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Department of Soil Science and Conservation
Slovak Academy of Agricultural Sciences

SOIL ANTHROPIZATION VIII

Bratislava, Slovakia

September 28 – 30, 2004

PROCEEDINGS

Bratislava, 2004

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International Conference: SOIL ANTHROPIZATION VIII,
Bratislava, Slovakia, September, 28 – 30, 2004

Editor: Jaroslava Sobocká

ISBN 80-89128-12-2

Leuven, 04. 08. 2004

Dear Dr. Sobocka,

very much to my regret it will not be possible for me to participate in ”Soil Anthropization VIII”. May I take this opportunity to present to you and to the Steering Committee my greetings and best wishes for the success of the meeting.

Soil Anthropization is much more important and extended than originally perceived. This new branch of soil science therefore deserves our full attention. The interest devoted to anthropogenic soils in different fora has unfortunately led to an unwieldy namegiving and classification. I am confident that “Soil Anthropization VIII” will contribute to streamlining the approaches and to reach a consensus on how to integrate anthropogenic soils in existing classification systems. The creation of a common terminology would be most useful. I would very much appreciate obtaining the proceedings of the meeting as a basis for a subsequent exchange of ideas.

I was delighted to meet you in Petrozavodsk and I am looking forward to another opportunity to discuss with you on this subject of common interest.

With best wishes and kind regards,

Rudi Dudal
Professor Emeritus

Prof. Dr. R. Dudal
Department of Land Management
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Leuven, Belgium

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PREFACE

The conference was organized by the soil scientists of the Soil Science and Conservation Research Institute (SSCRI) and Department of Pedology, Faculty of Natural Sciences of Comenius University in Bratislava. Also members of Societas pedologica slovaca and of the Department of Soil Science and Conservation of the Slovak Academy of Agricultural Sciences were helpful in many tasks of conference organizing. The founder of this conference cycles is Prof. Dr. Zoltán Bedrna, one of the outstanding soil scientists in Slovakia.

The main target of this conference was presentation of the latest research results in this quite not well-known, but quickly developing soil science field. Soil anthropization survey and research have been largely focused on agricultural and forest land, i.e. on intensively managed and disturbed soils. But the last decade we can observe the research interest in soils occurring in urbanized, industrial, traffic and mining areas, sometimes called “terra incognita” in soil maps.

Anthropogenic soils can be investigated with the traditional soil survey approach, however new theory and methodology have to be developed in this aspect. Human-induced factor acts as trigger of extremely rapid transformation cycles in soils comparing with those dominant under natural conditions. There is an inevitable prerequisite to continue in soil anthropization research in aspect of human health protection as environmental factor of living quality and natural resources conservation.

The conference has the following objectives:

- to stimulate fruitful discussion on role of human factor in soils in cities and agricultural-forest country;
- to present current approaches in classification and assessment of urban soils and anthropogenic soils;
- to illustrate new methodology to be used for description of soils affected by human impact;
- to compare national classification systems with other foreign systems to make one step to understanding of such soils.

Two-days paper presentation was in topics: A) Anthropogenic soils methodology, classification and assessment; B) Soil anthropization of agricultural land; C) Soil anthropization of forest land; D) Urban soil as a specific case of anthropic influence; E) Specific problems of anthropogenic soils, their quality and conservation. Still numerous gaps exist in this sphere. E.g. should we classify urban soils as “normal” soils without any specific features, or they have some new diagnostic and features? At what level should we classify anthropogenic soils? Do we distinguish terms anthropogenic soils and urban soils? Etc… Another important objective is to verify the methods of field and laboratory soil diagnostics in order to improve them and to correlate the data obtained in field and laboratory.

Conclusions of the conference involved at the end of these Proceedings are questions to the future soil anthropization development. I hope that you found the event useful and that it creates new opportunities and ideas for your coming work.

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At last I would like to express my sincere acknowledgement to my colleagues and members of the steering committee for their excellent work during the conference. Namely they were: Prof. Dr. Bohdan Juráni, Prof. Dr. Zoltán Bedrna, Dr. Bohumil Šurina, Dr. Marián Jaďuďa, Mgr. Katarína Poltárska, Dr. Rastislav Dodok and Martina Morová, as well. My best thanks belong to Prof. Dr. Pavol Bielek, director of SSCRI for support of our activities.

Jaroslava Sobocká
chairman of the conference

CLASSIFICATION OF ANTHROPOGENIC SOILS OF SOUTH AFRICA

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ABSTRACT

Man is part of the environment for a significant period of time in the history of earth's ecosystem and is also influencing the land since his creation. In recent times the earth become so overcrowded and high tech practices are so much in use that there is no chance for the soil to recover after pollution or malpractices. There for the anthropogenic environmental footprint becomes more pronounce day by day. Several prehistoric evidences of intensive land uses e.g. farming, gardening, road building, exists. Unused land occupied by polluted soil or manmade materials could be changed into productive land if more knowledge is available about their properties and characteristics. This is only possible by means of a proper classification system.

The demand of any soil classification system is driven by the need to know more about the soil to improve and optimize existing production or soil uses e.g. crop production, infrastructure, environmental rehabilitation. If there are no such soil uses or if there are still enough other soils to occupy, there will be no need to know more about the soils.

Little is known about the soil quality, management and production improvement of anthropogenic soils, but due to the ever increasing demand in land use, the situation demands more occupied land to be reclassified for land use purposes. The world wide issue about mine spoils and sustainable rehabilitation also requires a proper soil classification of these un-natural soils. To make this knowledge available for all present and future land users, contemporary and comprehensive classification systems should be developed which should fit into the concept of an international system. The four main issues about classifying Anthrosols are:

1. What is a soil, when can a medium been regarded as a soil?
2. Some Anthrosols are exposed to soil forming processes which are not so pronounced in normal soils e.g. quick oxidation, acidification e.g. pH change from 9 to 3 in a short period of time.
3. Should conventional practices and definitions been revised for Anthrosols? Some characteristics and properties of Anthrosols are difficult to describe in context with the conventional system e.g. artificial structure (bricks, plastic bags, bottles in urban soils).
4. Should all polluted and disturbed soils been regarded as Anthrosols? All soils disturbed by humans e.g. ploughed fields, should not necessarily be renamed on the highest level (soil form). A technique of using prefixes on form and family level may alleviate the problem.

INTRODUCTION

Pedology is the science of the morphology, characteristics, properties and geographical distribution of soils as well as the classification of the aforementioned. The science developed in the mid nineteenth century because of a drastic demand for more food and agricultural products due to the increase in population. By that time the information that was gathered over the years could not be used efficiently any more due to the lack of systematic classification and ordination of all the data. It started with the identification and characterization of soil bodies as well as the knowledge of the distribution and relationships between different soil types. Subordinate to the aforementioned were the improvement of communication and the conceptual methods to store and arrange data e.g. present day type data basis.

Several prehistoric evidences of intensive land use e.g. farming, gardening and road building exist. The Mesopotamia irrigation system, South American terraces, Chinese diversion of rivers for irrigation purposes are amongst others some of the most important ones. In more recent time the plaggen soil fertility method in Europe and Asia from the thirteenth century are good examples. This prehistoric and recent type of technology preceded the real application of science. The empirical knowledge about soil quality, management and production improvement was all fixed into collective knowledge amongst the farmers and other land users. To make this knowledge available to all land users, a classification system should be developed to include both the characteristics as well potential land use. In the case of anthropogenic soils, there are sometimes "new" or polluted soils with negative characteristics. A proper classification system should also give enough attention to the soil forming factors and processes to identify potential rehabilitation methods.

Classification is an important aspect of pedology that entails the description of the genesis, distribution and morphology of the soils. The major objectives of classification are to improve production or soil performance as well as communication between the pedologists and land users e.g. farmers, town planners, road builders or environmental managers etc.

MOTIVATION

The demand of any soil classification is driven by the need to know more about the soil to improve existing soil uses e.g. crop production, infrastructure development, rehabilitation of disturbed areas, environmental management etc. If there are no such soil uses or if there are still enough other soils to occupy, there will be no need to know more about the soils e.g. classification, fertility etc. Since the fifties in the previous century, a great emphasis was put on the development and improvement of agricultural production in South Africa, because the greater part of the population was either farmers or rural people who lived from the land. Since then the accompanied agricultural resources e.g. irrigation water and climatic conditions where developed and exploit to their full potential and together with a great population increase, more land was required to comply with the greater demand for food, other agricultural products and timber. Also in the fifties and sixties an environmental awareness started to develop to rehabilitate some of the gold mine tailings and coal discard dumps. All of them were not successful, mainly because of the lack of understanding the "soil" forming factors and processes involved in such "new" soils. At the same time large mining developments took place over large parts of South. In the nineties of the 20^{th} century people started to move to towns and cities and that cause a change in land requirements for township development.

The depletion of agricultural resources, increase in population, occupation of land by industrial and mining activities, increase in health hazards caused by ongoing pollution by the mines and industries, greater environmental awareness and change in land use patterns manifested in a different land use requirement which require a reassessment of all soil assets. By the end of the 20^{th} century large areas were occupied by different land uses that were not focused on crop and timber production or other types of efficient land use e.g. township development, infrastructure, industrial developments but rather by insufficient uses e.g.:

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- new man made “soils” e.g. garbage dumps, mine waste, discard dumps,
- anthropogenic affected soils e.g. intensive pollution around mines and industries, water stagnation and salinization due to excessive irrigation,
- normal soils which were physically disturbed e.g. permanent interruption like quarries for topsoil or building material or the intermixing of soil layers and horizons e.g. sink holes which formed due to dewatering of mines

METHODOLOGY

Although it could be say that soils from all agricultural fields, gardens and towns are to some extent influenced by anthropogenic activities, the total influence are not that great or the end land use did not change that much. Too much detail about anthropogenic soil characteristics is not necessarily important for all land uses. On the other hand one should be careful with generalized information which does not address the real problem. In many cases the characteristics of Anthrosols are destructive and concentrate on negative properties rather on positive properties and productive potential like in the case with normal soils. A basic difference between the classification of natural soils and anthropogenic soils is that the first one is based on positive or passive properties and characteristics while the last one is primarily based on negative properties and characteristics. The objectives of classification of natural soils are inter alia to identify the more appropriate method to improve or optimize an existing or specific land use, but there is in most cases a complete different objective for Anthrosols.

Different properties and characteristics (due to different soil forming processes) might be used to classify anthropogenic soils than normal soils. In many cases the absence or minimum vegetation present on anthropogenic soils are due to poor water regime or insufficient fertility, meaning that properties such as texture are very important, but not so much in natural soils. The challenge lies in the unbiased identification and interpretation of new properties and characteristics to succeed in the goal to provide sufficient information to improve future land use e.g.:

- which type of land use is the most appropriate
- what are the risks associated with conventional or different land uses
- what type of technology/equipment is required for the new or different land uses
- what is the rehabilitation potential (in the case of polluted or disturbed soils) to optimise land use
- finally what is the cost analysis involved in rehabilitation of disturbed areas or the development of alternative land uses.

The success of a classification system is determined primarily by the improvement of production or performance on such soils if the classification system is used.

An extension of the existing classification system for Anthrosols should go far beyond new names for different types of materials or types of pollution. The application of the system by soil scientist and the ultimate transfer of information to the land user will determine the success of the extension. To apply a certain system, interpret it and to convey or transfer that information to the end user, one requires knowledge with respect to the following:

- genesis of the medium (in the case of new or fresh materials)
- mode of transformation (in the case pollution and altered soils)
- potential to change their characteristic (in the case of unstable soils or new fresh material)

- relationship between morphology and factors of formation (keeping in mind the time factor)
- regularities in the distribution (very speculative in the case of new and polluted soils).

Some problems are foreseen with the anthropogenic soil classification system e.g.:

- “New soils” (mine dumps and tailings materials) are very young and not in a chemical equilibrium condition and therefore “soil genesis” of these soils are not understood completely because various soil forming factors such as geomorphology, parent material, bio-activity are at their infant stage and the time was turned back to zero. Fundamental pedological principles are often distorted to the extreme in these young soils e.g. quick oxidation in the upper zones, extreme pH, salinity, heavy metal concentration, continuous and quick weathering of soil mineral constituents. They are not normal for soils and therefore new hypotheses have to be developed and verified before it could be applied in a basic and principal discipline like classification.
- New technology often becomes available which turned some stabilised new soils into another new soil again e.g. rehabilitated tailings materials, which are reworked for alternative uses or for reprocessing the material again.
- In some polluted areas free access is not possible due to industrial secrets or due to extreme pollution which is covered or hide by the industries; in such areas the full spectrum of soil genesis or influence of pollutants on crops etc., will not be detected or identified.
- Fast development in alternative land use practices requires new information on short notice.
- The demand for informal township development is growing fast and very often it is not possible to keep update with soil surveys for these areas.
- Basic principles required for normal taxonomic soil classification are not necessarily applicable or sufficient for anthropogenic soils. An example is the interpretation of the properties of gold tailings materials, which is based on the genesis and chemical activity of the material rather than on easily observable characteristics and morphology, e.g. colour or structure. This could cause some controversial arguments amongst pedologists and some would not like to use the new system because of unconventional practices or new criteria.

However, it is necessary to start with the extension of the existing anthropogenic soil classification system and it should be seen as a challenge and opportunity and not an obstacle.

Due to the poor correlation (and sometimes complete absence) between normal soils and some new soils like mine waste rock dumps and tailings, new criteria should be developed for each of the new soil groups. Examples are:

1. Structure will have to include different types of structure (e.g. bottles, plastics, bricks, slag etc.) and their significance to water and air movement as well as root development. New types of structure e.g. structure medley, platy broken structure might be more appropriate.
2. Texture (type of rocks present might be important for water retention, erosion control etc.).
3. Compaction (water and air movement and root development).
4. Weathering potential of rocky material) e.g. AMD, shales, slags).
5. Organic carbon content (C : N ratio) (extreme values for anthropogenic soils from mine waste).

RESULTS

Different approaches of recognition and classification of anthropogenic soils exist, and it will be a real challenge to incorporate this information into useable system.

1) Conceptual differences and types of anthropogenic soils
   - New soil / material: (Transported soils)
     - Land fill sites
     - Garbage dumps
     - Mine waste and tailings
     - Thick topsoil layers (> 300 mm)
   - In situ altered / transformed without any physical disturbance of horizons
     - Chemical transformation e.g. by pollution
     - Changed of water regime e.g. drainage of wetlands e.g. dewatering of mines (conditions could change again to first normal e.g. Wonderfontien spruit, creation of new wetlands e.g. evaporation dams at mines)
   - Physically disturbed (original horizons changed)
     - Removal or destroying of certain horizons (e.g. deep ripping to disintegrate restricted clay layers, removal of top soil to strip plinthic layer or soft carbonate layer for road building and then replacing of topsoil)
     - Intermixing of horizons e.g. subsidence (e.g. caldera or dolines due to dewatering)
     - Explosion (e.g. battle fields)
     - Deep excavations (e.g. foundations, sports fields, cemeteries, parks and gardens)
     - Deep compaction (controversial?)
2) Change and alteration manifested into metamorphosed materials
   - Interpretation of change / influence could be controversial e.g. is a ploughed field a new anthropogenic soil and what about fertilization and liming (a quantitative definition to clarify the issue is necessary)
   - When is change significant enough to interpret it as anthropogenic: e.g. 200 mm of inert top material with minimum effect on performance and characteristics of underlying soils vs. 100 mm highly toxic cover with potential to change the soil characteristics permanently
   - Indicate whether the change is permanent or not e.g. all new soils are permanent as well as the majority of physical disturbed soils, but some chemically transformation could be rectified or restored my means of management e.g. salinity and some physical transformed soils could change with time to the same character as previous e.g. effect of deep ripping of restricted layers
   - Should predictable conditions regarded as anthropogenic e.g. expected change due to dewatering, new wetlands, salinization due to pollution e.g. pollution plumes.
   - Lateral variation (from undisputable polluted to complete virgin land) very much se same as the catena concept, where is the boundary and to what extent would one go with respect to predictable / expected / anticipated conditions

Detail and site specific characteristics and properties should be described by means of qualifiers.

RECOMMENDATIONS

1 Transported material > 1 500 mm
These materials cover or replace original soils and it could be from mine waste, domestic waste, industrial waste or even thick top soil covers. The material type are either, earthy (soil, rock etc.), non-earthy or organic (compost, manure etc.).

2 Transported material < 1 500 mm
The material characteristic description are the same as for materials > 1 500 mm.

3 Transported material > 15 % mixed with topsoil
Technogenic types e.g. roads, foundations, sportsfields, gardens etc. are examples. The transported material could be domestic waste, mine waste, top soil etc.

4 Natural soils physically disturbed
Examples are deep ploughing, deep ripping, compaction etc. where the original horizon and land use changed beyond recognition or original land use or the change is permanent. Thick clay layers, compacted horizons are examples. Shallow ploughing to 300 mm is not included into this section, because it is just a typical soil improvement, without changing any major characteristic permanently.

5 Selective or exclusive removal of horizons
Top soil stripping and plinthic material for road building, cemeteries, catastrophic cases e.g. sink holes, erosion is some examples.

6 Metamorphosed horizons

Typical examples are:

- Dewatered or drained hydromorphic soils;
- Stagnation or permanent wetting of original dry soils;
- Artificially leached or bleached horizons;
- Chemical pollution (salinization, acidification, alkalinization etc.)

7 Combo soils
These could be combinations of any one of the aforementioned changes or additions. A typical example is the stripping of the A horizon, filling it with domestic waste and then pollute it with a chemical industrial waste.

8 Detail
Detail characteristics and other nomenclature should make use of qualifiers for final description.

CONCLUSION

KISSS: KEEP IT SCIENTIFIC SOUND, BUT SIMPLE.

Content

BURNT SOILS – A PROPOSAL OF CLASSIFICATIONS

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ABSTRACT

This paper analyses the period of formation of relict creations. It also states various changes of characteristics and changes in fertility. The fires appeared in these areas as a result of self-burning of coal layers. Burnt soils are separated into a special group of soils, that is, technogenous soils. They are also called pyrogenic soils. Considering the way these fires developed, these creations are names Hypo-Pyrosol (deeper fires, burning). The fire can be started at the very surface and these are so called Epi-Pyrosols.

During the forming of these products, the fire is stated to be one of the most important pedogenetic factors that affect the development of these soils. As a consequence of soil burning and the geological layer, the following processes are ignited: increased acidification, decrease, that is, loss of organic matter and humus, hardening of the soil matter, formation of skeleton, worsening of the structure, expansion of water erosion process, widening of the SiO_2:R_2O_3 relation. Especially noticeable is the bigger presence of colour red and higher levels of quartz and hematite contents. During their further development in the post-burning period, Pyrosols acquire another special addition in their name and they can be: leptic, eutric, dystric, rendzic, lithic, mollic and luvic-Pyrosol.

Areas under relict Pyrosols are used today in forests, meadows and as arable land.

INTRODUCTION

The burning process of vegetation and soil are more and more result of different influences, out of which two are extracted as most common: (i) self-burning and (ii) human actions. These processes occupy great areas today and they continually tend to increase. Even though burning process usually affect firstly vegetation, as forests, meadows and peat areas, soil can also be damaged by fire. In previous researches, the main interest was directed towards the vegetation, while the consequences concerning soil were often disregarded.

During the pedological research done in the area of Tuzla (Northern Bosnia) Resulović (1985) indicates presence of burnt soils in the area of Tuzla, created by self-burning of coal layers. These occurrences are connected to the surface exploitation of coal (lignite), where huge areas are strongly red coloured. The layers coloured red reached to very deeply, some to several tens of meters and even the geological layer was included by this. This layer was mostly composed of marl (marl-clay, clay-marl, marl-sand). Red coloured soil and the geological layer in this region, covered area of several thousands hectares, therefore Resulović (1985) and Čengić (2004) are researching burnt soils in this area, from the aspects of their genesis, evolution and fertility. That was one of the reasons why this research was directed towards finding out the reasons that caused formation of these red creations. Colloquially, these occurrences are called by different names such as: burnt, Brant (derived from German language), burnt areas, red hill, etc.

The goals of this research are the following:

- define the causes of the formations,
- characteristics of the formations, and
- classification.

Causes of formation of these creations – exogenous and endogenous fires

The process of soil burning has been to some extent treated in literature and these texts refer to surface fires that are here called exogenous fires. These fires start at the surface where they take over the vegetation and then they affect the soil itself. Exogenous fires can be ignited at the following locations:

- on meadow fields,
- on peat areas,
- on dumpsites and recultivated areas, after the process of coal exploitation.

These forms of burning and burnt areas are also called recent burnt areas. On the other had, it had been noted that in these areas fires can be ignited under the surface, sometimes at levels more than several tens of meters deep. Cause of these fires is self-burning of coal layers (lignite). Fires started in this way can spread upward towards the surface, as well as downwards. This form of starting and development of fire is called endogenous.

From the aspect of time period of creation of these occurrences, this area is dominated by formations called relict. Certain locations contained recent formations as well, because some of the underground fires were present at the time of the research. Part of the areas influenced by these fires and high temperatures is now in use for forestry, some are covered with meadows and some are even used for production (vegetables) as ploughed fields. This paper also analyses characteristics of relict formations, that is, endogenous self-burning.

Specific characteristics of the genesis of the pyrogenic soils

Pyrogenic soils contain some special characteristics that are not found in non-burnt soils. Depending on the way the soils are formed there are three possibilities:

- Epi-Pyrosol,
- Hypo-Pyrosol,
- Amphi-Pyrosol.

This classification was composed according to the way burning was started. With Epi-Pyrosol, burning started at the surface and spread towards the deeper levels. With Hypo-Pyrosol, the beginning of burning is at a deeper level (including the geological layer) and then the fire spreads upwards. This type is particularly present in situations where coal layers burs. Burghardt (2001) investigated characteristics of soil in urban areas and he divided them in two groups: (i) without morphological changes and (ii) with morphological changes. Within the group of soils without any morphological changes, there is one sub-group called “relict soils”. Amphi-Pyrosol includes process that start at surface as well as those that start under ground. It is important to note that in these processes, the fire is one of the pedogenetic factors.

Regarding the time of these formations, there are two periods: relict period, and recent period. Sobocka (2001) investigates new trends in anthropogenic soil groups formation. Classification of anthropogenic soils is done according to several criteria, the mail one being human–induced

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impact. Relict period is the time in cases where the transformed soils were formed under the influence of high temperatures in some previous period.

Recent period is the time in cases of current burnings. These fires can occur several times and they can reach several different depths of soil. Consequences of these burnings are formations of different soils. Cases when fires completely cease, in the post-burning period there are pedogenetic processes that lead to formation of different soils that have many specific physical and chemical characteristics. Consequences of burning, that is, consequences of the influence of high temperature are the following changes:

- disappearance of vegetation,
- loss of organic matter and humus,
- formation of different types of minerals,
- changes in soil colour,
- changes in structure,
- creation of skeleton,
- hardening of soil,
- increase in acidity levels,
- decrease of the physiological soil depth,
- increase contents of physiologically available potassium,
- increased sensitivity to water erosion.

There are also changes in the geological-petrographical layer. Under the influence of burning and under very high temperatures (over 500 ^{o}C), the geological layer was affected. This is particularly noticeable because of the formation of hypo- and amphi-burnt areas. Original layer that was changed (from changes in colour to changes in mineral structure) causes changes in formation of new types of soil after the burning has ceased. Because of this, during investigation of formation and characteristics of these soils, two aspects should be considered with special care: fire and altered original layer.

Position in the classification of burnt soils

Burnt soils have to be differently treated because of the way they were formed and because of their special characteristics, which means that they have their specific position in classification of soils. Kozak, et al. (2001) has investigated development of Anthrosols on recultivated Deposols (dumpsites) and have especially indicated the vulnerability of soil structure. In FAO–UNESCO (1997) publication “Soil Map of the World” a special group of soils was named “Anthrosols”. There was no special group for technogenous soils.

Firstly, it should be noted that burnt soils come in the group of technogenous soils, these are burnt soils which have been named Pyrosols. By their time of formation they can be systemized as:

- relict Pyrosols,
- recent Pyrosols.

Further classification can be made according to the beginning of burning as follows:

- Epi-Pyrosols,
- Hypo-Pyrosols,
- Amphi-Pyrosols.

Furthermore they can be classified based on characteristics of these soils as follows:

- depth of soil captured by fire,
- physical characteristics, especially where there is formation of skeleton,
- decrease in physiological depth of profile,

– changes of chemical characteristics, such as loss of humus, nitrogen, increased acidification,
– formation of specific clay minerals,
– widening of the $SiO_2 : R_2O_3$ ratio.

In cases when fires completely cease, in the post-burning period, the leftover creations, depending on the development stage of the soil (climate, relief, organisms) can form special soil types. Naming these formations can be done by adding special prefixes to the name of the soil type – Pyrosol. This way, the following system units can be formed: Lithic-Pyrosol, Rendzic-Pyrosol, Eutric-Pyrosol, Dystric-Pyrosol, Petric-Pyrosol, Cambic-Pyrosol, Luvic-Pyrosol.

Some characteristics of the investigated burnt soils

This paper includes results of the investigation of some characteristics of burnt soil affected by relict burning process. In the investigated cases, the burning has stopped and new soils were formed. The investigation included burnt soils that are now used for forestry and as orchards. The characteristics of these soils are given in the Tables 1 and 2.

Table 1 Texture composure of burnt soils

Usage and depth (cm)	% of textural elements			Texture name
	2,00 – 0,06	0,06 – 0,002	< 0,002	
	mm			
Orchard				
0 – 20	20,97	51,70	27,33	Silty silt
20 – 44	17,05	48,55	24,40	Loam clay
44 – 85	16,42	36,46	75,08	Clay
85 – 100	5,95	18,97	75,08	Clay
Forest				
0 – 28	54,26	19,19	25,55	Sand-clay loam
28 – 50	66,08	7,87	26,05	Sand-clay loam
50 – 100	66,76	5,81	27,43	Sand-clay loam

Table 2 Chemical composition of burnt soils

Usage and depth (cm)	pH		Humus %	Available mg/100g	
	H_2O	M KCl		P_2O_5	K_2O
Orchard					
0 – 20	5,90	4,40	1,48	3,00	27,50
20 – 44	5,40	4,30	1,07	0,75	10,75
44 – 85	5,20	3,90	0,24	0,00	9,25
85 – 100	5,20	4,00	0,17	0,00	25,15
Forest					
0 – 28	4,70	3,40	0,45	0,00	9,50
28 – 50	4,90	3,90	0,12	0,00	5,70
50 – 100	5,20	4,20	0,12	3,25	8,00

From this data we can see that burnt soils are characterized by acid reaction throughout the depth of the profile, small humus content, very small content of available phosphorous, and mid-

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dle and high levels of available potassium. Regarding the texture, these soils are middle-heavy and heavy ones.

A proposal of classification of burnt soils

There is no doubt that burnt soils are a specific occurrence. Very important pedogenetic factor that influences the formation of burnt soils is fire. Because of the way they were formed these soils cannot be included into any existing groups. Besides that, these soils have special names. Being that the fire is the main pedogenetic factor that influences formation of these soils, this should be emphasizes in their names. That is why they are called "burnt soils", that is, Pyrosols or "Combustosols".

Further important question is to which soil group should these soils be added? These soils can be separated into a special group, so called, technogenous soils. Technogenous soils are soils that are formed in a special way, have processes that are not found in natural soils and represent specific pedo-creations.

These technical groups of soils are differentiated from, so called, anthropogeneous soils.

Differences between these two types of soils are the following:

- specific process of formation, with fire being the dominant influencing factor,
- because of the burning of soil many other factors and processes are being changed, such as: loss of carbonates (in cases of carbon layers) in the beginning phase of their formation, loss of organic matter and humus, changes in mineral composition, changes in colour, changes in fertility.

CONCLUSIONS

This paper is an investigation of technogenous soils formed by burning or soil, caused by self-burning of coal layers (lignite) and geological marl layers (marls). Two types of burning sites: relic and recent. As a result of self-burning specific soil formations were created and they are called Pyrosols. (Combustosols). These soils are included into a special soil group called technogenous soils. The group of technogenous soils include: Deposol, Recultisol, Pyrosol, Necrosol, Cinerosol. Pyrosols can be developed by different techniques in the post-burning period. By further, more detailed research of mineral clay, mineral texture and etc., we can find out more about these soils and their characteristics.

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THE MEASURE OF ANTHROPIZATION: PHOSPHATE CONTENT OF SOIL

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ABSTRACT

Since Arrchenius it is known that the phosphorus content of soil indicates the place of on-time settlement. It is supposed that phosphorus content shows the intensity of human activity (duration and magnitude) on a given place, as well. Phosphorus compounds are favourable in this respect while the rate of their accumulations and transformations are slow enough to follow the changes of the environment and the human impact. Thus the consequences of former conditions could be determined by phosphorus content of soil for thousand of years.

INTRODUCTION

The total phosphorus content is an excellent indicator of human activity. The quantity of phosphorus in soils of Hungary is generally around 1 000 mg.kg^{-1}. If higher or much higher values are recorded, this can only be attributed to human activity. It can be said that the total P quantity is directly proportional to the intensity of the activities of the humans living on the area, the length of time the area was inhabited, the population density and the diet of the inhabitants.

Quantity of total phosphorus

The quantity of total phosphorus in natural and arable soils is generally less than 1 000 mg.kg^{-1} in Hungary. Table 1 shows the total P in typical Hungarian soils (Füleky 1983).

The total-P content was determined after H_2SO_4 + H_2O_2 digestion (Füleky 1974) spectrophotometrically. The comparison of the Na_2CO_3 fusion and perchloric acid digestion methods with H_2SO_4 + H_2O_2 method shows, that all the three method give very similar total phosphorus values (Füleky 1973). Different extracts were compared to reflect the easily soluble phosphate content of soil. Both the acidic and basic solutions extract the phosphate amount of soil which depends on the soil characteristics (AL-method, Olsen $NaHCO_3$-method, etc). That is why the independent total phosphate is the proposed method (Füleky 1976). The long-term fertilization increases the total P content of soil, but not on extreme extent, maximum up to 1 000 mg.kg^{-1}. (Füleky 1975). Among some soil characteristics the total phosphate content was always determined at the excavation areas in Hungary.

The only special wish was to find a non-anthropogenetic soil reference profile in the neighbourhood of the excavation area. In some cases it was not an easy task, because of the wide-spread distribution of human influenced soils.

Historical example

At a Neolithic tell settlement in the Hungarian low-land, not far from the Tisza river core soil samples were taken inside and outside of the tell (Table 2). The total-P content in the 4 m deep sampling area was rather high, only below the original A-horizon became the total P-content less than 1 000 $mg.kg^{-1}$. At the same time out of the settlement the total P-content in the whole soil profile was far less than 1 000 $mg.kg^{-1}$.

At a Bronze Age tell in Százhalombatta very similar total P-content was detected in the 4 m deep core samples (Tables 3, 4). Throughout the 4 m tell the average total P-content was about 4 000 $mg.kg^{-1}$. In the buried original soil profile the maximum content of total P was about 800 $mg.kg^{-1}$. Measuring the total P-content in unknown core soil samples reaching the undisturbed original soil, the total P-content immediately drops to the maximum of 1 000 $mg.kg^{-1}$ value from the anthropedogenic horizons of some thousands $mg.kg^{-1}$ P-content.

All the total phosphate determinations in the soils of historical sites prove the facts:

- In the case of traditional farming and living conditions the total P-content of surface horizon and sometimes of deeper horizons are in close correlation with the intensity of the activities of men living on the area, the length of the time the area was inhabited, the population density and the diet of inhabitants. The source of total P-increase at historical sites are bone, kitchen refuse, night soil etc.
- There is a close correlation (r = 0,75) between the total P-content of the soil of a historical site (Endrőd) and the number of fragments collected from the same area.
- Total P-content very well shows the former human activity on the site, thousands of years later, too (Füleky 1992). Total P-content of soil on the surface and below it is in good correlation with the duration of inhabitation. At Endrőd on an inhabited small hill people never occupied the area below 84 m and at the same time total P remained below 1 000 $mg.kg^{-1}$. On the inhabited places the total P-content were always above 2 000 $mg.kg^{-1}$.

CONCLUSION

We can conclude that total P-determination is an excellent measure of soil anthropization especially on historical sites. Developing the existing WRB soil classification systems in the case of historical sites, that soils could be classified as Anthrosol which has high P-content of 1 000 – 1 500 $mg.kg^{-1}$ as a diagnostic criteria.

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Table 1 Total P-content of some typical Hungarian soils

Soil type	Horizon	Depth, cm	Total P mg.kg^{-1}
Calcareous chernozem, Nagyhörcsök	A_{sz}	0 – 32	980
	A	32 – 60	820
	B	60 – 104	612
	C	104 – 140	544
Meadows chernozem, Nagyhegyes	A_{sz}	0 – 22	796
	A	25 – 56	696
	B	56 – 93	632
	BC	93–123	600
	C	123 – 150	584
Brown forest soil, Keszthely	A_{sz}	0 – 5	484
		5–24	440
	A	24 – 54	328
	B	54 – 68	328
		68 – 85	404
	C	85 – 101	432
	C_{fe}	101 – 113	424
	D	113 – 132	392
Brown forest soil with clay illuviation, Nagykanizsa	A_{sz}	0 – 27	480
	B_1	27 – 47	560
		47 – 75	656
	B_2	75 – 115	768
	BC	115 – 160	808
Meadow soil, Hosszúhát	A_{sz}	0 – 25	692
	A	25 – 44	560
	B_1	44 – 68	500
	B_2	68 – 96	504
	C	96 – 140	584
Meadow solonetz, deep, Újszentmargita	A_0	0 – 3	736
	A_1	1 – 13	514
	A_2	13 – 23	240
	B_1	25 – 35	385
	B_2	40 – 50	524
	C_1	80 – 100	524
	C_2	120 – 130	516
Solonchak – solonetz, Apaj	A	1 – 4	570
	B_1	4 – 14	824
	B_2	14 – 25	596
	BC	25 – 45	468
	C	45 – 140	632

Table 2 Total P-content at the Neolithic Polgár-Csöszhalom tell

	Depth, cm	Total P mg.kg^{-1}
Out of the tell	0 – 30	785
	30 – 60	412
	60 – 90	345
	100 – 140	748
Inside of the tell	0 – 50	4 552
	50 – 100	4 120
	100 – 150	6 368
	150 – 190	3 990
	190 – 220	6 264
	220 – 250	2 484
	250 – 300	7 560
	300 – 350	1 256
	350 – 380	964
	380 – 400	772

Table 3 Total P-content out of the Százhalombatta Bronze Age tell

Soil type	Horizon	Depth, cm	Total P mg.kg^{-1}
Brown mixed	A cult	0 – 140	2 004
Brown	A	140 – 160	791
Reddish-brown	B	160 – 190	670
Grey sand	C	190 – 240	779
Iron crust	–	240 – 250	488
White tubercular limestone	–	250	730
Grey loamy marl	–	–	725
Grey clay marl	–	–	–
Greyish yellow marl	–	–	–

Table 4 Total P-content inside the Százhalombatta Bronze Age tell

Depth, m	Total P mg.kg^{-1}
0 – 0,20	3 699
0,20 – 0,65	2 577
0,65 – 1,00	3 457
1,00 – 1,05	3 771
1,05 – 1,20	4 614
1,20 – 1,30	4 354
1,30 – 1,55	5 709
1,55 – 3,00	6 968
3,00 – 3,80	5 760
3,80 – 4,05	1 349
4,05 – 4,45	1 337
> 4,45	1 130

THE TRICKY DELIMITATION OF THE URBAN SOILS

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ABSTRACT

Definitions, delimitations and classifications of the Anthrosols especially urban soils from non soils are the scope of this paper. These considerations begin with the delimitation of the urban soils from the other human impacted soils, demonstrated by pictures and by the classification after the World Reference Basis for Soils Resources, the German Soil Survey Manual, and the Austrian Soil Classification. Three tables elucidate these connections. Due the modest congruence between these three classifications a proposal for the definition and classification for urban soils (Disposal soils) is given on the end of this paper.

