An attempt of integrating the systematic of urban soils into the new Russian soil classification system

**Abstract:** An attempt to incorporate the popular systematic of urban soils proposed by Marina Stroganova with colleagues into the new Russian soil classification system is presented. It was facilitated by the coincidence of approaches in both systems: priority of diagnostic horizons and their combinations as criteria to identify soil types being the main units in all Russian classifications. The central image of urban soils – urbanozem – in Stroganova’s system found its due place in the order of stratozems (urbostratozem type) owing to its diagnostic horizon – urbic, which combines artificial and natural properties, and to its simultaneous formation with the parent material.

**Key words:** principles of soil classification, soils and non-soils, diagnostic horizons, urbic horizon, urbostratozems, natural and urban qualifiers

**INTRODUCTION**

The majority of approaches to urban soils (genesis, nomenclature, classification) give priority to specific soil-forming agents that account for the main soil properties and processes. Thus, in comparison with the regimes of reference soils in the natural environment not far from the town in similar catenary position the moisture regime of urban soils is more contrasting owing to artificial irrigation and snow accumulation/removal, urban soils are warmer because of diverse heaters and effects of traffic; conversely, some of urban soils lack vegetation, which mitigates the severity of atmospheric climate (Stroganova et al., 1998). The biological cycling in urboco-systems and functioning of biota do not have any natural analogues (Craul, 1992; Klausnitzer, 1987; Sukopp and Trepl, 2000; Kasimov, 1995; Kavtaradze et al., 2000). The artificial topography with its high buildings, leveled terraces and numerous fills drastically changed the matter fluxes; nevertheless, the parent material remains a key factor to produce specific soils and differentiate them in a town. The importance attached to parent material may explain the choice of lithological criteria in many groupings of urban soils (Lehmann and Stahr, 2007; Burghardt, 2000; Sobocka, 2001; Aparin and Sukhacheva, 2012).

Several broad groups of parent material may be identified in the urban environment: (i) ‘purely natural’, which are outcrops of hard or unconsolidated rock; (ii) natural mineral material transferred and deposited in different ways; (iii) mixture of natural materials with construction and domestic wastes (bricks, cement dust, reinforced concrete fragments, etc.); (iv) humus- or organic matter-enriched material mostly of natural origin, it may be composted, or mixed; (v) artificial substrates of industrial or mining provenance. Most urban soils are formed on substrates of the groups ii...v (IUSS Working group WRB, 2006), also they receive specific additions from the atmosphere, which volume (from 0.1 to 3 g/m²/day in Moscow) may be compatible with the thickness of their horizons, and which chemical effect may be prominent (Achkasov et al., 2006).

The substrate- and function-oriented classifications of urban surface bodies should be somehow integrated into the new substantive-genetic Russian classification system (RC) with its priority of soil properties implemented in diagnostic horizons and genetic properties (Shishov et al., 2004). It is worth explaining the hierarchy of the RC. The substrate formation/pedogenesis ratio is addressed to at the highest level of this system – trunks being responsible for grouping soils into synlithogenic and postlithogenic (pedogenesis is simultaneous with the mineral substrate formation or occurs on a ‘ready’ material, respectively), and organogenic trunks (Shishov et al., 2004). The diagnostic horizons become important for the second level – orders identified by common pedogenetic processes producing horizons inherent to
all soils of the order. Still more important are the diagnostic horizons at the third taxonomic level – soil types – identified by certain combinations of horizons; finally, the diagnostic properties serve as criteria at the subtype level. Lower categories are differentiated in accordance with the degree of manifestation of soil-forming processes, particle-size composition, and fine earth/stones ratio, origin of parent material or lithological discontinuity. The technogenic surface formations – TSF, or ‘non-soils’, are described in the RC apart from soils, and their clumsy names (artilithostrat, naturfabricat) emphasize this separation (Tonkonogov and Lebedeva, 1999).

When trying to find the due place for the urban soils there, we faced problems concerning the principles and terminology, and they were solved by accommodating the former and preserving old names as synonyms for the latter. The first solution was more difficult to be reached, though it was facilitated by the common idea of horizons’ priority. The difference in principles concerns first of all the perception of soil. In RC, soils are defined as (quasi)natural surface bodies composed of genetic horizons; if there are artificial layers instead of horizons, the body is qualified for a TSF. The second group of problems was more terminological than conceptual: it was necessary to consider the existing official documents for Moscow with the functional-genetic soil names, as well as many publications substantiating these names (Stroganova and Prokof’eva, 2000; Stroganova, 1998).

