ACTA SCIENTIFIC AGRICULTURE (ISSN: 2581-365X)

Volume 3 Issue 8 August 2019

Review Article

The Importance of the Soil in Urban Land Ecological Safety

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Received: June 03, 2019; **Published:** July 22, 2019

DOI: 10.31080/ASAG.2019.03.0583

Abstract

A new direction in the functioning of cities is the cultivation of food for citizens. Therefore, the assessment of soil and their ecological functions in cities is relevant. The paper presents the results of the content of heavy metals, humus, exchangeable sodium, pH, Eh in the soils of urban forests and urban cities of Moscow. It is shown that the soils of urban forest parks are the least polluted. They are close to zonal sod-podzolic soils in terms of humus content, pH and Eh.

The soils of the residential area of Moscow are contaminated with heavy metals throughout the soil profile (up to 80 cm), characterized by a high content of organic carbon and pH values from 6 to 7.9. The weakly alkaline reaction creates supportive environment for pathogenic microorganism which raises the exposure to diseases with people so special attention should be paid to organizing and monitoring of playgrounds, closes and sports grounds. It is proposed to use the ratio of heavy metals content in the soil to determine the source of pollution.

It has been shown that sodium accumulation in the soil absorbing complex leads to the accumulation of sodium, but in the summer and autumn the salts are carried out beyond the root zone. The use of highly soluble salts may cause stress with plants up to their death.

Keywords: Soil; Urban Lands; pH

Introduction

Like any other environmental setting, urban lands are characterized by different types of ecosystems, landscapes. The cities occupy a part of the anthroposphere, insignificant on the area – 2-3% (Figure 1). Well known, that the number of cities and population grow every year. By 2050 it will be more than 70% of the total population of the planet [1]. So the problem of urban ecosystems stability and organization is topical even today.

The population size and its density in metropolitan cities form a specific ecological environment. But the basic element of providing of urban lands stable development stays the same – natural ecosystems. More than 13 million people live in Moscow, the average population density is 4880 people / km. A new direction in the functioning of cities is the cultivation of food for citizens. There is the possibility of legislative management of soil quality. Therefore, the assessment of soil and their ecological functions in cities is relevant.

The purpose of the presented work is to evaluate the ecological functions and risks of urban soils in Moscow.

Figure 1: Cities as part of antroposhpere.

Objects and research methods

The soils were explored in two different zones of the megapolis Moscow: these are the «cleanest zones» of forests and parks (urban forests) and the most polluted parts of the city are roadside sites, playgrounds, residential areas (urban). As a result, 67 cuts were laid and 246 samples were taken.

The total content of heavy metals in the soil was determined by the X-ray fluorescence energy dispersive method and the results were expressed in mg/kg. The content of organic matter, exchangeable Na and pH, Eh was determined by traditional methods [2].

Results and Discussion

City ecosystems: There are some functional areas in the city: buildings of different purpose (educational institutions, offices, factories, plants, living accommodations, etc); roads, streets, squares; lawns, groups of trees along the reads; playgrounds, parks and avenues with simulated landscape, playing fields, cemeteries; urban forests (most closely approximate to natural ecosystems). There are areas with a special artificial biosphere – zoos, botanical gardens, greenhouses. They possess the highest possible biological diversity including endemic species. Special city areas also include areas of underground space (electrical grid and heating network, sewerage system, etc); bodies of water (ponds, small and large rivers, springs); overhead power transmission lines; landfills. The cyber-domain is a particular ecological environment. For example, messengers become a part of the new city space. Since 2013 the WhatsApp audience has increased in two and a half times and exceeded 1 billion users. Whatsapp, as a global electromagnetic environment, has a diverse impact on organisms and humans [10-14].

Different types of city ecosystems vary not only in their functional role but also in ecological state closely related to the human activity and health. For example, on the territories of underground services (electrical grid and heating network, sewerage system, etc) the soil gets thoroughly warmed in spring 2-3 weeks earlier. Consequently there is the awakening of the soil biota which includes ixodic tick provoking diseases with dogs. This is shown by the increased number of visits to animal clinics made by the owners walking their dogs at the territories of underground services.

The city ecosystems most closely approximate to natural ones are the urban forests. In Moscow the biggest ones are Elk Island, Sokolniki, Neskuchny Garden, Izmailovsky Park, Bitsa Park, etc. The second group of territories is typical urban areas: road-side lawns, private garden spaces, playgrounds and closes, etc. The comparing of soils of these two groups (urban forests and city ecosystems) shows the major difference between them in ecological properties.

The particularities of the soil cover in the city come down to the following. City soils are rich in organic matter, total nitrogen, potassium, phosphorus. Improving the quality of urban soils is achieved by applying organic fertilizers and peat in the composition of lawn soil-like mixtures. The subacidity or shift to mildly alkaline area (pH 6,0-8,5 compared to Moscow urban forests pH 4,0-7,0) and the redox potential (100-400 mv compared to Moscow urban forests 250-450 mv) create supportive environment for microbial communities including pathogenic ones (Table 1) which raises the exposure to diseases with people.

Disease	pH Optima
Leptospirosis	7,2-7,4
Pseudotuberculosis	7,2-7,4
Yersiniosis	6,9-7,2
Salmonellosis	7,2-7,6
Tetanus	7,0-8,2
Tularemia	6,8-7,4
Brucellosis	6,6-7,4
Botulism	7,4-7,6

Table 1: Optima of the environment acidity for pathogenic agents.

Therefore the soil medium reaction (its alkalinization) is a risk factor for human diseases in cities.

