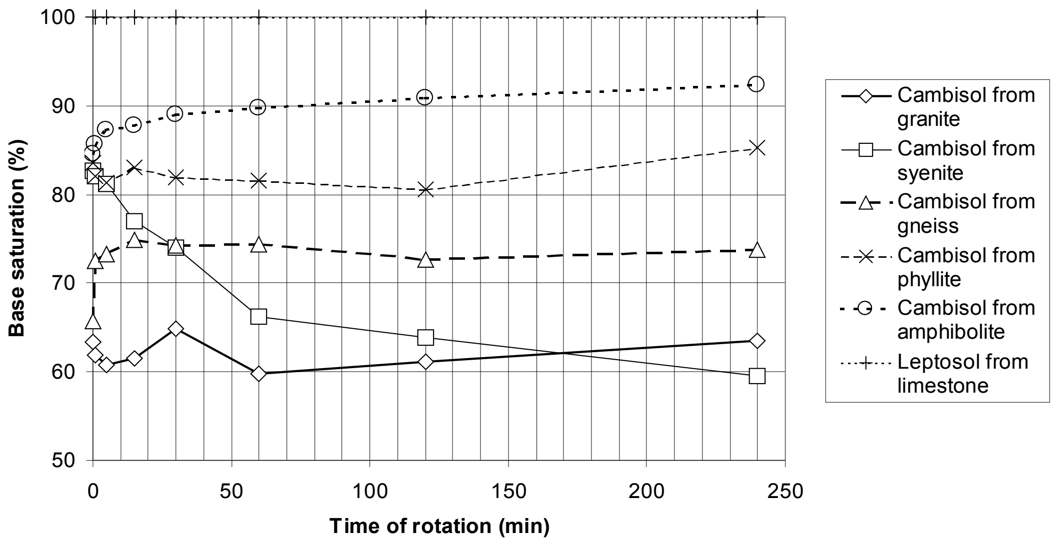
Figure 3: Changes in CEC of clay particles as dependent on period of rotation of steel prisms.



Cambisol developed from syenite, see 3540 mmol (+) .kg^{-1} and the sample of a topsoil Leptosol developed from limestone, viz. 3096 mmol (+) .kg^{-1}. Almost identical initial values were determined in samples of Cambisol developed from gneiss, viz. 2257 mmol (+) .kg^{-1}, Cambisol developed from phyllite, viz. 2216 mmol (+) .kg^{-1} and Cambisol developed from granite, see 2161 mmol (+) .kg^{-1}. The steel prism rotation causes an abrupt decrease in CEC of clay particles in samples of a topsoil Cambisol developed from amphibolite and Leptosol developed from limestone. In the course of all intervals of steel prism rotation, the highest CEC values of clay particles were in a topsoil Cambisol developed from syenite. After 240 min. of rotation the value reached 2153 mmol (+) .kg^{-1}. In other samples, after 30 min. of rotation the value of CEC of clay particles was decreased to 1368 - 1604 mmol (+) .kg^{-1} and also in other intervals of rotation the value of CEC of clay particles remains considerably near.

Changes in base saturation of plough layers under study as affected by various intervals of the rotary motion of steel prisms are presented in Figure 4. A topsoil Leptosol developed from limestone shows naturally 100 % base saturation in the course of the whole experiment. While the base saturation of a topsoil Cambisol developed from amphibolite increases during all intervals of rotation in case of a topsoil Cambisol developed from gneiss we recorded increase in base saturation only in the course of the initial 15 minutes. In a topsoil Cambisol developed from phyllite and Cambisol developed from granite values of base saturation only fluctuate in the range of several percents due to the effect of steel prism rotation. Base saturation of a topsoil Cambisol developed from syenite permanently decreases with the interval of rotation.

Figure 4: Changes in base saturation as dependent on period of rotation of steel prisms.



Conclusions

Due to the effect of steel prism rotation decrease in CEC values of fine and clay particles of the studied plough layer occurs. After 30 minutes of rotation, the decrease is markedly reduced.

Owing to the effect of steel prism rotation decrease in the content of soil skeleton occurs resulting in the marked increase of CEC of all particles during the first 15 minutes of rotation in samples of a topsoil Leptosol developed from limestone and Cambisol developed from amphibolite and in samples of Cambisol developed from syenite and Cambisol developed from phyllite to the CEC increase of all particles during the first minute of rotation.

Due to the effect of steel prism rotation increased base saturation values occur in a topsoil Cambisol developed from amphibolite and Cambisol developed from gneiss and, on the contrary, marked decrease occurs in a topsoil Cambisol developed from syenite.

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Differences in Some Properties of Humus Substances between Cultivated and Natural Soils

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Abstract

Due to a great significance of soil managering on organic matter content, we have used selected properties of organic matter for comparison of differences in organic matter quality and quantity between farmed and non-cropped soils. Results of our investigation confirm, that organic matter properties are sensitive indicator for that assessment. Qualitative composition of organic matter were more favourable in farmed soils (ratios cHK : cFK were 1,19 a 0,98 in farmed soils and 0,75 a 0,93 in non-cropped soils). Lower values of colour coefficients of humic acids isolated from cultivated samples are an evidence of higher degree of organic matter humification.

Introduction

A great importance of organic matter in the soil environment is known for years. Therefore the soil organic matter content is considered as one of ten agro-environmental issues of soil selected by OECD policy makers (Pascal 1997).

The organic matter is a heterogeneous product which is a result of humification process. The factors having influence on the humus status in the soil first of all are habitat (type of soil, plant cover) and anthropogenic - fertilisation, irrigation, the way of cultivation.

Soils in their native state have characteristic content of organic matter. Its quality and quantity is steadily changed due to simultaneously progressing processes of degradation and synthesis, which are in dynamical equilibrium characteristic for certain soil type and environmental conditions. This equilibrium is disturbed when soil is brought into cultivation (Sotáková 1982). In farmed soil the mineralization of soil organic matter is accelerated, therefore new equilibrium (which depends on farming system) is stated (Kubát, Lipavský 1999). Therefore is evident, that farmed soils differ in some properties from uncropped soils in the same pedo-ecological conditions. On the base of this fact we suppose, that determined differences can provide information about degree of soil degradation.

Material and Methods

For determination were used samples from cultivated soil and control samples from nearby virgin soil (oak-hornbearn forest) from Báb locality. The parent material is calcareous loess (Hraško 1970, Linkeš 1966).

Soil profiles were characterised in pairs:

Profiles No. 1 and 2 – their mutual distance was 80 m, located at upland position:

- profile No. 1 – forest soil, classified as Luvic Phaeozems;
- profile No. 2 – cultivated soil, classified as Haplic Chernozem.

Profiles No. 3 and 4 – their mutual distance was 60 m, located at colluvial foot slope:

– profile No. 3 - forest soil, classified as Orthic Luvisols;
– profile No. 4 – cultivated soil, classified as Orthic Luvisols.

Soil samples were analysed for the following parameters at intervals of 0.1 m for whole soil profile:
– organic carbon content - according to Tyurin method (Orlov, Grischina 1981);
– fractional composition of humus - by fractionation of Kononova-Belchikova (Orlov, Grischina 1981).

Humic and fulvic acids were isolated from topsoil by Orlov method (Stevenson 1982):
– Humic acids (HA) were analysed for absorption spectra in UV and VIS range (UV visible recording spectrophotometer UV - 240 Graphicord);
– Fulvic acids were analyzed for potentiometric (pH-meter, 420 A) and conductometric titration (712 Metrohm Conductometer).

The concentration of HA and FA used for measurement of absorption spectra, potentiometric and conductometric titrations was 10 mg TOC on 1 liter 0,001 M NaOH. The reaction of HA and FA solution was adjusted to pH 7 (by 0,1 and 0,01 M HCl and NaOH).

Results and Discussion

The results of organic carbon content are shown in Table 1. Each of them are mean values of three repetitions. The highest differences in soil organic matter (SOM) quantity were found in topsoil, where SOM content was 1.3 – 2 times higher in forest soil than in nearby cultivated soil.

The qualitative composition of humus determined by fractionation of Kononova-Belchikova was more favourable in topsoil of the farmed soil (ratio cHA : cFA were 1.19 and 0.98 in farmed, 0.75 and 0.93 in uncropped soil). Differences decreased with depth (Table 1).

Table 1: Humus content and humic and fulvic acids ratios.