MATERIALS AND METHODS

The objects to integrate were the following: soils arranged in a system used for the inventory and mapping of Moscow soils in accordance with official documents: Laws of Moscow Government concerning soils in the city (2007), environmental monitoring (2004), and information resources (2001). This system was based on the functional approaches of Stroganova with co-authors (Stroganova et al., 1998), and it used some ideas from the new Russian classification system (Prokof’eva et al., 2011). The groupings of urban soils recently proposed by colleagues from St. Petersburg (Aparin and Sukhacheva, 2012; Matinian and Bakhmatova, 2012) were also considered. These rather heterogeneous data had to be re-interpreted in terms of the RC with its main concept of the diagnostic and taxonomic functions of horizons and properties – qualifiers. This approach is similar to that of WRB, although there is a certain difference: in RC a soil type is identified by sets of diagnostic horizons, while a RSG in WRB is keyed out by the occurrence or absence of a diagnostic horizons, the lower-level qualifiers are used in approximately the same way.

The method to work out an appropriate solution was the comparison of ‘central images’ of urban soils from the point of view of their origin, functioning and substantive ingredients – horizons or layers – with the units of the RC. All soils (and TSFs) discussed correspond to the order of Anthropogenic soils in the Polish Soil Classification system (Komisja V Genezy, Klasyfikacji i Kartografii Gleb PTG, 2011).

RESULTS AND DISCUSSION

Basing on the concept of diagnostic horizons and diagnostic properties the central images of urban soils were allocated among soils and non-soils in the RC (Table 1). Most of them have a specific urbic diagnostic horizon; it was introduced as such by Stroganova with co-authors (1998) (Fig.). As a diagnostic element of filled substrates with artefacts, it appeared in the names of soils in different versions of the legend to the FAO/UNESCO Soil Map of the World, later it became a qualifier in the WRB (2006). Urbic has several provisional definitions (Gerasimova et al., 2003, Prokof’eva et al., 2011).

Urbic horizon (UR) is the horizon formed synthetically (concurrently with the parent material addition) in the course of biogenic transformation of organomineral natural and/or artificial substrate under the effect of human activities in the settlements. The volume of artefacts in it exceeds 10%. It is dark in color, has a weak structure, rather light texture and varying carbon content. Its particular feature is the elevated concentration of phosphates, toxicants and pathogenic bacteria, alkaline to neutral pH values. The
problem of the horizon’s definition is the variation of properties depending on the zonal position and place in the functional zone of the city, share of the ‘cultural layer’ material, age of the horizon, etc. Carbon content and humus composition vary in a broad range dependent on climatic conditions, moisture regime, vegetation and content of carbonates. Therefore, it was suggested to make part of the definition of urbic horizon relative to the reference soil. For example, in the urban soils of the forest zone, their topsoils are always less acidic than those in the reference soils owing to the input of carbonate-enriched construction wastes; this pH shift was not recorded in the urban soils of the subarid regions (Privalenko and Bezuglova, 2003). The criterion of artefacts is universal while that of texture is less important, and the elevated content of toxicants may be efficient for one or several groups of compounds (PAHs, HMs). Typical for urbic horizon is the human-induced addition of material, as with dust and aerosols, so with the surface runoff or through application of sand or organic fertilizers. The biological activity of the urbic horizon is shown to be elevated and increasing with its age (Rahleeva et al., 2007); hence, the introduced substrates and artefacts are obviously reworked and incorporated into the horizon’s body (Prokof’ieva et al., 2010). Such is the image of the urbic horizon – the most important diagnostic horizon for soils in towns, and its definition might be improved with the new data collected.

One more diagnostic horizon was proposed for the soils in the cities – filled organic-humus and mineral – material, with peat additions, produced by composting for the rehabilitation of damaged lands or reclamation of poor mineral substrates; it is almost unchanged by pedogenesis, its properties strongly vary depending on the technology of its production. Its index is RAT, which means Rehabilitation material in A horizon position with peat – T. Similar formations were named ‘introduced material’ by B. Aparin and E. Sukhacheva (Aparin and Sukhacheva, 2012) and described as diagnostic for soils of St-Petersburg. Thus, two diagnostic horizons were introduced for the urban soils. In accordance with the rules of RC, their combinations with ‘natural’ horizons or substrates give types of urban soils.

One more group of soil types in the towns is related to the technogenic deposits (TCH) of different composition and origin: cultural layers, transported industrial and construction materials, both natural and human-made, and municipal wastes. The TCH substrates may be combined either with UR and/or RAT horizons, or with the natural ones. Most common among the latter are the weakly developed W or O
horizons, however, more advanced horizons (AY, AU, AH, H…)\(^1\) are not impossible.