INTRODUCTION

To get the audience in the right mood, a number of questions must be answered. At the first there are some definitions. Tricky connotative difficult, but with a visual estimate, and instinct is possible to find a definition.

Concerning delimitations that's precisely the question where is the beginning, and where finish: One example for a possible sequence: Non-soil – raw natural soils – weakly developed soil – natural or quasi-natural soil – weakly moderated soil by men – cultivated soil – modified soil – artificial soil – Colluvium and/or Anthrosols – technological soil – urban soils – non-soil.

Way of looking of a problem

Urban soils: This name is taken from the Latin word "urbs, urbis", connotative the city, the town, former around with a wall, and the townsman. Now, where is the beginning of the city? Are they the town-moat, the town-hall the town wall, the municipal laws, the town residences? And, what is in opposition to the town? As an answer it can be served a little history.

The medieval city was around with the town wall, and the beginning and finish were fixed. The townsman was living into the town wall. Around the town wall was the glacis, the out of range area, an outside of the glacis the suburbs. What belong to the town (within the town wall, the glacis), and what is the opposite?

I can not give a binding answer, but I make the trial to find a row of arguments and hints for a solution of these questions – and we have more questions than answers. The criterions are: a minimum of area, the parent material a natural e.g., excavated material, outbreak material or artificial material e.g., building rubble, dumps.

The questions about the material was the first main point, the second point is the time of development, or with other words, how long is the soil development on this site, how deep is the solum and can we distinguish soil horizons? For that purpose some examples.

On the ruins of the roman time in Austria, e.g., Carnuntum at the Danube, we have an eolian deposition (eolian sand and dust), and on and from this substrate Chernozem-like soils. This phenomena indicate that at first in this area reigns a continental climate, and second since the 4th century is the soil forming in the direction to Chernozem and the solum is about thirty centimetres thickness. It is an urban soil?

Example number two. In many city of Austria we have many kinds of gardens in the courts, city parks, traffic gardens besides the streets (border), front gardens, yard gardens.

Are these soils urban soils or Hortisols – or artificial soils because these are intensively cultivated, fertilised, and irrigated too?

The initial stages for a solution is corresponding with the Word Reference Base for Soil Resources (WRB), the Bodenkundlichen Kartieranleitung (German Soil Survey Manual) (KA5), and the Österreichischen Bodensystematik 2000 (Austrian Soil Classification 2000) (ÖBS 2000).

According to the WRB have "Anthrosols a hortic, irragric, plaggic or terric horizon 50 cm or more thick; or an anthraquic horizon and an underlying hydragric horizon with a combined thickness of 50 cm or more." Anthropedogenic horizons comprise these horizons and show a "variety of surface horizons with result from long-continued cultivation like deep working, intensive fertilization, extraneous additions, irrigation, and wet cultivation". Anthropedogenic horizons differ from anthropogenic (= anthropogeomorphic soil material, remark of the author) soils materials, which are unconsolidated (?, remark of the author) mineral or organic resulting largely from land fills, mine spoil, urban fill, garbage dumps, dredging etc., produced by human activities. These materials, however, have not been subject to a sufficiently long period of time to have received significant imprint of pedogenetic processes."

Table 1 gives descriptions of anthropogeomorphic soil materials (according to the WRB)

Aric	Mineral soil material which has, in one or more layers between 25 and 100 cm from the soil surface, 3 percent or more (by volume) fragments of diagnostic horizons which are not arranged in any discernible order
Garbic	Organic waste material; land fill containing dominantly organic waste products
Reductic	Waste products producing gaseous emissions (e.g., methane, carbon dioxide) resulting in anaerobic conditions in the material
Spolic	Earthy material resulting from industrial activities (mine spoil, river dredgings, highway constructions etc.)
Urbic	Earthy material containing building rubble and artefacts (cultural debris > 35 percent by volume).

Remark: After Bridges et al. (1998) soils from "mine waste, urban fill, garbage and dredging from new parent materials and thus are placed in Regosols" and further "The parent material can be any fine-grained, unconsolidated weathering material. Deposits of mine waste, urban waste, landfill and dredging have had a little time for soil formation to occur, so soils in these deposits are included in Regosols."

The German Working-Group for Urban Soils of the German Soil Science Society (Arbeitskreis Stadtböden [AKS] der DBG) for the Soil Survey Manual (KA5) comprises the definition for urban soils on urban, commercial, industrial and by mining modified areas. In this definition are also soils and areas without soil cover, like different urban, commercial, industrial and mining use as from dangerous waste from the past included.

During the mapping must be recorded the specific entities like:

- reduced colours without influence of water,
- colour is given by concentration of contaminants,
- unexpected content of calcium carbonates,
- unexpected pH values,
- content and distribution of organic matter,
- restricted root penetration due compaction, contaminants, sealing.

After the kind of the deposition the materials are differentiated into 10 categories, therefore into anthropogenic deposed natural, anthropogenic deposed technological, and anthropogenic deposed mixture from natural and technological substrates. This German proposal shows 16 substrata-groups; the following sharing is given by the special kind of the material.

In the ÖBS 2000 we find into the order Terrestrial soils the class Colluvisols and Anthrosols with the six types.

The Colluvisols are developed partly as a natural partly as a human-induced processes, the Anthrosols are soils with a long-time and very intensive human impact. These changes can be an erosion and/or mixture of natural soil material or technological material. A concentration of nutrients or organic matter is the rule. The soils into this class show very changed horizons/layers. The minimum of thickness of natural material must be 40 cm, of technological material 20 cm. The Table 2 demonstrates the types, subtypes, and varieties.

Table 2 Types, subtypes, and varieties init the class of Colluvisols and Anthrosols

Type	Subtype	Variety
Colluvisol (Kolluvisol)	with calcium carbonate without calcium carbonate	gleyic, pseudogleyic
Cultivated-raw soil (Kultur-Rohboden)	with calcium carbonate without calcium carbonate	possible
Hortisol (Gartenboden)	with calcium carbonate without calcium carbonate	possible
Trenching soil (Rigolboden)	with calcium carbonate without calcium carbonate	possible
Bulk material soil (Schüttungsboden)	levelled soil (Planieboden) mound soil (Haldenboden)	with calcium carbonate, without calcium carbonate, gleyic, pseudogleyic
Disposal soil (Deponieboden)	with calcium carbonate without calcium carbonate	possible

While the Bulk material soils consist of natural transported material near the surface (=Levelled soil) or far-off the surface (=Mound soil) is the Disposal soil under discussion. The substratum of this soil is a technological material with a thickness of more than 20 cm. The material can be urban, commercial or industrial waste, e.g., building rubble, ashes, mud, clinker, garbage dumps, and compost. The entities of theses soils are reduction colours without influence by water, colour by accumulation of contaminants, non-typical content of calcium carbonate, non-typical content and distribution of organic matter, and a restricted root penetration due compaction, contaminants and/or sealing. All very different materials are possible. If the soil between the first 70 cm is transformed into a site-typical soil we must name this soil like a natural terrestrial soil.

I think we can put the urban soils in this category, we have the option to made subtypes concerning the content of calcium carbonate (or not) and we have the possibility to create further varieties. The expression urban soil in "sensu stricto" not to be in existence in the ÖBS 2000.

Conclusion and proposal for a classification

One principally remark: We have more than 100 years soil research in the open landscape, but only one generation soil research in the cities and industrial zones. For this reason we are standing in a developmental stage.

Colluvisols and Anthrosols are plus/minus human affected soils from a heterogeneous mixture of materials (natural and/or technological [= man-made material, anthropogenic material]) and the result of a long continued use.

Criteria for the classification:

- Kind of the material: natural or technological;
- Kind of human impact: physical (mechanical) and/or chemical;
- Intensity and duration of treatment and site-use – degree of the development to an A-horizon and regeneration to a quasi-natural soil.

What are the objects of our interest? Every garden, city park, traffic garden, front garden, yard garden, every street etc., and in which scale you dressed the map: 1:2,000 (fire-brigade plan) or 1:5,000 or cadastre? Finally the Table 3 will give an answer on these questions in the kind of a proposal for classification.

Table 3 Proposal for the position of urban soils.
Order: Terrestrial soils
Class: Colluvisols and Anthrosols

Substratum	natural	natural	Artificial e.g., urban fill, garbage, dumps, organic waste material, building rubble, urban waste ashes, mud, clinker, garbage, and compost.
Processes	natural	Man-induced e.g., deep ploughing, trenching, fertilizer accumulation, humus accumulation, irrigation	Man-induced
Type/subtype	COLLUVISOL / calcareous C. or non-calcareous C; Cultivated raw soil / calcareous C. or non-calcareous C.	CULTIVATED RAW SOIL / calcareous C. or non-calcareous C.; Colluvisol / calcareous C or non-calcareous C.; Hortisol / calcareous H. or non-calcareous H.; Trenching soil / calcareous T. or non-calcareous T.; Bulk material soil / Levelled soil and Mound soil	Disposal soil / urban soil) calcareous D. or non calcareous D.

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AGRICULTURAL ANTHROPIZATION OF ICELANDIC SOILS AS SEEN BY MIDDLE EUROPEAN SOIL SCIENTISTS

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ABSTRACT

Iceland is for sure an exotic and unique country for soil scientists. It is especially due to still very active volcanic ground spreading over the rift zone. Iceland is known as "domicile" of volcanic soils, mostly Andosols and Vitrisols, which can be seen nowhere in Europe in such extent and variability. However, Iceland is also the country utterly affected by anthropic activities, mostly those connected with anthropization of soil cover. Impressive signs of soil wind erosions can be found in desert interior occurring on Vitrisols and Andosols. We also try to provide brief view on typical soils as we have seen them in Iceland.

INTRODUCTION

Agricultural anthropization of soil is in any conditions tightly connected to history of agriculture as well as natural conditions of the area. According some misty sources (Jones 1980) Iceland has been settled in certain form already in 9th century. Jóhannesson (1960) describes Norwegians being the first settlers, which arrived in 874 A.D. With exception of few Irish monks man had not previously inhabited Iceland. The present population is about 275 000 inhabitants living mostly in Reykjavik and other small towns. In 1962, the population was approximately 170 000 with approximately 5 700 farms. Hence we can count for more serious agricultural influence on soil no much more than some 1000 years, what is much shorter period than 6000 years estimated in middle European region.

The area of Iceland is 102 829 km^2, which is located in North Atlantic between 63° 23´ and 66° 32´ northern latitude and 13° 27´ and 24° 39´ western longitude. The climate is cold oceanic with transition to sub-arctic and with pronounced influence of Golf stream. Mean annual temperatures in lowlands are reaching +2 to +5 °C, in highlands -2 to +2 °C. Mean January temperatures are -2 to -8 °C, mean temperatures in July are from +6 to +12 °C. Mean annual precipitation varies in lowlands from 450 to more then 2 500 mm, on highlands from 300 to more then 2 500 mm, on some places exceeding 4 000 mm.

There are two major geological formations on Iceland, Basalt and Palagonite Formations. The Basalt Formation, dated to Tertiary Period, consists of basaltic lava sheets ranging from 5 to 15 meters. Between basalt sheets there are thin beds of rocks, consolidated from "tephra" and other naturally loose surface materials. In some places there are sedimentary beds of sandstone and shale containing thin layer of coal. The Palagonite Formation is younger than Basalt one and it is mostly of Pleistocene age. It is composed of two kinds of formation: Older ("Hreppa") Formation and Younger Palagonite Formation. The Younger Palagonite Formation is the mixture of sub-glacial and sub-aerial eruptives and it partly consists of glacial, fluvial and eolian deposits hardened into rocks as time went by. Acid (rhyolitic) intrusive occurs both in older Basalt as well as Palagonite formations.

In the Tertiary Basalt region, landscape is characterised by succession of lava sheets, one above the other, on the sides of U-shaped valleys that were cut by glaciers. The Palagonite region is characteristic with extensive high and low plateaus, above which single volcanoes rise.

Generally said, the vegetation of Iceland is of sub-arctic type having increasingly arctic character from lowland up to higher elevations. It includes about 430 species of higher plants and ferns. Practically all of them are of European origin. Before settlers arrived all drier sites were covered by birch forests or shrubs. Cutting for fuel and grazing by animals have gradually eliminated the forests. Increase in grass abundance was another noticeable change in the native vegetation. Nowadays, with exception of some small territory covered by wood, practically all territory is covered by meadows, pastures and areas without vegetation (kind of deserts cover over 40 000 $km^{.2}$, another 10 000 km^2 is covered by glaciers)

Short rivers and streams, having origin mostly in the region of glaciers, are quite typical for hydrology of Iceland. Rivers are rather steep and watery during whole year.

Soil conditions and anthropization features

The main soil representatives of Iceland are listed in the Table 1 (Arnalds 2004a).

Table 1 Main soil types of Iceland

Soil type	Area (%)
Histosols	1.2
Gleyic and Histic Andosols	8.1
Brown and Gleyic Andosols	46.1
Leptosols	8.1
Cambic and Arenic Vitrisols	36.4

We have chosen two "typical" soil profiles classified as Andosols (adopted from Arnalds 2004b) aiming to show their morphology and analytical ground data (notice Figures 5, 6 and Tables 2, 3). It is evident that both soils are extremely rich in reactive iron (Oxalate Fe), which mostly occurs as poorly-ordered ferrihydrite. Both reactive silica and aluminium (Oxalate Si and Al), accompanied by iron of course, indicate crushingly intensive weathering of parent material.

Fig. 1 gives the idea how the parent material ("pumice" in this case) looks like. Pumice has extremely low bulk density, basically it is lighter then water. Histic Andosols are another specific feature of Icelandic ando-genesis. Such soils extremely rich on organic carbon, fulfilling histic properties, have andic properties due to high admixture of volcanic ash dust. Volcanic ash is very weak and potentially easy to transport. Windy climate and intensive erosion, connected to

Content

Figure 1 Pumice material

Figure 2 Massive erosive decay of soil body

anthropic degradation of landscape, enables huge transport of volcanic dust within the island, but also outside the isle. It causes intensive losses of soil material, but on the other hand it accelerates andic soil genesis in Histosols.

Table 2 Analytical Data for pedon Godafost (by Arnald 2004b)

Horizon	Depht (cm)	pH H_2O	pH NaF	pH KCl	C (%)	Al	Fe	Si	CEC meq 100 g soil^{-1}	BD (g/cm^{-3})	1.5 MPa %
						Oxalate (%)					
A1	0 – 4	5.9	5.5	10.4	9	2.8	4.3	2.5	41		40.3
A2	4 – 12	6.5		10.2	5	2.5	4.2	2.5	32		28.1
A3	12 – 20	6.3	5.4	10.2	4.6	2.4	3.8	2.5	40		27.4
A4 – (t1)	20 – 26	6.3	5.7	10.1	6.6	1.7	3	1.7	27	0.6	26.6
Bw1 – T	26 – 29	6.6	5.8	10	1.2	1	1.4	1.1	9		6.3
Bw2 – (t1)	29 – 41	6.7	5.9	9.9	7.1	2.2	4.5	2.3	44		36.7
Bw3	41 – 49	6.7	5.8	10.2	5.1	2.9	5.3	3.4	42		40.4
Bw4 – T	49 – 57	6.7	6.1	10.6	1.4	1.1	0.6	1.1	11		11.7
Bw5	57 – 65	6.6	5.9	10.4	4.1	3.2	4.5	2.8	41		35.9
Bw6	65 – 70	6.6	5.8	10.1	2.1	2.2	3.2	2	25		20.7
Bw7 – T	70 – 73	6.6	6	10.1	1.4	1.5	1.2	1.4	14		22.8
Bw8 – (t1)	73 – 91	6.7	5.9	10.3	4.4	5.9	6.8	3.5	44	0.58	59.3
2Bw9	91 – 101	6.6	5.8	10.1	1.3	3.1	4.5	2.7	26		22.4
2C	101 – 121	6.7	5.5	9.8	0.1	1	1.8	0.9	14	1.17	7.4

CEC = cation exchange capacity
BD = bulk density

The most specific feature of Icelandic soil conditions is soil erosion, dominantly wind erosion. Historical deforestation, changes in vegetation cover, dominantly with grassland, intensification of agriculture hand in hand with population growing has caused long year perennial overgrazing. Rather cold climatic conditions, short vegetation period and volcanic activities are also factors making process of wind erosion very active. Huge erosive decay of soil cover is caught by

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Fig. 2. It is also the typical picture of Icelandic desert interior. Stony deserts are typically covered by Vitrisols, which are in fact initial soils built mostly by rough and weakly weathered stone and ash material. They can be also considered as erosive rests of soil cover somewhere.

We also must mention specific pedogenic processes related to cold climate known by middle European soil scientists as "periglacial" features. They are typical geomorphologic structures covering topsoil of overgrazed uplands. Topsoil processes connected with ice crystallisation prevent integration of vegetation to compact canopy protecting upper soil layers. They are also significant signs of human previous activities and sort of landscape degradation (notice Fig. 3 and 4).

Figure 3 Polygon soils

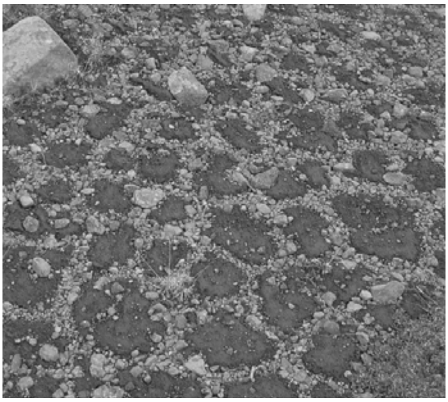


Figure 4 Soil surface eroded by ice activity

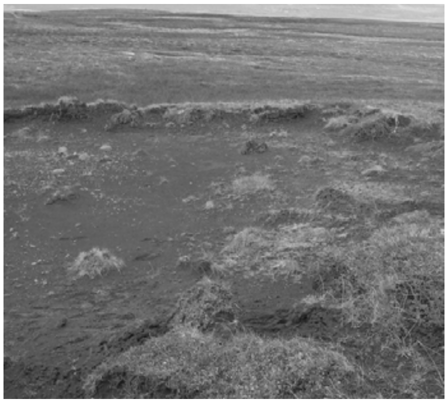


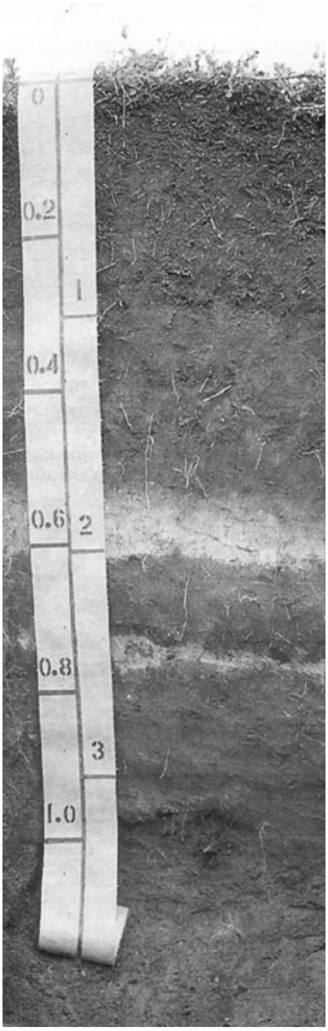
Table 3 Analytical Data for Pedon Mödruvellir (by Arnald 2004b)

Horizon	Depht (cm)	pH H_2O	pH NaF	pH KCl	C (%)	Al	Fe	Si	CEC meq 100g soil^{-1}	BD (g/cm^{-3})	1.5 MPa %
						Oxalate (%)					
A1	0 – 30	5.4	9.4	4.5	14.6	1.8	7.75	1.54	18	0.21	61
201	30 – 35	4.8	9.8	4.2	12.5	1.59	0.8	0.89	13	0.39	74
202	55 – 83	5.8	10.7	4.8	7.43	1.74	0.65	1.07	15	0.44	65
203	83 – 98	5.4	10.4	4.6	10.0	1.25	0.65	0.7	22	0.2	105
3C	98 – 104	5.6	10.9	4.6	1.38	0.45	0.07	0.4	2		11
401	104 – 145	4.6	8.6	3.9	35.4	1.13	1.24	0.27	37	0.18	250
402	145 – 180	5.1	8.7	4.5	37.7	1.29	1.36	0.27	69	0.17	270
403	180 – 200	5.2	9	4.7	34.8	1.23	1.36	0.55	65	0.13	139
404	200 – 260	5.1	9.3	4.5	28.0	1.47	0.76	0.53	58	0.16	205
405	260 – 300	5.2	10	4.6	27.3	1.91	0.68	0.95	54	0.17	302
406	300 – 350 +	5.1	7.4	4.6	41.8	0.61	0.99	0.21	86	0.15	288

CEC – cation exchange capacity

BD – bulk density

Figure 5 Andosol, pedon Godafoss, Iceland (by Arnald 2004b)



A1	7,5 YR 3/2, dark brown, mucky loam, platy struct.,v. friable, many f. r , clear smooth boundary.
A2	5 YR 3/3, dark red. brown loam, w. f. gran. struct., v. friable, m. f. r., clear smooth boundary.
A3	5 YR 3/3. dark red. brown loam, w. f. gran. struct.,v. friab., m. f. r., clear smooth boundary.
A4 (t1)	7,5 YR 3/2. dark brown, loam, w. f. gran. struct., v. friab. m. f. r., includes thin black (10YR 2/1) tephra layer, abrupt boundary.
Bw1 T	10 YR 2/1, black, loamy f. sand, weak subang. blocky struct., v. friable, common f. r., tephra layer (from 1477) abrupt boundary.
Bw2 (t1)	15 YR 3/2, dark red. brown, loamy f. sand, subang. blocky struct., friable, common f. r., tephra layer (H1) about 30% of horizon. clear smooth boundary.
Bw3	5 YR 3/3, dark red. brown, loam, w. med. & coarse subang. struct., friable, common f. r., abrupt wavy boundary.
Bw4 T	10 YR 5/4, yello. brown, silt loam, many med. district strong brown mottles, subangul. blocky struct. friable, common f. r., m. f. vesicular poors, Tephra (2900 BP), abrupt wavy boundary.
Bw5	5 YR 4/4, red. brown, silt loam, w. med. subang. blocky struct. friable common r., clear smooth boundary.
Bw6	5 YR 3/2, dark red. brown, loam, w. med. subangul. blocky struct. friable, few f. r., abrupt wavy boundary.
Bw7	10 YR 6/4, light, yell. brown, silt loam, m. f. dist. strong brown mottles, w. med. platy struct. friable, few f, r., H4 tephra (4000 BP), mottles along plate surfaces, r. chanels, abrupt wavy boundary.
Bw8	5 YR 4/6, yell. red, silt loam, w. med. & coarse subangl. blocky struct. friable, common. f. r., tephra layer accurs in the horizon, m. f. pores, clear wavy boundary.
2Bw9	5 YR 3/4, dark red. brown, loam, w. coarse subang. blocky struct. firm, few f, r, 10 % coarse fragments, clear wavy boundary.
2C	5 YR 4/2, olive gray, gravelly loam, w. coarse platy struct. friable, few f. r. glacial till, few oxidized dark reddish brown vertical planes extend through horizon, 25

CONCLUSION

We can consider wind erosion to be the main manifestation of agricultural anthropization on Iceland. It has catastrophic effect on soil cover, removing partly or totally fine sized part of soil profile. Due to low percentage of arable land, water erosion as manifestation of agricultural anthropization is less common. We also have to include unfavourable conditions which make land cover regeneration very difficult and slow. Due to specific geological constitution of Iceland mostly andic soils (Andosols and Vitrisols) represent leading soil cover. Both are known as extremely weak soils sensitive to wind erosion.

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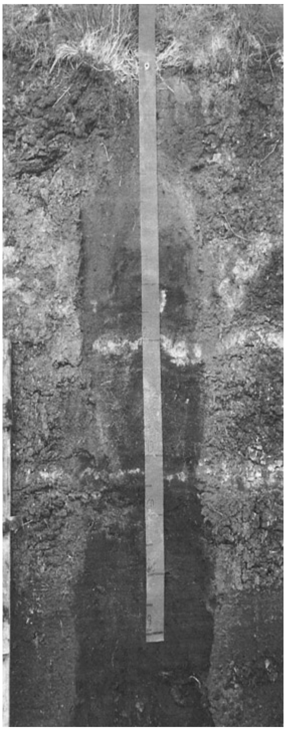
Figure 6 Andic Histosol, Pedon Mödruvellir, Iceland (by Arnald 2004b)



A1	7,5 YR 5/6, strong brown, loam, w. f. gran. struct., v. friable, m. w. f. to med. r., No mottles, abrupt wavy boundary
201	10 YR 4/3, dark brown, loam. v. w. thin platy struct., friable, m. v. f. and f. r., No mottles abrupt wavy boundary.
202	5 YR 3/2 silt loam, w. f. & med. subang. blocky struct.,, m. v. f. & f. roots. No mottles. Stratification visible with different colors, clear wavy boundary.
203	5 YR 2.5/2, dark brown, silt loam, v. w. thin platy and v. w. f. & med. subang. blocky struct., friable, yellowish undecomposed OM. No mottles, abrupt wavy boundary.
3C	10 YR 7/4, sandy loam, v. w. subang. blocky struct., firm, v. few f. r., few faint mottles, tephra layer (H3 – 2800 years old, covers 80 % of Iceland)), clear wavy boundary.
401	10 YR 2.5/1, black. V.w. thin platy & w. f. subang. blocky struct., few, v., f., & f. r., tephra layer at bottom, 102 cm, light reddish brown, abrupt wavy boundary.
402	5 YR 2.5/1. black, w. thin platy struct., few. v. f. & f. r., abrupt wavy boundary.
403	5 YR 2.5/1, black, w. thin. & w. med. subang. blocky struct., v. few v. f. r., faint reddish mottles around r., Abrupt wavy boundary.
404	5 YR 2.5/1, black, w., thin platy & w. med. subang., blocky, v. f. v. f. r., Clear wavy boundary.
405	5 YR 2.5/1,. black, v . w., thin platy v. w. med. subang. blocky struct. v. few v. f. r., No mottles, abrupt wavy.
406	5 YR 2.5/1 black, v. w. thin platy & v. w. med. subang. blocky struct. v. few v. f. r. no mottles, abrupt wavy boundary.

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Content

LAND USE AND SOIL ANTHROPIZATION

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ABSTRACT

Paper deals with problem of adequate evaluation soil anthropization processes in classification systems. Such degradation processes as soil erosion, degradation of physical, chemical and other soil properties provoke human-induced impact which cannot be appropriate captured only on the base of morphometric or morphogenetic characteristics. E.g. the soil erosion evaluation and classification only on the soil varieties level, has not to be from the view of soil ecological properties changing sufficiently and correct. Modern perceiving of precise agriculture is targeted to sustainable land use. It is well known that the non-sustainable fertilization, non-sustainable application of heavy mechanization, non-sustainable crop rotation, etc. have significant influences also on the change of mutual relationships among the soil properties and functions. There is a question, whether and why are not in the present soil classification systems. Referring to term "Kultizem" involved into the latest soil classification system we prefer general term Anthropogenic or Anthropic soils with the subsequent determination and classification of the visible and relevant soil properties changes conditioned by man.

INTRODUCTION

The present soil classification systems are based on one-sided morpho-metric or morphogenetic soil profile evaluation. The applications of the holistic relationships evaluation between the morphogenetic, chemical, physical and biological soil properties development including the soil function classification are solitary. Therefore the primary aim of this contribution is to engage attention also to the relationships evaluation between the non-sustainable land use systems application and soil anthropization. As "human activities create, by anthropic soil evolution, new chronosequences", it will be inevitable to "establish relationships between soil cover organization and functioning," and "on other side: ... erosion and others soil degradations in function of human activities" (Ruellan 2002) in more detail.

To the very negative soil anthropization factors belongs the non-sustainable application to have the large-scale farms field blocks and so the "large scale" man requirements in land use activities what conditioned the very dissimilar soil properties and soil units mosaic on the field blocks. The rule to respect the sustainable field blocks scale and his sustainable use is resulting from the objective reality, that every soil/land whole has its own specific ecological properties combination, which limited not only its properties and potential as well, but the positive economic effect of the sustainable land use, too. In this context of knowledge we understand the non-sustainable land use as the primary negative factor of the soil anthropization. On the other side well sustainable-managed land use can be resulted in positive soil anthropization.

Soil erosion

The soil erosion intensity is evaluated first of all according the sloping of area. These data are very valuable, but less is evaluated the fact that the primary reason of the soil erosion intensity in the sloping areas is in the non-sustainable land use. In many scientific presentations are very detailed and very valuable data about the relations between the crops rotation and intensity of soil erosion, which guide our attention to the correlations between the soil erosion intensity and sustainable land use in the sloping areas. This approach is and will be very desirable in the present time of the one-sided economical aspects preferring on account of the soil and land resources conservation. From this point of view the present soil erosion intensity can be more conditioned by the man as by sloping of area.

As the soil erosion intensity is conditional so by the time, the starting point of our question is, how to determine and evaluate the parameters of the original and new soil units affected by man. As the gradual raising of the morphometric parameters changing depends from the time, the essence of this question is how to evaluate and classify the influence and borders of the non-sustainable man influence on the soil unit change. The soil erosion evaluation and classification only on the soil varieties level, has not to be from the view of soil ecological properties changing sufficiently and correct.

Soil degradation

It is well known that the non-sustainable fertilization, non-sustainable application of heavy mechanization, non-sustainable crop rotation, etc. have significant influences also on the change of mutual relationships among the soil properties and functions. This reality evokes the subsequent question, whether and why are not in the present soil classification systems adequately evaluated also the new changes of the chemical and physical properties within the soil units. The appropriate example of these new changes can be also our results of the soil aggregate stability evaluation on the genetically very similar and identical soil units on Slovak and Austrian sides of border at Bratislava (Nestroy et al. 2001).

The penetrometric measurements of very similar soil units (Calcaric Chernozem and Chiernitza) shows on the Austrian side a plough-pan and compact subsoil, whereas on the Slovakian side these phenomena do not appear. It is a consequence of different ploughing and crop rotation. The aggregate stability of soil on the Slovakian side is a little higher like in Austrian parcels. It is the consequence of stable manure application and the positive effect of the various crops rotation.

Although these differences are in the present time small, their gradual growth cannot be excluded. It is rightful backwash of the new "commercial" land use which will be later very visible. Therefore the present "small" changes of the chemical and physical properties in the frame of the same or very similar soil units can be real reason for the question solution, how to evaluate and classify the man influence on the soil anthropization from the long-term point of view. As according the holistic approach also the "small" changes can indicate the next bigger and visible ecological and functional changes, it is very objective reason for the more detail evaluation and classification of these relationships.

Nomenclature

As the terminus technicus "cultivation" expresses only the very positive man influences, its application in the soil classification is very limited. It is very questionable if every "Kultizem" (Sobocká 1998, Morphogenetic Soil Classification System of Slovakia 2000, and

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another) had and has only the positive parameters. As in the present time we are, and namely in the future, we will be witnesses of the soil degradation escalation, will be more necessary to evaluate and classify the state of soil degradation, erosion, pollution, etc. too.

From the terminological point of view we prefer general term Anthropogenic or Anthropic soils with the subsequent determination and classification of the visible and relevant soil properties changes conditioned by man. Questionable is only the advance, whether and in what rate we come out only from the morphometric or morphogenetic or also from the holistic evaluation of relationships among the all the soil and environment properties and their changes in space and time. The significance of the holistic approach and also of the genetically soil science is in the knowledge that soil and land are fully integrated entities. Therefore every relevant man made changes of the soil properties should be expressed in the soil classification, too.

CONCLUSION

Based on the implying knowledge, into the group of Anthropogenic / Anthropic soils can be included only the soils, which due to the relevant man influence lost or significantly changed their original structure of horizons, or their original physical, chemical and biological properties. Present and potential impact of man on soil properties change should be expressed on the level of soil types and varieties according the character, degree and subsequence's of man influence.

As we are witnesses of the non-sustainable land use escalation, the results of the new interrelation analyses between the morphometrical, chemical, physical and biological soil properties changes and real land use systems evolution should be enforced in the anthropogenic soil unit classification, too. This is very briefly argued by our results of investigation on the genetically very similar soil units, but with very different land use on Slovak and Austrian sides of border at Bratislava.

These advances in the anthropogenic soil classification can motivate the discussion about such soil classification, which will be emanated not only from the morphogenetic parameters, but from the relevant chemical, physical and biological soil properties changes which are conditioned by the non-sustainable land use changing, too.

Supplement

In harmony with the topic of this Conference was presented some opinions about the priorities of the ecological and holistic approaches for the anthropogenic soil evaluation and classification. In this way formulated questions does not refuse recent soil classification results. Our target is to initiate the holistic understanding, and so adequately evaluation and classification of the relationships among the soil, environment and man.

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ANTHROPOGENIC SOILS OF GAS-FIELDS (GENESIS, DIAGNOSTICS, CLASSIFICATION, CARTOGRAPHY)

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ABSTRACT

The problems of genesis, diagnostics, classification and cartography of anthropogenic soils on gas-fields are discussed in this publication. Also classification problems of technogenic and chemically polluted soils are expounded. At last, the possibilities of GIS-technology's applications with cartography aim on gas-fields are regarded. Researching soils are formed under joint influence of natural and technogenic soil-forming factors. Anthropogenic soils of gas-fields at all bioclimatic zones are characterized as soils with disturbing profile and very negative physical, chemical, biological properties. Researching soils are subdivided on technogenic soils, chemically polluted natural soils and chemically polluted technogenic soils. Within a group of technogenic soils next soil's types are distinguished: Techno-soil – soil which contains superficial mechanical disturbances technogenic material in upper layers and conserved diagnostic horizons of natural soil (profile for zone of Derno-podzolic soils: Ad-Atr-TG (technogenic horizon)-E-BF(BI)-C); Technozem – soil-similar body which consists of series of natural and technogenic materials and without diagnostic horizons of natural soil (profile: Ad-Atr-TG1-TG2-BF(BI)-C); Turbi-soil – soil which consists of mixing natural horizons (profile: [A+E+BF(BI)]tr-BF(BI)-C); Embriozem – young soil developing on technogenic ground (profile: A-C). Within a group of chemically polluted natural soils next soil's types are distinguished: Chemically polluted soil – natural soil with polluting substances content that exceeds standards and can be identified only by means of analytic methods; Chemo-soil – soil with polluting substances which change morphology of soil's horizons and are found in some parts of profile; Chemozem – soil with profile which is very intensively reformed under influence of polluting substances. Chemically polluted technogenic soils combine properties of all describing soils.