Profile No.	Horizon	Cox(%)	Humus(%)	HA/FA
1 forest, upland	A	2.01	3.46	0.75
	C	0.53	0.91	0.91
2 cultivated soil, upland	A	1.54	2.65	1.19
	C	0.41	0.71	1.06
3 forest, slope	A	2.46	4.24	0.93
	Bt	0.62	1.07	0.97
	C	0.45	0.78	1.04
4 cultivated soil, slope	A	1.24	2.14	0.98
	Bt	0.50	0.86	0.87
	C	0.32	0.55	1.48

Humic and fulvic acids isolated from topsoil were characterized for absoption spectra. The basic structural elements of humus acids are aromatic and alicyclic rings, side aliphatic chains of carbohydrate type, proteins and amino-acids. Humus acids are a heterogeneous mixture, for which there is not single chemical formula. This is a consequence of the diversity among the material humified as well as the varied conditions of the humification process (Gonet-Debska 1993).

It is known, that humus substances of better quality contain more condensed nucleus (aromatic and alicyclic rings), therefore absorb more light than less condensed (humified). Because in UV VIS range humus acids do not create separate peaks, the absorbency coefficient (ratio of absorbencies at selected wavelengths) was proposed (Orlov 1974, Kumada 1987 a Gonet-Debska 1993). This parameter well characterises humification degree and indicate substitution of aliphatic and aromatic compounds of humus substances. Lower values of absorbency coefficient represent higher degree of humification.

There were found evidently higher absorbency values of UV VIS spectra in humic acids isolated from topsoil of the farmed soil. Absorbency coefficients (Table 2) confirmed higher quality of humic acids isolated from the farmed soil.

Potentiometric methods allow to determine number H^+ ions disociable from acidic functional groups of humus acids. Acidic character of humus acids is caused by ionization of number acidic functional groups (mainly COOH, OH, phenol). In typical titration curve of HA and FA the value of pH increase gradually with quantity of added NaOH, what reflects their buffer ability. The evidence of their high buffer ability is broad range of pH, when humus acids are able to neutralize acids and bases present in solution.

Table 2: Ratios of humic acids absorbances.

Profile No.	$A_{280/665}$	$A_{280/465}$	$A_{465/665}$
1 forest, upland	5.25	28.33	5.40
2 cultivated soil, upland	4.53	22.46	4.96
3 forest, slope	5.06	28.00	5.53
4 cultivated soil, slope	4.67	21.54	4.62

Fulvic acids were characterized for acidic functional group and buffer ability by potentiometric and conductometric titration methods.

Potentiometric titration curves had three plateau regions indicating the existence of three more or less distinct classes of acidic functional groups. We founded out, that inflection point of fulvic acids isolated from cropped soil had higher values of inflection point which was reached after adding of 1.3 ml 0.01 mol.l^{-1}, than that form the forest soil (1.2 ml 0.01 mol.l^{-1}), what is evidence of higher acidity and buffer ability of fulvic acids in the cultivated soil (Graph 1).

Conductometric titration curves did not confirm data obtained potentiometrically. The inflection point (the main break of conductometric curve) of fulvic acids isolated from forest soil on upland position and from cultivated soil on colluvial foot slope had higher, reached after adding of 1.0 ml 0.01 mol.l^{-1} NaOH, than fulvic acids isolated from forest soil on colluvial foot slope and from cultivated soil on upland position where inflection point was reached after adding of 0.9 ml 0.01 mol.l^{-1} NaOH (Graph 2).

Conclusions

Results presented in this work confirmed, that determined humus characteristics are sensitive index of differences between cultivated and natural soil and can be used as an indicator of anthropic influence on soil. The qualitative composition of humus was better in topsoil of the cultivated soil (ratios cHA : cFA were 1.19 and 0.98 in cropped, 0.75 and 0.93 in uncropped soil). Lower absorbency ratios of humic acids isolated from cropped soil are evidence of higher humification degree of humus in cropped soil. The potentiometric titration of fulvic acids isolated from cropped soil had higher values of inflection point (reached after adding of 1.3 ml 0.01 mol.l^{-1} NaOH) than that form the forest soil (1.2 ml 0.01 $mol.l^{-1}$ NaOH), what is evidence of higher acidity and buffer ability of fulvic acids in the cultivated soil. Values obtained by conductometric titration did not confirm data obtained potentiometrically.

Acknowledgement

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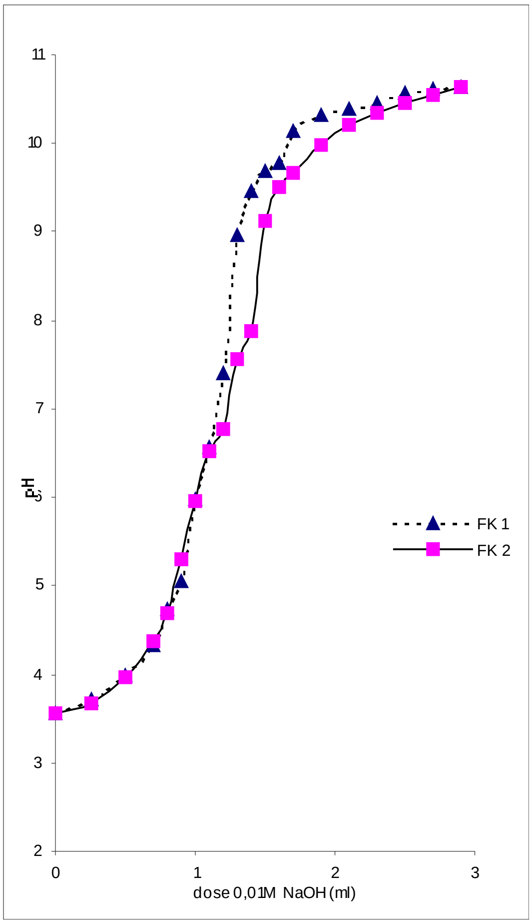
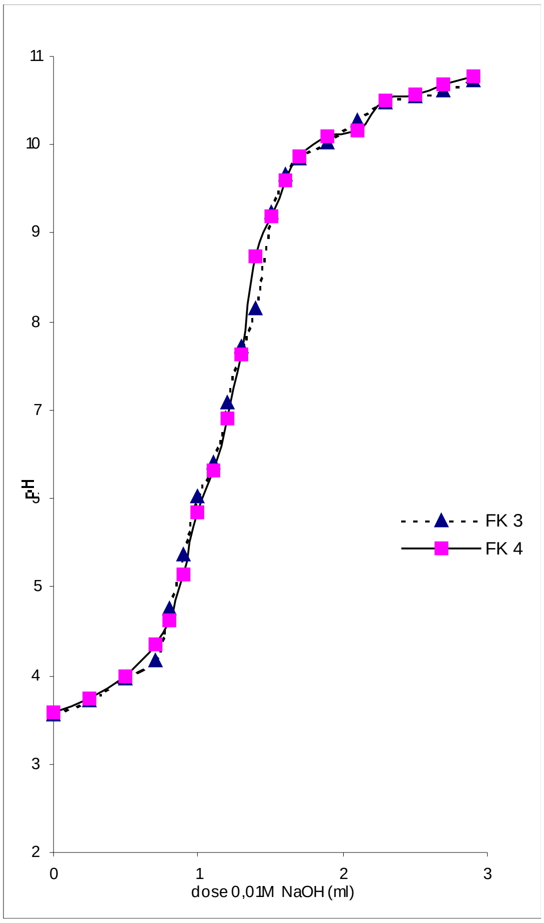
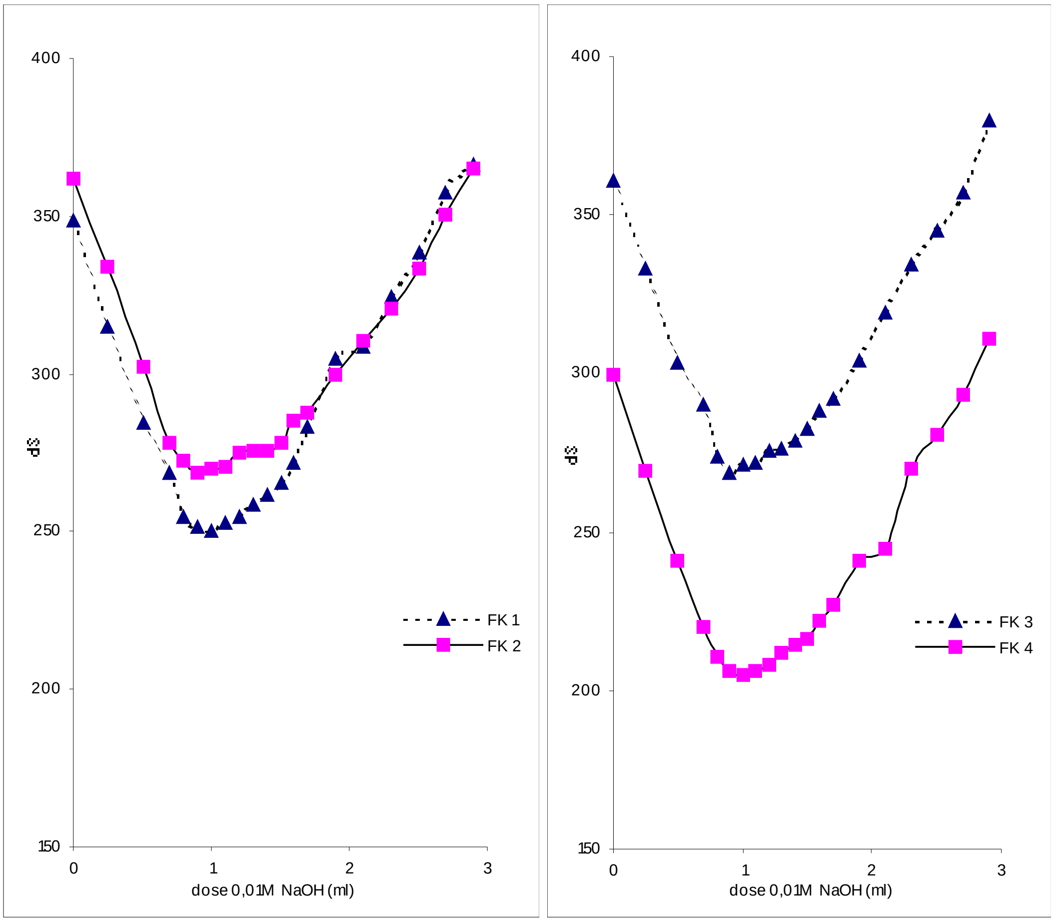
Graph 1: Potentiometric titrations of fulvic acids (FK) isolated from forest (1,3) and cultivated (2,4) soils.