Soil types with the above horizons may occur in all trunks (Table 1) in RC (urban soils of organoge
cnic trunk are very few, however, the city of Arkhan
gel’sk built on peatbog may have such soils). Special comments should be given for two cases: urbo-soils
in any order in the postlithogenic trunk and in the stratozem order in the synlithogenic trunk. Urbo-soils
are soils with urbic (and/or RAT) horizons and identifiable remnants of initial natural subsoil. For
example, these may be urbo-podzolic, urbo-alluvial soils. This approach is borrowed from the RC with its ‘agro-soils’ (Stroganova, Gerasimowa, Prokof’eva, 2005).

As for stratozems, the most typical soils of towns – urbanozems with their urbic horizon and continu
ing addition of material – may be termed urbostra
tozems on the natural or technogenic substrate, or on a buried soil.

Soils of the next taxonomic level – subtype – are easily identified and named following the rules of RC. The subtype qualifiers for natural phenomena like gleying, salinity, solonetzic, etc. are taken directly from the RC, while qualifiers for the urbic phenomena are also derived from the corresponding horizons and also indicated by lowercase letters. For example, we have a truncated soddy-podzolic soil with a 15-
cm-thick filled RAT horizon (or gradually accumulated UR horizon), with weak gleyn manifestation, and thin layer (< 5 cm) of sand mixed with petroleum; the profile formula will be: RATrx(URrx)-BELtr-BTg-C.

The volume of the paper does not permit to dis
cuss the non-soils (TSF), except for one aspect. We regard such formations made by depositing different layers - quasizems (constructozems, recreazems, technozems in the function-oriented systems) as non-soils only for rather a short time period, when they are not yet modified by soil processes (Table 1). As mentioned earlier, these processes are quick in towns, and the state of TSF is transient. In 1–2 years (in Mos
cow), a weakly developed humus horizon (W) ap
ppears, roots of pioneer plants colonize the filled lay
ers, and the TSF-substrates evolve into a weakly de
developed technogenic soil. The quasizems with thei
r RAT or RT horizons evolve into soddy technoge
nic soils approximately in 10 years. The temporal na
ture of the majority of TSFs does not exclude them

\(^1\) W – thin dark layer interlaced with roots; O – litter; AY – gray-humus horizon with crumb structure and AU – dark-hu
mus horizon granular structure; H – indicates mucky material.

from classification, since they should be mapped, and mapping units must have names.

**CONCLUSIONS**

Soils in urban environments cannot be classified apart from all other soils, and most of them are easily incorporated into the existing system of soil classification in Russia. The main prerequisite for performing this procedure is the priority of diagnostic hori
zens in both urban soils systematic and RC.

To integrate the urban soils, the set of diagnostic tools should be extended, and two specific urban ho
rizons and one layer were proposed (UR, RAT and TCH) with the derived qualifiers. The definition of urbic diagnostic horizon is not yet final, and it should be checked for its suitability for cities and towns other than Moscow.

The central image of urban soils is urbanozem, it fits the criteria of stratozem order (embracing soils, whose profiles are formed along with the accumula
tion of the solid-phase material on their surface – synlithogenic pedogenesis) in RC, and may be defined as urbostratozem at the type level.

Rates of urban pedogenesis are elevated, so that
the initial difference among and within the artificial bodies, deposited or truncated, is gradually mitigated owing to human efforts aimed at improving environment and soils for raising life standard. Probably, the trend to convergence of soil properties is a gene
ral pedogenetic trend, which tends to produce urba
nozem (urbostratozem) as an equilibrium urban soil.

Presumably, this experience of correlating the tra
ditional (or applied) and new basic soil classification systems may have a broader interest than only for Moscow; another aspect of studying soils in towns is a more adequate qualification of central images of urban soils and their taxonomic position in the contin
nuum of natural and anthropogenic soils.

**REFERENCES**


Aparin B.F., Sukhacheva E.YU., 2012. Principles of urban soils classification (with the example of S. Petersburg). (in Russian) [In:] Proceedings of the All-Russian Conference „Geochemistry of Landscapes and Geography of Soils“, dedicated to the 100th birthday of M.A. Glazovskaya. Moscow Lomo

Burghardt W., 2000. The German double track concept of classi
fying soils by their substrate and their anthropo-natural gene
sis: the adaptation to urban areas. [In:] Proceedings of First
International Conference SUITMA. Germany, Essen, 1: (Burghardt W. and Dornauf Ch. Editors): 217–222.


