Specifics of urban soils (Technosols) survey and mapping

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Abstract
Systems of soil survey, sampling and mapping e.g. for planning and zoning processes are complicated by ongoing consumption of urban soils; by sealing or building activities regardless the soil functions in urban landscape. For the case study of Bratislava city there are presented some peculiarities of survey and mapping processes. Also some obstacles met in this process are listed. The strategy of soil mapping is based on demands of soil quality according to site use of various groups of urban population. Proper methodology includes: recognition of urban ecosystems respecting demands of the urban population on soil quality; selection of representative soil profiles, soil description field book: urban pedon or polypedon description and classification, mapping: use of so-called pedo-urban complexes; sampling and analyses of surface or subsurface soil contamination on risk elements. To delineate soil complexes in urban areas there is a need for GIS based soil data. As a base for urban area delimitation and digitalization aerially scanned orthophoto maps at the scale 1:5,000 and digitized in ArcMap (ESRI inc.) were used. Outputs of the soil survey and mapping could provide many maps: e.g. soil map (at the scale 1:25 000), map of soil texture, map of parent materials (incl. anthropogenic) and many derived map compilations to be used for urban planning aims.

Key Words
Urban soil, Technosol, urban pedon, pedo-urban complex, soil sealing

Introduction
In most cities there are available data concerning soils and their various properties. Also methodological approaches which include urban soil survey; sampling and soil properties evaluation for urban planning and zoning processes have been revealed over the world, like TUSEC-IP (Lehmann *et al*. 2005), and other publications on urban soil assessment in landscape (Craul 1992, 1999, Vrscaj *et al*. 2008). Most of these approaches try to assess urban soils from the viewpoint of different soil functions. In cities we have areas like historical centers, industrial plants, urban greens and parks, playgrounds and schoolyards, residential areas, recreation areas, abandoned brownfields, etc. Survey and mapping of urban soils (mainly Technosols) is a very complicated and complex task. Human activities have played an overwhelming role in the distribution of soil or parent materials with different pedogenetic processes. Urban soil spatial variability represents a great deal of their complexity. Therefore understanding and knowledge of pedogenesis cannot be applicable to the whole urban landscape. Generally soils in cities are completely stripped and stockpiled or backfilled around the construction objects. Most commonly occurring soil group are Technosols (WRB 2006). In the paper there is described some new principles of urban soil survey and mapping methodology regarding numerous soil functions in an urban landscape. Also some obstacles referring to urban soil (Technosol) diagnostics and classification or soil sealing covers affecting the mapping process have been taken into consideration.

Methods
To achieve given aims the traditional pedo-geographical methodology of soil unit survey and mapping was recognized, verified by application using aerial orthophoto-maps and GIS tools. Methodology was completed by new ideas of urban areas mapping with knowledge about soil functions in urban landscape. General strategy includes pedogenesis of soils predominantly occurring in cities, mainly Technosols, classification procedure related to the Slovak Morphogenetic Soil Classification system (Collective 2000) what is the role of anthropogenic (human-transported) material and its properties by specific terminology concept (urban pedon, pedo-urban complex) was introduced into the urban soil mapping strategy. Also the problem of soil sealing is mentioned as one of the great factors in urban soil survey and mapping.

Results
Soil genesis of Technosols
Genesis of soil occurring in urbanized areas differs from soils situated in natural landscape. Soil genesis is conditioned by several factors:

– Parent material – soil properties are attributable to their origin (prevailingly from techogenic or semi-technogenic substrata); and to the manner of their disturbance rather than natural pedogenetic processes.
– Youth (initial soils) – the time period is to short for diagnostic horizons formation (Burghardt 2001)
– Mostly extreme physical and chemical properties not common in natural landscapes.
– Mostly excess contents of dust (PM_{10}), risk elements (contaminants) and pathogenic organisms
– Presence of artifacts (WRB 2006).

A lack of detailed urban soils classification in recognized in Slovakia. Taxonomic classification has progressed very slowly and has not gained widespread acceptance. If the urban soil is not readily classified mapping is not facilitated.

Soils found in cities

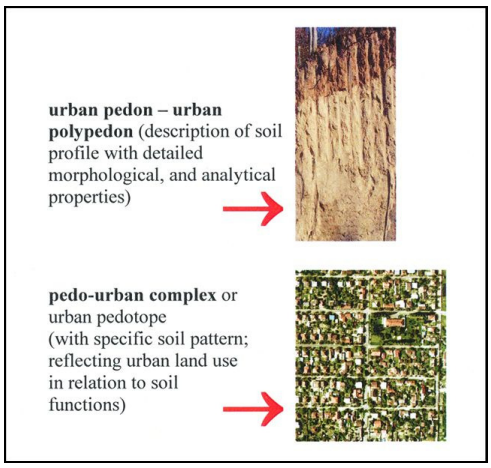
There are various soil types, a great variety with strong heterogeneity in the vertical direction (e.g. through soil profile) or horizontal direction (spatial differentiation). The variety of soil can be divided: (i) natural soils, (ii) man-influenced soils, (iii) man-changed soils; and (iv) man-made soils (artificial) soils.
In cities of Slovakia there are mapped mainly two groups of anthropogenic soils: Kultizems´s soil group at which diagnostic principles is profound "in situ" transformation or perturbation of top horizon by deep tillage, trenching, deep cultivation, fertilizer application, etc. They have many features similar to Anthrosols (WRB 2006) but they are not defined by the same way. Anthrozem soil group is most similar to Technosols (WRB 2006). They are man-made soils developed from human-transported material. This "ex situ" material is most important for diagnostics and is divided into three subgroups: with natural origin, with semi-natural origin; and with technogenic material (Sobocká el al 2000). Not all Anthrozems meet diagnostics of Technosols however the rule of 20 percent and more of artifacts in the upper 100 cm from soil surface is kept.