Graph 2: Conductometric titrations of fulvic acids (FK) isolated from forest (1,3) and cultivated (2,4) soils.



The Vulnerability of Subsoils to Compaction

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Abstract

Soil compaction is an important effect of anthropoid activities modifying both productional and non-productional functions of soils. Identifying the vulnerability of subsoils to compaction is an important issue both in planning and executing of farming operations and in evaluating environmental protection measures. This paper suggests a simple classification system for evaluation of subsoil vulnerability to compaction based on database of soil characteristics and qualities. Data concerning a soil texture, bulk density, porosity and a content of clay for first underplough horizon are used for calculation. The system of Main Soil Units according to the Soil Evaluating System was applied for classification of vulnerability to compaction categories due to its complete digitization for the whole Czech territory.

Introduction

Soil compaction, one of the ways of soil degradation, is mostly a problem of agricultural soils, but is not exceptional even in forest soils. More than 40 % (1 750 000 ha) of Czech agricultural soils are exposed to compaction. From this amount nearly 30 % (500 000 ha) are subject to the so-called genetic compaction (of natural origin), while the rest (1 250 000 ha) can be affected to technogenic compaction. The latter is a product of several causes of anthropic character. The genetic compaction is typical for heavy soils with a higher clay content. On the other hand, the technogenic or anthropic compaction can affect the soils of any texture. In heavy soils it can be combined with the primary, genetic compaction.

The technogenic compaction is caused by the intensive mechanisation of agriculture, by the enhanced machinery and equipment size and by the overall drive for greater productivity. Over the past 30 years larger and larger machines have been developed, which resulted in a significant increase of axle loads, always accompanied by a corresponding increase the it restricts ground contact area to prevent soil compaction.

Soil compaction manifest itself primarily as a change of physical properties of the soil. The structure of the soil, its bulk density, porosity, infiltration capacity of compacted soils are different from those in unaffected soils. In this way, both productional and non-productional functions of soils are affected.

Under Czech conditions the most serious phenomenon is the subsoil technogenic compaction. This is caused by anthropic influences and often is combined with compaction due to natural factors. The compaction of subsoil layers is an important degradation factor because:

- it restricts the affected depth of soil profile available to crops, especially field crops,
- it restricts the infiltration of water, accelerates the lateral surface outflow of water and thus increases the erosion risk,
- it reduces the water retention capacity of the soil,
- it suppresses biological activity in the soil, which obviously depends on air and water regime and thermic cycles of the soil.

Material and methods

The physical soil properties most closely related to the potential vulnerability of the subsoil to compaction are:

- soil texture expressed as a texture class,
- content of clay fraction,
- bulk density ($t.m^{-3}$, $g.cm^{-3}$),
- soil structure, its type, the size and development of peds,
- total porosity,
- actual soil moisture content (% vol.).

The data on soil texture class, clay content, bulk density and total porosity were taken from the numerical component of the Czech Information System on Soils, in which data on more than 1 400 soil profiles are stored. The potential vulnerability to compaction of the plough-pan layer (usually the part of the second horizon of the profile) was evaluated in three different ways and results were compared. These three ways of calculating the potential vulnerability of the second horizon were based on:

- bulk density,
- porosity,
- so-called "packing density" (according to R.J.A. Jones).

For the evaluation based on bulk density and porosity the following Table 1 of critical values for different texture classes (limits) was used.

Table 1. The vulnerability of subsoil to compaction according to bulk density and porosity.

Potential vulnerability	Soil characteristic	Soil texture					
		clay	**clay loam**	**loam**	**sandy loam**	**loamy sand**	**sand**
High H	bulk density $t.m^{-3}$	>1,35	>1,40	>1,45	>1,55	>1,60	>1,70
	porosity %	<48	<47	<45	<42	<40	<38
Medium M	bulk density $t.m^{-3}$	1,24-1,35	1,29-1,40	1,33-1,45	1,43-1,55	1,47-1,60	1,56-1,70
	porosity %	48-52	47-51	45-49	42-45	40-43	38-41
Low L	bulk density $t.m^{-3}$	<1,24	<1,29	<1,33	<1,43	<1,47	<1,56
	porosity %	>52	>51	>49	>45	>43	>41

For the evaluation according to "packing density" (R.J.A. Jones 2000), the following calculation and characteristics were used.
Packing density in $t.m^{-3}$

$$PD = BD + (0.009 . C)$$

where PD is packing density
BD is bulk density
C is clay content

Due to this small equation:

Table 2. The vulnerability of subsoil to compaction according to texture and packing density.

Texture	Packing density t.m^{-3}		
	<1,40	1,40-1,75	>1,75
	Vulnerability		
sand	L	L	M
loamy-sand	L	L-M	M
sandy-loam	L	M	M
loam	L	M	M-H
clay-loam	M	H	H*
clay	M	H	H*

Legend:
L - low vulnerability
M - medium
H - high vulnerability
H* - already compacted

The calculation of subsoil vulnerability was carried out for Main Soil Units of the Czech System of Soil Evaluation Units. The cartographic part of this system is fully digitized for the whole territory of Czech Republic. From the point of view of practical use this system is most suitable and, at present, in GIS the only widely used for soil and land applications. As it was already mentioned, all numerical values of physical properties of soils were taken from the existing data-base of characteristics of Czech soils.

Results

The following Table 3 characterizes the degree of potential vulnerability of subsoil to compaction for individual Main Soil Units of the Czech System of Soil Evaluation Units. It was carried out by use of three methods: on the base of soil bulk density, on the base of soil total porosity and on the base of "packing density". Evaluation in Table 3 was carried out in five degrees:

L : low vulnerability,
L – M : low to medium vulnerability,
M : medium vulnerability
M – H : medium to high vulnerability,
H : high vulnerability to compaction.

Conclusions

One map of potential technogenic vulnerability of subsoil to compaction for the district Rychnov nad Kněžnou is presented as a example of possible applications. The map was carried out by using the values of porosity; the use of values of porosity seems as the best; on the other hand the use of "packing density" method does not probably give clearly differentiated results.