City soils are polluted with heavy metals, their content exceeds the permissible exposure limit. However the soils of Moscow urban forests can be considered relatively “clean” in comparison with other city areas (Figure 2).

Figure 2: The heavy metals distribution in the soil profile in Moscow urban forests and city areas [2].

So, in metropolitan cities the urban forest soils which could be considered a control sample distinguish by "ecological cleanness" in comparison with other city territories (road-side lawns, private garden spaces, etc). Therefore while comparing soils of different cities in their pollution rate it's necessary to specify what functional zones were examined.

There are ecological maps with heavy metals distribution in the soils made for many cities. There are maps like this for Moscow too [3]. They give the general picture of the ecological state in city districts, of the general pollution of the territory. Still the maps don't give grounds for identifying the pollution source to collect damages and pay for the recovery work. In this respect the soil may help the municipal government. Unlike other ecosystems the city is notable for the high population density and high concentration of different buildings among which the pollution sources (plants, factories, gas stations, CHPP, roads, etc). The urban infrastructure creates special conditions in which the territory is often under the impact of many pollution sources. And the soil accumulates all polluting substances in its profile. To be noticed is that the export of heavy metals out from the soil profile is very insignificant [5]. Along with this the organic matter appears for the soil element binding the heavy metals. The organic matter content in the urban soils is elevated because the lawn soil mixtures contain peat and fertilizers. On the contrary the urban forest soil contains less of them (Figure 3). That's why in typical urban areas there's a bigger chance of accumulation of polluting substances in the soil than in the urban forests.

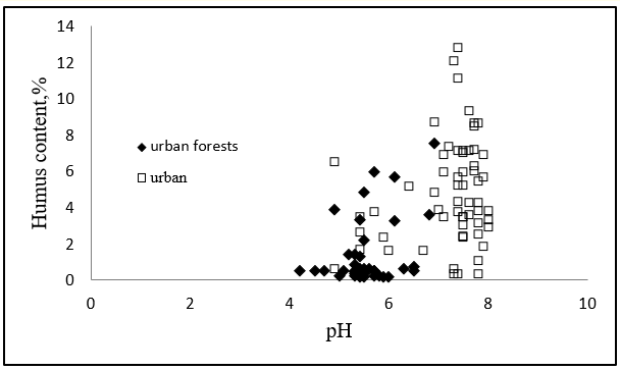

Figure 3: Humus content in the urban soils of Moscow depending on the environment acidity.

Consequently heavy metals accumulate in Moscow soils in spite of the flushing regime and it is a risk factor for the plants life activity.

There are two approaches to evaluate the pollution of the soil by heavy metals: on the basis of the total content of elements and on the basis of correlation ratio of technogenic elements, for example, Pb:Zn:Cd:Ni. The ratios of accumulation of chemical elements in the soil in the zones affected by manufacturing plants depend on the manufacture and emission type. For example, for the ciment manufacture there is the concentration ratio higher than 10 for the metals: mercury, strontium and zinc; for the superphosphate fertilizers – copper, chrome and arsenic; for the electronic and electrotechnical industry devices – antimony, zinc, bismuth, etc. So certain metal correlations in the urbanozem can be the key to finding the pollution source. However the solution of this vital problem demands special formulations.

Salts in the city

Let's consider the highly soluble salts behavior in the urban soils of the humid zone with flushing regime. They are absent in zonal sod-podzol soils. All highly soluble salts are in the urban area in South taiga zone of anthropogenic origin. They are dispensed on the walkways and on the roads as remedy for ice-slick. The ice-melting products in Russia differ in chemical properties, in classes of hazard (from safe up to class III) and in price: from 1000 rubles for a ton up to 9000 rubles for a ton [5]. The application of salt reagents in winter causes the anthropogenic soil salinization in spring during the melting of snow but in autumn the salts content in the upper horizon sometimes falls down to total disappearance in the soil profile.

However the high concentration of salts in spring causes stress with plants: the nutrient enrichment becomes slower. In 1997-1998 the salinization caused massive trees mortality in Moscow [6,7]. So the elevated salts content in urban soils in spring is a risk factor for plants life activity. By stemming the risk of road traffic accidents by deicing agents we shift the risk area from transport to ecology.

Conclusion

The urban lands are marked by different types of ecosystems, landscapes and by the pollution degree: from "clean" (urban forests) up to "heavily polluted" (urban). That's why at the evaluation

of city pollution it's necessary to specify the type of certain functional areas. Typical urban soils are rich in organic matter, total nitrogen, potassium, phosphorus. However the subacidity or shift of pH to mildly alkaline area and the low redox potential create supportive environment for pathogenic microorganism which raises the exposure to diseases with people. The making of soil pollution maps isn't always enough to evaluate the urban area pollution. The anthropogenic impact on soil properties dynamics is too strong and the works themselves are very expensive. The methods of pollution source identification after the soil properties are presently topical. Their elaboration will be necessary in a short time when the environmental damage compensation and the compensation for the soil reclamation works will be normal.

The correlation ratio of heavy metals in urban soils can be used for the pollution source identification. A lot of heavy metals and organic matter in the urban area provide a background for their accumulation in the soils. It becomes a risk factor of microorganisms and plants "health", and also it threatens by increasing of soil abiotic catalytic activity [8]. The use of salt mixtures as ice-melting products in winter causes the anthropogenic soil salinization in spring during the snowbreak. The highly soluble salts in the soil cause stress with plants, check their growth, suppress their nutrient enrichment, and also causes trees' death.

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