Soils and Man-Made Surface Formations in Urban Landscapes

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Abstract. Intensive and diverse human activity in large cities and their environs leads to a significant change in the environment: the relief, hydrographic network changes, natural vegetation is destroyed or replaced by urbophytocenoses, the soil cover is greatly transformed, climatic characteristics change, i.e. a specific type of urban microclimate is formed. In large cities, the anthropogenic impact becomes predominant over the natural factors of soil formation, which leads to the formation of specific soils and soil-like bodies (formations). In this case, the type of land use is the determining factor of the soil cover. Adverse environmental impacts lead to soil degradation, resulting in the destruction of vegetation. All this together leads to a deterioration in the chemical composition of the air and the general environmental situation that affects people's health. Unfavorable ecological processes significantly impede (prevent) the fulfillment by soils of the ecological functions assigned to them. A significant part of the territories of large cities is located in the zone of action of negative processes that affect the ecological state of the soil cover and soil functions. Ecologists predict that these impacts will intensify.

1 Introduction

The terms “urban soils” and “city soils” appeared at the early stages of studying soil formation in the urban environment and were defined in different ways [1]. The “soils of a city” include any soils on its territory: natural or almost natural (with a natural profile and analytical diagnostics of pollution or biogeochemical features that are clearly different from natural soils), “semi-urban” urban soils and actually “urban soils” - urbanozems and their variants [4]; the separation of urban soils from non-soil formations is carried out conditionally. It is generally accepted that they perform the ecological functions of soils and, therefore, can be considered as soils [9]. In foreign publications, urban soils mean not only urban soils, but also those that are in In the domestic tradition, it is customary to call technogenic soils, that is, soils disturbed by mining.In the international classification (WRB), all urban soils are included in the Technosols reference group. The present stage of soil evolution was preceded by a long stage of historical anthropogenic evolution of soils, in which human impacts were mainly local or focal, mostly indirect and manifested through changes in biota, as well as through changes in relief and hydrological conditions. The

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historical anthropogenic evolution of soils was characterized by complexity, alternating periods of landscape and soil transformation under human influence and periods of their restoration. In contrast to modern processes of soil transformation associated with direct intensive impacts under conditions of dense development, the ancient ones were predominantly indirect [3]. However, despite the relative weakness, discontinuity, and lower density (often, locality) of the impacts of the historical stage, its traces, due to its long duration, were in many ways quite pronounced in soils. The long duration of the historical period allowed evolutionary processes with long characteristic times to manifest themselves in the soil profile and soil cover. So, among them are the phenomena of degradation and progradation of soils, in terms of severity comparable to those that have natural causes. The main reasons for these processes, which are combined into the group of historical anthropogenic evolution of soils, were plowing, clearing forests and replacing them with secondary meadows, production activity, and the functioning of settlements. The historical anthropogenic evolution of soils is mainly characterized by nature-like processes similar to natural ones in their manifestations, but provoked by man. With such a similarity, they may differ from natural ones in quantitative parameters (usually they are faster), and partly in the nature of hydrothermal and lithological-geochemical conditions . Anthropogenic changes in soils in some areas began long ago. Plato writes about the rampant denudation caused by human activity and the depletion of the soils of Attica and Fr. Aegina in the 5th-4th centuries. BC. Soil degradation processes in Mesopotamia are even older [4].

Ancient traces of anthropogenic evolution are cited by F. Duchaufour (1970). He classifies the phenomena of transformation of brown forest soils, which are widespread in Western Europe as a result of felling, to the category of soil degradation. Soils under old oak forests with an admixture of beech in protected areas are similar on different rocks: limestones, dense clays and sands. These are brown forest soils with mullein humus [5]. The A horizons in them are carbonate-free and slightly acidic, but the B horizons lying at depth differ. On limestones, horizon B contains calcium carbonates (brown calcium-morphic soils according to Duchaufour); on dense clays, it is sometimes saturated with water and is characterized by patches of gleying (brown marbled soil); on the sands, it is enriched in iron and colored red (burozem). In connection with the intensification of human activity dating back to the Bronze Age and especially to the time of antiquity, forests were burned and used for pastures. As a result of this and under the influence of anthropogenic erosion, soils and vegetation degraded. Depending on the nature of the parent rock, anthropogenically modified soils are represented: on limestones, by thin rendzines under a xerophilic meadow; on clay, pseudogleys (texturally differentiated surface gleyed soils) under wet wasteland; on sands - podzols under dry wastelands [6]. The vast areas of prograded (regraded) soils should be associated with ancient human influences. They coincide with the territories mastered by the Scythian farmers. Agriculture is the most important branch of the economy, without studying which it is impossible to restore the different stages of the history of the development of society and the corresponding changes in the natural environment. Like many other factors of anthropogenic transformation of soils, agriculture includes a diverse range of impacts on soils and has a long and complex history, characterized by changes in the intensity and methods of farming. The special significance of agricultural impacts on soils is manifested in the fact that they are distributed over large areas. At the same time, significant changes in the morphological, chemical, and physical properties of soils, as well as large changes in the soil cover, are associated with them. Therefore, it is impossible to understand the current state of the soils used in the economy and imagine their further evolution without knowledge of the history of agriculture.