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Table 3.

Main soil unit	Soil texture (<0.01 mm)	Clay content % (<0.002mm)	Bulk density t.m-3	Porosity %	Packing density R.J.A.Jones t.m-3	VULNERABILITY		
						Bulk density t.m-3	Porosity %	Packing density R.J.A. Jones
01	loam	30,0	1,30	51	1,57	L	L	M
02	loam	31,4	1,34	49	1,62	M	M	M
03	loam - clay loam	27,8	1,44	46	1,69	M-H	M-H	M
04	loamy sand - sandy loam	12,5	1,49	43	1,60	M	M	M
05	sandy loam - loam	26,1	1,49	44	1,72	M-H	M-H	M
06	loam - clay loam	37,3	1,38	47	1,72	M	M	M
07	clay loam - clay	49,1	1,37	49	1,81	M-H	M-H	M-H
08	sandy loam - loam	28,1	1,38	48	1,63	M	L-M,L	M
09	loam	22,5	1,44	44	1,64	M	H	M
10	loam - clay loam	33,1	1,48	44	1,78	H-VH	H-VH	M-H
11	loam - clay loam	31,0	1,44	46	1,72	M-H	M-H	M
12	loam - clay loam	28,8	1,49	44	1,76	H-VH	H-VH	M-H
13	sandy loam - loam	21,8	1,48	45	1,68	M-H	M	M
14	loam - clay loam	22,2	1,43	44	1,63	M-H	H-VH	M
15	loam	28,5	1,48	45	1,76	H-VH	M	M-H
16	sandy loam - loam	25,3	1,48	45	1,71	M-H	M	M
17	sand -loamy sand	23,9	1,44	45	1,66	L	L	L
18	lack of data							
19	loam - clay loam	36,0	1,36	47	1,68	M	M	M
20	clay loam - clay	51,4	1,42	49	1,88	H-VH	M	M-H
21	sand -loamy sand	8,6	1,56	41	1,64	M	M	M
22	loamy sand -loam	23,1	1,54	41	1,76	M-H	M-H	M
23	loamy sand - clay	22,2	1,51	42	1,71	M-H	M-H	M-H
24	lack of data							
25	sandy loam - clay loam	23,4	1,49	43	1,70	M-H	M-H	M
Main soil	**Soil**	**Clay**	**Bulk**	**Porosity**	**Packing**	**VULNERABILITY**		

unit	**texture (<0.01 mm)**	**content % (<0.002mm)**	**density t.m-3**	**%**	**density R.J.A.Jones t.m-3**	**Bulk density t.m-3**	**Porosity %**	**Packing density R.J.A. Jones**
26	sandy loam - clay loam	23,4	1,50	45	1,71	M-H	M-H	M
27	loamy sand - loam	13,1	1,34	49	1,46	L-M,L	L	M
28	sandy loam - clay loam	25,0	1,36	50	1,59	L-M,L	L-M,L	M
29	loamy sand - sandy loam	14,4	1,51	44	1,64	M	L-M,L	M
30	loamy sand - loam	20,1	1,57	43	1,76	M-H	M-H	M-H
31	sand- loamy sand	12,8	1,50	44	1,62	L-M,L	L	L-H
32	loamy sand - sandy loam	9,5	1,31	45	1,39	L	L	L
33	loam - clay loam	34,8	1,43	49	1,74	M-H	M	M
34	loamy sand - sandy loam	10,6	1,30	51	1,39	L	L	L
35	sandy loam - loam	16,7	1,24	53	1,39	L	L	L-M
36	loamy sand - sandy loam	12,1	1,19	55	1,30	L	L	
37	loamy sand - sandy loam	11,3	1,51	45	1,61	M	L-M	M
38	loam	24,5	1,19	56	1,39	L	L	L-M
39	lack of data							
40	sand - loamy sand	16,4	1,50	42	1,65	L-M	L-M,H	L-M
41	loam - clay loam	33,3	1,42	48	1,72	M-H	M	M-H
42	loam - clay loam	21,6	1,44	48	1,63	M-H	M	M
43	loam - clay loam	21,7	1,45	46	1,65	H-VH	M-H	M
44	loam - clay loam	21,8	1,60	41	1,80	H-VH	H-VH	H-VH
45	loam - clay loam	21,7	1,37	48	1,57	M	M	M
46	loam	20,9	1,51	43	1,70	H-VH	H-VH	M
47	loam - clay loam	23,8	1,52	44	1,73	H-VH	H-VH	M
48	loam	22,9	1,55	41	1,76	H-VH	H-VH	L-M
49	clay loam - clay	49,8	1,40	50	1,85	M-H	M	M-H
50	loam	19,5	1,32	49	1,50	L,L-M	M	M
Main soil unit	**Soil texture (<0.01mm)**	**Clay content % (<0.002mm)**	**Bulk density t.m-3**	**Porosity %**	**Packing density R.J.A.Jones**	**VULNERABILITY**		
						Bulk density	**Porosity**	**Packing density**

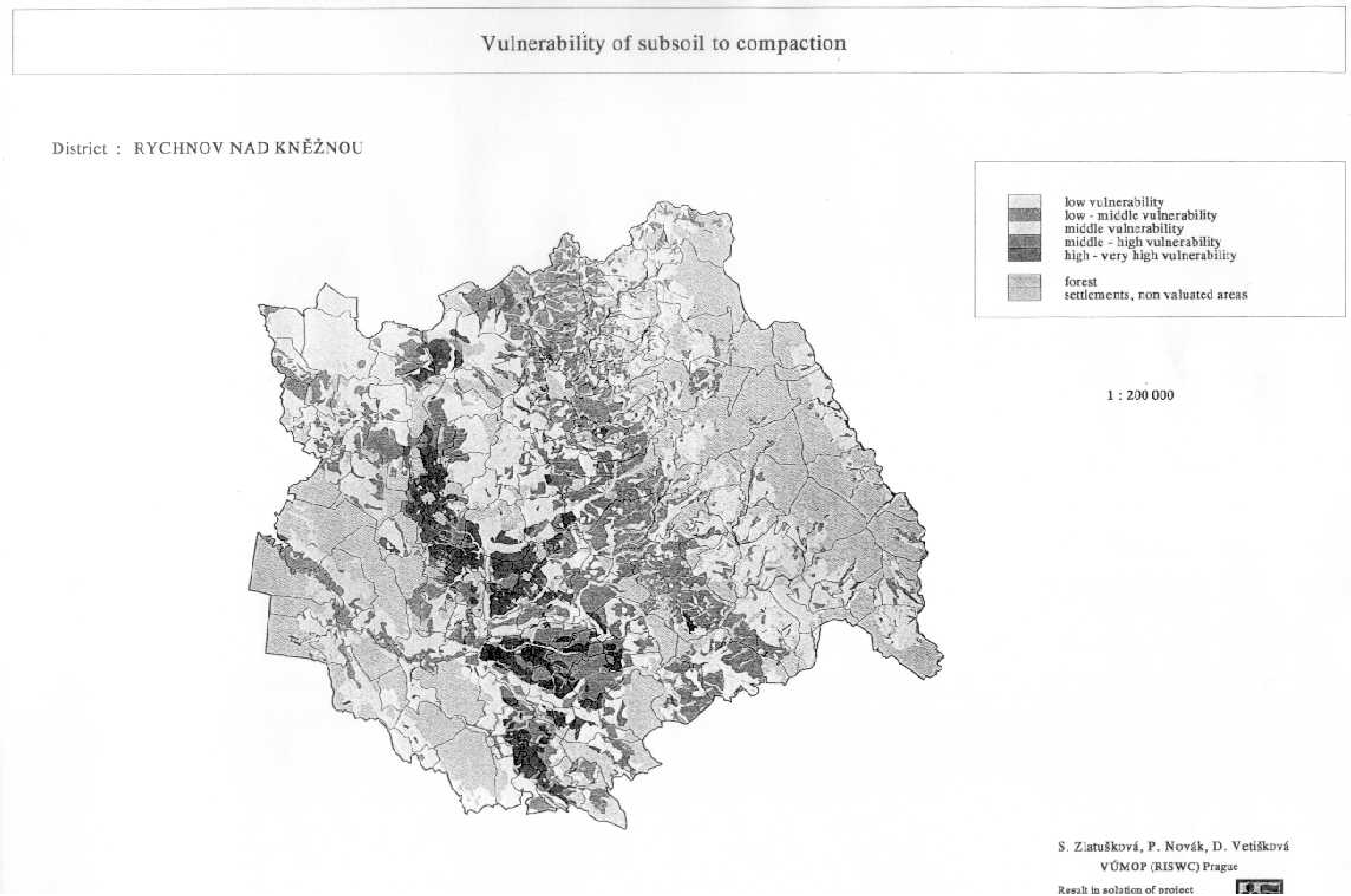
					t.m-3	t.m-3	%	R.J.A. Jones
51	sandy loam	22,2	1,59	43	1,79	H-VH	M	M
52	sandy loam	21,9	1,59	43	1,79	H-VH	M	M
53	loam	27,8	1,41	47	1,66	M	M	M
54	clay loam - clay	53,4	1,41	49	1,89	H-VH	M	M-H
55	sand -loamy sand	8,7	1,22	52	1,30	L	L	L
56	sandy loam - clay loam	21,8	1,30	51	1,50	L-M	L-M,L	M
57	clay loam - clay	46,2	1,40	50	1,82	M	M	M-H
58	sandy loam -clay loam	17,8	1,35	52	1,51	L-M	L-M	M
59	clay loam - clay	47,1	1,32	51	1,74	M	M	M
60	loam - clay loam	27,4	1,28	50	1,53	L-M	L-M	M
61	clay loam - clay	49,2	1,25	49	1,69	L-M	M	M
62	loam	28,6	1,07	55	1,33	L-M	L-M	L-M
63	clay loam - clay	49,8	1,32	49	1,77	M	M	L-M
64	loam-clay	29,5	1,20	55	1,47	L-M	L-M	M
65	lack of data							
66	loam - clay loam	34,3	1,55	42	1,86	H-VH	H-VH	M-H
67	loam - clay loam	25,6	1,42	46	1,65	M-H	M-H	M-H
68	sandy loam - clay	29,8	1,56	42	1,83	H-VH	H-VH	M-H
69	clay	26,4	1,53	44	1,77	H-VH	H-VH	M-H
70	clay	29,7	1,52	45	1,79	H-VH	H-VH	M-H
71	clay	29,8	1,52	44	1,79	H-VH	H-VH	M-H
72	lack of data							

