World Applied Sciences Journal 27 (7): 845-849, 2013
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2013.27.07.13723

The Research of the Biological Properties of the Rostov Region Soils

Olga A. Kapralova, Sergey I. Kolesnikov, Tatyana V. Denisova,
Ekaterina V. Naleta and Svetlana A. Tishchenko

Southern Federal University, Rostov-on-Don, Russia

Abstract: The article is devoted to the research of the effects of urbanization on ecological and biological properties of soils of Rostov region. The biological activity of soils of various functional areas of Rostov region (industrial areas, transport areas (crossroads) and parks) was analyzed, the regularities of the influence of urbanization on the biological properties of the soil were set: the number and activity of microorganisms, enzyme activity, etc. The investigated parameters allow reason about changes in biological activity of soils under the influence of anthropogenic pressure and can serve as a theoretical basis for the development of methods for monitoring the status of urbanozem.

Key words: Soil pollution · Heavy metals · Biological properties · Urban soils · Rostov region · Urbanization

INTRODUCTION

In the Rostov region untouched natural soil almost have not survived, all of them are affected by the processes of urbanization or agricultural activities. Ecological and geochemical studies conducted since 1989 showed that the qualitative and quantitative composition of HM in urban soils depends on the specificy of the industry and functional areas of the city [1-5].

The soil of the following urban landscapes were subjected to the studying regarding their functional load: industrial areas, transport areas (crossroads) and parks. The purpose of research: to establish patterns of changing of the biological properties of the soils of the Rostov region with heavy metal pollution.

MATERIALS AND METHODS

As objects of study soils of different functional areas of Rostov region were used industrial areas, transport areas (crossroads) and parks.

Transport areas (14 sites) includes roadside area along the highways of the city with the movement of varying intensity.

Industrial areas (4 sites) - the territory of industrial areas: plant "Empils" - one of Russia's largest producers of paints and zinc oxide, the plant "Molot" - printing production with 90-years old history, factory "Rostselmash", machine-building enterprise producing combine harvesters, etc.

Park areas (8 sites). The area is formed by the territories, which include park "Pleven", Gorky Park, Cherevichkin park, park "Friendship", etc. These sites occupy different positions in relation to major local sources of pollution of the city and also have significant differences in their genesis.

The granulometric composition of the soil of the city attributed to a variety of heavy and medium loam, with a predominance of large fractions of dust and mud. The pH of the soils in the study ranged from 7.6-7.8. The difference between the humus content of the samples examined was insignificant bands - from 2.6 to 3.4 %.

Methods: The investigations were carried out at the Department of Ecology and Nature Management, Southern Federal University.

Selection of soil samples from the upper layer was conducted on experimental plots with a depth of 0-20 cm. All venues were the lawns with well-developed herbaceous cover.

Soil sampling of full-profile cuts was held at each point of observation collected soil samples from all genetic horizons and anthropogenic layers and conduct mandatory morphological descriptions [6-8].

Corresponding Author: Olga A. Kapralova, Southern Federal University, Bolshaya Sadovaya, 105, Rostov-on-Don, Russia.

In the soil samples by X-ray fluorescence spectrometer "Spectroscan Max" content determined Cr, Cu, Ni, Pb, Zn, Sr, V, Co, As. Most often the soil of Southern Russia, including cities, polluted by these metals (6-8). To assess the cumulative effects of pollutants in an integral index was used the total coefficient of technogenic pollution (ZC), which is calculated based on adding the coefficients of technogenic pollution of the individual elements [9].

The identification of biological soil properties was performed using generally accepted in the biology and ecology of soil modification techniques [10]. Determined the abundance of bacteria of the genus Azotobacter, the activity of catalase and dehydrogenase phytotoxic properties of soils and other indicators.