INTRODUCTION

Soil cover is strongly transformed and polluted in consequence of underground gas storage building, pipelining, gas-wells drilling and exploitation. As a result of it, natural soils change and disappear in these areas. At the same time new soil-similar bodies appear. Soil cover is polluted intensively near field and disposal wells. The latter is used for sewage water pumping into deep layers of the earth. Nevertheless, sometimes this sewage water pours out polluting vegetation, soil cover, and subsoil-water. So, secondary pollution of soils and reservoirs may be fixed in the far distance from disposal wells.

Usually, underground gas storages are built near cities and occupy large territory sometimes including agricultural places. That is why even small transformations and pollutions of soil cover and other components of landscape could have serious environmental impacts. Under existing conditions, monitoring, registration and cartography of these anthropogenic soils are necessary

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on gas-fields. However, diagnostic, classification and cartography of anthropogenic soils on gas-fields require essential definitions and supplements.

The main aim of the present paper is elaboration of diagnostic, classification, and methodology of cartography of anthropogenic soils on gas-fields.

MATERIALS AND METHODS

The object of our exploration was soil cover of underground gas storages. Investigations were conducted in deferent climatic zones. The complex of traditional and express methods was used for diagnostic and cartography of anthropogenic soils in natural conditions. Salinity of soils was determined by express-method of electrical resistance and traditional method of water extraction. Level of soil bituminosity was defined by luminescent method with hexane extraction. Investigations of other soil's physical and chemical properties were conducted by traditional methods. Cartography of soil cover was carried out in detailed scale by square grid of 10 x 10 meters. Cartography fixation was conducted by using GPS-technology. Using computer programs of Geography Information System (MapInfo, ArcView, Surfer) let us construct different detailed maps.

RESULTS AND DISCUSSIONS

Anthropogenic soils of the gas-fields are formed under joint influence of natural and anthropogenic-technogenic soil formation factors. As a result, natural soils get specific properties and are transformed to new soil types.

Nowadays, the main problem of the anthropogenic soils investigation is the absence of universal classification reflecting all variety of these soils. Therefore, in present paper the basic attention was given to the further development of diagnostics and classification of anthropogenic soils of gas-fields. We considered next classification systems: FAO (1994), WRB (1998), MSCS (2000), France (2000), Russia (2000), Germany (1989), Soil Taxonomy of Great Britain (Avery, 1973, Clayden, Hollis, 1989) and USA (1999). Besides it scientific works devoted classification problems were analyzed. The classification principles stated in work "Anthropogenic soils" (Gerasimova, Stroganova, Mozharova, Prokopheva 2003) were taken for a basis in this paper.

For diagnostics, classification and cartography of anthropogenic soils of gas-fields a necessary condition is the study of all soil properties.

Morphological properties

Two types of technogenic soils – Techno-soils and Technozems are formed after drilling close near wells. Usually profiles of these soils consist of next horizons:

1) sod horizon of recent soil formation;
2) poured horizon formed at period of technical recultivation from humus material of donor-soil;
3) series of technogenic horizons consisting of technogenic and natural materials;
4) natural soil horizons (in case of techno-soils – El-BF-BFC-C (for zone of derno-podzolic soils), in case of Technozems – BF-BFC-C, where El – podzolic (eluvial) horizon, BF – illuvial horizon, C – parent rock). Technogenic material is offered by drilling mud consisting of drilling fluid, bentonitic clay, highly mineralized dredges, oil-products and debris.

Because of annual bottom hole flushing highly mineralized materials accumulate at the surface of the land in immediate proximity to gas-wells. Consequently, buried soils are formed near the wells. We suggest to diagnose these anthropogenic soils as technogenic buried or strato-soils (from Latin "stratum" that means flooring). Profile of these soils includes of next horizons TGstr-TG1-TG2-BF-BFC-C (for strato-technozems), where TG(1,2..) – technogenic horizons, TGstr – periodically restoring poured technogenic horizon. Under TGstr all kinds of soil horizons may lay. It is depends on previous properties of soils.

Anthropogenic soils with original profiles are formed during pipelining. These profiles consist of sod and poured humus horizons and layer of mixed disturbed natural horizons (profile for zone of derno-podzolic soils: Ad-Atr-[El+BF+C]tr-C). We call these soils the Turbi-soils.

Young soils (Embriozems) are formed on granite and asphalt coverings. Their profile consists of only two horizons: 1) low-powered humus-accumulative horizon of primary soil formation (thickness less than 5 cm); 2) parent rock.

Physical and physical-chemical properties

Anthropogenic soils and technogenic surfaced formations (TSF) of gas-fields have rather adverse physical properties: lumpy structure, high density, low contains of agricultural valuable aggregates, expressed in decreasing of structure factor of these soils in 2 – 3 times in comparison with background analogues. The entering of bentonitic clays into the soils makes the granulometric composition of these soils heavier. The oil film's formation covering the surface of soil particles increase the hydrophobility of these soils. As a result of replacement of soil air by oil products soil porosity and air-capacity decrease rapidly. Therefore, the air regime of these soils changes.

At the same time, a composition of the air changes in the soils of the gas-fields. Free carbon-hydrogen gases occur in the soil air (its concentration exceeds the background contents on 2 – 5 orders). It is characteristic for areas located above tectonically non-concentrated geological structures and in immediate proximity from technological objects. The raised contains of low-molecular hydrocarbons promotes lowering of redox potential in these soils, that intensify of iron migration processes.

Chemical properties

The basic substances polluting a soil cover of the gas-fields are the oil products, heavy metals, soluble salts, methanol, glycol and sometimes benz(a)piren. Usually pollution has a local character and its influence decreases as moves a way from the centre of pollution (field and disposal wells, methanol warehouses etc). Anthropogenic soils of gas-fields at all bioclimatic zones are characterized by the following chemical properties:

- Raised contents of organic carbon due to introduced fractions of oil products;
- High ratio C : N in structure of soil organic substances;
- High percentage contents of humin;
- Raised contents of heavy metals;
- Raised contents of benz(a)piren.

Soils of humid areas, besides get:

- Neutral or alkaline reaction;
- High contents of soluble salts;
- Technogenic alkalinity.

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Classification

Investigations of morphological, physical, physicochemical and chemical properties of anthropogenic soils of gas-fields let us complete existing classifications of anthropogenic soils. We suggest recognizing:

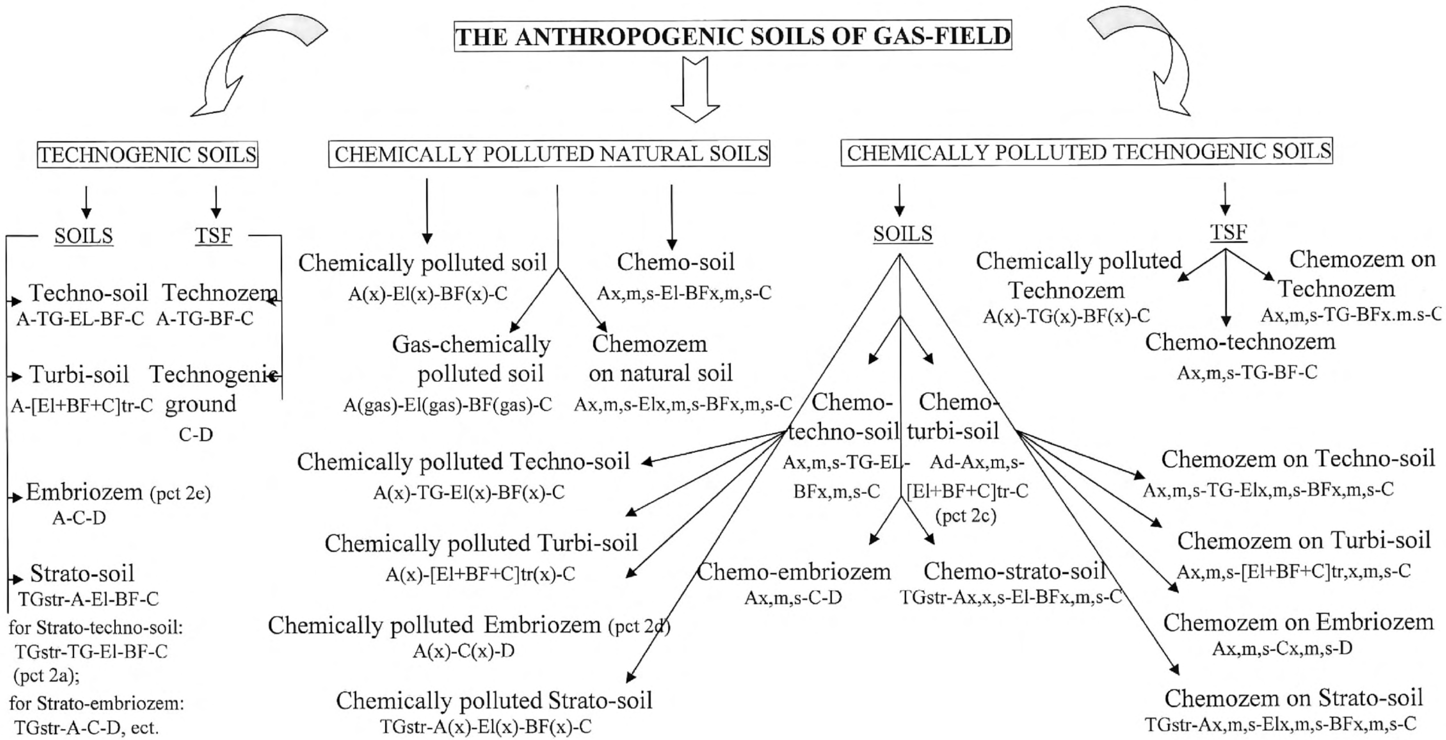
- Techno-soil – soil which contains superficial mechanical disturbances technogenic material in upper layers and conserved type-diagnostic horizons of natural soil (profile for zone of derno-podzolic soils: Ad-Atr-TG (technogenic horizon(s))-E-BF(BI)-C);
- Technozem – soil-similar body not retaining type-diagnostic horizons of natural soil and consisting of poured humus horizon of donor-soil and series of technogenic horizons (profile: Ad-Atr-TG1-TG2-BF(BI)-C);
- Turbi-soil – soil which consists of poured humus horizon of donor-soil (sometimes without it) and mixing natural horizons (profile: [A+E+BF(BI)]tr-BF(BI)-C);
- Embriozem – young soil developing on technogenic ground with humus horizon less than 5sm (profile: A-C-D);
- Strato-soil – initial natural or technogenic soil buried under periodically renewal highly mineralized technogenic material (profile for strato-podzolic soil: TGstr-A-El-BF-BFC-C).
- Chemically polluted soil – natural soil polluted liquid and solid substances which pollution exceeds standards and can be identified only by means of analytic methods (profile: A(x)-El(x)-BF(x)-C, where (x) – the possible presence of polluting substances identifying only by means of analytic methods);
- Gas-chemically polluted soil – soil seasonally polluted by gaseous substances which exceed standards (profile: A(gas)-El(gas)-BF(gas)-C);
- Chemo-soil – soil that have only several polluted natural horizons being chemically reformed and getting a new indexation (profile for example: Ax,m,s-El-BFx,m,s-C, where x – the presence of polluting substances (oil products, methanol, glycol, alkaline solutions, bentonitic clays, heavy metals, etc), m – the signs of structural and/or chemical-mineralogical transformations of soil materials, s – the presence of soluble salts in quantity more than 0,1 – 0,2%).
- Chemozem – soil with profile which is very intensively reformed under influence of polluting substances (all natural soil horizons are polluted and have got a new indexation). Particular qualities of substances migration and accumulation are changed in this soil (profile: Ax,m,s-Elx,m,s-BFx,m,s-BFCx,m,s-C).

Usually, the anthropogenic soils of gas-fields are formed under influence of several technogenic soil formation factors and combine properties of several soil types. These soils concern to a group of chemically polluted technogenic soils (Figure 1). Exactly these (chemically polluted technogenic) soils dominate at gas-fields.

Cartography and structure of soil cover

The soil cover of industrial zones at the gas-fields is characterized by high heterogeneity. Chemo-technozems are lining in immediate proximity from wells in limits of eluvial landscapes. They are formed in the time of drilling and recultivation works. As a result of wells exploitation Strato-chemozems on Technozems and Techno-soils are formed close near the wells. As moves from wells techno-chemo-soils are formed. Then they change into natural analogues. Embriozems are spread widely in industrial zones of accumulative landscapes. They are generated on sandy highly mineralized technogenic material spreading under gravel rock. Turbi-soils are formed along various assignment pipelines. Besides, it is necessary to note that all of anthropogenic soils of the gas-fields are gas-chemically polluted.

Picture 1 All variety of anthropogenic soils of gas-fields

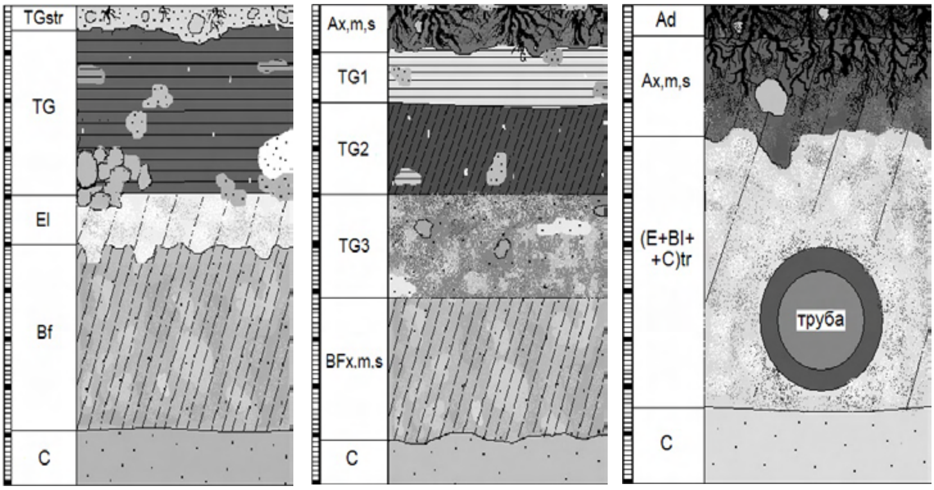


Notes: (gas) – periodically presence of gaseous substances which exceed standards; (x) – the possible presence of polluting substances (oil products, methanol, glycol, alkaline solutions, bentonitic clays, heavy metals, etc) identifying only by means of analytic methods; x – the presence of polluting substances in big quantities; m – the signs of structural and/or chemical-mineralogical transformations of soil materials; s – the presence of soluble salts in quantity more than 0,1-0,2%.

Content

Picture 2 Several morphological profiles of anthropogenic soils of gas-fields

a) Strato-techno-soil   b) Chemozem on Technozem   c) Chemo-turbi-soil



d) Chemically polluted embriozem   e) Embriozem

Chemo-techno-soils and Turbi-soils dominate in structure of the soil cover at eluvial and transit landscapes. Chemozems, Chemo-technozems, Strato-soils and Embriozems occupy the subordinated positions. In immediate proximity from gas-wells (on the area about one hectare) a complication and a contrast of soil cover reaches very high amounts. As moves from gas wells, the heterogeneity of soil cover comes nearer to natural and depends on saturation of industrial zones by wells. The share of anthropogenic soils in industrial zones can vary from 10 up to 99 %. Therefore, cartography of soil cover is expedient to carry out in large or detailed scales with application GPS and GIS-technologies.

CONCLUSIONS

Morphological, physical and chemical properties of anthropogenic soils of gas-fields have been studied. First attempts to classify the soils of gas-fields have been undertaken. Subsequent efforts are to be directed to elaboration of gas-field soils classification in different bioclimatic zones.

NOTES

Soil cover is strongly transformed and polluted in consequence of underground gas storage building, pipelining, gas-wells drilling and exploitation. As a result of it, natural soils change and disappear in these areas. At the same time new soil-similar bodies appear.

Content

Soil cover is polluted intensively near field and disposal wells. The latter is used for sewage water pumping into deep layers of the earth. Nevertheless, sometimes this sewage water pours out polluting vegetation, soil cover, and subsoil-water. So, secondary pollution of soils and reservoirs may be fixed in the far distance from disposal wells.

Usually, underground gas storages are built near cities and occupy large territory sometimes including agricultural places. That is why even small transformations and pollutions of soil cover and other components of landscape could have serious environmental impacts. Under existing conditions, monitoring, registration and cartography of these anthropogenic soils are necessary on gas-fields. However, diagnostic, classification and cartography of anthropogenic soils on gas-fields require essential definitions and supplements.

Anthropogenic soils of the gas-fields are formed under joint influence of natural and anthropogenic-technogenic soil formation factors. As a result, natural soils get specific properties and are transformed to new soil types.

Nowadays, the main problem of the anthropogenic soils investigation is the absence of universal classification reflecting all variety of these soils. Therefore, in present paper the basic attention was given to the further development of diagnostics and classification of anthropogenic soils of gas-fields.

Since suggesting classification is morpho-genetic first of all it is necessary to consider genesis and morphological properties of these soils.

Two types of technogenic soils – Techno-soils and Technozems are formed after drilling close near wells. Usually profiles of these soils consist of next horizons: 1) sod horizon of modern soil formation; 2) poured horizon formed at period of technical recultivation from humus material of donor-soil; 3) series of technogenic horizons consisting of technogenic and natural materials; 4) natural soil horizons (in case of techno-soils – El-BF-BFC-C (for zone of derno-podzolic soils), in case of Technozems – BF-BFC-C, where El – podzolic (eluvial) horizon, BF – illuvial horizon, C – parent rock). Technogenic material is offered by drilling mud consisting of drilling fluid, bentonitic clay, highly mineralized dredges, oil-products and debris.

Because of annual bottom-hole flushing highly mineralized materials accumulate at the surface of the land in immediate proximity to gas-wells. Consequently, buried soils are formed near the wells. We suggest to diagnose these anthropogenic soils as Technogenic buried or Strato-soils (from Latin “stratum” that means flooring). Profile of these soils includes of next horizons TGstr-TG1-TG2-BF-BFC-C (for Strato-technozems), TGstr – periodically restoring poured technogenic horizon.

Anthropogenic soils with original profiles are formed during pipelining. These profiles consist of sod and poured humus horizons and layer of mixed disturbed natural horizons (profile for zone of Derno-podzolic soils: Ad-Atr-[El+BF+C]tr-C). We call these soils the Turbi-soils.

Young soils (embriozems) are formed on granite and asphalt coverings. Their profile consists of only two horizons: 1) low-powered humus-accumulative horizon of primary soil formation (thickness less than 5sm); 2) parent rock.

Investigations of morphological, physical, physicochemical and chemical properties of anthropogenic soils of gas-fields let us complete existing classifications of anthropogenic soils. We suggest recognizing:

- Techno-soil – soil which contains superficial mechanical disturbances and technogenic material in upper layers and conserved type-diagnostic horizons of natural soil.

- Technozem – soil-similar body not retaining type-diagnostic horizons of natural soil and consisting of poured humus horizon of donor-soil and series of technogenic horizons.
- Turbi-soil – soil which consists of poured humus horizon of donor-soil (sometimes without it) and mixing natural horizons.
- Embriozem – young soil developing on technogenic ground with humus horizon less than 5 sm.
- Strato-soil – initial natural ortechnogenic soil buried under periodically renewal highly mineralized technogenic material.
- chemically polluted soil – natural soil polluted by liquid and solid substances which pollution exceeds standards and can be identified only by means of analytic methods.
- gas-chemically polluted soil – soil seasonally polluted by gaseous substances which exceed standards.
- chemo-soil – soil that have only several polluted natural horizons being chemically reformed and getting a new indexation.
- chemozem – soil with profile which is very intensively reformed under influence of polluting substances (all natural soil horizons are polluted and have got a new indexation). Particular qualities of substances migration and accumulation are changed in this soil.

Usually, the anthropogenic soils of gas-fields are formed under influence of several technogenic soil formation factors and combine properties of several soil types. It is necessary to say these soils concern to a group of chemically polluted technogenic soils. Exactly these (chemically polluted technogenic) soils dominate at gas-fields.

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NEW BROWN FIELDS (AND DERELICT LAND) IN SLOVAKIA

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ABSTRACT

Brownfields and some related problems which arose mostly during the transition period of Slovak Republic to EU (1993 – 2004) are presented. Due to big political changes, changing economies, non solved ownership brownfields resulted not only from industrial, but paradoxically also from agricultural (forestry) activities. Beside classification principles of brownfields, causes of their origin are described. The main task, however, is to stress the necessity of their redevelopment as most of them may cause real or suspected environmental problems. Unfortunately, at present existing legislation did not addressed this issue and problem in its scientific basis does not belong to EU priorities.

INTRODUCTION

"Brownfields" (black country, derelict land) are abandoned or under-used industrial, commercial and agricultural facilities, land which has been damaged by extractive or other activities where proper use, redevelopment or restoration of the former land use is complicated due to real or perceived environmental contamination, high costs and non solved ownership (Bridges 1987, US EPA 2002).

Every town, most of villages, rural and urban sites in Slovakia, has vacant, underused, and potentially contaminated properties. They arose rather recently with substantial political and economical changes in the country in nineties of the last century. During this period most of weapons (heavy machinery) industry, chemical and electro-technical industries has been destroyed and mining programs has been cancelled.

Agriculture and forestry which historically maintained the soil and land in productive state and they did not produce brownfields, during transition period have created many of them. Agriculture based mostly on co-operative type of farming with state subsidies has in more than 60 % of cases bankrupted. At that time some farms managed small manufactures and facilities. At present they gape partly or completely destroyed. No animals (except rats), no people. Hundreds of hectares were invaded by weeds. To such belong abandoned facilities of former co-operative farms, courtyards, field manure piles, silage holes, garages, storages of fertilisers, chemicals and pesticides. However, abandoned land with inlet of shrubs and bushes is another frequent phenomenon. Forestry, which is based prevailingly on state owned forests, is falling off. The felling of wood (clear cutting) is higher than forest recovery. Roads are not maintained in proper way, which caused heavy erosion.

This paper is not to write frightful scenario. The main task of it is show on examples of new brownfields in Slovakia, that they created real problems of first priority but unfortunately not deserve any scientific, political or public attention.

First of all, they are reflecting in impairing of soil function (adverse anthropization) which means that soil scientists should take an initiative in surveying such sites. However, surveying brownfields is principally team-work. On the other side brownfields represent some new potential for redevelopment. Also for this, soil scientists can get basis, and bring about how these efforts can help to build the natural asset base of poor communities.

Some basic principles of brownfields classification

The character of brown fields in Slovakia may vary from one region to another. In some parts of Slovakia has been caused by mining operations, industrial activities (chemical industry, heavy machinery industry, metal works) but most often in the rural areas has been caused paradoxically due to past agricultural activities (abandoned misused land, abandoned stables, yards, storages and other facilities). Those sites are mostly state owned or ownership is not solved yet or is unknown. The problem has fallen outside the scope of legislation. Lack of legislation, lack of public pressures, lack of money are the main reasons why brownfields issue has not been addressed, until now.

As many of such sites are potential contamination sources (for soil, water, and plants) they should be at least inventoried, surveyed and as soon as possible reclaimed. For these purposes it seems to be very important prepare a classification of brownfields in order to build the uniform national vide database as well as to portray them in the maps.

At least for the beginning, it seems to be reasonable, to follow basic classification principles of Collins and Bush (1969) for "... land which has been so damaged by extractive or other industrial processes that it gives offence to the eye and is likely to remain so until subjected to special forms of treatment". In this classification they describe a site with symbols which can be used to annotate maps or to record in database:

1. A capital letter is used to indicate general topography (A – at ground level, B – below ground, C – above ground level, D – installations)
2. The numbers are used for associated activity (1 – mineral working, 2 – refuse, 3 – industrial working, 4 – transportation, etc.)
3. More specifically with Roman numerals are described specific causes of dereliction associated with specific activity.
4. Pictorial description is used to describe categories like tips, dumps, pits, houses, factories, etc. For instance B1V c – could mean: below ground level limestone pit.

In addition, in such classification other attributes can be included such as amplitude, configuration, land cover etc. As brownfields are abandoned, idle, or underutilized sites where past users have left a legacy of environmental contamination, categories of contamination can be added to such classification (Haines 1981).

To use above mentioned principles detailed description and uniform presentation on maps of different scales and databases can be elaborated. On similar principles regional and national statistics may be assembled. However, uniform methodology should be used in inventory, surveying and reclamation of brownfields.

New brownfields in Slovakia

The landscape of our country has been modified by many generations. Mining operations are traced back for hundreds of years. However, most pronounced changes were recorded in post second world war period, with industrialisation, changing agriculture, traffic, with mining and quarrying of natural resources, (ores and coal), with fossil fuel combustion. Deteriorated and contaminated land together with factories, mining facilities, offices, has become the land of second category (brownfields) and has been abandoned. This is due to changing economies, bankrupting of many co-operative farms, cancellation of almost all mining and excavation operations.

From above stated is obvious that brownfields in Slovakia could be historical and new ones. New brownfields means such sites created within the last fifteenth years. Those are connecting with the following activities on the land:

1. Agriculture and forestry
2. Energy supply industries
3. Extraction of metals, mineral products and metal works
4. Metal goods
5. Transport and communications
6. Other services

1. Agriculture and forestry historically did not created brownfields as they maintained land productive („cultural“). During transition period (1993 – 2004) before assessing EU more than 60 % of co-operative farms in Slovakia has bankrupted. In many villages destroyed remnants of buildings, abandoned facilities of former co-operative farms, courtyards, field manure piles, silage holes, garages, storages of fertilisers, oil tanks, chemicals and pesticides, looks miserable in a landscape (see Figures 1, 2, 3, 4).
   Local roads (many of them formerly firm roads) to access different parts of village boundaries, forests, are not maintained. When partly damaged, “new and new” parallel roads appears in cultivated fields, in the forests, everywhere especially after heavy rains (Figure 5). Erosion is accompanying phenomenon.
   Clear cutting and approaching timbers in sensitive forests has caused severe gully erosion as well (Midriak 2004). In Banská Bystrica and Nitra districts inspection has revealed 200 and in Ipeľ Region about 60 abandoned storages of pesticides and chemicals. Hundreds of hectars abandoned plots invaded by weeds are spread in naturally picturesque landscapes (Figure 6).
2. Electro power stations, burning the coal, produced ashes sometimes with high content of metals (As). For instance, dumping of such ashes has caused in the past (1965) heavy soil pollution in drainage system of river Nitra.
3. Mining operations (former shafts, quarries), with all facilities (separators, crushers, transporters etc.) are spread on hundreds of hectares. Metal works and dumping sites of leaching slag’s are known to occurs on tens of hectares (Figures 7, 8). Another hundreds of hectares known by diffuse polluted sites, are situated around former smelters. Heavy machinery industry (including weapon industry) was destroyed. (“It was not human to produce the guns”… however, this business was taken by traditionally democratic countries !)
4. Transport with all infra-structure has lead to brownfields creation (abandoned buildings, storages, depots.
5. Other services like wood and food processing industries, transporting centres, recreation facilities create another group of new brownfields.

Related to brownfields one can expect many problems connecting with point and diffuse sources of contaminants like chemicals, heavy metals wastes, oils, paints, pesticides etc.

Brownfields redevelopment

The presence of brownfields near or in the middle of populated regions in Slovakia does not pose only potential danger for public health but it mortgages the further development and growth of affected regions. Brownfields may cause many environmental problems as they may influence relief deterioration and worsening of land stability. Many times are contaminated. Some of them are impairing drainage system, ownership and accessing the land. Brownfields, as abandoned sites mean usually at least soil losses. This is enough to accept a complex programme to rehabilitate such sites.

On the other hand, brownfields represent opportunity to revitalize older neighbourhoods and generate wealth for communities. In addition to direct commercial benefits realized by developers and users of the land, brownfields redevelopment within cities has the potential for economic, social and environmental benefits.

As a rule in Slovakia, regions with brownfields are accompanying with unemployment. Redevelopment may create employment opportunities and their retention, improving quality of life in neighbourhoods. When polluted, clean up means removal threats to human health and safety. Creation new green-fields mean new places for construction, reduction of urban sprawl, increasing aesthetic, cultural and landscape values of urban land.

It is clear also that air, soil and water quality are strongly linked to this problems. For redevelopment of brownfields in Slovakia no special national vide programme exist. In the EU research priorities brownfields are not included. Instead sealing is a first priority. From this it may be concluded that for redevelopment of such sites no legal, political, scientific and financial conditions exist.

New industrial parks and investment is going on ”green meadows” (green-land), first classes of soils, in lowlands. At least small part of benefits from this investment should go to this redevelopment. Later, can be too late or much more costly!

CONCLUSION

The presence of new brownfields in Slovakia in the middle of populated regions pose a potential danger for public health but also mortgages the further development and growth of affected sites. They were produced as a consequence of changes in agriculture and forestry, energy supply industries, extraction of metals, mineral products and metal works, metal goods, transport and communications.

Brownfields in default of special action it is unlike to be effectively used again within reasonable time and may be well be a public nuisance in the meanwhile. The lack of knowledge and information regarding the brownfields redevelopments (identification, investigation and assessment) together with the absence of legal, political and financial instruments is actually responsible for real situation and extending brownfields in Slovakia.

However, the redevelopment of brownfields besides soil scientists requires an efficient collaboration between all other involved parties: remediation experts, financing agencies, investors, local and governmental authorities. It seems that in present political and financial situation this is likely impossible.

Content

Figure 1 Former poultry farm on alluvial soils (about 5 ha of weeds)

Figure 2 Former diary cattle farm (together with other buildings about 15 ha)

Figure 3 Abandoned farm with oil tank (about 20 ha)

Figure 4 Former field manure pile, now non-controlled waste disposal

Figure 5 There is some hole in solid road, what about "constructing a new one" to the left?

Figure 6 Hundreds of hectares of abandoned arable lands – one of them

Figure 7 Abandoned Nickel works at Sereď, partly recultivated slag on the left. Alluvial plain of Váh river with shallow groundwater table

Figure 2 Dumping site of alumina works at Žiar nad Hronom. Very alkaline dust caused secondary salinization of soils due to leaching of salts

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URBAN SOILS OF THE CITY BRATISLAVA AND THEIR ENVIRONMENT

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ABSTRACT

Complete soil science investigation and analyses were used in the project "Urban soils as an environmental factor of living quality in cities (a case of city Bratislava)". This is the first project in Slovakia dealing with specific problems of urban soils (description, classification, assessment) and relating to the environmental factor conditioned living quality in cities. The project consists of soil survey, sampling and analyse of soil samples (incl. recognition of urban ecosystems, selection of representative soil profiles surface urban soil contamination on risk elements). On the base of the field and analytical results two maps were compiled: Map of urban ecosystems of the city Bratislava in the scale 1:25,000 and Soil Map of the city Bratislava in the scale 1:25,000. These documents will serve for delimitation of areas affected by environmental hazards assessment resulting from soils in the city Bratislava. As a practical tool, the Manual for description, classification and assessment of urban soils will be elaborated and published. Herein partial results are presented.

INTRODUCTION

The project: "Urban soils as an environmental factor of living quality in cities (a case of the city Bratislava)" is presented in the paper. The main goal of the project is to research and assess environmental risk connected with soil and substrate contamination of urbanized areas including possible risk elements transfer into contacted spheres and other hazards connected with various degradation forms of urban soils. A general goal of the project is to secure a high standard quality of urban population and its healthy development. It assume to provide totally new and complete materials about urban soils of the city Bratislava as a pilot project for description, properties and environmental functions definition, i.e. to characterize urban soil resources in the city Bratislava.

Human health is depending mainly upon quality of environment. The soil as one of the basic component of environment, have to be a healthy part of sustainable urban ecosystem. Environment of urban areas in cities of Slovakia has been monitored only via water and air. The soil has been wrongly neglected although almost all degradation processes run in soil and accumulated in soil. Therefore an assessment of the environmental hazard resulted from urban soils is the main goal of this project. This is the first – pilot project carried out in Slovakia.

MATERIAL AND METHODS

Research of the project includes:

1. Soil survey, sampling and analyse of soil samples:
   - recognition of urban ecosystems,

- selection of representative soil profiles in the city Bratislava with analyses of pedological characteristics (texture pH in H_2O, in $CaCl_2$, $CaCO_3$ content, Cox content, humus, Nt content, P content, in some cases heavy metals analyses (Cd, As, Pb, Ni, Cr, Hg, PAH and PBC analyses),
- surface urban soil contamination on risk elements (heavy metals: Cd, As, Pb, Ni, Cr, Hg) in Aqua Regia extraction.

2. Elaboration of results in data base form, compilation of map:
   - Map of urban ecosystems of the city Bratislava in the scale 1:25,000,
   - Soil Map of the city Bratislava in the scale 1:25,000. Ortho-photo maps, aerially scanned the entire city area in July 2002, serve as a background for urban areas delimitation and digitalization.
3. On the base of soil survey, laboratory analyses and all available materials evaluation, the pilot project delimitates areas with the most hazard resulting from soil and other aspects of soil degradation:
   - Map of environmental hazards assessment relating to soils in the city Bratislava in the scale 1:25 000.
4. As a practical tool for decision makers and stakeholders will serve elaboration and publishing of:
   - Manual for description, classification and assessment of urban soils.

RESULTS AND DISCUSSION

Urban sites recognition and representative soil profiles selection

Recognition of many urban sites in the capital of Slovakia – Bratislava (extent is 367.6 km^2, 451,000 inhabitants) was made according to urban ecosystem use. Thus, representative soil profiles were selected, described and sampled using basic and special pedological characteristics (Sobocká 2002, 2003). These procedures advocated to the Map of urban ecosystems compilation. For classification of soil units the latest Morphogenetic Soil Classification System of Slovakia was used (2000) (further MSCS) including anthropogenic substrata consideration. Table 1 shows representative soil profiles selection which depict urban soils in the city Bratislava. Table 2 complete description by analytical results.

Classification (according to the Morphogenetic Soil Classification System of Slovakia 2000): Anthrozem Initial, calcareous, urbic form, gravely-loamy texture, from natural-technogenic anthropogenic parent material.