Classes of susceptibility to compaction:

L…low

M…moderate

H, VH…high, very high


Vulnerability of subsoil to compaction
District : RYCHNOV NAD KNĚŽNOU
low vulnerability
low - middle vulnerability
middle vulnerability
middle - high vulnerability
high - very high vulnerability
forest
settlements, non valuated areas
1 : 200 000
S. Zlatušková, P. Novák, D. Vetišková
VÚMOP (RISWC) Prague
Result in solution of project

Soil Anthropization and Legal Aspects of Soil Conservation

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Abstract

A legal aspect of soils influenced by anthropic activities are not well-known and their solving is very problematic at the present stage of our legislation. The Bonitation Pedo-ecological Units (BPEU) represent relatively most homogeneous units concerning to soil and its ecological characteristics including main soil units (MSU) as substantial part of BPEU. Only some main soil units presented by 7-digital code reflect anthropic impact, and are: code "30" (Trenched Cultizems, or other soils intensively utilized), code "74" (Cultizems, transformed by trenching or terracing) and the code "10" (soils strongly deteriorated by emission spillage, as well as toxic varieties of soil types). As other human-induced impacts, mainly degradation activities incorporated in MSUs are considered: water and wind erosion, soil compaction. According the Act No. 307/1992 recultivated soils (Anthrozems in classification perceiving) must be return into original status like a natural soils, it means into the same BPEU, although the quality of soil do not correspondent with the original soil units. Therefore a research of incorporating anthropogenic soils in BPEU system regarding extra-productional function should be continued.

Introduction

By the introductory provision of Act No. 307/1992 on farmland conservation the farmland is assessed as an irretrievable natural resource and unique component of an environment. Everybody is obliged to protect their natural functions and prevent any action that could be lead to farmland deterioration. The way of farmland use must be adequate to natural conditions in given landscape and at the practical level of farming. It must not threaten an ecological stability of the territory.

Everybody who use farmland for agricultural production is doing duty to utilize farmland in such a way which conserve its natural fertility. Subsequently, by cited § 1 and 4, the § 5 says: "everybody, who by his activity deteriorates natural properties of farmland or provoke the risk of such deterioration, is obligated to carry out the amendment measures in order to remove hazard situation". Under hazard situation removing is mentioned so-called return to initial natural conditions, i.e. to original bonitation soil-ecological unit identification using appropriate reclamation measures.

Another important problem connected with legal aspect of soil conservation is a problem of soils in urbanized areas. Urban soils fulfil very significant environmental functions in urban ecosystem, but in the present farmland conservation legislation they are not involved. In this period of intensive interest of soil anthropization there is a need to solve these problems not only from the scientific view-point, but also practical stand-point may be reflected.

Material and Methods

The concept of soil bonitation (soil quality index) is based on pedo-ecological characteristics parameters for every of the plots. They are indicated by the Bonitation Pedo-ecological Units (BPEU). The BPEUs represent relatively most homogeneous units concerning to soil and its ecological characteristics, it means they consist of the main pedo-climatic units, which are in detail sub-divided according to categorization of slopes, depth, exposition, stoniness content and size-grain distribution in topsoil.

The first BPEU system included approximately 850 units (Linkeš 1997) that were defined by 5-digital code. In the code list of main soil units (MSU) containing 89 units there was occurred only one MSU “74” in which characteristics anthropogenic influence was incorporated - Anthropogenic Cambizem, trenched.

The BPEU structure of the 5-digital code:

X XX XX

Climatic region code	0 - 9
code of MSU	00-99 (total 89 MSU)
sequence number (combinations of slopping, exposition, texture, parent material)	

In 1994 the code list of MSU was extended to final number 100. In that time a new 7-digital code of BPEU was introduced in the bonitation system in what pedo-climatic properties were presented by this code combination.

The BPEU structure of the 7-digital code:

XX XX X X X

climatic region code	00-10
MSU code	00-99
sloping and exposition code	0-9
stoniness and soil depth code	0-9
soil texture code	1-5

Within the MSU of the code list these codes were included:

“30” characterized as Cultizems Trenched and/or intensively cultivated (without terracing);
“74” characterized as Cultizems transformed by trenching and terracing;
“10” characterized as soils strongly deteriorated by emission spillage (toxic varieties of various soil types).

In the 7-digital BPEU code first two posts indicate climatic region, the second two posts characterize the MSU, the fifth post is a combination of sloping and exposition to the cardinal points, sixth position provide combination of stoniness and soil depth. The seventh code represent soil texture. By combination of these parameters there were produced about 6 500 new codes of BPEU.

Soil productivity potential, which is assessed by point values of relative soil quality (productivity index) is range of 1 to 100 points, whereby the soil with highest quality have been indicated by high point values. Based on soil productivity potential soils are categorized in 9 productivity groups, which are a background of the Tariff levy for permanent or temporary soil delimitation out of farmland (No. 152/1996 Code).

Table 1. Cultizems - MSU 30, 74, according the latest up-grading have an extent of 11 240 ha.

District	MSU	Extent (ha)	District	MSU	Extent (ha)
Bratislava	30	787,48	Nitra	30	1441,02
	74	593		74	25,28
Trenčín	30	29	Komárno	30	727,3
Topoľčany	30	21,8	Nové Zámky	30	234,66
Trnava	30	1561,03	Levice	30	755,33
	74	88,0		74	11,29
Senica	30	244,6			
Lučenec	30	115,14	Rimavská Sobota	30	211,67
	74	191,77		74	240,87
Veľký Krtíš	30	980,42	Zvolen	30	205,05
	74	774,91		74	56,04
Žiar nad Hronom	30	66,03	Humenné	30	23,0
	74	15,1			
Michalovce	30	536,7	Košice	30	69
Rožňava	30	188,0	Trebišov	30	1046,5

Table 2. Soil productivity group representation in Slovakia (%).

Productivity group	1	2	3	4	5	6	7	8	9
%	9,2	19,6	20,0	7,9	13,0	13,5	9,6	5,2	2,0

Results and Discussion

Legal securing of the farmland conservation and utilization in Slovak Republic presently has not been yet complete in relation to its content and extent, both. In the legislation of farmland conservation the direct soil conservation measures are dominating. The farmland of highest quality is particularly protected. Delimitation of the highest quality farmland is qualified by high financial payments (levy).