Based on the most informative parameters determined integral indicator of biological state (IIBS) soil [11]. The present study was designed IIBS on the following parameters: the activity of catalase and dehydrogenase, an abundance of bacteria of the genus Azotobacter, radish seed germination rate (germination). Catalase and dehydrogenase belonging to the redox enzymes which are most sensitive to chemical contamination. Bacteria of the genus Azotobacter is traditionally and successfully used as an indicator of soil contamination by HM. Radish seed germination reflects the phytotoxic properties of chemically contaminated soil. The present set of indicators provides an informative picture occurring biological processes in the soil and its ecological status.

To calculate the value IIBS each of the four parameters mentioned above for controlling (in the uncontaminated soil) taken as 100 % and with respect thereto are expressed as a percentage value in the other embodiments, the experiment (in control soil). Thereafter, the average of the four selected indicators for each variant of the experiment. The procedure used allows to integrate the relative values of different parameters, the absolute value of which cannot be combined into a single component, as they have different units.

The results of the research were the basis for the variance and correlation analysis. analysis. For the calculations was used a computer program Statistica 6.0.

RESULTS

Estimates of GDP HMs in the surface layer of soils of the Rostov region showed the presence of multielement pollution. In urban soils average concentrations of zinc, cobalt, nickel, lead, arsenic, copper, strontium, higher values for natural soils (Table 1).

In general, the evaluation of the concentration of chemical elements in soils of the city on the scale of the danger of contamination of soil, prepared on the basis of overall pollution index value (Zc), revealed Contaminant Level (Zc from 1 up 15 conv. Pcs.) Parks and road junctions, moderately hazardous (Zc from 16 to 32 conv. pcs.) - for the industrial areas of the Rostov region.

The central part of the soil contaminated with HM more than western and northern residential areas of Rostov-on-Don. This is due to prolonged exposure (late 19th century) on the soil of industrial enterprises in the city center and major influence of some crossroads now.

The study found that in some cases the content of zinc in the soil, arsenic, copper, lead and cobalt values significantly higher than the maximum permissible concentration (MPC).

Zinc is a priority pollutant of the study area. Concentration ratio of contaminants equal multiplicity exceedance of this component of the background (control) values in soil Persianovskaya steppe showed excess zinc in the soil in the area of 30.9 times the plant "Empils" (site 3), Russia's largest manufacturer of decorative coatings and zinc oxide (zinc oxide), located in the city center. Concentration ratio of zinc in the soil of the transport area (site 11) is 4.1; site 15 - 3.9, in the Parkland - 4.2. High coefficient of zinc concentration in these areas can be attributed t o the close proximity (1.6-2.2 km) to the specified industrial facility. This testifies to the industrial origin of the accumulation element.

Win sites, in which the soil lead content of 2 or more times higher than the background, is 30% of their total number. The maximum level of accumulation observed in soils of industrial area, also exceeding the background values observed in the transport area. Soil parkland showed lead levels close to background.

Biological evaluation of soil condition in Rostov-on-Don, showed that the average value of IIBS in the Rostov parklands - 82.1%, in the crossroads - 73.1%, in the industrial areas - 65.9%. The maximum value of IIBS - 102.2 % is typical for soil sampled in the park "Pleven" (site 5), 95.9% - in the park "Friendship"(site 8), 92.3 - in soil of the transport area (site 10) (Table 2).

Minimum values IIBS - 51.1% registered in soils sampled near the plant "Empils" (site 3), 60.5 % in the soil on the site 9, 58.4% - in the soil sampled in the Gorky park (site 7).

Table 1: The total content of heavy metals in soils of different functional areas of Rostov region, mg / kg