Content

Table 1 Representative soil profiles of urban soils in the city Bratislava

Representative soil profile	Code	Location of the city Bratislava, urban site use, soil type
1	1a	Lamač, suburban forest, Kambizem Modal, loamy, from crystalline schists
2	1b	Lamač, suburban forest, anthropogenic embankment from 1866, Antrozem Modal, loamy, from removed natural anthropogenic material
3	2	Rača – vineyard, Kultizem Modal carbonate, trenched form, loamy, from deluvial carbonate loams
4	3	Dúbravka – abandoned urban area, Antrozem Initial, carbonate, urbic form, skeletal-loamy, from building debris material
5	BA12	Lovinsky street – abandoned garden, Kultizem Modal, gardening form, loamy from carbonate loess
6	BA13	Karlova Ves – Riviera, house garden, Kultizem Modal, gardening form, loamy from carbonate loess
7	BA05	Zlaté Piesky, recreation area with lake, Tchernitza Cultivated carbonate, loamy, from carbonate fluvial sediments
8	BA06	Vrakuňa, natural pedotop near dumpsite, Fluvizem Modal accumulated, carbonate, sandy loam, from carbonate fluvial sediments
9	BA07	Rusovce, arable land near highway, Fluvizem Modal, carbonate, loamy, from carbonate fluvial sediments
10	BA08	Vrakuňa – dumpsite from chemical refuse, Antrozem Initial, contaminated, stock-pile form, skeletal, from anthropogenic natural-technogenic material
11	BA09	Žabí majer, garden allotment near chemical plant, Kultizem Gleyic, loamy-clay, from soil tip + fluvial sediments
12	BA10	Čuňovo, arable land, near highway, Tchernitza Cultivated carbonate, sandy-loamy, from carbonate fluvial sediments
13	BA11	Devin, artificial embankment along the river, Anthrosol Initial, stock-pile form, skeletal, from anthropogenic natural-technogenic material

Comparison MSCS units with WRB system:
Kultizem Modal, trenched form = Ari-Anthropic Regosol, Kultizem Modal, gardening form = Hortic Anthrosol, Kultizem Gleyic = Gleyi-Hortic Anthrosol, Antrozem Modal = Anthropic Regosol, Antrozem Initial, urbic form = Urbi-Anthropic Regosol, Antrozem Initial, stock-pile form = Urbi-Anthropic Regosol, Kambizem Modal = Eutric Cambisol, Tchernitza Cultivated = Fluvic Mollisol, Fluvizem Modal = Eutric Fluvisol

Table 2 Pedological and special (risk elements) analytical results of the representative soil profile in Dúbravka

Texture:

Depth (cm)	Sand 0.05 – 2.00 mm	Silt 0.05 – 0.002 mm	Clay < 0.002 mm	Texture
0 – 25	60.16	27.72	12.12	sandy loam
50 – 70	64.50	24.08	11.42	sandy loam
130 – 170	65.36	26.27	8.37	sandy loam

Chemical properties:

Depth (cm)	pH/H_2O	pH/KCl	Cox %	Humus %	$CaCO_3$ %	ECe $\mu S/cm^{-1}$	P ($mg.kg^{-1}$)	K ($mg.kg^{-1}$)
0 – 25	8.27	7.39	0.96	1.66	2.30	364.5	21.46	135.0
50 – 70	8.26	7.47	0.56	0.97	0.40	119.9	23.28	90.0
130 – 170	8.07	7.89	1.16	2.00	6.90	1 372.0	13.33	90.0

Heavy metal content in 2M HMO_3:

Depth (cm)	As* (mg.kg^{-1})	Cd (mg.kg^{-1})	Co (mg.kg^{-1})	Cr (mg.kg^{-1})	Cu (mg.kg^{-1})
0 – 25	1.10	0.316	5.387	9.38	0.053
50 – 70	1.04	0.033	1.071	1.54	0.028
130 – 170	1.36	0.153	1.185	3.86	0.058

Depth (cm)	Mn (mg.kg^{-1})	Ni (mg.kg^{-1})	Pb (mg.kg^{-1})	Zn (mg.kg^{-1})	Hg** (mg.kg^{-1})
0 – 25	139.0	7.5	62.5	80.7	0.053
50 – 70	101.0	0.9	4.4	7.4	0.028
130 – 170	178.5	2.2	45.8	27.1	0.058

As* – extraction in 2M HCl
Hg** – total content

Surface soil contamination investigation

Sampling of surface dust contamination was carried out from 20 selected sites, affected prevailingly by contamination from traffic (roads, crossroad, squares, …) where we assumed an impact on soil from traffic emission, then other sites like residential areas, historical centre of Bratislava, playing ground, market centre, pumping station, near chemical plant etc. (Poltárska 2003) (Table 3). There were analysed samples on heavy metals content currently occurred in cities: Cd, As, Pb, Ni, Cr and Hg. Analytical results were evaluated according to the Decree of Agricultural Ministry SR No. 531/1994 – 540 (Table 4). Risk elements (As, Cd, Cr, Pb, Zn, Hg extracted in Aqua Regia) are presented in Table 5.

Table 3 Sampling of dust contamination in the city Bratislava

No.	Code	Location in the city Bratislava
1	BAk-01	Bridge of the SNP
2	BAk-03	Crossroad Trnavska + Tomašikova streets
3	BAk-03a	Račianske mýto crossroad
4	BAk-03b	Trnavské mýto crossroad
5	BAk-04	Hurban square
6	BAk-06	Zlaté Piesky recreation area
7	BAk-07	Slovnaft, chemical plant
8	BAk-08	Nobel street, residence area near ISTROCHEM
9	BAk-09	Bajkal street, ESSO pumping station
10	BAk-10	Patrónka cossroad
11	BAk-11	Square of the SNP
12	BAk-12	Petržalka, shopping centre TESCO
13	BAk-13	Mlynská dolina student campus
14	BAk-14	Devínska Nová Ves village
15	BAk-15	Hlavné square, historical site
16	BAk-16	Kamenné square commercial zone
17	BAk-17	Dulovo square
18	BAk-18	Dlhé diely, residential area
19	BAk-19	SSCRI, Gagarinova street, bus-stop
20	BAk-20	Dolné Hony, Čilizská street, bus-stop

Table 4 Limit values for risk elements in agricultural soils of Slovakia (Decree No. 531/1994 – 540)

	Limits			
Metals	**A**	**A_1**	**B**	**C**
As	/29/	5	30	50
Ba	500		1 000	2 000
Be	3		20	30
Cd	/0,8/	0,3	5	20
Co	20		50	300
Cr	/130/	10	250	800
Cu	/36/	20	100	500
Hg	0,3		2	10
Mo	1		40	200
Ni	/35/	10	100	500
Pb	/85/	30	150	600
Se	0,8		5	20
Sn	20		50	300
V	120		200	500
Zn	/140/	40	500	3 000

Table 5 Risk elements results from surface soil contamination in city Bratislava

	As mg/kg	Cd mg/kg	Cr mg/kg	Pb mg/kg	Zn mg/kg	Hg mg/kg
BAK-01	3.95	0.24	24.90	102.64	53.39	0.0653
BAk-03	7.90	0.82	32.45	120.34	342.69	0.1662
BAk-03a	6.70	0.53	59.30	31.95	162.45	0.0597
BAk-03b	5.40	0.45	38.45	67.11	205.82	0.1389
BAk-04	6.50	0.20	36.90	51.28	109.53	0.1001
BAk-06	4.38	0.67	30.70	61.23	171.39	0.0400
BAk-07	1.58	0.23	16.25	23.58	101.77	0.0439
BAk-08	6.73	0.80	39.85	68.95	257.80	0.1814
BAk-09	3.73	0.72	35.75	38.50	184.10	0.0440
BAk-10	5.03	0.75	41.30	49.77	444.45	0.0375
BAk-11	6.63	1.19	49.00	79.09	237.78	0.1883
BAk-12	5.88	0.42	38.45	34.21	133.60	0.0414
BAk-13	5.98	0.28	30.70	22.69	152.70	0.1435
BAk-14	3.78	0.34	21.15	23.11	111.72	0.0166
BAk-15	6.68	0.28	28.80	20.75	91.57	0.0628
BAk-16	10.35	1.20	28.65	112.69	453.27	0.3450
BAk-17	6.60	0.24	28.75	15.74	87.76	0.0745
BAk-18	3.40	0.88	44.00	33.32	204.28	0.0512
BAk-19	4.98	0.95	43.55	62.39	293.36	0.0703
BAk-20	4.45	0.39	30.60	22.49	134.85	0.0327

Light grey marked – values exceeding limit A, dark grey – values exceeding limit B

Figure 1 An example of representative soil profile (code 3 Dúbravka site)

Adic (0 – 2 cm) 10YR 4/4, structureless (individual gravels and grains), sandy loam, strongly psefitic (> 60%), friable, angular to rounded granitic rock fragments (anthroskeleton), moderately rooted

C1c (2 – 30 cm) 10YR 4/4, dry, structureless, sandy loam, strongly psefitic (> 60%), loose, angular to rounded granitic rock, sandstone, shales, anthroskelet presence like brick, plastic iron, calcareous anthropogenic material

C2c (30 – 90 cm) 10YR 6/3, weakly moist structureless, sandy loam, loose, 10 – 15 % granite fragments, single stones (ø 20 cm), iron, calcareous heterogeneous stratified buiding material

C3c (90 – 150 cm) 10YR 7/2, dry or weakly moist, structureless, sandy loam, strongly psefitic with lens of silt, mortar, cement, loose, 50% of angular gravel, rarely stones (ø 10 cm) anthroskeleton iron wires, plastic, concrete panels (ø > 50 cm)

Results of surface soil contamination confirmed our presumptions about contaminated urban areas almost in all urban sites, i.e. near crossroad, squares, along traffic roads, in residential areas, pumping station, villages, etc. Clean areas were registered only two:

- Hlavné square, historical site which is urban site very well managed area in the historical centre of Bratislava and
- Dulovo square which was after complete reconstruction in recent time.

On the base of soil survey, laboratory analyses and all available materials evaluation, the pilot project delimitates areas with the most hazard from soil and other aspects of soil degradation.

Map of urban ecosystems of the city Bratislava compilation

Map of urban ecosystem of Bratislava was compiled on the base of some resources:

- Basic topographic maps of the city Bratislava in the scale 1:10,000 (20 sheets): 44-21-20, 44-21-25, 44-22-16, 44-22-17, 44-22-18, 44-22-19, 44-21-21, 44-22-22, 44-22-23, 44-22-24, 44-23-05, 44-24-01, 44-24-02, 44-24-02, 44-24-03, 44-24-07, 44-24-08, 44-24-12, 44-24-17, 44-24-23.
- Ortho-photo maps, imagines of Bratislava aerially sensing in July 2002. Ortho-photo-maps were produced by the EUROSENCSE firm.

Digitalization of the city Bratislava was made on the base of ortho-photo maps (scanned in July 2002) making detailed drawing on the topographic maps background Figure 2). Additional correction of urban sites delineation was made not only into ortho-photo maps base, but field recognition was needed to do. The map was executed by means of ArcMap GIS Sft. The legend of the Map of urban ecosystems of the city Bratislava, 1:25,000 is specific, created according to the relation to urban soils (Table 6). The Map of urban ecosystems of the city Bratislava will be use as a background for other maps compilation like (soil map, map of geomorphologic units, etc.) (Figure 3).

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Table 6 Legend of Map of urban ecosystem of Bratislava

1. Built-up areas > 60 %
2. Built-up areas < 60 %
3. Industrial areas
   a) chemical industry, incineration plants
   b) surface mining, quarry, gravel quarry
   c) other industry
4. Infra-structure, roads, railways, airports and other traffic areas
5. Areas of public green, recreation areas
   a) sporting areas
   b) ornamental garden, parks
   c) kindergarten, playgrounds, schoolyards
   d) cemeteries, crematories, burial grounds
   e) green areas
6. Agricultural land
   a) arable land
   b) orchards, gardens
   c) vineyards
   d) meadows, pastures
7. Forest and suburban forest, protected areas
8. Abandoned areas (brownfields)
9. Water streams and areas
   a) water streams
   b) dams, lakes,
   c) bogs

Figure 2 Digitalization of the urban ecosystems of city Bratislava based on ortho-photo maps

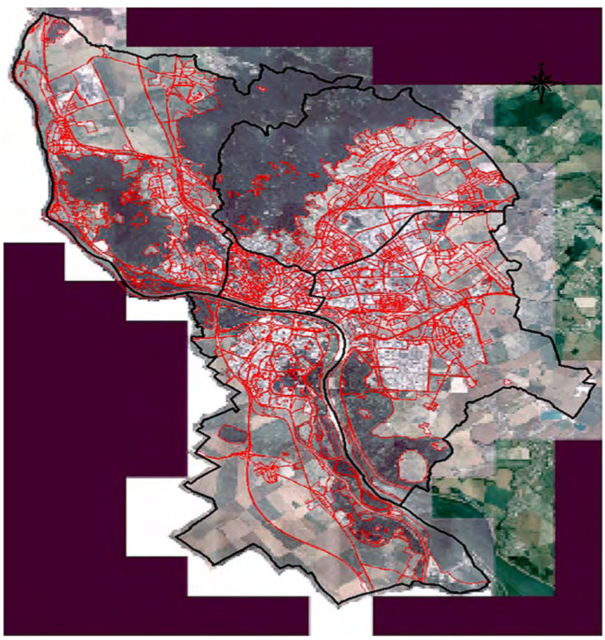
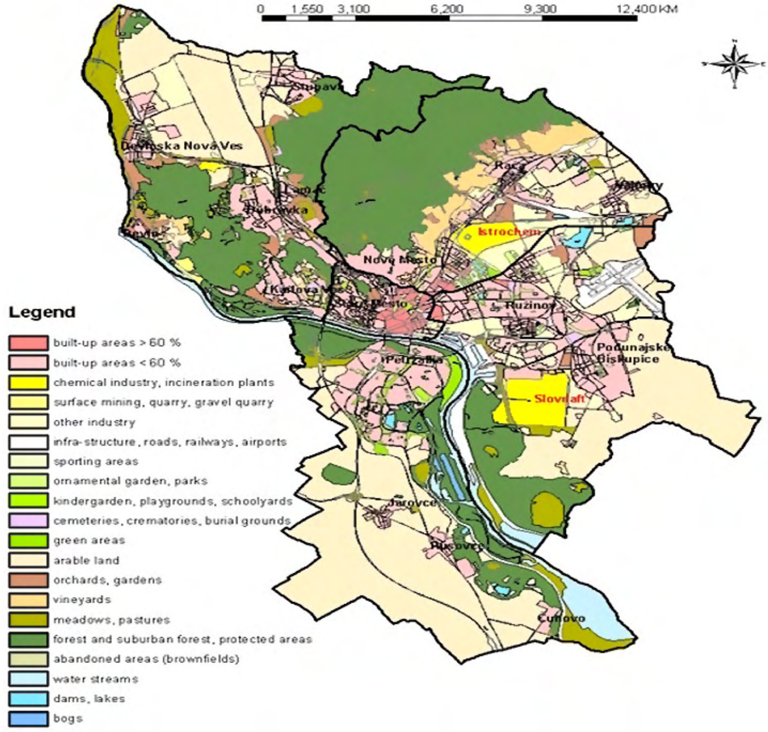


Figure 3 Map of Urban Ecosystems of the City Bratislava, final version in the scale 1:25,000



Map of urban soils compilation

The Soil map of the city Bratislava has been compiled on the base of above mentioned Map of urban ecosystems and other sources:

- Basic soil maps of the county Bratislava, in the scale 1:50,000 from the General Soil Survey of Agricultural Soils,
- Maps of texture, skeleton and moisture of the county Bratislava, in the scale 1:50,000 from the General Soil Survey of Agricultural Soils,
- Maps of parent materials of the county Bratislava, in the scale 1:50,000 from the General Soil Survey of Agricultural Soils,
- Own soil survey in cities, mainly in non-mapped areas

CONCLUSION

There is well known that environment of urban areas in cities of Slovakia has been monitored only via water and air. The soil is wrongly neglected although almost all degradation processes run in soil and accumulated in soil. We register a lack of knowledge about urban soils as one of the part of urban ecosystem and suspect that contact of urban population with soil can be dangerous in aspect of health. There is an urgent need to know, evaluate and respect environmental soil function in cities.

Expected issues of the project: are:

- Soil Map of the city Bratislava in the scale 1:25,000
- Map of the environmental hazard resulting from soils
- Manual for description, classification and assessment of urban soils

The project can provide totally new and completed background about urban soils in Bratislava as a pilot project including of their environmental functions definitions. As key issues, following items are listed below:

- assessment of pedological and pedochemical analyses on the base of soil survey and detailed environmental hazards resulting from soils
- assessment of urban soils quality, which can serve as indicator of city environment
- allowing establishment of urban soil monitoring as a part of urban ecosystem investigation
- enabling proposal of a new legislation concept for urban soil in aspect of risk elements limits
- providing city authorities, managers and planners with necessary information respecting city environment
- help to better awareness about living quality in cities.

There are presented partial results of the first research of urban soils in Slovakia. In the project, there is introduced a co-operation with municipal authorities of the city Bratislava (Atelier for Environment). The project (will finish in 2005) provides urban soil information for administration management as one of the background for decision processes and management in urban planning.

Acknowledgement
This work was supported by Science and Technology Assistance Agency under the contract No. APVT-27-022602

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SOIL QUALITY PARAMETERS AND SPECIFICATIONS FOR ANTHROPOGENIC SOILS OF MINE WASTE

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ABSTRACT

The main objective of rehabilitating mine waste in South Africa is to minimize dust and water erosion to such an extent that the waste management program complies with legislation. One of the requirements is that the land must be rehabilitated to its natural state, or to a predetermined and agreed standard or land use which conforms with the concept of sustainable development. Another requirement is that monitoring should be carried out continuously to all the elements of the mine residue to indicate that the closure objectives as stipulated in the Environmental Management Program or Closure Plan have been met. Soil qualities with respect to sustainable land management of re-vegetated mine residue should be identified and certain parameters should be set. These parameters should be used in the final Closure Plan as objective benchmarks to monitor the rehabilitation performance.

The complete different pedogenic origins of the mine waste reacts and behave different from natural soils. Therefore natural soil quality parameters could not be used per se as a reference base line for the new anthropogenic soil. The first step is to identify the relevant pedogenic factors and processes which dominate the anthropogenic soil properties and qualities. These factors and processes determine the long-term qualities (reactions and behavior) which will ultimately determine the sustainability of the re-vegetation and the end land use. Conceptual principles with respect to the specifications of the soil qualities should be verified under field conditions to ensure a sound and scientific base for sustainable rehabilitation. The real challenge in the rehabilitation of mine residue is to create synergy between different components of a specific end land use e.g. residue (growth medium) on the one side and the vegetation, fauna, climate, topography and water management on the other side.

INTRODUCTION

Early scientific endeavours recognized the importance of categorising soil type and soil variables or properties in regard to land or soil use, especially for agricultural purposes. In more recent years, due to concerns with soil degradation and the need for sustainable soil management in agro systems, there has been a renewed scientific attention to soil variables. Coupled with this is the idea of soil use, which has emphasized the value of soil and soil properties for a specific function. Generally, modern concerns with soil quality evolve around the various functions that soils perform in ecosystems. This ecological approach to soil recognises soil-human interactions, and the relationship of land managers to soil (Richter 1987). Thus soil quality becomes inseparable from the idea of system sustainability, and is considered a key indicator of ecosystem sustainability. The emphasis for soil quality shifts away from suitability for use to whether soil functions are operating at some optimum capacity or level within an ecosystem. However, optimum capacity in the case of anthropogenic soils, do not exist. The challenge lies with the creation of minute capacity in the rehabilitation phase, and then improves on that over

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time, and only after many decades (or millenniums) one can look after the optimization of certain soil characteristics which influence soil quality.

Placing a value upon soil in regard to a specific function, purpose or use leads to the concept of soil quality. However in contrast to water and air, for which the function can be directly related to human and animal consumption, the function placed on soil is often diverse and usually not directly linked or involved in human health. Thus, the concept of quality is relative to a specific soil function or use. Although soil may have a wide array of possible functions the following functions of special importance and significance have been identified:

Doran and Parkin (1994)

- As a medium for plant and biological production
- As a buffer or filter to attenuate or mitigate various environmental contaminates and pathogens,
- As a promoter of plant, animal, and indirectly human health (Soil Science Society of America, 1995).
- Sustaining biological activity, diversity, and productivity
- Regulating and partitioning water and solute flow
- Filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials
- Storing and cycling nutrients and other elements within the earth's biosphere.

Warkentin (1995)

- Recycling organic materials to release nutrients and energy
- Partitioning rainfall at soil surface
- Maintaining stabile structure to resist water and wind erosion
- Buffering against rapid changes in temperature, moisture, and chemical elements
- Storing and gradually releasing nutrients and water
- Partitioning energy at the soil surface.

Anthropogenic soils derived from mine waste does not have all these functions on the same level than normal soils, in fact, some of them do not even exist. The primary purpose of rehabilitation of these soils is to create or improve on these functions to such an extent, that the soil will eventually reacts like a normal soil.

Soil quality can only be assessed by measuring properties and therefore involves both an observer and an interpreter. The range of observers, from individuals to interest groups to society as a whole, and the concomitant range in their value systems, ensure diverse views on soil function and consequently on measures of soil quality. In the case of new horizons and soil units as in the case of the anthropogenic soils, it is much more the case. Functions of soil, and thus soil quality, can be assessed at the field, farm, ecosystem, pedosphere, and global scale. It is recognised, however, that management of soil becomes increasingly difficult at larger scales. Management of new ecosystems and new soils are even more difficult due to the lack knowledge, experience, literature, or any references. Soil, and consequently soil quality, cannot be managed at the global scale. Many aspects of soil quality can be addressed, however, in a practical way at the lower scale.

Defining soil quality

Early concepts of soil quality dealt mainly with various soil properties that contribute to soil productivity, with little consideration of a definition for soil quality itself. However, mere analysis of soil properties alone, no matter how comprehensive or sophisticated, cannot provide a measure of soil quality unless the properties evaluated are calibrated or related against the designated role or function of the soil. Thus, implicit in any definition of soil quality is an understanding of the stated function of the soil, or what the soil does. The following definitions were given for soil quality:

Anderson and Gregorich (1984)

"The sustained capacity of a soil to accept, store and recycle water, nutrients and energy"

Gregorich and Acton (1995)

"The soils capacity or fitness to support crop growth without resulting in soil degradation or otherwise harming the environment"

Larson and Pierce (1991)

"The capacity of a soil to function within its ecosystem boundaries and interact positively with the environment external to that ecosystem"

Soil Science Society of America (1995)

"Soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation"

Doran et al. (1996)

"The capacity of a soil to function, within ecosystem and land use boundaries, to sustain biological productivity, maintain environmental quality, and promote plant, animal and human health".

These definitions imply that soil quality has two parts: an intrinsic part covering a soil's inherent capacity for crop growth, and a dynamic part influenced by the soil user or manager. The latter underlines the lessons of history that poor management can degrade good quality soils. Generally, dynamic soil quality changes in response to soil use and management (Larson and Pierce 1994).

Inherent soil quality

The quality of any soil depends in part on the soil's natural or inherent composition, which is a function of geological materials and soil forming factors (parent material, topography, climate, biota, and time). Attributes of inherent soil quality, such as mineralogy and particle size distribution, are mainly viewed as almost static and usually show little change over time. It is generally recognised that some soils have poor natural quality and are not fit or suitable for a specific purpose. In some cases, due to adverse management and/or climatic effects, a soil that original possessed good inherent quality can deteriorate (e.g. erosion, salinization, acidification, compaction, loss of organic matter etc.). Characterization of inherent soil quality for crop production also involves consideration of extrinsic factors, those factors apart from soil that influence crop yield (Janzen et al. 1992). These factors include such things as climatic (rainfall, evaporation demand, and air temperature), topographic, and hydrologic parameters. Generally, inherent soil quality for crop production cannot be evaluated independently of extrinsic factors.

Dynamic soil quality

Dynamic soil quality encompasses those soil properties that can change in response to human use and management. In general, a management system would be viewed as sustainable only if it maintains or improves soil quality (Larson and Pierce 1994). As implied in the terminology,

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attributes of dynamic soil quality are subject to change over relatively short time periods. For example, total organic matter may change over a period of years to decades, whereas pH and labile organic matter fractions may change over a period of months to years. In comparison, microbial biomass and populations, soil respiration, nutrient mineralization rates, and macro porosity can change over a period of hours to days. Thus, maintenance and/or improvement of dynamic soil quality deals primarily with those attributes or indicators that are most subject to change (e.g., loss or depletion) and are strongly influenced by management practices. Management of new soils is even more difficult, because of the poor literature references, lack of experience etc.

Concepts of soil health

It has long been recognised that there is an indirect relationship between soil health and the health of animals and humans, via the quality of crops (Warkentin 1995). Here, soil health is mainly concerned with the balance and availability of plant nutrients, and freedom from plant diseases and pests. More recently, the above approach to soil quality has led to the idea of characterizing a soil's health (Doran et al. 1996). In this development, the soil is seen as a living system, and the functions placed on soil can be viewed in terms of "goals", "potentials", "normal states" or "optimum states", and their condition (i.e., health) assessed and compared against some standard. In addition, the ability of a soil to handle stress and to recover equilibrium (i.e., resilience) after some form of perturbation can also be viewed in terms of "health". Thus, in this approach soil health very closely parallels soil quality. In the case of anthropogenic soils, there is little or no animal health present in the initial stage, and one could make the conclusion that soil quality does not exist or it is very low.

The concept of "health" can be considered at many levels of biological organization, from the individual (i.e., organism) to a community of individuals (i.e., system) (Rapport 1992, Callicot 1995). In the former, health is a composite picture of the condition of an organism's (e.g., human body) various parts and functions, and characterizing many different factors assesses it. In the same way, using the soil-as-an-organism analogy, soil health is a composite picture of the state of the soils many physical, chemical, and biological properties, it's shape and morphology, and the processes that interact to determine this quality. For the "system" or "community-of-individuals" analogy, health implies a viable and self-sustaining condition, a system that is producing the "goals" and maintaining the "values" placed upon it by society (Rapport 1992). The concept can be applied at the agro ecosystem and ecosystem levels. Generally, the soil-as-a-community analogy is of greater utility for describing soil health than the soil-as-an-organism analogy (Doran et al. 1996).

Soil quality and land sustainability

Soil quality is considered to be a key element of sustainable agriculture (Warkentin 1995). The latter can be defined as "agricultural and agri-food systems that are economical viable, and meet society's need for safe and nutritious food, while conserving or enhancing natural resources and the quality of the environment for future generations" (Globescan 1996). Overall, sustainability refers to the productivity, economic, social, and environmental aspects of land use systems (Smyth and Dumanski 1995). Generally, the main areas involved with agricultural sustainability are as follows: maintaining or improve farm productivity, avoiding or minimizing adverse impacts on natural resources and associated ecosystems; maximizing the net social benefit derived from agriculture; and promoting flexibility of farming systems to manage the risk of climate and markets. Thus, although sustainability issues are much broader than soil quality, the strong emphasis on maintaining the natural resource base ensures that maintaining good soil quality is an integral part of sustainable agriculture (Miller and Wali 1995).

As indicated earlier, the concept of "quality" implies purpose, use and value. In natural ecosystems this concept does not readily apply, as "better" and "worse" environments do not exist (Hamblin 1995), although most natural ecosystems are influenced in some degree by anthropogenic processes (e.g., change in climate and/or biodiversity). Generally the means to assess agricultural sustainability is by identifying indicators that reflect an attribute or sets of attributes of sustainability. Such indicators are considered tools to both warn of deleterious environmental changes and to compare farming practices. The very most challenge of rehabilitation of mine waste, it to create a sustainable ecosystem which can looks after itself, even in a low soil use concept (high production is not required from these new soils).

Evaluating soil quality

A useful framework to evaluate soil quality is based on the following sequence: function, processes, attributes or properties, attribute indicators, and methodology. Soil quality is evaluated on the basis of the function in question. Functions deal with "what the soil does", or "what the soil is asked to do". Each function can be characterised by specific soil processes that support the function being imposed upon the soil. Soil quality attributes can be defined as measurable soil properties that influence the capacity of the soil to perform a specific function (Acton and Padbury 1993).

Generally, attributes describe a critical soil property involved with the process or processes underlying a function. The attribute, or soil property, is most useful when it reflects or measure change in the process. In many cases the specific property may be difficult to measure directly, so an indicator (an associative property, i.e., surrogate or proxy) or pedotransfer function (a related property; Bouma 1989) can be used to serve as an indirect, practical measure of the attribute.

Indicators can represent a single attribute or a set of attributes. It is generally acknowledged that indicators should be easily measured and verifiable, have some sensitivity to variations in soil management (but not overly sensitive), and have a relative low sampling error. Indicators that have a relatively long record of sampling or are found in historical record are of particular use. The choice of indicator would be based on the provision of available methodology, including ease of duplication and facility for accuracy and speed. Table 1 illustrates the above approach, and the following subsections address specific aspects of the framework to evaluate soil quality of normal soils. Anthropogenic soil quality indicators would be very similar, but the threshold values might be different from normal soils.

Table 1 Example of a framework for evaluating soil quality of normal soils (capacity to perform a specific function, e.g., medium for plant growth)

Process	Attribute or property	Indicator for attribute	Possible method for measuring attribute
Capacity to accept, hold and release water	Infiltration, water-holding capacity, permeability	Infiltration rate Water retention curve Hydraulic conductivity	Infitrometer Tension plate Permeameter
Capacity to accept, hold, and release energy	Organic matter Labile organic matter Particle size	Organic carbon Microbial biomass Carbohydrates Macro organic matter Clay	Combustion Chloroform fumigation Acid hydrolysis Dispersion/sieving Hydrometer

Function of soil for crop production

With respect to crop production, the function of soil is to nurture and sustain plant growth. This function is related to the efficiency with which soil provides essential nutrients, substrates, and environment to support the conversion of CO_2 to organic molecules using energy from sunlight (via photosynthesis). The function of soil for crop production can be subdivided into several components as follows: provide a medium of plant growth; regulate and partition water; gas and energy flow; and serve as a buffer or filter system. Evaluating these function components, to assess a soil for its quality to produce crops involves considering the soil's chemical, physical, and biological properties. Table 2 list the functions of a soil related to plant growth, and some of their characteristics. These are applicable for normal and anthropogenic soils.

Table 2 Characterizing the main function components of a soil in regard to crop production

Function component	Function characteristics/processes
Medium of plant growth	Suitable medium for seed germination and root growth Absence of adverse chemical conditions (acidity, salinity, sodicity) Supply balance of nutrients Suitable medium for microbes (nutrient cycling, decomposition) Promote root growth and development
Regulates water	Receive, store, and release moisture for plant use Adequate water retention to buffer and reduce effects of drought Adequate infiltration and storage capacity to reduce runoff
Regulates gases	Accept, hold, and release gases Adequate air movement and exchange with atmosphere
Regulate energy	Store, release (recycle) energy rich organic matter
Buffer or filter	Accept, hold, and release nutrients Sequester energy compounds and/or bio toxic elements Detoxify substances harmful to plants

Attributes of soil quality

Numerous soil properties can serve as attributes of soil quality for crop production and agricultural sustainability. The challenge is to identify soil properties that reflect the capacity of the soil to generate and sustain plant growth, as the link between some soil properties and crop response may have little empirical basis. For example, soil organic matter may explain a significant proportion of the variability in crop yield but is limited as a sole indicator of overall soil productivity (Janzen et al. 1992). This is because soil productivity is a result of multiple variables of which organic matter is but one. In a similar fashion, many soil physical properties act only indirectly on crop growth. Soil bulk density, for example, is often poorly related to plant yield, but does influence several other soil properties (e.g., strength, permeability, water retention) that can individually or collectively impact directly on crop productivity (Koolen 1989, Carter 1990). This characteristic, common to many important soil properties, should be considered in the quest to identify potential soil quality attributes.

Various studies have attempted to identify sets of attributes or properties that can characterise a soil process or processes in regard to a specific soil function (Larson and Pierce 1991, Gregorich et al. 1994). A major goal in soil quality studies is to ascertain, where possible, links between properties (or indicators/proxies/surrogates) and a specific function of the soil (e.g., crop productivity). Once a property is identified, information on the critical (threshold) level and range of the attribute (property) associated with significant changes (usually adverse) in the function of interest (e.g., optimum crop production), is needed. The international organisation for standardisation (ISO) is developing various standards for soil quality measurements that address the different phases (e.g., soil sampling, handling, storage, analysis) involved in soil characterisation (Hortensius and Welling 1996). This approach will be the same for anthropogenic soils, although the entry and threshold values might be different.

Minimum data sets

Identifying key soil attributes that are sensitive to soil functions allows the establishment of minimum data sets (MDS) (Larson and Pierce, 1991 and 1994). These MDS for rehabilitated soils will most probably not the same as for normal soils. Such data sets are composed of a minimum number of soil properties that will provide a practical assessment of one or several soil processes of importance for a specific soil function. Ideally, the property should be easily measured, and the measurements reproducible and subject to some degree of standardisation. In cases where the property of interest is difficult or expensive to measure, an indicator or pedotransfer function may provide an alternative estimate (Table 3). For anthropogenic soils from mine waste, more frequent assessments are required, because of the dynamic geochemical nature of the material.

Different soil processes require different MDS, although they may contain some common attributes or properties. In addition, MDS can be developed to provide a compilation of sub-attributes to further describe a specific attribute, such as sub-attributes or properties to describe the multi-faceted role or function of soil organic matter (Gregorich et al. 1994) (Table 4). The MDS can be expanded to assess and accommodate a much broader scheme, such as soil health and ecological concerns (Doran and Parkin 1994). The sub-attribute concept could be used to develop a proper understanding of processes in new soils. However, much more MDS are required for anthropogenic soils than for normal soils, because the statistical record for new soils is very small comparing to normal soils.