This levy is determined for the cases, if the farmland is intending to use for other purposes as agriculture.

When farmland conservation purposes are connected with some degradation influences (e.g. accelerated erosion caused by inappropriate soil management), a special farming system is established by the Act No. 307/1992, which involves erosion control measures or the measures for soil structure, water regime or chemical properties improvement.

Table 3. Financial levy according productivity group valid in Slovakia.

Soil productivity group	levy (th. Slovak Crowns per 1 ha)
1	11 300
2	8 465
3	6 090
4	4 170

5	2 510
6	1 306
7	535
8	103
9	50

Most serious farmland problem in Slovak Republic is water erosion. Water erosion risk include 1 360 000 ha (approximately 55 %) of farmland.

Table 4. Erosion risk extent in Slovakia.

Erosion risk	Farmland total		Arable land		Grassland	
	%	ha	%	ha	%	ha
medium	19,0	475 784,6	24,2	362 467,4	13,3	113 317,2
strong	17,4	435 179,6	15,1	226 638,2	24,6	208 541,4
extreme	18,0	449 844,5	4,2	62 171,8	45,6	387 672,7

Wind erosion potential is relatively low. Extreme risk is recognized only on 1.3 % of the farmland, strong erosion risk is observed on 0.4 %, and medium risk on 4.8 % of farmland.

Relative high extent of compacted soils was registered in Slovakia, occurred in approximately 192 000 ha of farmland. Compaction processes have been potentially running in further 457 000 ha of farmland.

Due to soil compaction, both productional and extra-productional soil functions are markedly limited, or decreased. Compacted soil control is besides the Act No. 307/1992 also legal determined by Slovakian Government Directive No. 76/1993 Code, where are regulated conditions and form for subsidies of the State Fund for Farmland Conservation and Improvement.

In the case of permanent and temporary land delimitation out of the farmland there is a duty to cut humus horizon and accomplish some measures for optimal use of the spoil material. In the case of temporal land delimitation out of the farmland cited Act orders soil return back into original status. However it may be soil deteriorated (degraded), the Act charges recultivation measures with return the soil into the original status regarding the soil quality.

As a soil quality is assessed according of the BPEU system, the term “order into the original status” is meant order into original BPEU (as natural soil). As a result of recultivation or remediation processes are soils of anthrozemic type (Anthrozems) with artificially formed soil profile. These soils are not possible to be classified in the present BPEU system. One of the reason of this fact is an absence of BPEU code list for anthrozemic soil types. Establishment of new BPEUs is conditioned by creating of production parameters set of these soils that should be a result of economical bonitation research. Besides production functions there will be a need to assess also extra-productional function, as well.

Conclusions

As present legislation standards do not comprehend all problematic range of farmland assessment and conservation, in future there will be necessary to regulate a duty for all soil functions conservation. In BPEU system the code list may be extended by including of anthropogenic soils. Also the elaboration of guidelines for BPEU changes registration based on anthropic impacts, both positive or negative will be necessary to do.

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Soil Erosion Control in Urbanized Areas

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Abstract

The city Bratislava is by its geomorphologic character divided in two parts:

- one is plain, lying upon the alluvium of Danube river;
- the second one is located in undulated terrain of the Little Carpathians mountain, most with exposition to Southwest and in western part with other, variable expositions.

Water erosion is very important problem in the territory between Rača and Main Railway Station area, typical with conglomerate of urbanized areas and vineyards. The problem number one is here water erosion. Very erodible soils composed of weathered granites and erosionally unprotected vineyards introduce permanent erosion risk, connected with flooded streets with high quantities of sediments. Possible and viable solution is complete erosion control in form of terraces and grass cover.

Remaining western parts of the city of undulated character are exposed both, to water and wind erosion. Water erosion is in most cases successfully controlled with plant cover that has character of the park. However in small areas (gardens, vineyards, orchards) can be serious local problems with water erosion that should be controlled locally – by means of plant cover (grass, perennial plants).

Occurrence of sandy soils, as a rule, is connected with wind erosion, particularly in time of winter end and start of vegetation period, and occurrence of western and northern winds of high intensity. Again reliable erosion control is possible in the form of permanent perennial plant cover – grass cover, parks, gardens, orchards and forests.

Introduction

The cities usually are spread in very heterogeneous and undulated terrain, where significant role also play processes of water and wind erosion that in some circumstances can be serious risk for quality of environment.

We have chosen for our purpose the city Bratislava that from greater part has been lying in undulated strong erodible terrain. In plain parts of the city sometimes can be registered wind erosion. This is true mainly in western part of Bratislava gravitating to Záhorie, where can be found larger areas of sandy soils. On texturally loamy to silty soils wind erosion risk is quite negligible. Though wind erosion in urbanized areas is ecologically relative serious problem, as its impact is extended directly into human dwellings. There is actual danger in extra-vegetation period, when strong gusty wind is capable to disturb large areas of erodible soils – less protected with plant cover (e.g. plowed soil, winter crops) or completely without any plant protection.

On the other hand water erosion does not penetrate into human dwellings, however in time of torrential rains by their direct effect (runoff, rills, sedimentation, pollution) it directly harms soils and surroundings of urbanized area. Sedimentation effect brings about serious damages on municipal nets and communications, not speaking about damages on polluted water resources.

Material and Methods

The Bratislava city territory primarily consists of the axis – Danube river, typical with plain or only very moderately undulated relief. Smaller part of the territory is also formed by Morava river alluvium (sands). Remaining part of the territory formed by the slopes (completely urbanized area) are the location of runoff sedimentation - product of recent intensive erosion activities. The slopes of Little Carpathians are typical with soils deposited upon weathering granites.

Soils are texturally light and very easily erodible. Little Carpathians is the mountain that is touching Danubian alluvium with relatively steep (and markedly eroded) slopes of terrace character. In some places the slopes directly touch Danube river. This character of relief forms a belt situated from Šafárikovo námestie – through Vodný Vrch – Karlova Ves – till Devín. Here the slopes of Devínska Kobyla touch alluvium of the Morava river.

Results and Discussion

Erodible part of Bratislava city territory can be divided into several wholes:

– Rača (Komisárky, Krasňany)
– Vinohrady
– Horský park, Slavín
– Vodný Vrch, Bôrik
– Karlova Ves, Kútiky
– Dúbravka, Lamač, Podvornice
– Devín, Devínska Nová Ves.

Mentioned city parts are forming more than half of Bratislava territory. By this settlement way is various. Significant part is occupied by multi-storied buildings of changing age or housing estates with modern way of construction, where the land out of buildings is most covered by lawn and park-like plant cover. Considerable part of the territory is presented by villas with gardens and fruit-trees. Large part – south-eastern slopes of the Little Carpathians are covered with vineyards.

In western part of the city is water erosion particularly actual in housing estates located in very complicated terrain with steep slopes (above 10°), e. g. housing estates Karlová Ves, Dúbravka. Here grass cover is not complete, soil surface is unsatisfactorily protecting and runoff exceeds threshold. Most exposed sites should be besides grass also covered with trees, in park-like mode. In this way is water erosion kept within tolerable limits. Necessary is also grass maintenance that should have systematic character.

Special attention should be paid to the objects and areas of plays and recreation. They are play-grounds and sand pits, as well as park-areas with benches. These areas should be wholly protected against erosion with aspect on hygiene and pollution prevention.

The gardens are areas of active recreation. Small sites of the plots as well as the care of users are reliable guarantee of tolerable erosion. The gardens are either concentrated within sub-urban colonies or dispersed around villas and houses. Most frequented measures of erosion control in gardens or in their complexes with villas and houses are terraces, walls and soil cover with some materials with long longevity (concrete, plastics, bark, and other organic or inorganic materials).

Vineyards are mosaic-like combined with urbanized areas. This mosaic is landscape-forming element. The complex of vineyards and urbanized areas forms continual belt from the housing estate Komisárky (Rača) via Krasňany and Vinohrady to the Main Railway Station and Koliba. Only smaller part of the vineyards has been terraced and shows tolerable erosion extent. However great part of them is with their rows oriented down the slope. Rainfall with intensity above 10 mm/h. can cause runoff and erosion. Rainfall with intensity 30 mm/h. can cause erosion event of catastrophic character.