Urban soil survey and mapping

The complexity of soil units in the urban landscape is so great that single mapping units could not be used, however each recognizable urban soil unit is important for interpretation because it contains capabilities for soil function implementation.
Two-levels of urban soil survey and mapping is considered in Figure 1

1) urban pedon, urban polypedon (description and classification of soil profile according to morphological, physical-chemical and analytical properties
2) pedo-urban complex or urban pedotope (with specification of the urban pattern reflecting urban land use in relation to soil functions).

Figure 1. Levels of urban soil survey and mapping



The system is complicated by ongoing land consumption and by sealing regardless to soil functions respecting. Two levels of terms have to be distinguished: soil sealing as impervious cover of soil surface by asphalt, concrete, roads, etc.; and land consumption as land use change for buildings, construction activities with possible open green areas maintenance. Predominantly soil sealing has strong impacts on soils, their properties and consequently on inner-city green areas reduction.

Strategy of soil survey and mapping

The strategy of soil survey, mapping sampling and assessment of urban soil was demonstrated in a case study of Bratislava city (Sobocká 2007). It consists of:

1) recognition of pedo-urban complexes (land use) respecting the demand of urban population on soil quality
2) selection of representative soil profiles (e.g. industrial sites, commercial-housing areas, residential sites, traffic infrastructure, green zones, parks, recreation sites, child playing grounds, cemeteries etc.
3) soil description field handbook (urban pedon or polypedon)
4) sampling and analyses for analysis of risk elements (heavy metals, organic pollutants)
5) mapping of soil units: using pedo-urban complexes delineation and digitalization of aerially scanned ortho-photomaps in the scale 1:5,000; GIS tools use (ArcMap, ESRI, inc.)
6) soil map compilation (in the scale 1:25,000 and other derived maps for various aims compilation (Figure 2 and 3).

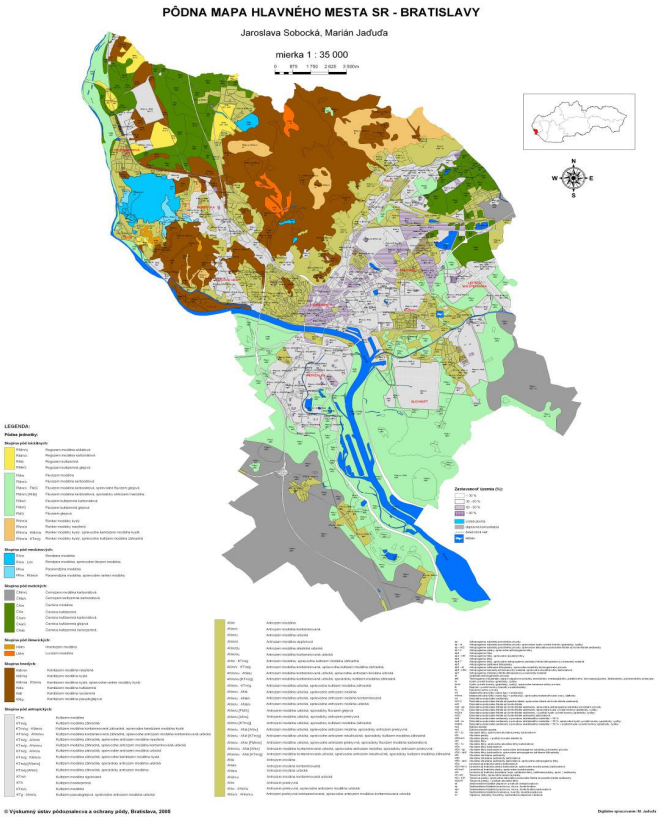


Figure 2. Soil map of Bratislava city at the scale 1:25 000

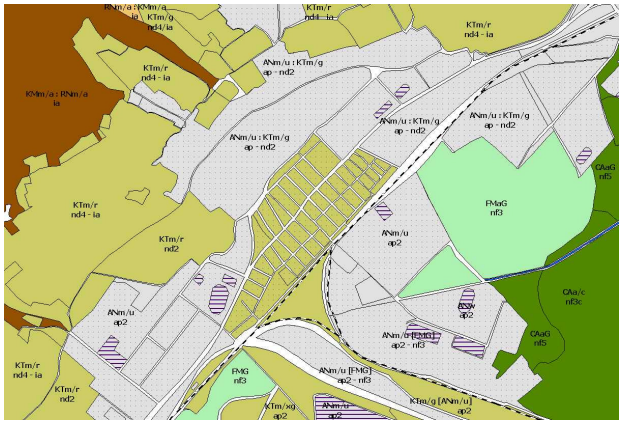


Figure 3. Detail of the soil map of Bratislava city

What are main obstacles in urban soil survey and mapping?
There are several problems:
- to identify and classify soil units with anthropic features
- to identify and classify variability of anthropogenic (technogenic) material
- to measure analytical data for noxious compounds
- to measure soil sealing using appropriate methods
- to identify auxiliary data incl. urban site history knowledge
- to use strong digging technology in urban soil pits and be aware of tubes, cables and other subsurface elements
- to respect private owners in cities at soil pits.

Conclusions
For urban planners and designers there is a urgent need to create a Manual for urban soil description, classification and assessment as helpful guidelines can be included and to enable awareness of soil in urban planning processes. Also urban survey can indicate new soil types which can enlarge the current soil classification system.

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