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Table 3 Minimum data set of soil chemical, biological, and physical attributes (properties), with selected indicators and variables of pedotransfer functions, to assess the main functions of soil for plant growth

Soil attribute or property	Indicator	Pedotransfer variables	Methodology
Nutrient availability	Soil extractants	Plant accumulation	Soil test
Adsorbed nutrients	Cation exchange	Clay type + organic C	Displacement
Organic matter	Organic C	Clay + silt	Combustion
Texture	Hand or "feel" method	–	Particle size analysis
Available water	Water constants	Particle size & organic C	Desorption curve
Structural form	Density, porosity	Particle size & organic C	Bulk density
Structural stability	Aggregate stability	Clay & organic C	Wet sieving
Strength	Penetrability	Density&water	penetrometer
Rooting depth	Penetrability	Bulk density	Observation of roots
Reaction	pH	–	Electrode
Soluble salts	Electrical conductivity	Plant growth	Conductivity meter
Sodicity	ESP, SAR	Soil strength	Saturation extracts, displacement

Table 4 Minimum data sets of attributes of soil organic matter to address different soil processes (Gregorich et al. 1994*)

Process	Minimum data set	
	Normal soils*	**Remarks for new soils**
Soil structural stability	Total organic C Microbial biomass Carbohydrates	Same, but very minute quantities will be required for substantial differences in initial stage of production
Nutrient storage	Total organic C Microbial biomass N, and mineralizable N Light fraction and macro-organic matter	Highly complex and difficult, but rehabilitation will enhance it
Biological activity	Microbial biomass Enzymes Mineralizable C and N	Virtually not existent, but very important in new soils

Assessing change in soil quality

Dynamic soil quality for crop production is concerned with changes in soil quality attributes or properties resulted from land use and management. One of the goals of sustainable agricultural systems is to maintain soil quality. Thus evaluating soil quality, in addition to characterizing functions, identifying attributes and developing MDS also require strategies to evaluate soil quality change. Larson and Pierce (1994) discuss both the comparative assessment and dynamic assessment approach to evaluate soil quality change. The former is commonly used and involves a single comparison of one system against another. However, although this approach may provide a measure of change over a specific time span (if the initial data are available), it gives little information on trends in soil quality or rates of quality change over time. In contrast, dynamic assessment compares or evaluates soil quality attributes continuously over time. Larson and Pierce (1994) identify both computer models (which use attributes as variables) and statistical (i.e., temporal pattern of attribute mean and standard deviation) control as a means to assess soil quality change over time. Monitoring of soil characteristics (attributes of soil quality) for rehabilitated new soils is absolute necessary. It will contribute to the MDS, but also gives an understanding of some critical processes e.g. microbial activity, nutrient recycling and eventually in total soil function and quality.

In many cases, dynamic assessment requires a monitoring system to provide a regular surveillance of soil quality attributes or indicators. Monitoring has been commonplace for air and water but not for soil. Some studies, such as soil erosion, have employed monitoring to estimate rate of soil loss but information on change in soil productivity or other quality measurements are generally not obtained (Pierce 1996).

In regard to change in soil quality, standards are needed to assess if the recorded changes are within natural variation or optimum range of the soil attribute in question, or if the changes are related to management practices that may require changes if quality is deteriorating. Since within a minimum data set individual attributes or indicators may show opposite or different changes (e.g., organic matter increasing, but porosity decreasing), the interpretation of such changes and the required management response underlines the importance of "experience" and "skill" in the soil manager.

Soil quality for improved land management

The goal of the land manager is to sustain and improve the quality of the soil resource base. Thus, soil quality is in the hands of the land manager (Pierce and Larson 1993, Pierce 1996). Monitoring soil quality does not in itself change the soil condition, but serves only to indicate if changes in management are required. Monitoring is important but the usefulness of the data will only be realised if it is used in management decisions to correct deficiencies or improve the quality of the soil resource. Management of new and rehabilitated soils are extremely difficult because of the following reasons:

- Lack of MDS
- Lack of management experience (for this specific soils)
- Lack of norms and standards for specific soils
- End land use and ultimate soil function requirements are not fully identified yet
- Total soil potential is not identified yet
- Dynamic geochemical activity
- Commitment from the land owners and regulators to manage these systems
- Lack of capacity and capabilities to manage it

Land managers need well-designed soil and land management systems and quality control procedures to ensure that those processes that are important to soil quality and at the same time responsive to management are operating at an optimum level. Therefore, soil quality control in soil management involves both monitoring and regulation. The latter activity relates to the continued application of management inputs and improvements to ensure that soil quality is not deteriorating (Pierce 1996). For example, monitoring may indicate that organic matter levels in a specific soil are in decline or to low to resist soil erosion. Application of the regulatory aspect of soil quality control could proceed in two parts as follows: 1) assess if the soil management system is capable of producing or providing adequate organic matter, and 2) assess if management strategies allow the best use or placement of present organic matter inputs. A negative conclusion in the first part would indicate a non-sustainable land management system and emphasize the need for change in the agricultural system; a negative in the second part may call for better management practices, such as use of a cover crop and/or a change in tillage tool components to improve crop residue cover.

In reference to the above concerns, Pierce and Larson (1993) emphasize that sustainable land management should include the following assessment: evaluate land suitability for a specific use, identify key soil quality attributes for the specific system and derive a minimum data set, establish soil quality standard limits, identify management inputs that strongly influence soil quality attributes (e.g., residue levels influencing soil organic matter), employ soil quality control techniques to monitor the system, and modify management as needed to maintain soil quality control. These modifications are essential for normal soils, but much more essential and necessary for new soils. If these modifications are not in practice for the new soils, it could deteriorate very quickly back to a hostile environment again.

Soil quality at the ecosystem level

As noted earlier, soil can serve various functions besides its role in crop production and agriculture. At a higher level, soil performs certain functions in ecosystems and at a global scale. All of these expanded functions of soil can be evaluated on the basis of "quality" as described in previous sections. However, it is recognised that "quality" relates to the role given to the soil. Thus soil of high quality for agriculture may be of sub optimal quality from an ecosystem or global perspective.

Terrestrial ecosystems contain soil, atmosphere, water, vegetation, and animals. As components of ecosystems, soils function to both regulates biotic processes (e.g., supplying plants with mineral nutrients and water) and flux of elements (e.g., turnover and storage of C, N, P, and S). These soil functions also affect other components of the ecosystem (i.e., aquatic, atmospheric, and biological), as well as adjacent ecosystems. Soil alters the chemical composition of precipitation and distributes water through the environment; contributes to the gas, water, and heat balances of the atmosphere; and serves as a reservoir of biodiversity and genetic material. Table 5 illustrates some of the wider functions of soil at both the ecosystem and global levels.

The fundamental unit for assessing soil quality at the ecosystem level is usually the soil horizon. The properties of soil horizons (thickness, organic matter content, pH etc.) are used to characterise the pedon. At higher levels or scales of organization, pedons can be grouped into catena's, soil types, land types, ecotops, etc. Levels or scales of soil organisation below the horizon, such as aggregates and organo-mineral colloids, control the internal processes or physiology of soil. Understanding these processes is fundamental to understanding the higher levels or scales of soil organisation and the overall functioning of soil in an ecosystem. For example, regional levels of greenhouse gas emissions cannot be estimated on soil type alone without knowledge of decomposition and denitrification processes at the micro site level.

Overall, the value of considering soil quality at the ecosystem level is that it provides an integrative approach and examines the function of soil in its natural context. It allows detailed investigation of specific soil properties and processes, but require that results be interpreted in relation to the whole.

However, in the case of rehabilitated mine waste, the total land changed to such an extent that a new ecosystem was formed. The topography, water regime, soil characteristics, soil dynamics, vegetation dynamics, vegetation diversity, biological diversity and many more ecosystem attributes changed permanently and irreversible. Therefore there are no doubts about the existence of a new ecosystem. One of the major attributes of soil quality on ecosystem level, is the new (and in most cases geo-chemical active) soil horizons. Traditional type of diagnostic horizons e.g. organic, plinthic, gleyic simply does not exist. The identification and formulation of new quality parameters for the new horizons and soil units are absolute necessary. In some cases agricultural norms could be used as reference or starting point, but one must be care full not to use these norms as such. In most cases, it will require a paradigm shift to move away from the existing agri-norms and to think out of the box.

CONCLUSIONS

Although soil quality can be simply defined as a soil's "fitness for use", it is in reality a complex concept and significantly more challenging in its assessment than air or water quality. Soil quality can basically be divided into inherent and dynamic quality. The former is a component of land quality, whereas the latter is strongly influenced by the soil manager. In the case of anthropogenic soils derived from mine waste, it is even more applicable. Measurement of soil quality involves placing a value upon soil in relation to its fitness to perform a specific function or purpose.

Table 5 Characterizing the function of soil at the ecosystem and global scale

Function	**Example of function characteristic**	
	Normal soils	**Anthropogenic mine waste soils**
Accumulation and store of biogenic energy	Storage of energy rich organic matter and regulator of C, N, P, S cycle	In most cases, no biogenic energy exist initially, it develop over time, build up of these biogenic attributes takes time
Maintenance and storage of organic matter	Storage of active, cycling organic biophilic elements	Only present if applied artificially, build up of organic matter starts from zero
Mitigation of toxic elements	Sequestration of soluble Al in aluminium-organic complexes	Due to a great variety of pH conditions, Al are predominant on the exchange complex, or complete absent
Mitigate accumulation of atmospheric CO_2, NO_x, and CH_4	Terrestrial pool of organic carbon and a source and/sink for CO_2, NO_x, and CH_4	In some cases, the anion pool are extremely dominated by certain anions, due to the geochemistry, additives, or weathering products
Hydrological cycle	Water storage, runoff, infiltration, and leaching	Great variety, from extreme high hydraulic conductivity (course and thick material, to non-existent in the case of layered material
Buffer climatic transitions	Dampen daily and seasonal oscillations of temperature and moisture	Due to extreme exposed surfaces on the slopes, climatic buffering is not very common

Functions can vary in relation to both use of soil and scale. Once a function has been established, it is possible to identify and characterise soil processes and attributes that describe the function, the indicators that are related to the attributes, and methodologies for measuring these. This allows the development of soil quality standards and control techniques, and subsequently the design of sustainable land management systems.

In the case of anthropogenic mine waste soils, the active geochemical properties, is one of the major issues to address. Ongoing weathering of primary minerals (which are predominant), increase in exchange capacity, leaching, change in texture and structure etc. are just some of the soil attributes which influence total soil quality and land use capability.

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DEGRADATION OF AGRICULTURAL SOIL BY MINING AND ITS ASSESSMENT, A CASE STUDY

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ABSTRACT

The town Kutná Hora is considered to be remarkably polluted by potentially risk elements, mainly by arsenic, but also by cadmium, copper, lead and zinc. The pollution is primarily caused by one of the largest historical ore mining areas. The high contents of the elements are present mainly in the material of old mine dumps and surrounded soil but due to migration also in all other environmental compartments. The task of the study was to completely assess potential risks from pollution of soil, water, air and biota for ecosystems and human health.

The main study area (about 100 km^2) was divided to 11 sectors according to level of pollution, population, microclimatic and relief characteristics. As a part of the first RA stage following risk elements were included to the study: As, Cd, Cu, Pb, Zn as the main elements and Cr, Ni, Hg as supplementary elements. Based on the projection of validated results to GIS, additional sampling was proposed to cover all the sectors evenly and to provide enough data for statistical evaluation. As a result, following number of samples for individual compartments was available for risk assessment: soil - 298, ore dumps – 73, sediments – 18, plants – 150, fresh water – 21, ground water – 158, air – 237.Several methods were used for the evaluation of results: comparisons with background values, comparisons with valid and proposed limit values and finally ecological and health risk assessment methods. In ecological risk assessment, the values of PEC/PNEC relation were counted. In health risk assessment, different exposition scenarios were considered and oral, dermal and inhalation risks were counted as CVRK value.

Both according to standard assessment (comparison with limit values) and risk assessment, the materials of old mine dumps and soil were found to pose the most serious risk for humans and environment. The substantial part of the computed risks was caused by arsenic, much less by cadmium, lead and zinc, omissible by copper and almost none by chromium, nickel and mercury. The average contents of arsenic in soil of the study area were app. 40 times higher than the average value for agricultural soils in the Czech Republic.

Evaluation of ecological risks shows exceeding the PEC/PNEC relation in all sectors, mostly for arsenic and central sectors. The average value for the whole area is 3.06. For humans the most serious risks were found for the scenario ore heaps → oral and dermal both for non-carcinogenic and carcinogenic risks. Based on the results, appropriate preventive and technical measurements were proposed for the whole area, as well as proposals for inventarization and monitoring.

INTRODUCTION

The traditional goal of regulating risks is to protect and improve public health and well being as the number of measurable and perceived risks continues to increase (IPCS 2000). Since the 1980s, risk assessment (RA) has increasingly formed the methodological basis in many countries, particularly industrialized nations, for the regulation of occupational and environmental chemicals. Risk assessment aims to provide a synthesis of estimates of exposure levels and

Content

health risks, as well as identifying sources of uncertainty in scientific data. The results of this assessment are subsequently used to identify chemical exposures that pose no significant health threat and those that present significant risks. Additionally, risk assessment presents the basis for a range of options available for subsequent risk management.

The basic scheme of risk assessment procedure was first used by the US National Academy of Science in 1983 and comprises from four steps:

1) hazard identification,
2) dose-response relationship assessment,
3) exposure assessment,
4) risk characterization. It was followed by risk management, and risk communication, as well.

For practical purposes and case studies, the above scheme is sometimes modified, e.g. according to Teck Cominco Metals report (2002) – the four-step framework that incorporates the standard risk assessment was accepted:

Step one: Is a risk assessment required? – evaluation of all knowledge on a study area.
Step two: Problem formulation – what stressors might pose hazard to which species?
Step three: Screening level risk assessment – which combination of sources, pathways and receptors need detailed study?

- Exposure analysis – using the measured concentrations of chemicals in the environment (e.g. in soil, sediments, fresh water, groundwater, plants, air, animals) to estimate the chemical intake of receptors of interest (i. e. in both ecological and human health RA how much of the chemicals of concern are the ecosystem compartments and/or humans exposed to by contacts with water, drinking the water, eating the plants, breathing the air etc.)
- Effect analysis – comparing the estimated chemical intakes with the best available estimates of the levels at which adverse effects may start to occur in the various exposed species (dose – response relationship).

Step four: Remediation / risk management plan

- Different sources of both ecological and human health risk include contamination of air, water, soil, food, plants and animals.

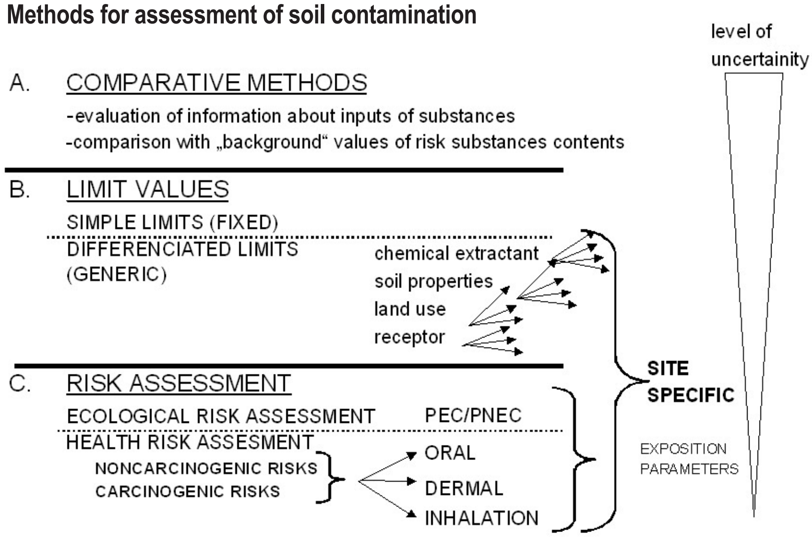
Assessment of soil contamination

Contaminated soils pose serious risks both to the man and the environment. There are several ways how to assess these risks, use of which depends on the following characteristics of the problem: a) number of contaminated sites, b) available information about the site (sites), c) identification of hazards, d) cost effectiveness. According to the characteristic, the appropriate method must be selected (Figure 1). The last and the most complex method – RA usually includes also the lower stage methods:

Objectives of the study

The town Kutná Hora is considered to be remarkably polluted by potentially risk elements, mainly by arsenic, but also by cadmium, copper, lead and zinc. The pollution is primarily caused by one of the largest historical ore mining areas. The high contents of the elements are present mainly in the material of old mine dumps and surrounded soil but due to migration also in all other environmental compartments. Soils and sediments are the compartments with the most

Figure 1 Methods for assessment of soil contamination



serious impact. Elevated contents of risk elements are present both in agricultural soil and urban soil which makes them a source of contamination for water, air, plants and animals.

The task of the study was to completely assess potential risks from pollution for ecosystems and human health. One of the conditions given by the investor of the study was to use all valuable data on contamination from previous studies.

MATERIAL AND METHODS

In the preliminary study, all the existing data on the contents of risk elements in environmental compartments were gathered and validated. Only data with uniform characteristics were used (Aqua Regia soil extractant, similar method of sampling and analysis, clear reference, geographical coordinates). The main study area (about 100 km^2) was divided to 11 sectors according to level of pollution, population, microclimatic and relief characteristics.

As a part of the first EA stage following risk elements were included to the study: As, Cd, Cu, Pb, Zn as the main elements and Cr, Ni, Hg as supplementary elements. Based on the projection of validated results to GIS, additional sampling was proposed to cover all the sectors evenly and to provide enough data for statistical evaluation. As a result, following number of samples for individual compartments was available for risk assessment (Table 1).

The results were statistically processed and compared to valid legislative concentrations for individual compartments. The ecological risks were computed for soil and sediments only, based on relation of predicted environmental concentration and predicted no effect concentration (PEC/PNEC). Human health risks, both non-carcinogenic (HI – hazard index) and carcinogenic (CVRK – characterizes individual lifetime risk of cancer) were computed according to US EPA methodology (US EPA 1989, upgraded for new reference values). The exposition scenarios are shown in Table 2. For each location given by geographical coordinates the risks were computed for appropriate pathway and source.

Table 1 Number of samples for individual environmental compartments used for risk assessment

Environmental compartment	Number of samples		
	Old	New	Altogether
Soil	234	64	298
Ore dumps	36	37	73
Sediments	18	0	18
Plants	126	24	150
Fresh water	21	0	21
Groundwater	158	0	158
Air	0	231	231
All compartments	593	356	949

Table 2 Kutná Hora study: used exposition scenarios

Compartment (source)	Pathway	Note
Soil and mining dumps	dermal	skin contact with the material
	oral	swallowing the dust from air and/or hands and/or food
Drinking water	oral	drinking the water (wells)
	dermal	showering, bathing
Fresh water	dermal	swimming, wading
Air	inhalation	outdoor activities
Food	oral	intake of home grown vegetables

RESULTS

Both according to standard assessment (comparison with limit values) and risk assessment the material of old mine dumps and soil were found to pose the most serious risk for humans and environment. The substantial part of the computed risks was caused by arsenic, much less by cadmium, lead and zinc, omissible by copper and almost none by chromium, nickel and mercury. The average contents of arsenic in soil of the study area were approx. 40 times higher than the average value for soils in Czech Republic. Comparison of the risk element contents with limit values according to the decree no 13/1994 Coll. and proposed precautionary values is given in Figure 2.

Figure 2 Percentage of soil samples exceeding the valid and proposed limit values

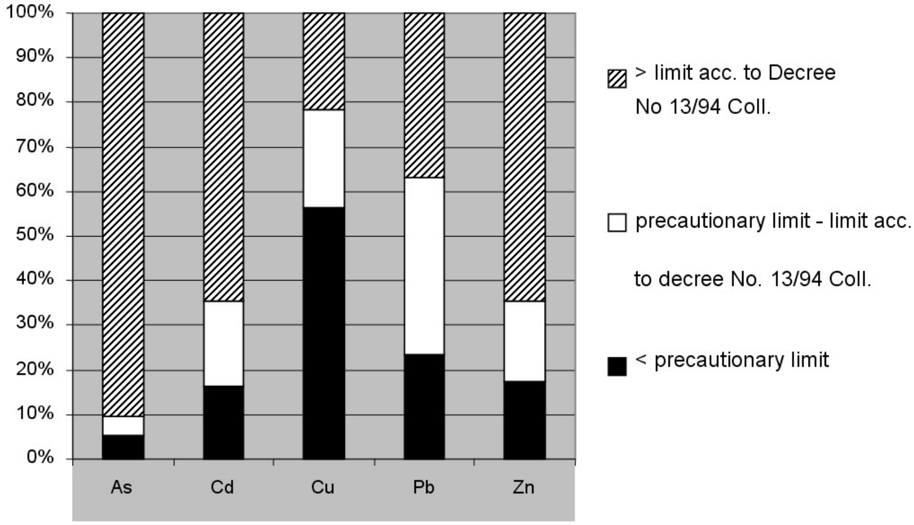


Table 3 Hazard indexes for individual sectors and scenarios

Compartment	Exposition	HI for individual sector										
		1	2	3	4	5	6	7	8	9	10	11
Soil	dermal	6	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Mining dump	dermal	nd	<1	6,3	1,9	1,1	<1	<1	3,7	<1	nd	<1
Soil	oral	<1	<1	<1	1,0	<1	<1	<1	<1	<1	<1	<1
Mining dump	oral	nd	1,5	41,8	12,5	7,4	5,4	5,1	24,1	3,5	nd	4,0
Groundwater	oral	nd	nd	nd	1,4	<1	nd	3,6	<1	<1	nd	nd
Groundwater	dermal	nd	nd	nd	<1	<1	nd	<1	<1	<1	nd	nd
Fresh water	dermal	nd	nd	nd	<1	<1	nd	nd	nd	nd	nd	nd
Air	inhalation	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carrot	oral – diet	nd	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Potatoes	oral – diet	nd	nd	<1	nd	<1	nd	<1	<1	<1	nd	nd
Cucumbers	oral – diet	nd	nd	nd	nd	<1	nd	<1	<1	nd	nd	nd
Lettuce	oral – diet	nd	<1	<1	<1	<1	<1	<1	<1	<1	nd	<1
Tomatoes	oral – diet	nd	nd	nd	nd	<1	<1	<1	<1	nd	nd	nd
Corn	oral – diet	nd	<1	nd	nd	<1	nd	nd	nd	<1	nd	nd
Cabbage	oral – diet	<1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

nd = no data for given sector

Evaluation of ecological risks shows exceeding the PEC/PNEC relation in all sectors, mostly for arsenic and central sectors (3, 4, 8, 9). The average value for the whole area is 3,06.

The results for non-carcinogenic risks are expresses as HI in the Table 3 and for carcinogenic risks as CVRK in the Table 4. For humans the most serious risks were found for the scenario ore heaps oral and dermal both for non-carcinogenic and carcinogenic risks.

Table 4 CVRK for individual sectors and scenarios

Compartment	Exposition	CVRK for individual sector										
		1	2	3	4	5	6	7	8	9	10	11
Soil	dermal	6	6	5	5	5	5	6	5	5	6	6
Mining dump	dermal	nd	5	3	4	4	4	4	4	5	nd	4
Soil	oral	5	5	4	4	4	5	5	4	4	5	5
Mining dump	oral	nd	4	3	3	3	3	3	3	4	nd	4
Groundwater	oral	nd	nd	nd	4	5	nd	4	5	5	nd	nd
Groundwater	dermal	nd	nd	nd	$<1E^{-6}$	$<1E^{-6}$	nd	6	$<1E^{-6}$	$<1E^{-6}$	nd	nd
Fresh water	dermal	nd	nd	nd	$<1E^{-6}$	$<1E^{-6}$	nd	nd	nd	nd	nd	nd
Air	inhalation	$<1E^{-6}$	$<1E^{-6}$	6	$<1E^{-6}$	$<1E^{-6}$	$<1E^{-6}$	$<1E^{-6}$	$<1E^{-6}$	$<1E^{-6}$	$<1E^{-6}$	$<1E^{-6}$
Carrot	oral – diet	nd	$<1E^{-6}$	5	6	6	6	6	6	6	$<1E^{-6}$	$<1E^{-6}$
Potatoes	oral – diet	nd	nd	5	nd	6	nd	6	5	6	nd	nd
Cucumbers	oral – diet	nd	nd	nd	nd	5	nd	5	5	nd	nd	nd
Lettuce	oral – diet	nd	$<1E^{-6}$	6	$<1E^{-6}$	$<1E^{-6}$	$<1E^{-6}$	$<1E^{-6}$	$<1E^{-6}$	$<1E^{-6}$	nd	$<1E^{-6}$
Tomatoes	oral – diet	nd	nd	nd	nd	6	6	$<1E^{-6}$	$<1E^{-6}$	nd	nd	nd
Corn	oral – diet	nd	$<1E^{-6}$	nd	nd	$<1E^{-6}$	nd	nd	nd	$<1E^{-6}$	nd	nd
Cabbage	oral – diet	6	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

[1)] expressed only in the form of exponent ($6 = 1E^{-6}$)   nd = no data for given sector

Based on the results, appropriate preventive and technical measurements were proposed for the whole area, as well as proposals for inventarization and monitoring.

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Vyhláška MŽP ČR č. 13/94 Sb., kterou se upravují některé podrobnosti ochrany zemědělského půdního fondu.

ANTHROPOGENIC ACTIVITY IN RELATIONSHIP TO SOILS OF THE EAST-SLOVAKIAN LOWLAND

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ABSTRACT

The East-Slovakian Lowland (ESL) to agricultural high production areas of Slovak Republic is arranged. ESL has specific soil and climate conditions and it is agriculturally intensive used. Soils of the East-Slovakian Lowland have high content of clay elements in topsoil and subsoil, too. Heavy soils are disposed to negative changes of their basic properties and production process required most energy than middle and light soils. Sustainable agricultural suppose to realize cultivation measures which no-deteriorate of basic soil properties. More than ten-year period (1991 – 2003) of distinct limited possibilities inputs into the plant production negatively manifested itself in soil chemistry. Low intensity of fertilization and liming had negative effect on soil fertility not at region of the East-Slovakian Lowland, but at whole Slovakia, too. Compared with year 1989 area of acid soils were increased and area of arable land with neutral soil reaction were decreased. The share of arable land with low content of phosphorus and potassium were increased and share of soils with good and high content listed above nutrients were decreased. In region of ESL decreasing of inputs to plant production and using of unsuitable soil tillage technologies caused not only make worse of agro-chemical soil properties but also increasing of soil compaction. Already in topsoil high values of penetration resistance above limiting values for critical soil compaction were found. These negative changes may be obstacle for using of energy advantageous soil protective technologies.

INTRODUCTION

In relationship to field crops soil acts as environment which secure rooting of plants and adequate supply of water and substances of mineral nutrients to roots of cultivated plants. Soil created by weathering of bedrocks and it has physical, chemical and biological properties, which are in interaction.

The East-Slovakian Lowland (ESL) to agricultural high production areas of Slovak Republic is arranged. Its area is approximately 200 000 ha. ESL has specific soil and climate conditions and it is agriculturally intensive used. Soils of the East-Slovakian Lowland have high content of clay elements in topsoil and subsoil, too. Farming in area with high presence of heavy and very heavy soils is importantly intricate and especially material costs to production process are increased. For soils with higher content of clay elements, so heavy soils, is necessary different access to their tillage. Heavy soils are disposed to negative changes of their basic properties and production process required most energy than middle and light soils. Total production and quality of agricultural products dependent not only on acreage and mainly from soil quality. Very important property of soil is its fertility, then ability to secure for cultivated plants sufficiency of nutrients and water. For ensuring of fertility and production ability of soil is necessary keeping and improvement of its physical, chemical and biological properties and then also keeping of optimal contents of nutrients in soil and stabilization of favourable values of soil reaction (Bujnovský 2003, Čermák 1998).

After year 1990 in majority of agricultural establishments on the East-Slovakian Lowland isn't secured lossless balance of nutrients. This fact is in correlation with selection of crop rotation, which is oriented to advantageous market crops, without return of soil nutrients used by yield. A long with in comparison with Slovakia in majority of establishments on the ESL lower supplies of nutrients in soil were ascertained and this is cause of lower production ability of soils. Production of agricultural farms is less effective and that plant production on the East-Slovakian Lowland has lower competitive ability in comparison with Slovak Republic.

MATERIAL AND METHODS

Chemical properties of soil of ESL were evaluated by results of soils analyses. Soil samples were taken in years 1989, 1994 and 1999 from 200 – 300 parcels of agricultural subjects in districts Michalovce, Trebišov and Sobrance. Samples were analyzed in agro-laboratory of Research Institute of Agroecology Michalovce. In taken samples were determined parameters as follows: content of available phosphorus, content of available potassium, values of exchange soil reaction (Kobza et al. 1999). Results were evaluated by criteria of valuation of results by Bízik et al. (1998).

For evaluation of changes of chemical properties of soil in Slovakia results from last three cycles (VIII. – X. cycle) of agrochemical testing of soils were used (Kotvas et al. 2000).

Penetration resistance of soil was determined directly by penetrate mechanical sound. Measured data were valued by Šimon – Lhotský et al. (1989) and by authors at critical values of penetration resistance for all soil types actual moisture status is very important. By these authors critical values of penetration resistance for clay-loamy soil till clayey soil are in range 3.2 – 3.7 MPa at 24 – 20 % of soil moisture. For loamy soil are these values in range 3.8 – 4.2 MPa at 18 – 16 % of soil moisture. In continuity with fertilization arrangements provisions measurements of penetration resistance were realized in 31 agricultural subjects on total area 17 162 ha in districts Trebišov (9 661 ha), Michalovce (5 811 ha) and Sobrance (1 690 ha). Tested soils were arranged to soil types as follows: middle heavy, heavy till very heavy Eutric Fluvisol, heavy till very heavy Fluvi-eutric Gleysol, Albic Luvisol till Albo-gleyic Luvisol, middle heavy Orthic Luvisol till Stagno-gleyic Luvisol.

RESULTS AND DISCUSSION

Soil situation of ESL is result of complicate geological processes, which caused large soil heterogeneity of this area. From point of view of particle-size composition on area of the East-Slovakian Lowland is presence 3.2 % of light soils, 54.1 % of middle heavy soils, 22.1 % of heavy soils and 20.6 % of very heavy soils. Till 65 % of ESL arable land present soils with gleyic processes (Vilček 1998).

Mainly assumption for effective development of plant production and its permanent preservation on ESL is consequent realization of rational using of production potential of soil and regional units as it influence from structure of type-production categories (Table 1).

Table 1 Structure of type-production categories of farm soils on ESL

Type-production categories	Area [ha]	Farmland [%]
Potential arable lands	109 796	54.7
Alternating fields	53 510	26.6
Perennial grass stand	37 373	18.6
Areas unsuitable for agro-systems	109	0.1
Total	200 788	100.0

Before the year 1980, in consequence of hydro-melioration construction on ESL, area of arable land significantly increased. Development in structure of soil fund after year 1980 but tends to decreasing of area of arable land and to increasing of perennial grass stands (Table 2).

Soil reaction is one from most important chemical properties of soil. Various field crops have different requirements to soil reaction. Environment with slightly acid to neutral soil reaction is suitable for majority of cultivated plants and therefore keeping favourable of soil reaction must be important part of productive process.

Table 2 Use of agricultural soil fund on ESL [ha, % f. l.]

Year	Agricultural culture					
	Arable land	Vineyards	Gardens	Fruit-gardens	Perennial grass stands	Farmland
1946	138 798 65.8	956 0.5	1 471 0.7	– –	69 744 33.0	210 969 100
1980	152 259 75.1	3 582 1.8	6 000 3.0	2 023 1.0	38 683 19.1	202 347 100
1989	143 532 71.2	3 097 1.5	8 652 4.3	1 408 0.7	44 974 22.3	201 663 100
2002	134 408 67.3	2 590 1.3	7 562 3.8	1 346 0.7	53 707 26.9	199 613 100
View	122 980 62.8	2 515 1.3	7 596 3.8	1 250 0.6	64 781 32.5	199 122 100

In the Table 3 values of representation of soil reaction categories are compared. On the East-Slovakian Lowland the greatest decreasing (in percentage) was determined in category of neutral soils as follows: in year 1994 opposite year 1989 about 14.2 % and in year 1999 opposite year 1989 about 10.7 %. On the other hand the greatest increasing was found out in category slightly acid and also acid soils in year 1994 about 8.7 – 11.4 % and in year 1999 opposite year 1989 about 4.2 – 12.9 %.

More than ten years period of limited inputs to plant production influenced all soil chemism. Radical savings on inputs into plant production caused significantly negative balance of nutrients in comparison to their taking by plant yield. Development of consumption of artificial fertilizers on 1 ha farm land on the East-Slovakian Lowland and in Slovakia is situated in the Table 4.

In year 1990 on ESL consumption of artificial fertilizers was on level 194.0 $kg.ha^{-1}$ of farmland. In Slovakia consumption of artificial fertilizers was higher about 45.7 $kg.ha^{-1}$ NPK. These doses of nutrients was justified, secured high yield and contributed to keeping and increasing of soil fertility. On ESL, but also in Slovakia, in year 1991 was noted decrease of consumption of artificial fertilizers on half of last year. In further years consumption of artificial fertilizers rapidly decline till on approximately 45 kg NPK per hectare of farmland in Slovak Republic and maybe on 22 kg

NPK per hectare of farmland on ESL. After year 2001 consumption of artificial fertilizers moderately increased (on ESL – 47.8 kg.ha^{-1} NPK, in Slovakia – 65.5 kg.ha^{-1} NPK). From applied fertilizers nitrogen had biggest part – 86.8 % on ESL, respectively 69.3 % in Slovakia.

Table 3 Development of soil abundance by categories of soil reaction

Region	Year	Representation of categories [%]			
		Acid	Slightly acid	Neutral	Alkaline
ESL	1989	17.6	38.4	34.6	9.4
	1994	26.3	49.8	20.4	3.5
	1999	21.8	51.3	23.9	3.0
Slovakia	1989	9.6	28.0	34.9	27.5
	1994	13.8	24.4	40.4	21.4
	1999	12.3	31.5	34.6	21.7

where: acid – extreme acid, strongly acid and acid soil reaction, alkaline – alkaline and strongly alkaline soil reaction

Table 4 Consumption of artificial fertilizers [kg.ha^{-1}]

Region	Nutrients	Year						
		1990	1991	1992	1993	1995	1999	2001
ESL	N	83.7	49.4	28.6	14.9	17.5	16.9	41.5
	P_2O_5	61.9	31.6	12.3	5.0	3.3	2.4	4.0
	K_2O	48.4	13.4	7.3	1.6	1.7	1.8	2.3
	total	194.0	94.4	48.2	21.5	22.5	21.1	47.8
Slovakia	N	91.6	62.8	39.5	28.4	30.6	31.9	45.4
	P_2O_5	69.0	30.7	12.6	7.2	7.8	6.4	10.7
	K_2O	49.1	29.6	11.8	6.0	6.6	5.2	9.4
	total	239.7	123.1	63.9	41.6	45.0	43.5	65.5

Low intensity of fertilization by artificial fertilizers caused decreasing of supply of soil nutrients and also making worse of physical and biological properties of soils. In the Table 5 is noticed area representation of soil, which is arranged into same categories from point of view of analyzed contents of available phosphorus and potassium.

In comparison with initial year 1989 abundance of soils with very low and low content of available phosphorus and potassium increased and abundance of soil with good and high content of these nutrients decreased. Similar trend, as consequence of decreasing of artificial fertilizers consumption, was noticed not only on ESL, but also in Slovakia. In 1989 till 36.2 % of soil on ESL were arranged to category of soil with good till high content of available phosphorus, but in year 1999 it was only 25.3 % of arable land. Abundance of soils with very low and low content of available phosphorus increases from 20.1 % determined in 1989 to 37.8 % in year 1999. Similar tendencies were noticed also at comparison of area abundance of soils in separate of valued categories in whole Slovakia.