In not very old history of the city (2nd half of 20th century) were in the mid of summer (August) registered several serious erosion events. One of the main streets - Račianská street was in time of several minutes flooded. It was changed to a river that besides water brought many of sand, loam and stones, which remained in the street after the event. The sediment layer thickness used to be about 1 m.

There is only one protection measure that should be practized – complete vineyard terracing supplemented with complete grass cover in vineyard. Runoff should be lead out of streets and communications. Solution of this problem – effective erosion control could substantially improve environmental stability of the city.

Parks, parks-forests, forests lawns, grass-cover introduce high ecological plus of the city, which has stabilizing character. This statement is fully valid at such complexes as e.g. Horský park, Slavín, Sitina, Mestská hora, Kráľová hora, Devínska Kobyla, etc.

Conclusions

Water and in smaller rate wind erosion belong to such degradation processes that in Bratislava city environment play important, though negative, role, which is markedly reflected in lowered ecological stability for the city inhabitants. From this aspect, as largest minus we are feeling non solved large-area erosion in vineyards, which besides negative effect on soil itself. It is elevated forefinger for large part of the city – Rača, Krasňany, Vinohrady and city-centre along Račianská street.

Erosion control should be solved by means of large-scale terracing and grass-cover in vineyards gravitating to the city. Whole the system should be completed by the system of small dikes, which would retard flow of erosion runoff.

Existing parks, park-forests are considered for stabile. Gardening also belongs to stabilizing factors with protective effect on erodible soils.

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The Effect of Nitrogen Fixation Activity of Inoculants Isolated from *Alnus incana* and *Alnus glutinosa* Root-Nodules on the *Alnus incana* Plant Development

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Abstract

This paper is aimed to compare the effect of nitrogen fixation activity of inoculants, which were isolated from root-nodules of *Alnus incana* and *Alnus glutinosa* species, on the *Alnus incana* plant development. Seeds of *Alnus incana*, which were inoculated by bacteria isolated from root-nodules of *Alnus glutinosa* (localities of the soil sampling: village of Moravský Svätý Ján – side of the water canal, village of Závod – on the Podzols soil type, Town of Bratislava – Železná studnička – from underwater tree roots) and *Alnus incana* (locality: village of Nálepkovo – the creek alluvium) were planted into the sterile soil. An experiment was practiced in three variants: 1st variant – without fertilisation (O), 2nd – the fertilisation by nutrients except of nitrogen ($–N_2$), 3rd variant – the fertilisation by nutrients including nitrogen ($+N_2$). All the variants were treated by inoculants. Tree individuals without inoculation served as a blank. A total leaf area (mm^2), an aboveground plant-biomass respiration (mg CO_2), a soil respiration (mg CO_2), a leaf dry matter ($g.vessel^{-1}$) and a root dry matter ($g.vessel^{-1}$) was estimated after the plant growth to 10 – 15 cm height had been accomplished. Based on the laboratory results, the correlation between the nitrogen fixation and measured values, except of those for the aboveground plant-biomass respiration, was proved in the variant without nitrogen. This negative correlation proves, that the nitrogen fixation activity of isolated inoculants affects the plant growth in negative meaning in the mentioned variant. The correlation between nitrogenase activity and two measured values – the aboveground plant-biomass respiration and the total respiration – was proved in the variant O. These values were negative as well. The correlation between the aboveground plant-biomass respiration and the nitrogenase activity of used inoculants was not proved in the variant without nitrogen. In values: the total leaf area, the soil respiration, the leaf dry matter, the root dry matter and the total dry matter in the variant O as well as in all values in the variant with nitrogen no correlation was proved.

Introduction

The nitrogen fixation by soil microorganisms is in generally considered to be a process, which positively affects the plant organism. We try to compare the effect of nitrogenase activity of inoculated clones on the leaf area (mm^2), on the aboveground plant-biomass respiration (mg CO_2), on the soil respiration (mg CO_2), on the leaf dry matter ($g.vessel^{-1}$) as well as on the root dry matter ($g.vessel^{-1}$) in this paper.

Material and Methods

Sampling. Used bacterial cultures were selected from root-nodules that were taken off from four localities. On the locality Nr. 1, 2, 3, the samples from *Alnus glutinosa* roots were taken, on the locality Nr. 4 from the *Alnus incana* root system.

Locality Nr. 1: Závod (the side of Morava River water canal, alliance *Alnion glutinosae*). Root-nodules were cut off from ten-year-old individual, 20 cm under water level. The nodules were small (1-2 mm in diameter) of dark-orange colour.

Locality Nr. 2: Moravský Sv. Ján - Wejmutovky (The Morava River alluvium, an association *Frangulo alni-Quercetum*). Three samples of root-nodules were taken on this locality.

1. from ten-year-old individual (∅ 1-3 mm, orange colour)
2. from ten-year-old individual (∅ 1-2 mm, orange colour)
3. from 3-10 year old shoots (∅ 1-1,5 mm, orange colour)

Locality Nr. 3: Bratislava - Železná studnička (Vydrica River, Danube River watershed, an association *Aegopodio-Alnetum glutinosae*). Two samples of root-nodules were taken - both of them from 30 - 40 year old individuals growing near to the Vydrica River. Nodules were cut off from roots over the water level at the time of sampling. These nodules created big and well visible groups of orange colour that were about 5 mm in diameter.

Locality Nr. 4: Nálepkovo - Surovec, altitude 790 m a.s.l. (association *Alnetum incanae*). A sample was taken from ten-year-old individual of alder in the Surovec River alluvium.

Sample analysing. Root-nodules were cut off from the root system (separated nodules only or nodules with root fragments not longer than 2 cm). They were washed by stream of water and by distilled water. They were disinfected according to procedure of Sharaya et al. (1982) by antiseptic solutions after that. They were sterilely removed (1g) onto Petri disks with an agar medium of MPA and the Asby agar (Obernauer et al. 1999) that had evoked the growth of accessory microflora. After 14 days of cultivation in a cultivate box with 24°C according to methodics of Pariyskaya et al. (1982), the pieces of nodules were verified for their sterility and mixed in bray-bowl with the Rogers-Wollum liquid culture medium. A primary suspension (1g of nodules for 10 ml of culture medium) and dilutions with the Rogers-Wollum culture medium (10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6} times) were inoculated onto the Petri disk with the same culture medium after that. After other 14 days of cultivation, active colonies were reinoculated into 20 ml ampoules containing the agar medium of Rogers-Wollum with sloping surface. Nitrogenase activity was estimated by methods of the nitrogen acetylene reduction (Hardy et al. 1967) after 14 days of cultivation in a cultivate box.

The microbial biomass of used clones was washed by distilled water into the sterile Petri disks containing *Alnus incana* seeds. These seeds have been sunken under water for one hour to swell before. After procedure mentioned above, the seeds were removed onto the sterile soil surface. All the inoculants were examined by two repetitions in three variants: 1st variant – without fertilisation (O), 2nd – the fertilisation by nutrients according to Murashige et al. (1962) except of nitrogen ($–N_2$), 3rd variant – the fertilisation by nutrients according to Murashige et al. (1962) including nitrogen ($+N_2$). All the variants were treated by inoculants. Tree individuals without inoculation were considered to be a blank.

Just two individuals of plants for one flowerpot were selected after the plant growth had been finished to approximately 3 cm height. After reaching the plant height 10 – 15 cm in average (approximately 3 month), when some individuals began to have some marks of leaf drying, we measured the total leaf area (mm^2), the aboveground plant-biomass respiration (mg CO_2), the soil respiration (mg CO_2) and the leaf dry as well as the root dry matter ($g.vessel^{-1}$).

We used 50 leaf specimens of various sizes to count the leaf area using scale paper. The shape of alder leaf is, approximately, of mirror circular section. We estimated an empirical equation: $P= 2.(\arcsin l/r.r^2 - x.l)$, where l – leaf length, h – leaf height, $x = ((l/2)^2 - (h/2)^2)/h$, $r=h/2+x$. The comparison of leaf areas calculated by this equation with the leaf areas counted using their perimeters on the scale paper shows high correlation (r = 0.987). We calculated the leaf areas on the base of their height and length by mentioned equation therefore.

The aboveground plant-biomass respiration as well as the soil respiration was estimated according to procedure of Schingera et al. (1993). Flowerpots with plants were placed into plastic bathtub with water.