2 Research Methodology

A.L. Aleksandrovsky and S.N. Zharikov (1990) collected and summarized a large amount of literary and cartographic material and compiled maps of the duration of agrogenic impact on the territory of the world and certain regions of the European part of Russia. The analysis of these maps is important not only for revealing the agrogenic patterns of soil geography, but also for analyzing the natural patterns of pedogenesis, both actualistic and evolutionary [1-2]. This is due to the fact that modern soil formation is superimposed not on a purely natural background, but on a background modified to varying degrees by anthropogenic processes of the past. In this respect, Eurasia must differ significantly from North and South America and from Australia, whose agriculture before colonization by Europeans was local or undeveloped at all. The proposed map (Fig. 1) focuses on agricultural development. Agricultural impacts can be subdivided into direct and indirect ones. Direct impacts directly change the soil and topsoil. They cause turbation of the upper and less often deep horizons; causing the formation of a plow pan and the like; stimulate soil erosion. Indirect impacts affect soil changes through changes in other landscape components such as vegetation [11]. Thus, meadow cenoses that exist at the site of fallow or felling in the forest-steppe zone and in the south of the forest zone enhance the sod process.

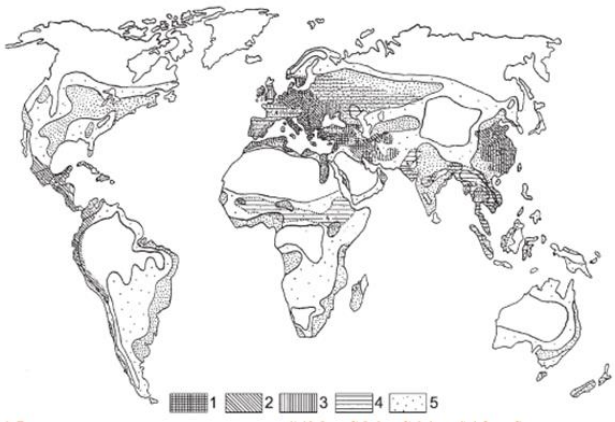

Fig. 1. Duration of agricultural development of soils in the world: 1) 10–8 t.l.; 2) 8–6 t.l. 3) 6–4 t.l.; 4) 4–2 t.l.; 5) modern landscapes: dense dots - highly modified (arable land, orchards, vineyards, plantations) rare dots - moderately modified (pastures, hearths, agriculture, clearings) without dots - little changed (natural landscapes, secondary forests)

In the classification of soils in Russia, as in some others, the taxonomic position of the soils of the city, slightly changed by its influence, does not cause any particular difficulties, and they are classified together with natural soils at the level of subtypes [8]. Changes are understood as pollution and the presence of a foreign substrate on the surface; according to these genetic features, the corresponding subtypes are distinguished: chemically polluted (x) and urbanized (ur). However, even in this, at first glance, a simple classification decision, much remains unclear, not only in relation to the quantitative criteria for both genetic traits, but also in the essence of the traits themselves, which are closely related to the definition of "urban soils" proper. This is even more true for transitional urban soils [6].

In addition, the impacts are divided according to their duration in time, which is associated with the use of different farming systems. They can be intermittent (slash-and-burn, shifting, fallow) and continuous action (monopoly and two-three-field systems, crop rotation, etc.) [7]. Agrogenic impacts change the soil to varying degrees. At the same time, soil change depends on the technology and intensity of farming: cultivation with a digging stick, hoe, shovel, plowing with a plow, plowing with a plow (shallow and deep), planting,

soil construction, etc. and anthropogenic soils [12]. The developed soils are slightly changed and differ little from the virgin soils; cultivated and cultural are formed with higher agricultural technology; the converted ones have been significantly changed as a result of reclamation; anthropogenic are newly created by man (for example, recultivated, "rice" soils) [8]. After the cessation of exposure, the soil either recovers within a certain time and becomes almost identical to its natural counterpart, or changes irreversibly. The change in properties can occur both gradually (multi-stage) and abruptly (single-stage). According to the degree of their manifestation, changes are divided into deep - affecting most of the profile (deep plowing, melioration) and small - concentrated in the upper part of the profile (cultivation, hoe farming), and according to spatial expression - into continuous (area), local (point, focal) and linear [9].