Table 5 Changes of area soil abundance of ESL and Slovakia [%]

Region	Year	P			K		
		Low	Middle	Good	Low	Middle	Good
ESL	1989	20.1	43.7	36.2	6.9	30.0	63.1
	1994	27.4	51.3	21.3	12.7	45.7	41.6
	1999	37.8	37.1	25.3	16.1	34.1	49.7
Slovakia	1989	13.1	42.1	44.8	3.5	18.3	78.2
	1994	11.9	38.0	50.1	8.3	25.3	66.4
	1999	19.6	42.1	38.3	10.8	31.3	57.9

where: low – very low and low content of available nutrients, middle – middle content of available nutrients, good – good, high and very high content of available nutrients

Similar situation also at potassium was determined. In year 1989 till 63.1 % of soils had good till high supply of this element, but in year 1999 it was only 49.7 %. On the other hand soil abundance with very low and low content of potassium increased from 6.9 % to 16.1 % of plots. Also in Slovakia during this period similar trends were noticed.

In last time compaction of soil is important problem. To natural causes of compaction of soils on ESL are as follows: high portion of heavy soils with high content of clay elements (smectic soils with montmorillonit), long-lasting wetting caused by soil properties and orographic relations, large range of filed marco- and micro-depressions, un-sufficient input of organic matter in soil and low content of humus.

In the Table 6 are showed average values of penetration resistance, which were measured in spring period at suitable of soil moisture. Measured values are significantly higher than critical values for harmful penetration resistance, which for clayey till clay-loamy soils is 3.2 – 3.7 MPa. Very important is but it, that such values were measured already in depth 0.05 – 0.20 m, what is in topsoil, and in depth 0.30 m also values 3.90 – 6.00 MPa were determined. In subsoil (0.35 – 0.45 m) penetration resistance was in range 4.27 – 6.00 MPa. Deeper to soil profile penetration sound no-penetrated and it testify about soil compaction in depth under 0.45 m, too.

In comparison with Slovakia in majority from agricultural enterprises on ESL lower supply of nutrients in soil were determined and it is cause of lower of production soil ability, enterprises produce less effective. From these arguments in comparison to Slovakia plant production on the East-Slovakian Lowland has less of competitive ability. In future time on account of no-system of access to liming, rationalization and optimise of nutrition and fertilization of plants trends with negative consequences still more show increased sensitivity of agricultural unit of meteorological conditions and cultivated system, lower competitive ability of arable crops towards of weed and reduce of resistance to diseases and pests mainly at realization of no-tillage systems.

For keeping of attained degree of soil fertility and total improvement of basic properties of heavy soils on ESL is necessary henceforward to realize fertilization arrangement provision of no-investment character. Only at regularly input of organic matter to soil, liming and chiselling in view will possible more to used also minimizing and no-tillage technologies without risk of decreasing of soil fertility.

Content

Table 6 Average penetration resistance of soil [MPa]

No. of subject	Area [ha]	Depth [m]								
		0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45
1.	1 762	1.29	2.12	3.07	4.05	4.84	5.26	5.34	–	–
2.	1 534	1.30	2.16	2.90	3.73	4.30	4.86	5.26	5.39	5.60
3.	2 099	1.89	2.44	3.58	4.79	5.23	5.44	5.83	–	–
4.	300	1.21	1.89	2.54	3.55	4.37	4.82	5.05	5.28	–
5.	36	1.17	1.92	2.72	3.67	4.18	5.03	5.38	5.50	–
6.	744	2.33	2.88	3.31	3.76	4.04	4.28	4.56	4.77	5.02
7.	1 477	2.96	3.60	3.98	4.35	4.82	5.07	5.28	5.48	6.00
8.	684	1.65	2.18	2.89	3.75	4.79	5.32	5.51	5.60	–
9.	257	1.44	2.06	2.86	3.84	4.44	5.10	5.48	5.60	–
10.	454	1.27	2.20	3.27	4.20	5.00	5.30	5.40	–	–
11.	314	1.29	2.13	2.89	3.74	4.51	5.09	5.43	5.63	–
12.	611	1.51	2.11	2.90	3.74	4.59	5.24	5.81	6.00	–
13.	617	1.40	2.09	2.88	3.72	4.31	4.87	5.11	5.33	6.00
14.	42	1.24	1.87	2.61	3.49	4.06	4.91	5.32	5.55	5.75
15.	309	2.89	3.54	4.36	4.80	5.47	6.00	–	–	–
16.	292	1.32	2.40	3.10	4.17	4.60	5.07	5,.38	5.53	–
17.	562	1.25	2.11	3.10	4.00	4.73	5.06	5.08	5.25	–
18.	438	1.46	2.20	2.78	3.16	3.86	4.39	4.73	5.10	–
19.	261	1.44	1.92	2.54	3.27	4.11	4.65	5.08	5.17	5.27
20.	1 064	3.31	3.87	4.09	4.49	4.82	5.00	5.40	6.00	–
21.	200	1.26	2.34	3.07	4.10	4.50	4.94	5.34	5.46	5.50
22.	388	1.40	1.89	2.41	2.85	3.44	3.90	4.27	–	–
23.	308	1.23	2.42	2.91	3.45	4.08	4.36	4.62	5.12	5.39
24.	719	1.38	1.83	2.66	3.18	3.75	4.56	5.28	5.62	–
25.	175	1.58	2.48	2.93	3.38	4.10	4.30	4.43	4.50	–
26.	138	2.00	2.80	3.05	3.85	4.00	4.45	–	–	–
27.	208	1.40	2.20	2.74	3.20	3.84	4.38	4.86	5.24	5.60
28.	413	1.24	2.10	2.82	3.46	4.09	4.76	5.06	5.34	5.67
29.	185	1.35	2.25	3.03	3.65	4.03	4.33	4.98	5.15	5.60
30.	221	1.31	2.31	3.10	3.88	4.38	4.86	5.27	5.44	5.50
31.	350	1.18	1.54	2.41	3.23	3.93	4.64	4.92	5.45	–
Total/∅	17 162	1.58	2.32	3.02	3.76	4.36	4.85	5.15	5.38	5.58

CONCLUSION

Development of using of soil found on the East-Slovakian Lowland perspective aim to decreasing of area of arable land and to increasing of area of perennial grass stands.

For keeping of soil fertility, mainly of arable land, is necessary to realize not only precision plant nutrition, but also no-investment fertilization arrangement provision – liming, chiselling, regularly input of organic matter.

Continued passive balance of available nutrients (P, K) and making worse of soil reaction testify about lower of soil fertility and total lower efficiency of plant production on ESL. From comparison the East-Slovakian Lowland and Slovak Republic influenced, that most categories with less favourable agro-chemicals parameters is located on ESL.

High values of penetration resistance already in topsoil indicate that making worse of physical properties of heavy soils of ESL and increasing of their penetration resistance may be obstruction for invocation energy profitable of soil protective technologies.

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ARE DEGRADATED SPRUCE STANDS IN MARTINSKÉ HOLE MTS A HERITAGE OF THE PAST HUMAN ACTIVITY?

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ABSTRACT

Spruce forest stands represent a dynamical system that tends to be ecologically stabile. Ecological stability of spruce forests can get significantly thinner under conditions which do not suit to Norway spruce (Picea abies (L.) Karst.), despite it has wide ecological valence. Spruce stands in Martinské Hole Mts are highly edaphically affected by extremely acid soil cover and, moreover, by high water saturation of the topsoil. Decreased vitality of spruce individuals has been observed for long time, at least for 60 years. Is this miserable state of the spruce stands a result of anthropogenic input? We focused especially on soil limitation properties and soil auto-regulation feedbacks, which are crucial for ecological stability of spruce stands here. It is evident that especially long-time atmospheric depositions of acid reagents could be dangerous in mountain ecosystems especially on acid soils. Stands growing on acid and dystric soil cover are closely exposed to the effects of the soil acidity as aluminium phytotoxicity, higher mobility of heavy metals and nutrient leaching. We also consider the heavy metal loads by atmospheric depositions and anthropogically induced surface moisture. Against anthropogenic loads act auto-regulation soil mechanisms that tend to sustain homeostatic state. Soil acidity buffering and binding of heavy metals by organic matter seem to be very important here. Long-time accumulation of stress under unfavourable conditions can, however, result into degradation of spruce forests.

INTRODUCTION

Naturally developing ecosystem is usually resistant against the ambient affect of unfavourable factors. If the impact persists too long or it is too strong, natural stability in way of resilience or resistance can be broken. Auto-regulation feedback is insufficient and equilibrium of the system is disturbed. Natural ecosystem represents dynamical system with processes of exchanging substances, energy and information. When any of these cycles does not work or is changed, ecosystem becomes more susceptible to its degradation. In the present time, probably there is not possible to find any ecosystem more-less unaffected by human activities.

Slovak Republic belongs to the "second black triangle" together with Poland and Czech Republic. This "label" includes the states with the strongest air pollution within the Central Europe. Strong air pollution of Slovak Republic is also raised by the unfavourable position. Much of the air pollution is bringing by the predominant circulation of the wind from the north-west side as trans-boundary pollution. The most spreading heavy metal loads are lead inputs (Makovníková 1999). Recently, decrease of lead depositions was observed, but however, mercury depositions increased (Percy 2002). Degradation of the spruce stands in Martinské hole Mts has been observed at least since

40's of the last century. Although Norway spruce has wide ecological valence, which means various conditions for living, stability of the spruce stands is significantly tinned under these conditions. This reduced stability is demonstrated by yellowing and defoliation of spruces, which present continuous stands here. Here occurs a relict species Picea abies ellipsoconis (Mruškovič et al. 2000).The analyses were focused to the critical soil properties and soil auto-regulation.

MATERIAL AND METHODS

Soil profiles were sampled in different stands of damaged spruce trees and clasified by WRB 1998 as Enti-Histic Podzol and Enti-Haplic Podzol. For analyses, also samples of spruce needles were taken from both, healthy and damaged trees. Soil samples were air-dried at room temperature and passed through a 2 mm sieve to remove stones and plant debris. Soil reaction (pH in 0,01 M $CaCl_2$) was analysed by Fiala et al. 1999 (modif.). Exchangeable acidity (AE), sum of base cations (SOB), cation exchange capacity (CEC) and base saturation (BS) were analysed by Hraško et al. 1962. Total organic carbon (C_{org}) was analysed by Walkley-Black method in wet (Hraško et al. 1962). Method by Kjeldahl for analysis of total nitrogen (N_{tot}) was used (Hraško et al. 1962 modif. by Anonymus 1995). Humic substances were separated to fulvoacids (FA) and humin acids (HA) by Fiala et al. 1999. Analysis of exchange aluminium in 1 N solution KCl was realized by Sokolov (Fiala et al. 1999).

A content of the accessible forms of phosphorus and potassium (P, N) was made in Mehlich II. Retention of phosporus was analysed by USDA/NRCS/NSSC (1996). Mercury concentration was determined by ASS on the one-purposed mercury analyser TMA 254. Lead, chromium and magnesium were determined by AAS on the Perkin-Elmer analyser after the total dissociation by HNO_3 and $HClO_4$ mixture. The contents of the heavy metals were evaluated according to The Decree of Ministry of Agriculture of Slovak Republic about the highest accessible values of harmful substances in soils and about the assessment of organizations justified to determine the veridical values of these substances from the year 1993. The heavy metal (Pb, Cr, Hg) contents in the needles were evaluated by Maňkovská (1996). Soil texture was specified by pipette method according to Novák (Hraško et al. 1962).

RESULTS AND DISCUSSION

Soil properties of spruce ecosystem

Three soil profiles were sampled in different areas of degraded spruce stands. Profiles were classified according to WRB as Enti-Haplic and Enti-Histic Podzol. Example of soil profile description shows Table 1. The results of pH analyses point at the extremely to ultra acid soils. Especially topsoil and upper subsoil is rich in organic carbon. Soils are extremely dystric with base saturation usually less then 20 %. In the topsoil horizons, very low storage of total nitrogen occurs. Retention of phosphorus reaches usually more than 70 %. The values of available potassium and phosphorus are moderate to low. Investigated soils are loamy to sandy with high volume of stones. Basic characterization of the example shows Table 2.

Table 1 Soil profile example

Enti-Histic Podzol		
Martinské Hole Mts., altitude 1 380 m, moderate slope (5°), NW, substrate granite, under spruce forest with disintegrated canopy		
O(h)	(+5 – 0 cm)	
Aop	(0 – 9 cm)	10YR 2/2, slightly moist, weak, fine granular, sandy-loam, moderately stony (gravel)
Bsv1	(9 – 19 cm)	10YR 3/3, slightly moist, weak, fine granular, sandy-loam, moderately stony (gravel)
Bsv2	(19 – 50 cm)	10YR 3/4, slightly moist, weak, fine granular, sandy-loam, moderately stony (stones and gravel)
B/C	(> 50 cm)	10YR 3/4, slightly moist, weak, fine granular, loamy-sand, very stony (stones)

Table 2 Basic chemical and physical properties of the example Enti-Histic Podzol

Horizon	pH $CaCl_2$	C_{org} [%]	CEC [$cmol^+.kg^{-1}$]	SOB [$cmol^+.kg^{-1}$]	EA [$cmol^+.kg^{-1}$]	BS [$cmol^+.kg^{-1}$]	N_{tot} [%]
O(h)	3.26	29.8	19.6	0.8	18.8	4.1	0.98
Aop	3.64	5.7	16.2	0.8	15.4	4.9	0.42
Bsv1	3.79	3.9	14.8	0.8	14	5.4	0.28
Bsv2	3.84	3.8	15.1	0.5	14.6	3.3	0.19
B/C	4.06	2.6	12.8	0+	12.8	0+	–

Horizon	P_{MEHL} [$mg.kg^{-1}$]	K_{MEHL} [$mg.kg^{-1}$]	P_{ret} [%]	Sand [%]	Silt [%]	Clay [%]
O(h)	1.36	201	76	71.4	20.6	8.0
Aop	0.71	118	79	65.3	27.2	7.5
Bsv1	0.38	77	79	70.6	25.8	3.6
Bsv2	0.19	99	86	72.3	21.1	6.6
B/C	0.62	38	93	78.2	16.7	5.1

Annotations: pH $CaCl_2$ – soil reaction in 0.01 M $CaCl_2$, C_{org} – organic carbon content, CEC – cation exchange capacity, SOB – sum of base cations, EA – exchangeable acidity, BS – base saturation, N_{tot} – total nitrogen, P_{ret} – phosphorus retention, P_{MEHL}, K_{MEHL} – phosphorus and potassium content in Mehlich II.

Anthropic long-term impact

Atmospheric depositions of acid reagents

Trans-boundary long-term transmission of pollutants represents more than 60 % of air pollution and acid rain in Slovakia (Collective 1993). Increasing of rain acidity is mainly caused by H_2SO_4 (65 %), HNO_3 (30 %) and HCl (less then 5 %). After high increase of SO_2 in 70's it dramatically decreased after 1980 (above 77 %) (Percy 2002). The nearest towns to the study area are Martin and Žilina. The annual (year 2001) average concentration of nitrogen dioxide was 22.5 $\mu g.m^{-3}$ and annual concentration of sulphur dioxide was 15.4 $g.m^{-3}$ in the town of Martin.

The limit values were not exceeded for any parameter. Daily concentrations of oxides of nitrogen exceeded the ambient air quality standard on 14.2 % days within the year 2001 in the town of Žilina. The air pollution by sulphur dioxide is substantially less, annual average 15.1 $\mu g.m^{-3}$ (Vlčince) and 20.5 $\mu g.m^{-3}$ (Veľká Okružná) (Collective 2003).

Loads by lead and mercury

The most spreading heavy metal loads are lead inputs with their atmospheric depositions by 80 – 90 % of all inputs (Makovníková 1999). Lead's maximum was reached in 70's in the last century. In the period of the years 1980 – 1998, it was observed decrease of lead depositions at the level around 49 %, but however, mercury depositions increased in 15 % (Percy 2002). There is a geochemical abnormality of lead in the Malá Fatra Mts (Linkeš 1989).

Table 3 shows results of heavy metal (Pb, Hg) total content in study soil profiles. The contents of heavy metals were evaluated according to The Decree of Ministry of Agriculture of Slovak Republic about the highest accessible values of harmful substances in soils and about the assessment of organizations justified to determine the veridical values of these substances from the year 1993. In all topsoil horizons Pb content exceed background A-limit, in one case (Enti-Histic Podzol) also B-limit of contamination (198.3 $mg.kg^{-1}$ is over B-limit 150 $mg.kg^{-1}$). The over-limit of A-limit for Hg was determined in the same sample of Pb contamination.

The contents of chosen heavy metals (Pb and Hg) and plant nutrient Mg in needles are summarized in the Table 4. Over-limit of Hg was recorded in two cases of needle samples (contents overreached Hg limit 0.1 $mg.kg^{-1}$ – evaluated by Maňkovská 1996). Pb contents in needles are normal, probably high content of organic matter plays an important role here. The results of Pb, Hg and Mg contents were compared with the concentrations from selected mountains (see Table 4). There are small differences in the contents, except of Hg over-limit, which was not recorded in comparing areas.

With respect to the Mg optimum for spruce (15 000 $mg.kg^{-1}$ – Stefan et al. 1997), magnesium content is deficient.

Table 3 Total contents of Pb and Hg in soil profiles

Soil type	Horizon	Pb [$mg.kg^{-1}$]	Hg [$mg.kg^{-1}$]
Enti-Histic Podzol	O(h)	83.9	0.266
	Aop	80.4	0.184
	B/B	26.8	0.132
Enti-Haplic Podzol	Aop	125.8	0.228
	B/C	20.5	0.015
Enti-Histic Podzol	Oh	198.3	0.375
	Bsv	16.7	0.027

Table 4 Pb, Hg and Mg in spruce needles in selected mountains

Locality	Soil type	Pb [$mg.kg^{-1}$]	Hg [$mg.kg^{-1}$]	Mg [$mg.kg^{-1}$]
Martinské Hole Mts.	Enti Histic Podzol	< 1.2	0.170	727
	Enti Haplic Podzol	1.80	0.197	554
	Enti Histic Podzol	1.93	0.060	486
Nízke Tatry Mts.	Cambic Podzol	< 1.2	0.023	512
Kremnické vrchy Mts.	Sceletic Dystric Andosol	2.94	0.035	344
Vysoké Tatry Mts.	Haplic Podzol	2.58	0.014	755

Content

Surface soil irrigation

Intensive periodical water saturation of topsoil might be partially caused by removing of natural vegetation cover long time ago and by following intensive pasturing. But it is also natural phenomenon due to flat relief and moisture water regime, in which acid peat soils developed here. Spruce has flat and shallow root system, which is mostly depending on surface conditions (Svoboda 1953).

Soil auto-regulation feedback

Aluminium buffer range

Soil acidification is buffered by dissolution of reactive aluminium in dealt soils (Enti-Histic and Enti-Haplic Podzols). Two different mechanisms occur, buffering by a complex reaction on the soil organic matter in the topsoil organic-rich horizons (1) or by dissolution of allophane and gibbsite-like minerals in Bs-horizons (2) (see Figure 1). These mechanisms of acidity buffering are accompanied by aluminium release, which has phytotoxic effect (see Table 4), especially in the topsoil horizons.

(1) Al-MIN + $3H^+$ <=> Al^{3+} + $3H_2O$
$LogK_1 = log(Al^{3+}) + 3pH_{CaCl_2}$ (Lindsay 1979)

(2) Al-ORG + xH+ <=> Al^{3+} + ORG
$LogK_2 = log(Al^{3+})C_{org}/Al_{pyr}) + 1.06pH_{CaCl_2}$ (Wesselink et al. 1996)

Table 4 Concentration of Al^{3+} and content of humic substances in an example

Horizon	Al^{3+}	HA [%]	FA [%]
O(h)	860	1.19	2.95
Aop	495	1.5	2.39
Bsv1	405	0.67	1.47
Bsv2	383	0.57	1.38
B/C	232	0.44	1.46

Annotations: HA – humin acids, FA – fulvoacids, Al^{3+} – exchangeable aluminium in 1N KCl

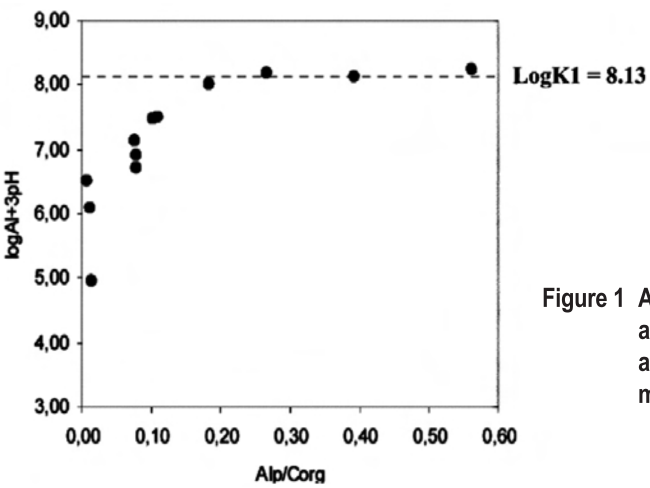


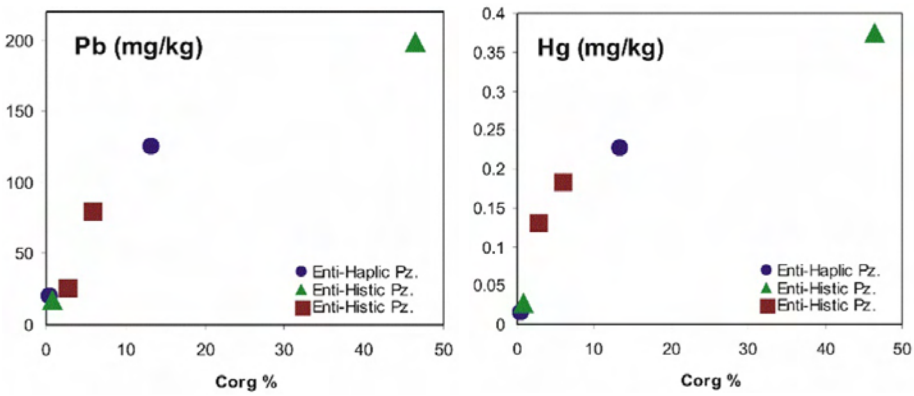
Figure 1 Al-dissolution plotted as a function of pH in $CaCl_2$ and saturation of organic matter by aluminium

Content

Binding effect of organic matter

Enti-Histic and Enti-Haplic Podzols in the Martinské hole Mts have fulvic character of humic substances (see Table 4). The fraction of humic acids/fulvic acids varies between 0.3 to 0.8, depending on soil horizon. Lead as well as mercury has high affinity to soil organic matter (OM) (Kabata-Pendias et Pendias 1992) and therefore OM acts like a binding agent in mentioned soils. Studied Podzols with signs of histic horizon accumulate lead and mercury mostly in the topsoil (Figure 2).

Figure 2 Total Pb and Hg as a function of organic carbon content observed in Podzols in Martinské hole Mts (topsoil and bottom horizons)



CONCLUSION

Norway spruce belongs to the trees more affected by site conditions than by hereditary properties. (Svoboda 1953). In various grounds the soil conditions are limiting for the healthy grow of spruce in Martinské hole Mts. The studied soils are extremely acid with low base saturation. Especially in the topsoil, aluminium ion content reaches high concentrations, which affect phytotoxically. Insufficient content of magnesium, with respect to its optimum (15 000 $mg.kg^{-1}$), is common feature in Slovak forests. In one case of soil sample (Enti-Histic Podzol), lead contamination was observed by exceeding of B-limit. In all topsoil horizons, Pb content exceeds background A-limit. Stands suffer by over-limit of mercury, which was recorded in two cases of needle samples. Surface soil irrigation can be also one of unfavourable factors affecting health of spruce stands.

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GRADIENT ANALYSIS OF THE GEOCHEMICAL PROPERTIES AND THE LEVEL OF SOIL DEGRADATION WITHIN THE CHVOJNICKÁ HILLY LAND REGION

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ABSTRACT

Within the observed region, in the Chvojnická hilly land region, the geochemical soil properties, such as the heavy metal's content (mg/kg): Ba, V, Cr, Hg, Co, As, Cr, Mo within the A-topsoil horizon, was analyzed by means of the mutli-variable analysis. Whereas the nonlinear gradient analyzes PCA (Principal Components Analysis) was used in order to specify/assign following element groups:

- Group I. with dominancy of Barium element along with the main unconstrained ax
- Group II. of Zn, V, Hg, Co, As, and Cu elements
- Group III. of Ni and Cr elements and
- Croup IV. of Mo.

By using the linear gradient analyses RDA, two soil characteristics (% content of clay and organic carbon) were selected according to the statistical confidence level. Furthermore those two characteristics were projected by the given projection at the ordination diagram.

The percent content of clay and organic carbon in the A-topsoil horizon is thought to represent one of the most significant factors of heavy metals sorption. Clay sorption is taken into account for heavy limit's calculation according to the Decree of Ministry of Agriculture no. 531/1994-540. On the bases of the decree, the A-limits for all selected potentially risk elements, heavy metals were recalculated respecting the clay content. Those recalculated A-limits were exceeded, in the case of nickel, 39 times, from which in two cases exceeded the B-limit. Likely chrome, as its concentration is exceeding the A-limit five times, and the B-limit in two cases. Both two increased chrome concentrations are intimately related to the local anthropogenic contamination seemingly caused by metalwork situated nearby the Brezová pod Bradlom town. From the copper distribution point of view, it is obvious that the distribution of all Cu concentrations exceeding the A-limit (in 39 cases) is of a planar character and related to geology. Those exceeded values of the Cu concentration are bound mainly to forest soils, Cambisols of the north most part of the region, developed from the flysch sediments of the Biele Karpaty Mts. It is necessary to say that the distribution of the potentially risk elements in the studied region all above reflects the chemical structure of parent material, from which soils are developed. Behavior of substances in soils, both of natural and anthropogenic origin, is highly dependent on soil reaction (pH), carbonate, clay and organic carbon content, as well as on Fe, Mn oxides occurrence in soils. Those soils properties significantly influence fixation and mobility of chemical elements within the soil.

INTRODUCTION

From geomorphologic point of view, the studied region, the Chvojnická upland is a part of the Záhorská lowland. Furthermore, it is geomorphologically subdivided into units of secondary order, subunits as follows: subunit Unínska upland, Senická upland, Zámčisko and Skalický hájik (Mazúr, Lukniš 1980). The observed region is represented mainly by mildly undulating terrain with altitude that varies in a range of 200 up to 350 m (max. altitude 434 m, Zámčisko). The prevalent part of the region is characterized by a typical hilly land relief with presences of flat ridges that downwards branch into valleys.

With respect to hydrology of the studied region, the Chvojnická upland belongs to the catchments of the river Morava and the river Myjava. Agricultural land represents the largest part of the whole region area, while the rest of the area is covered by forest and urbanized zones.

Results of geochemical analysis (heavy metals content; V, Cr, Hg, Co, As, Cr, Mo) serve as a significant matrix entering the multivariable analysis in a way to respect the selected gradient of nature, e.g. characterized by fundamental soil attributes such as pH (in H_2O), content of $CaCO_3$, Cox, silt, sand and clay. Mathematical and statistical approaches of processing numerical data are regarded currently as relatively new trendy methods for interpretation of measured data. Based on above mentioned, it can be concluded that those new methods result with an exact and unbiased analysis of measured and obtained data that are of an important background to defendable interpret and settle interesting scientific conclusions and hypothesis.

MATERIAL AND METHODS

The term multivariable analysis (or gradient analysis) is used for all the methods that search for relationship between species data (Lepš, Šmilauer 2000). In our case represented by geochemical properties – content of heavy metals Ba, V, Cr, Hg, Co, As, Cr, Mo in the topsoil A-horizon and gradients of environment (herein represented by elementary soil properties pH in H_2O, % content of $CaCO_3$, Cox, clay, sand and silt in the topsoil A-horizon). In our concerning region Chvojnická upland we used methods of Principal component analysis (PCA and Redundancy analysis (RDA). Canoco for Windows Version 4.0 (Te Braak 1988) was used both for methods and the parameter selection.

Both two linear methods try to find values for a new variable (called x), which might be of a good prediction for values of all parameters. The value of this variable for i-record is x_i and is used for value prediction of K-parameter in i-sample (y_{ik}):

$$y_{ik} = b_{ok} + b_{1k}x_i + e_{ik} \quad (1)$$

In this case, PCA (and just RDA as constrained method) is thought to predict two sets of parameters as follows: values x_i (sample score) for gradient axis and regression coefficients for each parameter (b_{1k}). Next parameter (b_{ok}) is an intersection of searching regression curve.

At this point, the similarity between both PCA and RDA method ceases, as in constrained – direct method, sample score values are restricted by a next condition: since values are defined as a linear combination of environmental (explanatory) variables. Concerning two variable existences, there is following expression of constriction:

$$x_i = c_1z_{i1} + c_2z_{i2} \quad (2)$$

Listed relation is possible to combine as:

$$y_{ik} = b_{ok} + b_{1k} c_1 z_{i1} + b_{1k} c_2 z_{i2} + e_{ik} \quad (3)$$

where products of b_k x c_j are coefficients of multidimensional regression model. Coefficients are constrained by their own definition: they are defined with two small groups of sample scores and scores of explanatory variables.

RESULTS

Herein, given descriptive statistics are values of arithmetic mean and variability of the heavy metal's content in the topsoil horizons. Only those samples were taken into geo-statistics analysis, which were analyzed for a chemical content. Furthermore, obtained values of a concentration of an individual element exceeded the detect limit. Descriptive statistics for all selected potentially risk elements are stated within the following table (Table 1)

Pertaining multivariable analysis, one of the PCA graphical outputs is the length of statistical vectors derived from the ordinary diagram. The length of the vector represents the statistical significance level for each individual specimen that is considerable for Ba, Zn, V, Cr, Hg, Co, As, Cr, whereas for Mo is not as depicted within the graph (see in the Graph 1).

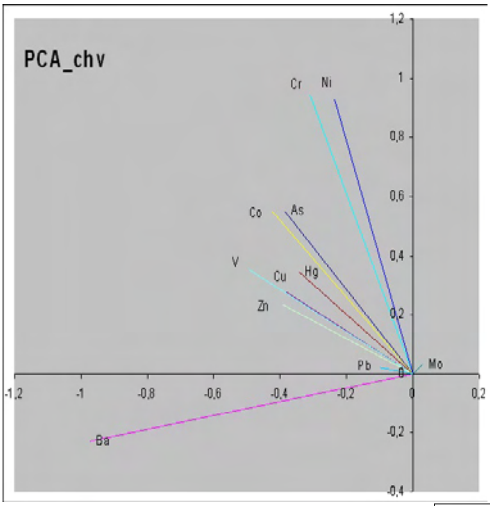
Another characteristic that is possible to get from the ordinary diagram of PCA analysis is the correlation rate. It is calculated as cosines of an angle between diverging lines, in this case between individual elements and axes. Within the graphical diagram there are obvious following correlations

1) between the vertical ax and barium,
2) between the group of elements, Zn, Cr, V, Hg, Co and As,
3) between nickel and chrome, and
4) molybdenum.

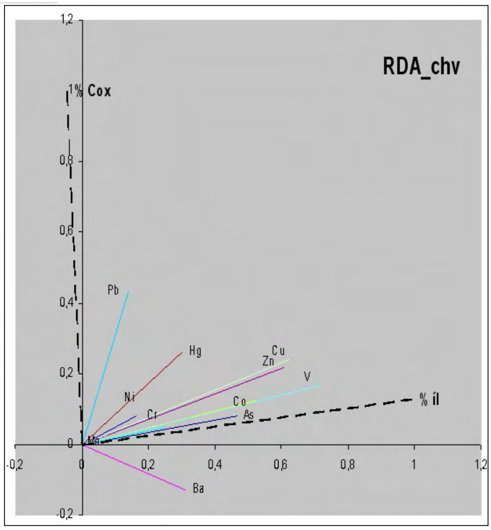
Table 1 Descriptive statistics of potentially risk heavy metal's distribution in the region of Chvojnická uplands

Element (mg/kg)	Counting rate	Arithmetic mean	Minimum	Maximum	Standard deviation	Skewness	Steepness
As	208	737	0.80	18.10	2.59	-0.29	1.67
Ba	209	362.88	85.40	638.90	79.19	-0.10	1.59
Be	196	1.54	0.26	2.76	0.54	-0.42	-0.05
Cd	37	0.19	0.10	0.70	0.12	2.29	7.08
Co	209	8.71	0.70	20.60	3.38	-0.17	1.12
Cr	209	83.25	5.89	652.00	55.01	6.80	64.47
Cu	209	27.22	6.00	69.20	10.36	0.54	1.48
Hg	209	0.07	0.02	0.28	0.03	2.68	11.97
Mo	207	0.54	0.20	3.40	0.31	4.62	36.81
Ni	209	31.77	2.20	474.60	35.95	9.95	116.24
Pb	209	17.76	9.40	40.40	4.97	1.23	2.52
Se	156	0.26	0.10	0.93	0.14	1.78	6.21
Sn	191	3.02	1.00	7.00	1.65	0.62	-0.48
V	209	74.80	6.78	153.60	30.04	-0.43	0.13
Zn	209	63.00	16.20	176.30	21.96	0.70	3.44

With respect to the method used, PCA – indirect gradient analysis, it is not feasible to give names directly to the axes. However, using the direct analysis, RDA, as a next step of our survey, helps us to characterize the axes by means of following correlations between the content of heavy metals in soils and measured soil characteristics, such as, e.g. clay content, content of organic carbon, etc.



Graph 1 Indirect (PCA) and Direct (RDA) analysis of geochemical properties in the soils of the studied region



Observing the correlation of the heavy metal's contents, following soil characteristics were statistically proven as significant, using the permuted test, at the confidence level α = 0.05, number of permutations = 1999.