Hemical element	Hazard classification according to GOST 17.4.1.02-83	Control soil (Persianovskaya steppe)	Industrial areas (n = 4)	Transport areas (n =14)	Park areas (n =8)	Maximum permissible concentration (MPC) (total content, mg / kg) according to GN 2.1.7.2041-06
Zn	I	79,7	717,7 (121,9-2462,0)	157,9 (81,4-327,2)	131,7 (86,38-336,7)	-
As	I	7,75	13,61 (8,15-23,62)	12,44 (7,13-18,96)	13,52 (9,17-16,47)	2
Pb	II	30,2	48,48 (32,94-82,92)	44,68 (19,69-67,01)	43,5 (20,9-66,7)	32
Cu	II	34,9	64,6 (43,7-82,3)	56,5 (46,9-70,1)	58,4 (43,5-76,0)	-
Ni	II	22,7	75,2 (71,4-92,4)	55,6 (37,0-68,7)	60,1 (42,5-65,1)	-
Co	II	2,1	17,0 (12,3-20,5)	14,7 (9,22-18,9)	15,1 (9,3-21,0)	-
Cr	II	74,6	105,1 (87,1-117,8)	103,5 (80,4-124,0)	105,0 (87,1-117,8)	90
V	III	68,5	95,7 (82,5-113,0)	94,2 (73,1-117,5)	92,6 (82,7-101,5)	150
Sr	III	128,8	216,5 (171,3-312,9)	183,0 (126,8-258,5)	115,6 (85,4-154,3)	-
Z_c		-	22,1	12,3	8,22	

n – number of investigated sites; Zc - total pollution index

Table 2: Biological properties of Rostov region soils, % of control

Sites	Catalase activity	Dehydrogenase activity	Abundance of Azotobacter	Germination	IIBS
Persianovskaya steppe (control)	100	100	100	100	100
	Industrial areas				
1	48,8	81,9	68,0	94,8	73,4
2	50,2	81,4	48,0	83,2	65,7
3	31,6	58,9	48,0	66,0	51,1
4	50,7	84,9	66,0	92,0	73,4
Average value	45,3	76,8	57,5	84,0	65,9
	Parklands				
5	60,0	160,7	88,0	100,0	102,2
6	47,5	102,3	80,0	92,0	80,5
7	46,3	35,3	70,0	82,0	58,4
8	62,7	132,8	88,0	100,0	95,9
9	39,7	85,7	82,0	84,0	72,8
Average value	52,0	104,3	80,8	91,5	82,1
	Transport areas				
10	47,1	150,1	92,0	80,0	92,3
11	44,9	67,2	60,0	70,0	60,5
12	45,6	95,2	98,0	88,0	81,7
13	48,0	72,9	84,0	86,0	72,7
14	41,2	37,8	88,0	86,0	63,3
15	43,1	65,5	84,0	90,0	70,7
Average value	46,2	84,1	77,6	87,0	73,1

It should be remembered that due to lower biological activity of soils with high content of heavy metals in the soil, soil contamination consequences HM is not always unambiguous. Although reduction of soil biological activity observed in most cases, with a slight contamination is not uncommon for increasing the number of microorganisms, the intensity of the microbiological processes, enzymatic activity in the soil, etc. [10]. Therefore, between the metal content in the soil and the degree of reduction of soil biological activity is not always a straight line and the more proportional relationship.

Thus, we can conclude that with the increase in soil HM soil properties deteriorate. However, certain properties of the soil, for example, some of the indicators of biological activity can be increased at low doses contamination.

CONCLUSIONS

- The priority pollutants of the Rostov soils are zinc (in some cases, the content in the soil is greater than background values of 30.9 times), cobalt (9.8 times), nickel (4.1 times), lead (2.7 times), arsenic (3 times), copper (2.4 times), strontium (2.4 times).
- The intensity of HM accumulation (excess above the background) in the soil of industrial area decreases in the order: Zn> Co > Ni> Cu> As> Sr> Pb> Cr = V; in the transport area: Co > Ni> Zn = As> Cu> Cr = V> Pb = Sr; in the park: Co > Ni> Zn> Cu = As> Pb> Cr = V = Sr.
- The highest level of HM contamination of Rostov soils is in the transport area, the lowest level is in the parklands.
- Contamination of soils in Rostov-on -Don HM, usually leads to a deterioration of their biological properties: reduced activity of catalase and dehydrogenase, an abundance of bacteria of the genus Azotobacter, worsens the initial germination and plant growth.
- Indicators of biological activity does not always correlate closely with the degree of soil contamination HM. The maximum values of the correlation coefficients were observed in the industrial area, which is associated with the highest pollution HM soil of this area.
- According to the degree of informativeness of biological indicators form the following series: catalase activity > germination > abundance of bacteria of the genus Azotobacter> dehydrogenase activity.
- Biological indicators, such as the activity of catalase and dehydrogenase, an abundance of bacteria of the genus Azotobacter, germination capacity should be used for state biodiagnostics urban soils exposed to pollution by HM.