3 Results and Discussions

In the history of the development of many regions, there were significant breaks associated with changes in the geographical environment, including the social component. The territory as a whole was developed unevenly - in separate spots (foci) and unevenly in time: locally-pulsating nature of development or focal-periodic at a higher level of its development. The socio-economic heterogeneity of a society at any stage of its development is associated with a different level of development of the productive forces, therefore, with a different impact on the components of the geographic envelope [10]. In this regard, there is a metachronous development of society and changes in the environment [13]. Within the ranges of archaeological cultures, there are clusters of monuments, around each of which, development could be continuous, but between them there were significant undeveloped spaces. Usually, the ancient farmers settled along the river valleys, and the interfluves were settled later. At the same time, preference was often given to areas with more easily cultivated sandy soils. The discontinuity and discontinuous nature of the impacts led to the restoration of fertility and the genetic profile of soils during periods of interruptions in human activity. Therefore, only the effects of the last stages are reflected in the modern soil profile, which, moreover, differ in the great intensity and depth of the effects. The division of crops into agricultural and pastoral is to a certain extent conditional. Thus, ancient agricultural cultures from the moment of their appearance included both cattle breeding and elements of an appropriating economy [11]. The Trypillians at the first stages of the development of their culture were engaged in hunting, cattle breeding and agriculture in approximately equal proportions; then - mainly agriculture and cattle breeding, and only at the last developed stage - mainly agriculture. The economy of the pastoralists of the steppe zone was "cleaner", but it was also associated with agriculture, since without fodder reserves, cattle breeding became risky. Therefore, elements of agriculture arise within the pastoral cultures themselves, and conditions are also created for the settlement of farmers in the vicinity of nomadic areas. In Western Europe, the cultures of pastoralists and farmers often coexisted on the same territory, exchanging their products [12].

The historical anthropogenic evolution of the soils of the forest-steppe differs from the natural Late Holocene one: the reverse course of the process (progradation instead of degradation) and the reverse displacement of zonal boundaries to the north; mosaic and a large number of identified options; what was quite recent (the last 1000 years with maximum activity in the last few hundred years); often faster processes. The historical anthropogenic evolution of soils differs from the anthropogenic and technogenic one in its longer duration, less mosaic nature, and the possibility of implementing processes with medium and long characteristic times. In many cases, these natural processes provoked in the historical past by man, but in fact, natural processes are moving towards the restoration

of the pre-anthropogenic state of soils and geosystems. In addition to the phenomena of progradation, the historical anthropogenic evolution of soils in the forest-steppe and forest zone is also characterized by degradation erosion-sedimentation processes. In the key areas of Radonezh, Podolsk, and Kulikovo Pole, thick deluvial strata 1–2 m were revealed, composed of material from arable horizons and filling the bottoms of ravines and valleys of small rivers. The beginning of their accumulation dates back to the 13th-14th centuries. Due to the long history of erosion, compensatory soil formation led to a partial or almost complete restoration of the profile of eroded soils [15]. Therefore, in areas with a long history of development of agrolandscapes, there is a discrepancy between thick eroded and weakly eroded soils. It should be noted that plowed soils are restored under natural vegetation in several decades. In the more western regions of Europe, the duration of the historical stage of the anthropogenic evolution of soils is longer. Agriculture began here in the Neolithic and further intensified during antiquity. There are significant areas of graded (regraded) chernozems and dark gray forest soils [14]. Their formation should be associated with anthropogenic deforestation, begun by the Scythians long before the emergence of the Old Russian state. In the steppes of the southern part of the Russian Plain, the progradational direction of pedogenesis at the stage of natural soil evolution changed to the degradation of the anthropogenic stage, which is opposite to the evolutionary trends in the forest-steppe and forest zone.

4 Conclusions

The experiments carried out to assess the state of urban soils by biological indicators confirmed the decrease in the ecological functions of soils in areas of negative impact on urban lands of emissions from industrial enterprises and vehicles. The assessment of soil phytotoxicity obtained by the method of seedlings of test plants at different stages of technogenic change in urban lands serves as a sensitive recording response, while analytical research methods are effective when threshold values of pollutant concentrations are reached. Sufficiently high information content of biological assessment methods is confirmed by the revealed relationship: an average correlation was established at a 95% probability level between soil phytotoxicity and its biological activity . Reducing the total technogenic load on urban lands located in the zone of influence of industrial enterprises should be carried out through special management measures aimed at minimizing pollutant emissions from potential sources.

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