Table 2 Statistical confidence of observed soil characteristics

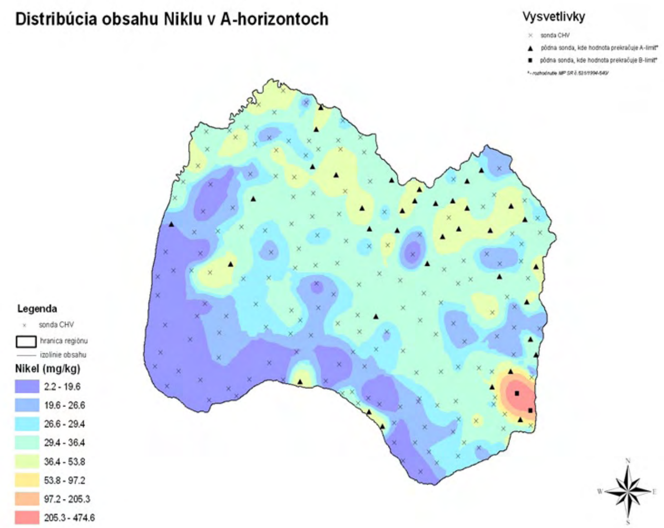
Soil parameter	F-value	*P-value	Statistical significance
Sand content (%)	37.33	0.0005	Significant
Clay content (%)	29.46	0.0005	Significant
Silt content (%)	26.11	0.0005	Significant
pH in H_2O	4.38	0.0090	Significant
Cox (%)	3.23	0.0415	Significant
$CaCO_3$ (%)	0.70	0.6115	Non-significant

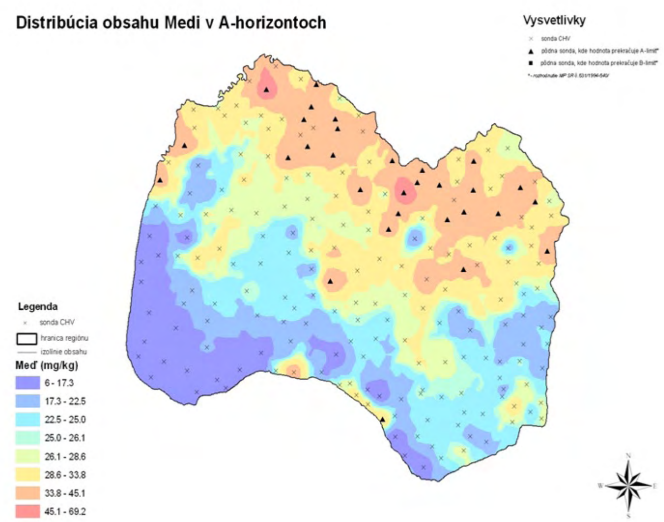
*P-confidence level, F-value is ratio of individual F-values: explained and residual variance

Content

For the sake of the final interpretation, two statistically significant soil characteristics were selected as follows: clay content and content of organic carbon Cox. Those duly selected characteristics fully respect given requirements, such as the statistical confidence, inter/mutual independency and geochemical correlation. Even though, the significance level of other soil parameters, such as sand and silt content, and pH seems to be higher than of selected characteristics (see Table 2), those ones are not appropriate for the interpretation due to not accomplishing the remaining requirements. Examine the RDA diagram (see in Graph 1), in general, the group of elements As, Co, V, Zn and Cu shows significant correlation with the clay content, whereas lead is more correlated with the organic carbon content. Elements such as Hg, Ni and Cr indicate correlations with both clay content and Cox.

Figure 1 Spatial characteristic of selected potentially risk elements, Ni and Cu, within the studied region





As already mentioned before, A-limits for the individual elements, As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn in nonstandard soils (standard soil: 25 % clay content, 10 % organic carbon content) were calculated according to the given formulas within the Decree of Ministry of Agriculture no. 531/1994-540 as the function of the clay and organic carbon content. Therefore, the content of each specimen was assessed individually. The A-limit exceeded values were determined for following heavy metals: Ba, Co, Cr, Cu, Mo, Ni, Se, V and Zn in the studied region of Chvojnická upland (see Table 2).

The Figure 1 depicts spatial distribution areas of heavy metals that exceeding the A-limit values. As representatives of spatial distribution of exceeding A-limit values in the upper soil horizon are given Cr and Ni that occur most frequently in the sample set.

Table 2 Exceeded A-limit values for the following heavy metals in the studied region of Chvojnická upland

	Number of samples exceeding limits								
Element	**Ba**	**Co**	**Cr**	**Cu**	**Mo**	**Ni**	**Se**	**V**	**Zn**
A-limit	8	1	5	39	7	37	2	10	2
B-limit			2			2			

DISCUSSION

The methods of gradient analysis currently represent a significant tool for executing of multivariable data, which geochemical soil properties undoubtedly are. Mutual relations between individual geochemical properties of soils abounded in the region of Chvojnická upland, analyzed by means of the both linear gradient analysis, are very well illustrated by the enclosed ordinary diagrams. Based on the results obtained from the analysis, it is obvious the tight association between geochemical properties (contents of heavy metals) and content of clay and organic matter in soils. Both characteristics are statistically significant and independent on each other, in contrary with physical properties. Thus, those characteristics cover wild scale of soil specimen and so they ensure to record risk elements input to soils.

CONCLUSION

Although heavy metals are mostly inherited from the parental rocks, in general their distributions within the soil profile reflect various pedogenic processes as well as the external factors such as agricultural management practices, pollution etc. Fate and behavior of heavy metals in soil is strongly dependent on their associations with the particular soil phase and soil components (e.g. clay fraction/clay minerals and organic matter).

Kabata-Pendias claims (2001), based on results of numerous studies and observation, that the main soil parameters governing processes of sorption and desorption of trace elements are of as follows: 1) pH and Eh, 2) clay content, 3) organic matter, 4) Fe and Mn oxides and hydroxides. According to the research results, the strongest positive correlation was obtained for the metals and clay (fine soil fraction). Even though this relation tends to vary, it is nicely illustrated by increasing mean content of trace metals in soils with increasing content of clay fraction. It is known that soil organic matter effects the distribution of most metals, but only about 15 % of the relative explanation.

All in all, above mentioned findings support the results of the gradient analysis presented herein. It is obvious that all trace metals studied are mainly distributed and mostly abounded in the association with the clay and organ matter within the soil profiles of the studied region Chvojnická upland.

Moreover, it is inevitable to say that the selected approach of soil quality assessment of the given region is duly in accordance with the Decree of Slovak Ministry of Agricultural number 531/1994. Since analytic methods used are in conformity with the mentioned Decree, therefore the recently launched and already established new law on Soil Protection number 220/2004 was not taken into consideration in the geochemical properties assessment.

ABC limits given within the Decree no. 531/1994 rely and are based on both the clay and organic matter content. Moreover, it gives the equations for calculating the limits for not standard soils according to concrete values on the clay and organic matter content. In this decree, the standard soil is characterized by the clay content of 25 % and the 10 % organic matter content in soil.

Apart of that, limits stated within the New Law on Soil Protection no. 220/2004 are based on the 3-degree textural fraction, so called Novak textural classification and on the total clay content (fraction below 0,01 mm), while omitting the organic carbon content. In a short, the wherefores of using the approach according to the Decreed no. 531/1994 are mainly of analytic methods used and respecting the clay and organic matter content as well.

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ZÁKON Č. 220/2004 Z.z. z 10. marca 2004 o Ochrane a využívaní poľnohospodárskej pôdy a o zmene zákona č. 245/2003 Z.z. o integrovanej prevencii a kontrole znečistenia životného prostredia a o zmene a doplnení niektorých zákonov. 2278-2315 str.

MAN-MADE SOILS CLASSIFICATION

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ABSTRACT

Man-made soils such as soils of reclaimed areas after mining, soils of urban areas and reclaimed landfills occupy relatively large areas. Both area and importance of these soils will increase in the future according to the growth of human activities as mining and urban planning. For this reason more attention should be paid to evaluating and development of classification of these soils not only at national, but also at international level.

Classification of these soils should be related to existing classifications on one side, on the other side it should be able to describe specific characteristics and functions of man-made soils. For this reason it is very important to determine specifics of man-made soils that make these soils different from natural soils. These differences are caused by human activities which can vary in type and intensity. The aim of this paper is to make an overview and summary of approaches to man-made soils classification.

INTRODUCTION

Man as a forming factor of soils expresses himself on significant large areas. The intensity and way of the man's influence vary greatly by time and space. The influence on the soil can be direct or indirect. The changes can occur due to man's effort for improving the fertility of the soil, or can happen by degradation of the soil by improper land use, or can be done by other activities that greatly or fully change the soil environment as large settlements, industry or mining. Soils that are influenced by human activity are called anthropogenic soils. Almost each national soil classification system has included or suggested various taxonomic levels for classifying of human impact on soil formation according to the importance in given country. The name "Anthropogenic soils" can include a wide range of soils, soils affected slightly as arable land, pastures, forest land, then soil affected strongly as agricultural land with intensive management, e.g. vineyards or hop-fields, and finally areas with soils which are totally changed or created by humans such as soils of urban and industrial areas, landfills, and mine sites – "man-made soils". The aim of this contribution is to make an overview and summary of approaches to the man-made soils classification.

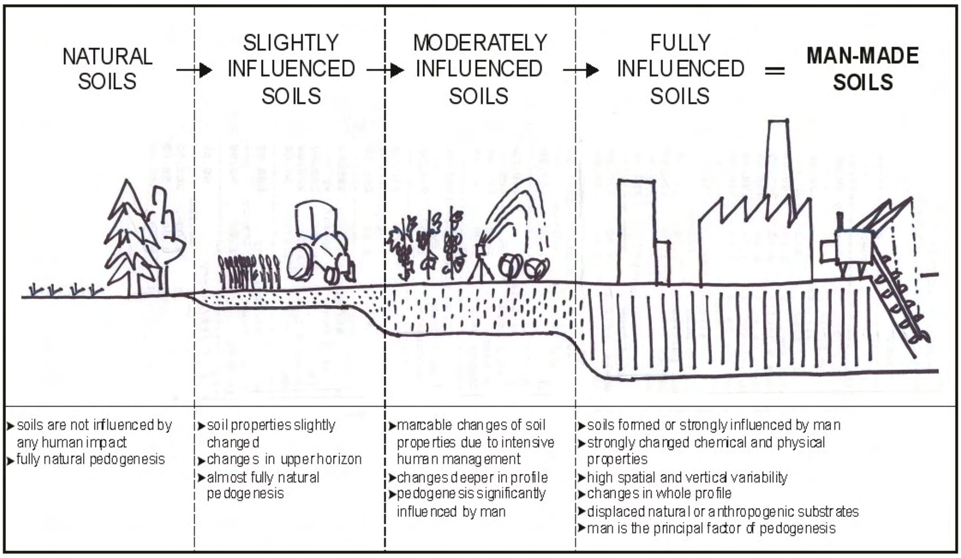
Man-made soils

Many soils are affected by human activity that causes different more or less significant changes in the soils. These changes can be represented by changes of some soil properties, chemical and physical (pH, bulk density, etc.), enrichment by different materials, contaminants, changes in hydric regimes, and so on. These changes can take place in different parts of soil profile and the intensity of these changes differs throughout the soil profile as well. Type and intensity of these changes are given by different human activities. Important factors of activities that cause the changes of soils are type, intensity and time when these processes take place.

Soils that are the most modified by anthropogenic influence are man-made soils. Man-made soils are represented by soils that were newly created from different materials or the original soil profile was buried under thick layer of materials.

One group of man-made soils are soils that were newly created by man from natural displaced materials. Example of these soils can be found on restored areas after mining. These soils formed from natural materials can be subdivided to two types according to used materials. One type is presented soils formed from materials that were a part of soil profile in the past. These materials carry on one side at least partly properties developed during the former pedogenesis. On the other side, these properties are changed by human activities such as disturbance, transporting, storing, deposition, and, moreover, these soils lost their original environment (Burghardt 2001). This means that soils formed from these materials, even if layered in the same sequence as they were excavated from the natural profile, have not the same properties as the original soils and cannot be regarded as original natural soils. However, the fact that they are created from pedogenetically developed materials should be taken into account in their classification. Approaches to classification of these soils vary significantly.

Figure 1 Levels of soil anthropization



The World Reference Base for Soil Resources (WRB) (FAO, 1998) and Soil Taxonomy (USDA-NRCS, 1999) classify these soils as natural – Regosols and Entisols, respectively. The anthropogenic influence is taken in consideration on lower taxonomic units, e.g. as subgroup Anthropic Regosols in WRB. In other classifications, the anthropogenic influence is considered on high classification levels corresponding to level of orders of Soil Taxonomy or major classification units of WRB. They are classified as Anthropozems, Anthrozems or Anthroposols in Czech, Slovak or Australian classification systems where they are further subdivided on lower classification levels according to the human impact of soil formation (see Table 1). In Russian classification, these soils are classified as “Quazizems“ from “technogenic surface formation”.

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Burghardt (2001) proposed these soils as Phaeno-types of natural soils, e.g. Phaeno-Cambisol, Phaeno-Gleysol.

Second type of man-made soils is presented as soils created from natural materials that were not a part of soil profile and are newly exposed to pedogenic process. Typical representative of these materials is mine spoil, dredging and others. These soils are very young, without any diagnostic features. It makes them similar to Regosols, natural weakly developed soils. However, same as the above, these soils are out of their original environment and soil properties are changed. Classification of these soils is similar as for the previous mentioned group of soils. Significant changes in classification are in Russian classification (see Table 1). And some changes are on lower taxonomic levels for example in Slovak classification where these soils are classified as Initial Anthrozems.

Soils that are created from non-natural (anthropogenic) materials as household waste, garbage, ashes, building rubble, tar, etc., or from mixtures where these materials are present significantly are represented by "urban soils" that occur in built-up areas, industrial areas or around traffic trails. Their formation and genesis is under conditions that are not present in natural systems. Very intensive human influences given by building activities, waste disposal and atmospheric deposition create very specific soil pattern. These soils are typical by their very high spatial (horizontal and vertical) variability, high skeleton content, changes of soil reaction, compacted soil structure, restricted aeration and water drainage, presence of contaminants and other properties. Because these soils are usually very young, their classification is based on the features of the substrate from which these soils developed. The substrate can be described by the type, deposition, treatment and skeleton content (Burghardt 2000). Classification of these soils is elaborated at different level in world-wide and national classifications. Detailed classification of these soils is in Russian classification (Stroganova and Prokofieva 2000). Extended classification of substrates that are the main criterion for description of these soils is in Germany (Burghardt 2000).

Classification of these soils in WRB and Soil Taxonomy, as internationally accepted soil classifications, is limited. WRB includes these soils to natural soil classes at the highest classification level. Regosols, Leptosols and Arenosols represent these soils. The anthropogenic influence is considered on lower units by subtype Anthropic, however, in Regosols only. Anthropic Regosols are subdivided further according to their characteristics as Garbic, Reductic, Urbic and Spolic. Recently, there is a feeling that WRB does not properly accommodate soils of urban and industrial areas.

Therefore, there are some proposals of adjustments in WRB. In Working Document: Classification of urban & industrial soils in the World Reference Base for Soil Resources (Rossiter and Burghardt 2003), three options of changes in current WRB are proposed. The first option could be to make changes in definitions of some reference soil groups with adding new qualifiers to them (e.g. Sludge-organic for Histosols, Spolic and Urbic for Leptosols, Anthropic for several reference soil groups, etc.), and description adjustment of some diagnostic horizons (e.g. terric, andic, vitric, toxic, etc.). The second option could be to add new reference group Technosols which would accommodate soils from technogenic materials. And the third option could be to unite undeveloped technogenic soils in the Anthropic Regosols; in reference soil groups of natural soils should then be noted that these soils are not formed from technogenic soil material. There is also proposed detailed qualifying of soil parent materials with anthropogenic origin.

Overview of classification of these soils in selected national and international classification systems is in the Table 1.

Table 1 Approaches to classification of man-made soils

Classification systems	Newly created soils by man – "man-made soils"			References:
	Newly created soils from natural displaced materials:		Soils created of non-natural materials as household waste, garbage, ashes, building rubble, tar, etc.	
	1) that were a part of soil profile in the past	2) that were not a part of soil profile (mine spoil, dredging, etc.)		
WRB	Regosols (Leptosols, Arenosols) Anthropic (in Regosols only)	Regosols (Leptosols, Arenosols) Anthropic (in Regosols only)	Regosols (Leptosols, Arenosols) Anthropic (in Regosols only) Garbic, Reductic, Urbic, Spolic (in Anthropic Regosols only)	FAO, 1998
Soil Taxonomy	Entisols Orth-	Entisols Orth-	Entisols Orth-	Sencindiver and Ammons 2000
Australian	Anthroposols	Anthroposols Dredgic, Spolic, Scalpic	Anthroposols Garbic, Urbic	Isbell 2002
Bulgarian	Anthrosols Leptic Technogenic	Anthrosols Leptic Technogenic	Anthrosols Urbogenic, Technogenic	Gencheva 2000
Czech	Anthrosols Anthro(po)zems	Anthrosols Anthro(po)zems	Anthrosols Anthro(po)zems Urbic, Contaminated, Reductic	Nemecek et al. 2001
German	classification based on substrates	classification based on substrates	classification based on substrates (Lithosol, Reductosol, Structosol, Nekrosol)	Burghardt 2000
Russian	Technogenic surface formation Quazizems Replantozems, Urbiquazizems	Technogenic surface formation Naturfabricats Abraliths, Lihtostrats, Organostrats	Technogenic surface formation Artifabricats Artiindustrats, Artiurbistrats, Artifimostrats	Tonkonogov et al. 2001
Slovak	Anthrozems Recultivated, Modal	Anthrozems Initial, Recultivated	Anthrozems Modal, Initial Urbic, Dumpic	SSCRI, 2000
UK	Man-made Soils		Man-made Soils, Terrestrial Raw Soils	Dudal et al. 2002

Content

CONCLUSION

Classification of man-made soils is relatively young issue that is complicated by many facts as presence of non-natural materials in substrates, high spatial variability, non or very weak pedogenic features and others. Due to this, classification of man-made soils is not uniform. There are very different approaches to their classification in the world or national classification systems.

With increasing interest in anthropogenicaly influenced soils, including the man-made soils, their classification has been widely developing in recent years at national and international levels. Proposals of considerable changes in classification of the two world-wide used classification systems – WRB and Soil Taxonomy – are the most significant examples. These proposals are proofs that man-made soils (and other anthropogenic soils as well) are an important part of soil science.

Acknowledgement

This contribution was supported by the grant of the Ministry of Education, Youth and Sports of the Czech Republic no. 836-G6: Specifics of soil survey of reclaimed dumpsites.

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NECROSOL AS A NEW ANTHROPOGENIC SOIL TYPE

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ABSTRACT

Soils of cemeteries and burial grounds are occurring in urban and countryside areas in almost all settlements. Soils of these areas substantially influence soil profile horizon sequence and physical, chemical and biological properties, too. The reason for such research is a problem of not sufficient rotting time of buried human or animal body. Urban administration authorities have been asked us for rotting time determination as a special pedological study. Two soil profiles were described, analysed and classified in the historical cemetery of Dolný Kubín: (1) soil profile – 27 years age grave (Necrosol), (2) soil profile – non-disturbed soil profile at the same grave (Pararendzina). On the base of our research we have defined Necrosol as a soil formed by special human activity in cemeteries and burial ground with specific soil horizons sequence. We have classified Modal Necrosol, calcareous, loam clay, from mixed anthropogenic material including weathered flysh shales. We have found that processes accelerating decay of biological material depends mainly upon climatic conditions, sufficient temperature, availability of air and moisture, appropriate values of textural fraction (sandy – loamy soils).

INTRODUCTION

Problem of burial ground and soils in cemeteries in aspect of soil science is presented very rarely by the scientific literature. Some articles were published by Smolík (1957) and Švec, Hlína (1978). Newly some issues are discussed in Burghardt 1994. Cemetery soils are relating to urban soils as their location is situated rather in urbanized areas. Their occurrence is registered in almost all cities and villages.

In Slovakia the Edict Ministry of Health No. 46/1985 "about processing at decease and funeral service" stipulates conditions for rotting time of biological material and other aspects of cemetery soils. According to this edict the rotting time is determined for more than 10 years. By that edict a district sanitarian designates the length of that at cemetery foundation on the base of hydro-geological survey. We presume that also soil scientists could contribute to these problematic issues. Soils of cemeteries underlies by burial processing, which completely changes soil horizon sequence and alters soil physical, chemical and mainly biological properties. Knowledge about these soils can explain the role of soil properties in aspect of many soil processes running in burial ground. They are: mineralization, gleyic processes, decay of organic matter, micro-organism activity, activities of pathogenic organisms, etc.

MATERIAL AND METHODS

Two soil profiles were submitted by soil science research using standard methodology for description and classification of pedons (Čurlík, Šurina 1998). The pedons were described, analysed and classified in the historical cemetery of Dolný Kubín: (1) soil profile – 27 years age grave (Necrosol), (2) soil profile – non-disturbed soil profile at the same site (Pararendzina). Special attention was paid to processes taking place in soil after burial.

As the main soil properties at burial soils are considered texture, soil moisture (water content), organic carbon content, amount of micro-organisms, amount of soil edafon (micro-fauna and macro-fauna) like bacteria, action-mycetes, micro-mycetes, yeast fungi, algae, protozoa, nematodes, etc. Biological activity of soil depends upon its ability to supply micro-organisms by carbon, nitrogen and other biogenic elements because soil is the main source of carbon dioxide and slightly mobilized nitrogen, phosphorus and sulphur. By means of organic matter and micro-organisms there is running permanent mobilization and immobilization of biogenic elements (Sotáková 1982). Increase of organic matter in soil can cause increasing of biological activity and process of soil mineralization is forced.

At mineralization processes is important soil texture testing. According to Smolík (1957), soil texture influences decay processes of biological material. Mineralization in air is approximately eight times shorter than in soil. Strongly sandy soil considerably accelerates mineralization, on contrary clayey soils in case of wet conditions or even gleyic processes. In sandy soils strongly aerated in the depth of 2 m at adults and 1 m at children decay process take time approximately 4 months. The real mineralization is lasting about 7 years. Pathogenic organisms are active before decomposition of wood coffin. The ground water level has to not more than 2 – 2.5 m under burial bottom.

Nevertheless, the mineralization in textural heavy and gleyic soils lasts for several decades of years. For instance, in permanently frozen soils human bodies can be conserved. In very light, air-conditioned and dry soils human bodies behave like mummies. Therefore, in our climatic temperate conditions, cemetery situated in areas of textural heavy (clayey) and wet soils are dangerous due to rotting time prolongation. In this case self-cleaning process is seriously elongated accompanying by “cemetery smell”.

Švec, Hlína (1978) describe hydro-geological assumes at cemetery location which have to be very carefully consider. Ground water level, respecting oscillation must be at least 3 m under surface to avoid water contact with graves. Soil has to be sandy or loamy, porous, well aerated due to decay retardation or stagnancy in wet soils. In sandy soils decay process is lasting for approximately 7 years, in loamy soils decay time is prolonged in 1 – 2 years. In strongly wet soil conditions decay process is stopping and biological matter obtain grey-white colour with wax signs. In absolutely dry soil at high temperature burial bodies loose water and decay is stopped and skin acquires parchment signs (mummification).

Decay of dead bodies runs very quickly at warm weather during some hours after burial but at least in 2 – 3 days. First, it is stagnant decomposition conditioned by micro-organisms activity present in internal apparatus of dead man. Then soil organisms share in further decomposition like insect larvas, and other pedo-fauna. The length of decay process is depending upon soil texture, aeration, moisture and temperature. In standard conditions this process lasts for 3 – 4 months. Later this is following by mineralization without any smell. Soft parts of bodies decompose completely and remain only bones.

Stagnant decomposition can be presented as anaerobe process which is characteristic by:

- reduction of proteins and amino-acids, degradation of fat acids, release of organic substances, and following
- rotting which transforms by oxidation released basic compounds into water, carbonate, nitrate, nitrite, sulphate and phosphates.

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These stages of decomposition last about 8 – 9 years. This time is indicated as rotting (decay) time to be incorporated in low. In Slovakia according to Edict Ministry of Health No. 46/1985 it is determined ≥ 10 year without any other specifications.

RESULTS AND DISCUSSION

Two soil profiles were described, analysed and classified in the historical cemetery of Dolný Kubín:

- pedon 1 – soil profile of 27 years old grave;
- pedon 2 – non-disturbed soil profile at the same grave.

Description and classification of pedons are represented in Figures 1 and 2. Soil samples from 3 horizons of pedon 1 were submitted by standard physical and chemical analyses: texture (pipette method using FAO textural fraction), pH in H_2O, pH in KCl, $CaCO_3$ (%), Cox (%) and organic matter content (%). Analytical results of soil texture are presented in Tables 1 and 2. Chemical properties characterized by usual pedological properties are presented in Table 3.

Figure 1 Description and classification of pedon 1

Location: historical cemetery in Dolny Kubín
Date: 14.02.2001
Age: 27 years
Pedon 1: uncovered grave

Soil profile description:
Surface – timber grave

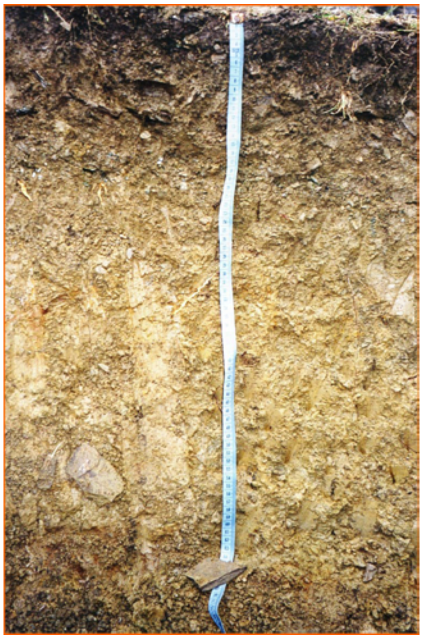
Cb1c (0 – 32 cm) – 10YR 4/4, wet, weakly sticky, angular, silt-loam, 50 % of stoniness (weathered detritus), strong rooting, anthropogenically mixed material with remnants of artifacts, distinct transition to

Cb2c (32 – 92 cm) – 10YR 6/4, wet, sticky, strongly angular to massive structure, silt-clay-loam, moderately rooting, 80 % of slightly calcareous shale detritus (gravel and stone), anthropogenically mixed material, sharp transition to

Cb3c (> 92 cm) – 10YR 6/5, wet, strongly sticky, strongly angular to massive structure, silt-clay-loam, 50 % of stoniness, 25 % of artifacts (remnants of coffin, buried body)

Classification according to Sobocká (2003): Necrosol modal, calcareous, psefitic (silt-clay-loamy), form urbic, from mixed anthropogenic material

Figure 2 Description and classification of pedon 2



Location: historical cemetery in Dolny Kubín
Date: 14.02.2001
Age: 27 years
Pedon 2: non-disturbed side of the same grave

Soil profile description:

Amc (0 – 23 cm) – 10YR 4/3, wet, weakly sticky, angular, silt-loam, 35 % of stoniness, distinct transition to

A/Cc (23 – 30 cm) transition horizon gradually to

Cgc (> 23 cm) – 10YR 6/5, 6/6, 80 % of stoniness, relict redox features in lower part of profile, weathered calcareous-silicate rock, flysh shales

Classification according to the MSCS (2000): Pararendzina modal, calcareous, silt-loamy, from calcareous-silicate rock

On the base of our research we have defined new anthropogenic soil type what is included in the latest proposal of the anthropogenic soil classification by Sobocká (2003). It is named Necrosol according to Burghardt (1994) followed by Stroganova et al. (1998). Necrosols are defined as soils formed by special human activity in cemeteries and burial ground with specific soil horizons sequence, specific physical, chemical and biological properties. In our case we have classified pedon 1 as Modal Necrosol, calcareous, loam clay, from mixed anthropogenic material including weathered flysh shales, urbic form (Sobocká 2003).

In spite of that, pedon 2 is classified according to the Morphogenetic soil Classification System of Slovakia (2000) like natural soil unit. It is Pararendzina modal, calcareous, silt-loamy, from calcareous-silicate rock. Comparison of both soil profiles of the same grave register two different soil units characterized by completely different soil horizon sequence and properties.

Table 1 Texture (FAO classification, pipette method)

Sample	> 0.25 mm (%)	0.25 – 0.05 mm (%)	0.05 – 0.02 mm (%)	< 0.02 mm (%)	0.02 – 0.002 mm (%)	< 0.002 mm (%)
Cb1	7.37	17.49	16.72	58.41	33.51	24.91
Cb2	2.05	12.37	17.12	68.46	34.16	34.30
Cb3	2.56	13.75	16.30	67.38	33.87	33.50

Table 2 Texture characteristics (by USDA triangle)

Sample	> 0.05 mm (sand)	0.05 – 0.002 mm (silt)	< 0.002 mm (clay)	USDA triangle
Cb1	24.86	50.23	24.91	Silt-loam
Cb2	14.41	51.28	34.30	Silt-clay-loam
Cb3	16.32	50.17	33.50	Silt-clay-loam

Table 3 Chemical properties analyses

Sample	pH in H_2O	pH in KCl	$CaCO_3$ (%)	Cox (%)	Organic matter (%)
Cb1	7.84	6.76	0.80	2.89	4.982
Cb2	8.03	6.32	0.20	1.04	1.792
Cb3	7.81	6.42	0.50	1.72	2.965

Two approaches were chosen at Necrosol characterization:

- to outline diagnostic criteria and features to be involved in a classification system
- to outline main pedological characteristics and properties sharing in rotting processes (by our opinion only hydro-geological conditions investigation is not sufficient for rotting time estimation).

Diagnostics criteria

We assume that as diagnostic feature for newly presented soil type can be served

- changed horizon sequence,
- change of original soil properties like soil texture (mixture of original composition), Cox and organic matter presence.
- increased content of phosphorus
- abundance of organic matter at bottom of Necrosol (in the 3rd horizon we have observed non-usual content of organic matter)
- amount of micro and macro-edafon is suitable to know
- presence of artefacts (remnants of coffin, non-decomposed parts of burial body etc) is inevitable to take into consideration (Figure 3).

Figure 3 Remnants of artefacts at the bottom of grave, coffin decay after 27 years

Pedological properties sharing in rotting processes

For character and rapidity of organic matter change in soil have to be consider textural fraction of fine earth with various rapidity of carbon cycle in soil (Jurčová, Bielek 1997). Rapidity is a factor given by time necessary to carbon mineralization in specific textural fraction. In our climatic conditions was found that in sandy and loamy soils there is running an intensive carbon mineralization (more than 6 %) whereas in clayey soils mineralization retards (less than 11 % C).

According to our investigation in historical cemetery in Dolný Kubín the study soil profile was analysed and results used for rotting time estimation. Profile 1 was characterized as loamy or clayey loamy (USDA triangle) with relatively high content of clayey particles (< 0.02 mm) 58 – 68 % and very low content of sand (> 0.05 mm) 15 – 25 %. Content of skeleton (flysh shale detritus) was ranging in 50 – 80 %. At the bottom 25 % of artefacts were found out. Relatively high content of coarse fragments can ensure good porosity in soil profile, i.e. good conditions for aeration and accelerated mineralization.

There was registered sufficient content of Cox (1 – 2 84 %) and high organic matter presence (1.7 – 4.8 %). According to presence of high content of organic matter we can deduce high amount of soil edafon. Soil properties like pH and $CaCO_3$ presence do not participate substantially at rotting processes.

By field finger testing soil moisture was middle to high (wet conditions) accompanying by lower soil temperature. Climatic conditions are defined as moderately cold and moderately wet (climate code 8). Ground water level is more than 5 m under surface.

Resulting and interpreting above listed properties we have estimated rotting time at 15 – 20 years, not less. The estimation reflects: inappropriate textural fraction, wet conditions in soil profile caused by quite cold and wet climate of this region (Dolný Kubín is situated in the North of Slovakia).

We assume that as pedological properties sharing in rotting processes can be mentioned (except of hydro-geological and climatic conditions):

- textural fraction (sandy and sandy loamy fraction are most appropriate)
- soil porosity
- soil moisture (water content)
- soil temperature
- content of C and organic matter (accelerated soil mineralization)
- amount of soil edafon (micro- and macro-organisms).

CONCLUSION

Comparing of two soil profile of the same grave we have tried to define new soil profile Necrosol – formed by human and characterized as anthropogenic soil type developed "in situ". Two approaches were chosen Two approaches were chosen at Necrosol characterization: to outline diagnostic criteria and features to be involved in classification system, and to outline main pedological characteristics and properties sharing in rotting processes.

We have found that processes accelerated decay of biological material depends mainly upon climatic conditions, hydro-geological conditions, appropriate texture fraction presence, sufficient temperature, availability of air and moisture, appropriate values of Cox and also amount and activity of micro-and macro-organisms in soil is appropriate to learn.

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URBAN SOILS OF SOME LOCATIONS IN NITRA TOWN

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ABSTRACT

Urban soil is general term for soil occurred in urbanized, industrial, traffic and mining areas. For their complicated morphological, physical and chemical properties they are still not characterized in most of urban areas. Because of urban soil in urbanized areas are important component of human environment, the aim of the work reported here was to characterize urban soils in some locations in town Nitra. Soil properties were characterized for 3 soil profiles. Profile No. 3 (control) was located at Slovak Agriculture University park and was minimally influenced by human. Profiles No. 1 (in 100 m distance from control profile) and No. 2 were located at town greenery close to street and buildings. Profiles No. 1 and 2 distinctly differed from control profile No. 3, mainly in considerable vertical heterogeneity, artefacts, carbonates, chlorides content, high vertical heterogeneity in humus quality and quantity. Humus horizons also differed in soil texture. A-horizon of control profile No. 3 was silt-loam, A-horizon of profile No. 1 was sandy loamy and profile No. 2 loamy. The content of silt did not exceed 60 % in any from studied horizons, but content of PM_{10} (respirable air dust) exceed 10 % in each of studied humus horizons. In spite of great importance soil was still not analyzed for inorganic and organic pollutants. High content of pollutants in soil mean real danger for population in urbanized areas. Described characteristics of soil profiles confirmed idea of Stroganova-Prokofieva, that main soil-forming factor in town is the land use type. According to Morphogenetic Soil Classification System of Slovakia (2000) are profiles No. 1 and 2 classified as "Antrozem initial" and profile No. 3 as "Fluvizem cultizemic". The WRB (1994) classifies soils of profiles No. 1 and 2 as Urbi-Anthropic Regosols and profile No. 3 as Eutric Fluvisols. According to Soil Classification System proposed by Sobocká (2003) are profiles No. 1 and 2 classified as Skeletozem – formed from skeletal anthropogenic material.

INTRODUCTION

Urban soil is general term for soil occurred in urbanized, industrial, traffic and mining areas. For their complicated morphological, physical and chemical properties they are still not characterized in most of urban areas. Several characteristics of the urban soil emerge, as contrasted to their natural counterparts:

- Great vertical and spatial variability
- Modified soil structure leading to compaction
- Presence of a surface crust on bare soil that is usually hydrophobic
- Modified soil reaction, usually elevated and variable chemistry
- Restricted aeration and water drainage
- Interrupted nutrient cycling and modified soil organism population and activity
- Presence of anthropogenic materials and other contaminants

- Highly modified soil temperature regimes
- Non-oriented rock fragments in the profile
- Unpredictable rooting patterns and lack of earthworm activity (Craul 1992).

To our 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 process exist around the world. There is a great deficit on soil investigations in the cities. The research until now is too much concentrated on pollutant content than on the understanding of the medium soil which determines the effect of the pollutants (Burghardt 2001).