The research was found that the concentration of mobile forms of all studied heavy metals zinc, copper, lead and nickel significantly exceed the value of the maximum permissible concentration (MPC). Maximum excess MPC - 2462 mg / kg (37-fold) was observed for zinc in the vicinity of the plant " Empils", Russia's largest manufacturer of decorative coatings and zinc oxide (zinc oxide), located in the city center. Also exceeded the MRL for zinc was detected in all other samples, including samples from parks.

The study found that industries and motor vehicles are the major factors of soil contamination with heavy metals.

Thus, in the soils of the Don Basin recorded pollution urban landscapes with regard to their functional load: industrial areas, road crossings, parks and mobile forms of Mn, Ni, Co, Pb, Cr (ammonium acetate- hood) and excess MPC significant.

Of particular concern is the fact that with the constant growth in the number of vehicles on the streets increased pressure anthropogenic pressure on the environment, which leads to suppression of natural processes of soil formation and, consequently, to further degradation of the ecosystem of the city.

ACKNOWLEDGEMENTS

Investigation was supported by the Southern Federal University program (213.01-24/2013-56).

REFERENCES

1. Frankenberger, W., Jr. Johanson and J. Johanson, 1982. Influence of crude oil and refined petroleum products on soil dehydrogenase activity. J. Environ. Qual., 4: 602-607.
2. Wilke, B.M., 1997. Effects of non-pesticide organic pollutants on soil microbial activity. Adv. GeoEcol. Reiskirchen, 30: 117-132.
3. Popa, A., 2000. Inducing soil as ecotoxicological test for organic pollutants and Orsan. Stud. Univ. Babes-Bolyai. Biol., 1: 129-138.
4. Restoration of contaminated soil ecosystems, 1988. Moscow: Nauka, pp: 312.
5. Kolesnikov, S.I., I.V. Kutuzova, M.G. Zharkova, E.V. Naleta and K.Sh. Kazeev, 2013. The Dynamics of the Recovery of the Biological Properties of Ordinary Chernozem Contaminated with Oil (In the Modeling Field Experience). World Applied Sciences Journal, 25(9): 1280-1284.
6. Motuzova, G.V., 0000. Soil-chemical environmental monitoring. Moscow: Moscow State University Press, pp: 86.
7. Privalenko, V.V., 1993. Geochemical assessment of the environmental situation in the city of Rostov -on-Don. Rostov Region, pp: 167.

8. Privalenko, V. and O. Bezuglova, 2003. Ecological problems of anthropogenic landscapes Rostov region. Volume 1. Ecology city of Rostov region. Rostov region: SKNTS VS, pp: 209.
9. Snakin, V. and A. Juror, 1995. Ekological assessment of soil: Trying quantitative approach. Math. RAS. Ser. Biol., 1: 105.
10. Kolesnikov, S., N. Petrova, K. Kazeev, E. Dadenko, T. Denisova and S. Tischenko, 2013. Biodiagnostics of sustainability of chestnut soil to pollution with oil and heavy metals. World Applied Sciences Journal, 26(5): 653-656.
11. Kolesnikov, S., V. Gayvoronskiy, K. Kazeev, E. Dadenko, T. Denisova and S. Tishchenko, 2013. Simulation of Ordinary Chernozem Pollution by Heavy Oil to Determine Environmentally Safe Concentration. World Applied Sciences Journal 25(9): 1339-1342.