Glass pots, to protect experiment against air, covered plants together with beaks containing 20 ml of 0.1 M NaOH. 2 ml of 0.5 M $BaCl_2$ were added into the plant-NaOH system after 24-hour of incubation to precipitate a white coagulum. The excess of NaOH was titrated by 0.1 M HCl on phenolphthalein (3-4 drops) to decolourisation from violet to a clear liquid. The final consumption of HCl assigned the CO_2-consumption by the aboveground plant-biomass or by the soil respectively (after cut the plant).

The leaf dry matter and the root dry matter was measured after drying the aboveground part of plant or the root system respectively in a drying box at 75°C during 24 hours. It was weighted after that.

Results and Discussion

We collected our results into table Nr. 1 – 7 for individual measurements and into the final table Nr. 8, which shows correlation coefficients between measured values and the nitrogen fixation of used inoculants. Table Nr. 8 proves, that the correlation between the nitrogen fixation and measured values except of those for the aboveground plant-biomass respiration is significant in the variant without nitrogen. This negative correlation proves, that the nitrogen fixation activity of isolated inoculants affects negatively the plant growth in this variant. In the variant O, the correlation between the nitrogenase activity and two measured values – the aboveground plant-biomass respiration and the total respiration – was verified. It is negative in this case as well. The correlation between the aboveground plant-biomass respiration and the nitrogenase activity of used inoculants was not proved in the variant without nitrogen. In values: the total leaf area, the soil respiration, the leaf dry matter, the root dry matter and the total dry matter in the variant O as well as in all the measurements in the variant with nitrogen, there was proved no correlation.

Conclusions

Based on our results, we can say, that the nitrogen fixation of inoculated cultures in all the variants affected the plant development negatively or it didn’t affect the plant growth at all.

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Table 1. The effect of nitrogenase activity on the leaf area.

Sample label	Total leaf area (mm2)			Nitrogenase activity
	Without fertilisation	**Fertilisation including nitrogen**	**Fertilisation excluding nitrogen**	**mMC_2H_4/mgCbio.hour**
K	2176	6336.5	22441	0
S 1412	4520.00	6184.50	3371.50	57.35
N 1321	11910.67	7562.540	16699.75	31.83
M 4613	6060.00	5281.50	10144.00	4.13
Z 1013	780.25	7827.50	7831.75	3.61
M 4423	10984.25	9580.25	10443.25	3.23
S 2012	1550.00	10548.50	8344.00	68.65
M 3013	15507.50	17952.50	12470.50	2.53
S 2312	5824.25	4485.75	4678.50	54.80
*N 131	20252.00	4824.50	5550.50	28.14

Table 2. The effect of nitrogenase activity on the aboveground plant-biomass respiration.

Sample label	Aboveground plant respiration (mg CO_2)			Nitrogenase activity
	Without fertilisation	**Fertilisation including nitrogen**	**Fertilisation excluding nitrogen**	**mMC_2H_4/mgCbio.hour**
K	12.00	-14.05	33.57	
S 1412	103.00	-5.07	20.38	57.35
N 1321	163.50	-8.90	35.32	31.83
M 4613	165.50	-2.23	30.71	4.13
Z 1013	170.25	1.61	12.89	3.61
M 4423	166.00	1.18	25.29	3.23
S 2012	158.50	4.54	19.63	68.65
M 3013	174.00	6.16	19.95	2.53
S 2312	163.50	-6.33	25.68	54.80
*N 131	162.50	-4.95	16.93	28.14

Table 3. The effect of nitrogenase activity on the soil respiration.

Sample label	Soil respiration (mgCO_2)	Nitrogenase activity

	Without fertilisation	Fertilisation including nitrogen	Fertilisation excluding nitrogen	mMC$_2$H$_4$/mgCbio.hour
K	27.00	35.20	30.80	
S 1412	22.00	30.36	23.76	57.35
N 1321	29.75	32.12	21.12	31.83
M 4613	27.00	32.12	28.60	4.13
Z 1013	25.25	30.80	33.66	3.61
M 4423	31.50	28.82	30.80	3.23
S 2012	32.00	29.48	32.56	68.65
M 3013	29.50	34.76	34.76	2.53
S 2312	34.50	35.64	23.98	54.80
*N 131	45.50	33.00	23.76	28.14

Table 4. The effect of nitrogenase activity on the total respiration.

Sample label	Total respiration (mg CO_2)			Nitrogenase activity
	Without fertilisation	Fertilisation including nitrogen	Fertilisation excluding nitrogen	mMC$_2$H$_4$/mgCbio.hour
K	39.00	21.15	64.37	
S 1412	125.00	25.29	44.14	57.35
N 1321	193.25	23.22	56.44	31.83
M 4613	192.00	29.89	59.31	4.13
Z 1013	195.50	32.41	46.55	3.61
M 4423	197.50	30.00	56.09	3.23
S 2012	190.50	34.02	52.19	68.65
M 3013	204.50	40.92	54.71	2.53
S 2312	198.00	29.31	49.66	54.80
*N 131	208.00	28.05	40.69	28.14

Table 5. The effect of nitrogenase activity on the leaf dry.

Sample label	Leaf dry matter (g.vessel^{-1})			Nitrogenase activity
	Without fertilisation	Fertilisation including nitrogen	Fertilisation excluding nitrogen	mMC$_2$H$_4$/mgCbio.hour
K	0.07	0.35	0.78	
S 1412	0.15	0.24	0.12	57.35
N 1321	0.41	0.40	0.83	31.83
M 4613	0.04	0.23	0.39	4.13
Z 1013	0.39	0.36	0.34	3.61
M 4423	0.64	0.37	0.52	3.23
S 2012	0.48	0.57	0.39	68.65
M 3013	1.07	0.88	1.02	2.53
S 2312	0.10	0.22	0.20	54.80
*N 131	0.29	0.21	0.23	28.14

Table 6. The effect of nitrogenase activity on the root dry matter.

Sample label	Root dry matter (g.vessel^{-1})			Nitrogenase activity
	Without fertilisation	Fertilisation including nitrogen	Fertilisation excluding nitrogen	mMC_2H_4/mgCbio.hour
K	0.01	0.16	0.18	
S 1412	0.07	0.07	0.06	57.35
N 1321	0.14	0.29	0.42	31.83
M 4613	0.01	0.03	0.07	4.13
Z 1013	0.05	0.14	0.34	3.61
M 4423	0.32	0.06	0.09	3.23
S 2012	0.30	0.16	0.07	68.65
M 3013	0.75	0.70	0.73	2.53
S 2312	0.12	0.03	0.09	54.80
*N 131	0.52	0.04	0.04	28.14

Table 7. The effect of nitrogenase activity on the total dry matter.

Sample label	Total dry matter (g.vessel^{-1})			Nitrogenase activity
	Without fertilisation	Fertilisation including nitrogen	Fertilisation excluding nitrogen	mMC_2H_4/mgCbio.hour
K	0.09	0.51	0.95	
S 1412	0.21	0.31	0.18	57.35
N 1321	0.54	0.69	1.26	31.83
M 4613	0.05	0.26	0.46	4.13
Z 1013	0.44	0.50	0.67	3.61
M 4423	0.96	0.43	0.61	3.23
S 2012	0.78	0.72	0.46	68.65
M 3013	1.82	1.58	1.74	2.53
S 2312	0.23	0.25	0.29	54.80
*N 131	0.80	0.25	0.28	28.14

Table 8. Correlation coefficient.

	Nitrogen fixation activity (mM C_2H_4/mgCbio.hour)		
	Without fertilisation	Fertilisation including nitrogen	Fertilisation excluding nitrogen
Total leaf area (mm^2)	-0.3233	-0.3022	**-0.4526**
Plant respiration (mg CO_2)	**-0.5542**	-0.3050	-0.0086
Soil respiration (mg CO_2)	0.0725	-0.0354	**-0.4327**
Total respiration (mg CO_2)	**-0.4545**	-0.3228	**-0.3597**
Leaf dry matter (g.vessel^{-1})	-0.3103	-0.1972	**-0.4626**
Root dry matter (g.vessel^{-1})	-0.1308	-0.2947	**-0.4444**
Total dry matter (g.vessel^{-1})	-0.2375	-0.2508	**-0.4717**

Significance level á = 0,01.