MATERIAL AND METHODS

Town Nitra is positioned on South-West part of Slovak Republic. The most spread soil-forming substrates are quarter sediments – clay and loess and main soil types are Fluvisols, Mollic Fluvisols, Haplic Luvisols and rarely on different substrates Cambisols. Groundwater level varies in depth 1.2 – 2.5 m and is influenced mainly by river Nitra, which crosses town. Because of urban soil in urbanized areas are important component of human environment, the aim of the work reported here was to characterize urban soils in some locations in town Nitra.

Morphological and chemical parameters were characterized for three soil profiles:

- Profile No. 3 (control) was located at Slovak Agriculture University park and was minimally influenced by human.
- Profile No. 1 was located at town greenery close to street A. Hlinku in 100 m distance from control profile
- Profile No. 2 was located at town greenery close to street and buildings (Damborského st.).

Each horizons of Profiles 1, 2, 3 were analysed for following chemical properties:

- total soil organic carbon content (Cox) – by Tyurin method (Orlov 1981)
- soil pH – potentiometrically – in 0.01 $mol.dm^{-3}$ $CaCl_2$
- sum of bases and hydrolytic acidity – by method of Kappen (Hanes 1999)
- carbonates content by volumetric method (Čurlík et al. 2003).

Physical parameters were determined only in Profile No. 3, because Profiles No. 1 and 2 were extremly stony and sampling was too complicated. Soil texture was analysed by pipet method (Hanes et al. 1995) for each horizons of Profile 3. For Profile 1 and 2 was textural composition determined only for humus horizon.

RESULTS AND DISCUSSION

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 (Burghardt 2001).

From morphological description in Tables 1 – 3 we can see that horizons in Profile 3 (control profile) slightly differed in colour and other morphological properties, and none horizon contained stones, gravel or artefacts. Profiles No. 1 and 2 had clear vertical heterogeneity and soil horizons (layers) distinctly differed. Because of control profile 3 was without coarse fragments, gravel and stones presence in profiles 1 and 2 we consider as material input into soil artificially by human.

Morphological description of studied soil profiles

Table 1 Morphological properties of profile No. 1

Adic	0.01 – 0.05 m	10YR 2/3, slightly moist, angular blocky structure, moderately dense root system, without coarse fragments, $CaCO_3$ presence
Cc	0.05 – 0.18 m	10YR 4/6, slightly moist, angular blocky structure, moderately dense root system, gravel (> 60 %) and $CaCO_3$ presence
D_1c	0.18 – 0.45 m	10YR 3/4, slightly moist, non-structure, slightly dense root system, gravel, stones (70 %) and $CaCO_3$ presence
D_2c	0.45 – 0.55 m	10YR 4/4, slightly moist, non-structure, slightly dense root system, stones (80 %) and $CaCO_3$ presence
concrete	0.55 – 0.70 m	
D_3c	> 0.70 m	10YR 4/4, slightly moist, non-structure, without coarse fragments, $CaCO_3$ presence, natural alluvial sediments

Table 2 Morphological properties of profile No. 2

Adic	0.01 – 0.10 m	10YR 3/3, slightly moist, angular blocky structure, moderately dense root system, without coarse fragments, $CaCO_3$ presence
Cc	0.10 – 0.19 m	10YR 3/3, slightly moist, without coarse fragments, sub-angular blocky structure, moderately dense root system, $CaCO_3$ presence
D_1c	0.19 – 0.40 m	10YR 4/4, slightly moist, non-structure, slightly dense root system, gravel (> 60 %) and $CaCO_3$ presence
plastic	0.40 – 0.41 m	plastic anthropogenic artefacts
D_2c	0.41 – 0.45 m	10YR 5/2, non-structure, slightly dense root system, gravel (80 %) and $CaCO_3$ presence
piping	0.45 – 0.55 m	town piping
D_3c	0.55 – 0.65 m	10YR 5/2, non-structure, slightly dense root system, gravel (80 %) and $CaCO_3$ presence
D_4c	> 0.65 m	10YR 5/4, non-structure, slightly dense root system, $CaCO_3$ presence, natural alluvial sediments mixed with gravel

Table 3 Morphological properties of profile No. 3

Aoc	0.01 – 0.25 m	10YR 4/4, slightly moist, sub-angular blocky structure, dense root system, without coarse fragments, < 1% $CaCO_3$ presence
A/Cc	0.25 – 0.55 m	10YR 4/6, slightly moist, angular blocky structure, slightly dense root system, without coarse fragments, < 1% $CaCO_3$ presence
CGoc	> 0.55 m	10YR 3/3, slightly moist, angular blocky structure, Mn-nodules, without coarse fragments, < 1% $CaCO_3$ presence

Physical properties

Physical properties were determined only for Profile No. 3, because of Profiles 1 and 2 contained high amount of stones and gravel without fine earth fraction. Particle density (ζ_s) changed slightly in whole soil Profile 3. Obviously, bulk density (ζ_d) and porosity (P) changed more distinctly (Table 4). Due to favourable soil structure, porosity, content of humus and dense root system in humus A-horizon there was found the lowest ζ_d. We suppose, that pedo-compaction (higher ζ_d) in depth 0.2 – 0.3 m was caused by mini-tractor used for cutting the lawn in the University park.

Table 4 Physical properties of Profile 3

Depth [m]	ς_S [t.m^{-3}]	ς_d [t.m^{-3}]	P [%]	θ [%]	θ_{KN} [%]	θ_{30} [%]	KMK [%]	θ_{KMK} [%]	θ_{RK} [%]	P_N [%]	P_K [%]	P_S [%]	V_{AM} [%]	V_A [%]
0.0 – 0.1	2.53	1.22	51.48	39.37	46.28	44.55	35.29	43.33	41.52	6.93	41.52	3.03	12.11	18.19
0.1 – 0.2	2.53	1.38	45.36	36.24	43.44	41.35	29.00	40.09	38.50	4.02	38.49	2.85	9.12	16.36
0.2 – 0.3	2.59	1.44	44.49	26.17	41.89	39.11	26.12	37.54	35.59	5.38	35.59	3.53	18.32	6.95
0.3 – 0.4	2.59	1.42	45.41	24.36	42.19	39.67	26.84	37.94	35.44	5.75	35.44	4.23	21.05	7.47
0.4 – 0.5	2.57	1.34	46.19	24.99	43.09	39.94	27.64	38,19	35.94	6.26	35.94	4.00	21.20	8.00

ζ_s – particle density, ζ_d – bulk density, P – porosity, θ – soil moisture, θ_{KN} – capillary soaking up, $\theta_{30'}$ – moisture after 30 minutes of drainage, θ_{KMK} – maximal capillary water capacity, θ_{RK} – retention water capacity, P_N – non-capillary pores, P_K – capillary pores, P_S – semi-capillary pores, V_{AM} – minimal air capacity, V_A – volume of soil air

Textural composition of humus horizons in Profiles 1 and 3 (their mutual distance was 100 m) distinctly differed. A-horizon of control profile No. 3 was silt-loamy A-horizon of Profile No. 1 was sandy-loamy (Table 5). Such a high difference we consider as strong anthropogenic influence, because soil texture is one of the most stabile soil parameters

Many urban soil have high content of silt particles (0.002 – 0.05) > 60% and also excessive dust content – respirable air dust from soil and parent material measured as PM_{10} (particle matter < 10 µm) (Sobocka 2003). The content of silt did not exceed 60 % in any studied horizons, but content of PM_{10} exceed 10 % in each of studied humus horizons.

Table 5 Textural fraction

Profile No.	Horizon	Depth [m]	Particles fraction (%)						Soil class
			> 0.25	0.25 – 0.05	0.05 – 0.01	0.01 – 0.001	< 0.001	< 0.01	
1	Adic	0.00 – 0.05	33.62	17.49	30.07	12.28	6.54	18.82	Sp
2	Adic	0.01 – 0.10	27.76	15.94	25.38	15.36	15.56	30.92	Sh
3	Aoc	0.01 – 0.25	7.26	9.46	30.86	27.28	25.14	52.42	Ssh
	A/Cc	0.25 – 0.55	1.84	12.02	31.73	29.73	24.68	54.41	Ssi
	$C_G$oc	> 0.55	7.60	15.66	19.11	18.86	38.77	57.63	Si

Sp – sandy loam, Sh – loam, Ssh – silt loam, Ssi – silty clay loam, Si – clay loam

Chemical properties

Characteristics of soil sorption complex and pH values did not differed distinctly in studied soil profiles (Tables 6, 7, 8). Urban soils tend to have soil reaction values somewhat different from their natural counterparts. In most cases, pH values are higher in the urban environment (Craul 1992). Distinctly higher content of carbonates in Profiles 1 and 2 was also caused by anthropic influence on soil, because of original soil-forming substrate on studied area contains less than 1 % of $CaCO_3$ (Tables 6, 7, 8). Carbonates in urban soil mainly come from construction spots or secondary carbonated soils as remains of former building activities (concrete, lime, bricks…).

Table 6 Humus content, soil reaction a characteristics of sorption complex in Profile 1

Horizon	Depth [m]	Humus [%]	pH $CaCl_2$	$CaCO_3$ [%]	H	S	CEC	V [%]
					[$mmol.kg^{-1}$]			
A1c	0.0 – 0.05	7.63	7.29	7.0	3.5	499.4	502.9	99.3
Cc	0.05 – 0.18	3.22	7.66	6.2	3.5	499.4	502.9	99.3
D1c	0.18 – 0.45	7.49	7.57	6.6	3.5	498.9	502.4	99.3
D2c	0.45 – 0.55	2.14	7.65	5.4	3.5	498.8	502.3	99.3
D3c	0.55 – 0.70	2.48	7.28	7.6	3.5	498.7	502.2	99.3

Table 7 Humus content, soil reaction a characteristics of sorption complex in Profile 2

Horizon	Depth [m]	Humus [%]	pH $CaCl_2$	$CaCO_3$ [%]	H	S	CEC	V [%]
					[$mmol.kg^{-1}$]			
A1c	0.01 – 0.1	4.45	7.43	6.8	3.5	498.4	501.9	99.3
Cc	0.10 – 0.19	1.83	7.66	25	3.5	498.4	501.9	99.3
D1c	0.19 – 0.40	2.07	7.70	15	3.5	498.4	501.9	99.3
D2c	0.41 - 0.65	1.85	7.75	14.5	3.5	498.2	501.7	99.3
D3c	> 0.65	0.94	7.66	2.6	3.5	492.5	496.0	99.3

H – hydrolytic acidity (H, Al), S – sum of bases (Ca, Mg, Na, K), CEC – cation exchange capacity, V – base saturation

Higher content of chlorides in A-horizon of Profile 1 compared to Control profile 3 is evidence of salt accumulation due to winter maintenance of streets in town Nitra (Table 9).

Humus content lowered uniformly in the control profile 3. On the contrary, the content of humus lowered very variously in Profiles 1 and 2, what can be assess as anthropic mixing of different soil layers, or as gradual stratification of materials, which originally come from other localities (Tables 6, 7, 8).

Table 8 Humus content, soil reaction a characteristics of sorption complex in Profile 3

Horizon	Depth [m]	Humus [%]	pH $CaCl_2$	$CaCO_3$ [%]	H	S	CEC	V [%]
					[$mmol.kg^{-1}$]			
Aoc	0.01 – 0.25	3.83	7.34	0.4	6.1	450.9	457.0	98.7
A/Cc	0.25 – 0.55	2.18	7.52	0.8	5.7	488.5	494.2	98.8
CGoc	> 0.55	2.06	7.64	0.4	5.3	381.5	386.8	98.6

The best humus quality was found in A-horizon of Profile 1 (rate HA : FA = 1.237). Lower humus quality was in A-horizon of Profile 2 (HA : FA = 0.934) and the lowest in A-horizon of control profile 3 (HA : FA = 0.636). Such a low rate HA : FA is typical for Fluvisols. Because of humus in Fluvisols is naturally of low quality, we consider, that A-horizon in Profiles 1 and 2 is not original, or, high content of favourable organic matter was added (Table 10).

Results of chemical properties presented here are in agreement with values determined by Zaujec (2000) in years 1981, 1982. In spite of great importance soil was still not analyzed for inorganic and organic pollutants. High content of pollutants in soil mean real danger for population in urbanized areas.

Content

Table 9 Total content of water-soluble cations and anions

Profile No.	Horizon	Sum Ca^{2+}, Mg^{2+}	Ca^{2+}	Mg^{2+}	Cl^{-}	NaCl	Water-soluble salts content	Presence	
		[mmol.kg^{-1}]			[%]			CO_3^{2-}	HCO_3^{-}
1.	Adic	360	256	52	0.023	0.038	0.29	no	yes
2.	Adic	240	192	48	0.016	0.027	0.19	no	yes
3.	Aoc	504	336	168	0.017	0.028	0.15	no	yes

Table 10 Humus quality in humus A-horizons of Profiles 1 – 3

Profile No.	Horizon	Cox [%]	Humus [%]	Humus substances		Humic acids		Fulvic acids		HK/FK
				Cox [%]	[%]	Cox [%]	[%]	Cox [%]	[%]	
1	Adic	4.42	7.63	1.111	25.11	0.614	13.88	0.497	11.23	1.237
2	Adic	2.58	4.45	0.641	24.83	0.309	11.97	0.331	12.81	0.934
3	Aoc	2.22	3.83	0.627	28.20	0.244	10.97	0.383	17.24	0.636

Total soil organic carbon (Cox)

Classification

Described characteristics of soil profiles confirmed idea of Stroganova-Prokofieva (2001), that main soil-forming factor in town is the land use type. On the base of determined morphological, physical and chemical properties we can classify studied soil according to different soil classification systems:

According to Morphogenetic Soil Classification System of Slovakia (2000) are:

- Profiles No. 1 and 2 classified as „Antrozem initial" and
- Profile No. 3 as „Fluvizem cultizemic".

The WRB (1994) classifies soils of:

- Profiles No. 1 and 2 as „Urbi-Anthropic Regosols" and
- Profile No. 3 as „Eutric Fluvisols"

According to Soil Classification System proposed by Sobocka (2003) are:

- Profiles No. 1 and 2 classified as „Skeletozems initial calcareous" – formed from calcareous skeletal, natural-technogenic anthropogenic material.

CONCLUSION

The survey and mapping of urban soil are complex task, because of extreme spatial and vertical variability of urban soil. To understand the problems presented in the urban soil, it is necessary to fully consider the modifications of the morphological, physical, chemical and biological properties as compared to natural soil.

Acknowledgements

The paper was published thanks to grants 1/1279/04 and 1/1318/04 Scientific grant Agency of Ministry of Education of the Slovak Republic.

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SPECIFIC PROBLEMS OF URBAN SOILS RESEARCH IN THE AREA OF PREŠOV

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ABSTRACT

The specific problems of urban soils are presented in this contribution. There are the results of detailed research of urban soils in chosen area in Prešov. Our study area is situated in central part of East Slovakia in north part of Košická kotlina (basin) on the flood-plain of Torysa river. Housing development – Sídlisko III as observed segment was chosen.

INTRODUCTION

The post-agricultural growth of human populations, combined with technological advancement, has led to the widespread transformation of natural ecosystems into those dominated and heavily managed by human beings. The transformation of productive agricultural land to urban is nowadays very intense.

The „urban soil" is meant as a general terminological concept for soils in urbanized, industrial, traffic and mining areas. There are Urbic Anthrosols on the largest areas in the towns. These soils are very specific. They have a special diagnostic Ad-horizon which is man-made from various (nature, nature-technogenic and technogenic origin) materials. They are several signs typical for urban soils: vertical and horizontal heterogeneity, large stratification of soil horizons and layers (unnatural sharp and straight), extreme physical, chemical and biological characteristics, presence of anthroskeleton, existence of various functions of urban soils and various categories of land use in towns.

„Urban soils have got many various and diverse soil properties. Quality of urban soils does not depend upon crop production parameters like at agricultural soils, but based on their specific site use in urbanized areas. Social-economic and environmental functions as buffering, sanitary, barrier, water retention, nutritional, etc. have priority in assessment of urban soils." (Sobocká 2003, p. 77)

Research and development is a critical part of any soil interpretation especially of urban soils. It is very difficult and complicated to map urban soils because their properties are very variable, because of the strong compaction and a lot of anthroskeleton; and also by financial, time and space demands.

MATERIAL AND METHODS

The research was realized in Prešov city. The town is situated in the central part of eastern Slovakia, in the north part of the Košická kotlina (basin) on the flood-plain of Torysa river. The presented localities are on housing development – Sídlisko III. Their natural geosystem was formed by Holocene fluvial sediments. Fluvisols and floodplain woods were formed on these sediments.

These areas were utilized by Bulgarian greengrocers since the first Czechoslovac Republic. Due to the establishing of the housing estate Sídlisko III in the 70ties of the 20th century the anthropogenic transformation of this geosystem started. In present on the territory of the research areas we can find qualitatively different forms of land use. The selected localities are the most suitable for the study of specific problems of urban soils.

RESULTS AND DISCUSSION

Urban soils have simple construction of soil body as A-C, or A-C-D profiles. Generally they are young soils. Differentiation of urban soils from natural soils is done according to some morphological abnormalities in soil profile and almost all soil properties.

Characteristics of urban soils
horizontal heterogeneity
vertical heterogeneity
stratification (sharp and straight boundary)
land use ↔ character of layout of the layers
extreme compaction
presence of anthroskeleton

Morphologically it can be observed heterogeneity of soils at vertical and horizontal level. Soil profile is changing in many cases abruptly by distance of several centimetres (Figure1).

Figure 1 Horizontal heterogeneity of urban soils

Content

The urban soils, especially those forming on anthropogenic substrates, have very clear stratification. The boundaries between horizons are sharp and straight. (Figure 2).

There are several categories of land use in our research area. They have their typical character of layout of the layers. There are buildings, pavements, roads, sandy areas for children, areas for garbage, green areas near building and green areas near communication in Sídlisko III.

We divided these areas into two groups. There are buildings in the first group – areas without soil. These localities are typical with its special profiles. We can say that these profiles are not soil profiles (Figure 3). There are two categories of land use in next group (areas with soil) close and open. The pavements, roads, sand areas for children and areas for garbage are close. The soil profile is under asphalt or concrete (Figure 2).

It is question whether we can find soil under the asphalt. In our opinion the soil is really under such surfaces. It is soil in new point of view. It has non productive function. Social-economic and environmental functions are their priority. The green areas near building and the green areas near communication are open. They have direct connection with atmosphere. This fact is very important for chemical analysis. Typical soil profiles under green areas have mostly three layers. The first is under grass. It looks like A-horizon in agricultural soils. The second and the third layers are various. They are very compacted or they are full of gravels. The gravels are natural, but character of their layout is unnatural. It is typical sign of urban soils. (Figure 4)

Figure 2 Pavement

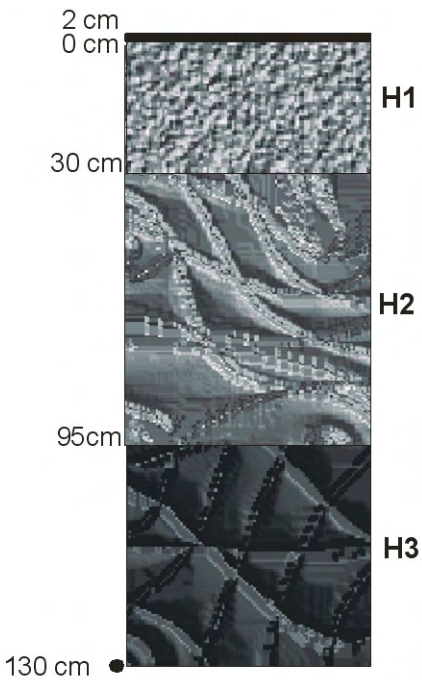

Figure 3 Typical profile under the building (area without soil)

Content

Figure 4 Main types of soil profiles under green area

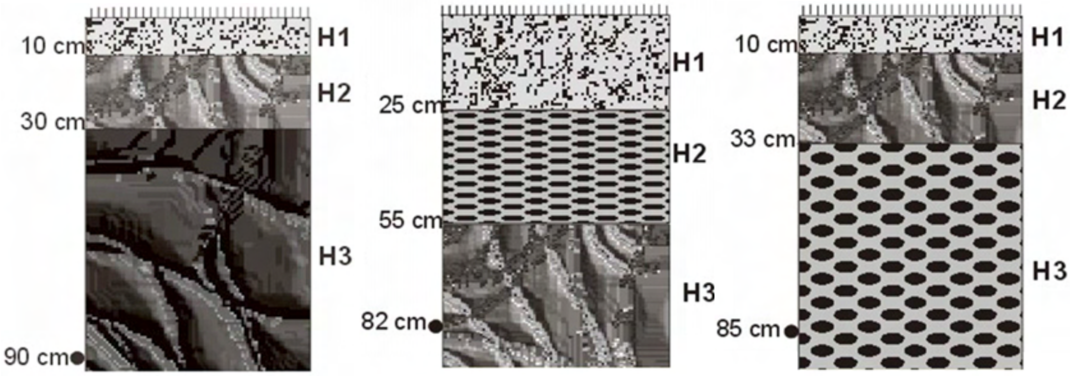

Figure 5 Extreme compaction of urban soils

Characteristic problem of urban soils is compaction. Trampling by feet and wheels, especially on wet soil, causes loss of air space – great for buildings, bad for plants and micro-organisms. The extreme compaction inhibits root growth, reduces water retention, reduces the amount of available water to a plant, reduces populations of soil organisms and also reduces plant growth. The difficulty in probing the soils, only horizontally growth of roots and poor plant growth are important symptoms of compaction (Figure 5).

In profiles of many urban soils can be visible fragments of various anthroskeleton. For example asphalt, plastic material, paper, textile, glass, concrete, metals, brick, slag, etc. (Figure 6)

Research obstacles

changes of soil profile in space and time
demanding sampling
necessity of heavy machinery
financial and time demands
analysis of physical, chemical and biological properties
administration (permissions from offices, owners,...)

Figure 6 The fragments of various anthroskeleton

CONCLUSION

There are several research obstacles in urban areas. There are changes of soil profile in space and time. They are due to various forms of land use in urban areas and high degree of man impact. The demanding sampling and heavy machinery are necessary because of the extreme compaction and presence of anthroskeleton. The special analysis of physical, chemical and biological properties are very important when we can observe for urban soils characteristics. These facts along with contamination cause financial, time and administration obstacles.

Along with the difficulty of research and spatial interpretation of soil in urban areas we can point out that there are certain relationships between land use and character of stratification in soil profile. There are various types of lands with different functional responses in Prešov.

It is necessary to use scale 1:1 000 for mapping because of these specific problems of urban soils mentioned.

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RESISTANCE OF SOILS IN SLOVAKIA

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ABSTRACT

Hazardous metals are passing into soil by via natural and anthropogenic process. Soil pollution in Slovakia is connected especially the industry, mining and metal treating activity. Their effects are expressing on the soil, where we can observe impairment of physical, chemical and biological properties, affecting of soil regime and increasing of receipt harmful substances with input into food chain. As hazard pollutants account As, Cd, Cr, Co, Cu, Hg, Ni, Pb and Zn.

INTRODUCTION

Almost all the human society development was linked with the technology of obtaining and processing metals. By winning and metals processing man gives them not only new form, but he brings about also intensive their wide-spreading in environment. Soil is typical with high sorption capacity and is very well sorbic positively loaded ions of metals.

Therefore permanent supplying, though in low concentrations during long period, is leading to metal accumulation in soil. „Metallic pressure“ on biosphere conditioned by man activities can provoke technogenic and geochemical anomalies, their values will be permanently increased parallel with growth of economic people activity intensity. Therefore is necessary to know potential risk of the metals, regularities and their behaviour in the system soil – plant, as well as character and intensity of their input into food chain.

MATERIAL AND METHODS

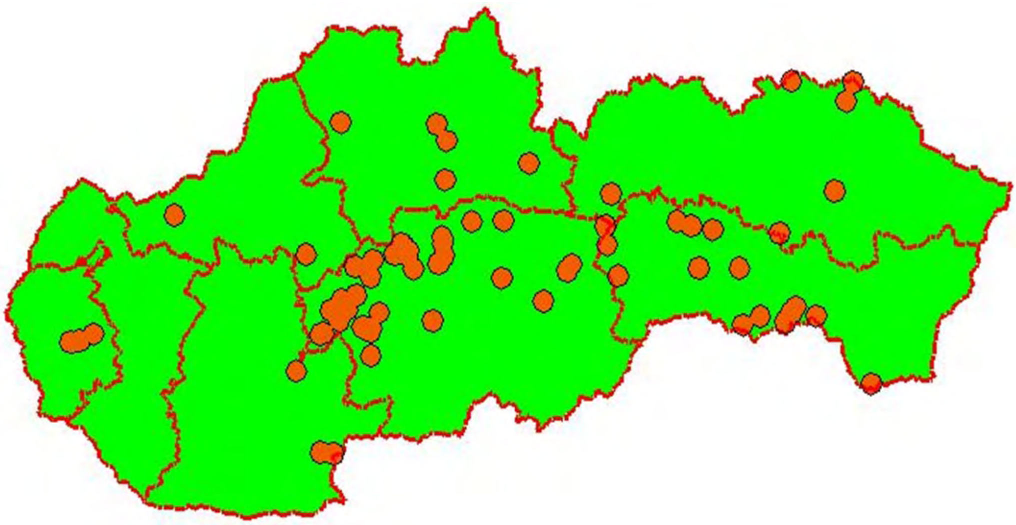
Hygienically status of the soil resources was assessed based on agronomic characteristics of farmland and criteria for the farmland contamination judgment by valid legislation (Bielek et al. 2003). The hygienically status of soils in Slovak Republic was elaborated based on soil characteristics and valid legislation (Decree of Agricultural Ministry SR no. 531/1994-540). Data of soil pollution were assumed from the Slovakian Soil Geochemical Atlas Part V. – Soils (Čurlík, Šefčík 1999), as well as data of the Soil Information System of the soil Science and Conservation Research Institute (AISOP-PC 1991).

RESULTS AND DISCUSSION

Soils distinguished with conjunction of contamination with heavy metals may characterize as a soils with high grades of potential jeopardize of quality live in quoted regions. Spatial reach of contamination have impact on the agricultural producer, where mainly small-scale producer producing for own necessity, can be expressively stricken of group, which directly is jeopardized by soil contamination (Figure 1).

As originates from this, these areas are to contaminate by multi-element pollution, where we can create till 6-element combination of contamination.

Figure 1 Spatial identification of polluted arable soil of Slovakia for B-value



Relation between pollution and physical and chemical properties of soils is solved through the evaluation of resistance the soils, where on basis of physical - chemical properties of soils is suggested the classification system of soil resistance towards impurity (Tables 1, 2). As results has been constituted Map of resistance agricultural soil SR against contamination

Table 1 Parameters for valuation soil's resistance

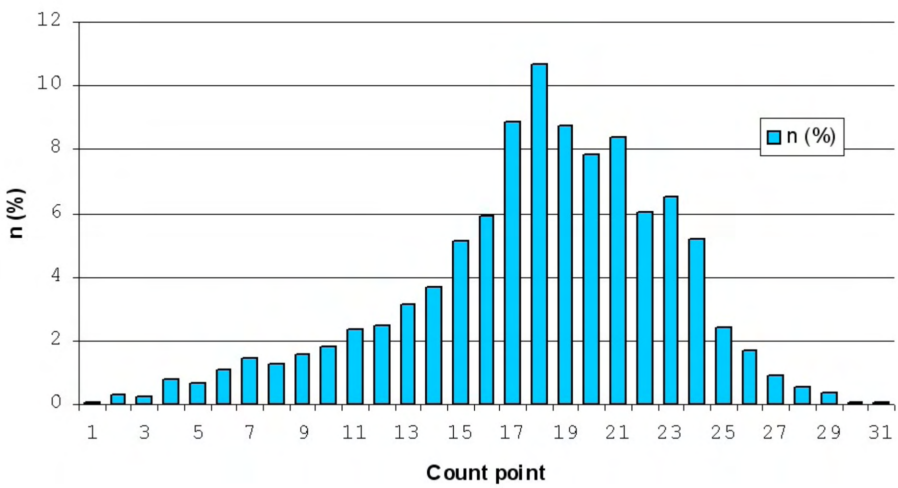
No	Parameter	Symbol
1	Contents of skeleton	Sk
2	Graininess	Zr
3	Contents of carbonate	Rca
4	Content of humus	Qhf
5	Soil reaction	Ph
6	Depth of horizon	Hlb
7	Slope of relief	Rlf

Table 2 Classification of soil according the resistance

Resistance of soils	Classification of resistance	Point	Number of group
Very resistance of soils	7	29 – 32	4
Good resistance of soils	6	26 – 28	3
Resistance soils	5	22 – 25	4
Relatively resistance soils	4	16 – 21	6
Few resistance sensitive soils	3	11 – 15	5
Few resistance very sensitive soils	2	6 – 10	5
Non sensitive soils	1	2 – 5	4
Range of points		1 – 32	31

Graph 1 Distribution of soil resources (PPF) according to class's resistance

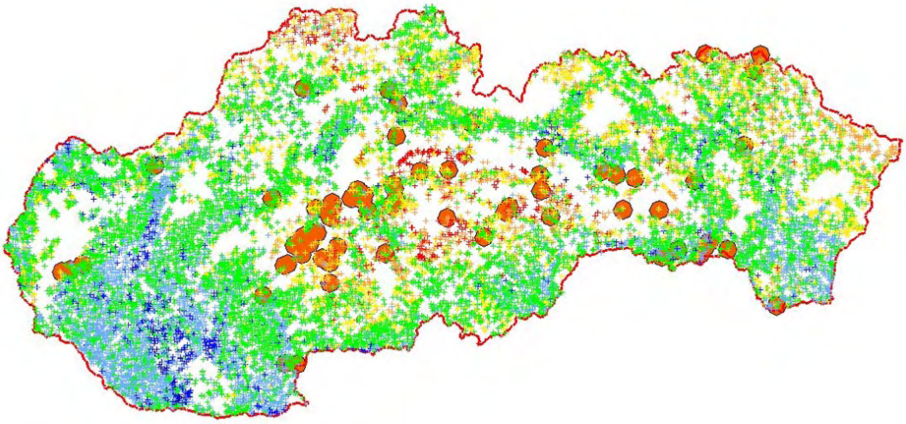
Graph 2 Distribution of soil resource according to evaluation of resistance



Content

Relation between soil contamination and physical and chemical properties of soil is solved whereby scheme of evaluation soil resistance, where on basis physical and chemical properties we proposed classification system of soil evaluation towards contamination. Conclusion is the Map of soil resistance (Figure 2).

Figure 2 Map of resistance of soils Slovakia for selected area (B-value of contamination)



Legend:

Symbol	Classes of resistance	Description
red	T1	Non sensitive soils
orange	T2	Very few resistance very sensitive soils
yellow	T3	Few resistance sensitive soils
green	T4	Relatively resistance soils
light blue	T5	Resistance soils
blue	T6	Good resistance of soils
indigo	T7	Very resistance of soils

Sign	*Mean of sign*
heptagon	Area with contamination > B - value
(red line)	Boundary of Slovakia

CONCLUSIONS

Whereby the connection of contamination and physical-chemical properties has been created evaluation system for assessment of potential risk of polluted soils on production of health safe agricultural product.

This map ascent is well applied on:

- Recommendation next exploitation to contaminate soil in separate system maintenance
- Suggested price valuation soil
- Working-out financial sanction for subject contamination farmland soils.

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International conference
SOIL ANTHROPIZATION VIII
September, 28 – 30 2004, Bratislava, Slovak Republic

CONCLUSIONS

(Conclusions were elaborated after conference discussion by all participants)

In the soil anthropization research it is inevitable to:

1) recognize and define the role and significance of human influence and impact on soil (time factor and composition of substrate is presented as some of the important factors)
2) define and assess soils occurred in urbanized, industrial, traffic and mining areas with respect to their heterogeneity and genetic principles
3) consider and reflect anthropogenic soils (mainly man-made soils) and leading to the definition of soil alone – is it soil, or non-soil, or soil body? Where is limitation to soil definition or can we change traditional perceiving of the soil?
4) consider the problem of terminology confusion which appeared in many scientific references and leads to the no-unified perceiving and each to other understanding

Examples:

- How do we understand urban soils, what is their definition and delineation on the map
- How do we understand anthropogenic soils, what is their definition and delineation on the map
- How do we understand other terms like artificial soils, man-made soils, soil-like bodies (technozem) and are they by their meaning?
- How do we distinguish such terms as rehabilitation, reclamation, renaturalization, revitalization, remediation, recultivation?

5) classify anthropogenic soils and urban soils, observe obstacles in definitions of diagnostic horizons, layer, features and intergrades type classification
6) consider the problem of diagnostic features, properties of characteristics of anthropogenic material (substrate), is it cover of original soils, replaced material, domestic waste, mine waste, etc. Technogenic material is the contrast of natural material e.g. urban, or industrial made, building rubble, ashes, mud, slag, cinder, garbage dump and compost (Is it minimum depth 20 cm?).
   - How to define technogenic material (substrate), what feature is the main differentiation criterion
   - Is anthroskelet presence and how do we quantify it?
   - Is phosphorus presence and how do we quantify it?
   - To what depth has this layer or substrate to be considered?
7) determine the scale of urban soils mapping, it is recommended not more than 1: 25.000 to be based on maps of 1:5.000 or 1:10.000, for more detailed soil survey and mapping scale 1:2.000 or 1:1.500 is appropriate
8) carry out a qualification of urban soils in relation to their environmental functions and declared generally a worse soil quality of urban soils, the problem of brown fields and derelict land is therefore always

Content

9) consider archaeological sites to be subjects of anthropogenic soil research or not? Cultural layers and horizons are often occurred in historical urban areas and old settlements, e.g. content of phosphorus in amount of 1 000 $mg.kg^{-1}$ Ii proposed as diagnostic horizon of anthropogenic soils?
10) new approach to soil survey, description, methodology and analyses is an inevitable tool for non-time-consuming research, e.g. method of magnetic susceptibility is available in aspect to heavy metal content monitoring in urban and industrial areas
11) actualize ongoing reactions and progressive development of certain issues, e.g. in Bratislava yearly extent of consumption is 140 ha, continuous environmental loads and pollution, health of urban population, adequate use of urban sites, etc.
12) identify the need about the awareness of soil anthropization ideas, their promotion and enhancement have to be done.

Bratislava, October, 16, 2004

Proceedings

International Conference: SOIL ANTHROPIZATION VIII,
Bratislava, Slovakia, September, 28 – 30, 2004

Editor: Jaroslava Sobocká

Technical editor and design: Štefan Moro

Published by: Soil Science and Conservation Research Institute Bratislava

Print: Edition Centre of Soil Science and Conservation Research Institute Bratislava

Pages: 134

Edition: 300

ISBN 80-89128-12-2

ISBN 80-89128-12-2