

Research Article

Chemical and Biological Features of Soils of Urban Territories

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ABSTRACT

There have been observed chemical and biological qualities of urbanized soils and soil-like bodies of the city of Kazan. There has been given an assessment of their enzymological (urease) activity of the speed of degrading of urea, of reaction of soil solution, of contents of organic carbon. It is shown that chemical and biological qualities of studied soils have been seriously transformed and significantly differ from the complex of qualities of original natural analogs. There has been discovered the increase of pH of soil solution up to 7,0-8,2, high variation in contained organic substance, available forms of elements of nutrients of plants (nitrogen, phosphorus, potassium), flexible compounds of heavy metals and variety of activity of enzyme of urease. There has been discovered the absence of dependence of enzymological activity of city soil-like compounds from their acid-alkaline conditions and contained organic body. The necessity to work out new approaches and methods of studying urban soils and with the aim to assess their ecological state and forecasting of their impact on the city environment.

Key words: urban soils, chemical qualities, biological qualities, enzymological activity

1.INTRODUCTION

The environment of urban territories is subjected to a high level of transformation and soil has to experience especial pressure. It is transferred as a result of distortion of soil profile and genetic horizons as well as the result of pollution and isolation of soils from functioning city ecosystems. It is known that soil, thanks to its unique qualities and ecological functions, becomes the most significant biogeochemical barrier to spread of a great number of ectogenous compounds turning into a store of pollutants [1]. Under the impact of automobiles, industry, construction the chemical, physical, biological qualities of soil transform and they are unable to carry out the most important ecological functions. Nowadays scientists pay special attention to working out approaches to evaluation of

ecological state of city soils and soil-like bodies based on diagnoses and monitoring of changes of a wide range of biogenic compounds and physicochemical qualities of soils [2,3,4]. It is considered that combination of soil microorganisms and biochemical parameters of soil under the influence of obvious anthropogenic impact undergo changes in first place and they are especially vulnerable to polluted state of soil [5,6,7]. The aim of the paper is the research of the features of chemical composition and enzymological (urease) activity of soils of urbanized territories in order to evaluate their ecological state.

2.OBJECTS AND METHODS

The object of the research were the soils and soil-like bodies of parks and gardens of the city of

Kazan. The samples were collected in June by the standard method “envelope” from various depths from the surface horizons (0-5sm and 15-20sm). The following chemical qualities as actual acidity (pH) by potentiometric method, composition of organic carbon by Tyurin, composition of available forms of phosphorus and potassium by Chirickov, easily hydrolyzed forms of nitrogen by Cornfield.

Composition of portable forms of heavy metals were defined in extraction 1 n HNO₃ by flame atomic-absorbntional spectrometry on spectrometer AAnalyst 200 (Perkin Elmer) [8]. To characterize the biological activity the express method of T.V.Aristovskaya, M.V.Chugunova [9] was used, which is considered to be highly informative and the most corresponding for diagnosis of anthropogenic changes of polluted urban soils.

3.RESULTS

The studied soil formations and lawns of parks and gardens of Kazan have the depth up to 15 cm and more, they contain industrial and domestic garbage and are landed in some cases by soil and ground or remnants of horizons of natural soil. They have been formed by bulk grounds of different structure-crushed stone or rubble, turfs, turf-compost, sand, loam. In general, the composition of the studied parks and gardens has a high level of destruction, the features of being cultivated are mainly connected with the creation of soil bodies by means of covering the surface of lawns with turf or turf-compost (the layer 0-10 sm). Indications of actual acidity (pH of water extraction) and data on the contents of organic carbon in the studied sample are presented in table 1.

Table 1. Indicators of the actual acidity and the organic carbon content in soil of parks and gardens

№	The sampling location	Actual acidity (pH _{aq.})		C org., %	
		0-5 sm	15-25 sm	0-5 sm	15-25 sm
1	Chemists park	7,4	7,4	4,96	0,40
2	Uritsky park (SE)	7,2	7,4	4,64	1,79
3	Uritsky park (NW)	7,0	7,1	3,41	1,78
4	Admiralty park	7,1	7,3	3,88	1,72
5	Petrov park	7,8	7,6	13,28	1,37
6	Vosstaniya st. (district "Mayak")	7,4	8,4	6,25	0,26
7	Gagarin-Korolev st.	7,4	7,9	5,46	0,61
8	Gagarin st., "Behetle" shop	7,9	7,4	4,70	3,11
9	Publishers park	7,2	7,5	6,53	3,72
10	Ibragimov prospect	7,7	8,1	3,14	0,57
11	Volgogradskaya st.	7,8	8,0	7,11	1,04
12	Levchenko st., DK "Polymer"	8,2	8,3	2,01	0,67
13	Levchenko st., "Magnet" shop	8,1	8,4	2,93	0,56
14	The crossroads of Vosstaniya st.	8,0	8,3	6,54	2,05
15	The park at the administration of a Porokhovoy plant	8,0	8,5	7,62	1,28
16	The park near lake Khorovoye	7,2	8,1	0,99	0,59
17	The park near the Youth center	7,3	7,6	24,33	4,26

Carried out analysis shows that the samples of parks and gardens on indication of acidity are significantly changed. There is obvious growth of pH in the upper layer (0-5sm) up to 7,0-8,2, in comparison to sod-podzolic and grey forest soils, which contain natural background of the territory

of Kazan and have an acid and slightly acid reaction of medium.

The following regularity is observed: the lower layer (13-25sm) of soil bodies differs from the upper layer (0-5sm) by higher alkalinity. Thus, the meaning pH of water extraction of the lower layer

are in the limits from 7,1 to 8,5 and more these meanings pH in the upper layer (table 1).

Content of organic carbon varies in layer 0-5 sm from 2% to 24% and in layer 15-25 sm – from 0,4% to 3,7%. There has been discovered statistically significant difference of content of

organic carbon in layers of soil of different depth. There is the following regularity in all samples: the upper layers (0-5sm) of soil-like bodies of parks and gardens differ from the lower layers (15-25sm) in significantly higher content of organic carbon, by more than 4 times.

Table 2. The content of available forms of nutrient elements and mobile forms of heavy metals

№	The sampling location	N, mg/100g		P ₂ O ₅ , mg/100g		K ₂ O, mg/100g		Mn, mg/kg		Cu, mg/kg	
		0-5 sm	15-25 sm	0-5 sm	15-25 sm	0-5 sm	15-25 sm	0-5 sm	15-25 sm	0-5 sm	15-25 sm
1	Chemists park	43,7	2,8	22,2	19,8	18,0	9,0	102,9	121,5	8,8	2,9
2	Uritsky park (SE)	15,1	3,4	14,1	3,3	28,0	7,0	299,8	287,7	4,9	1,8
3	Uritsky park (NW)	7,3	2,8	4,5	-	9,0	4,0	411	373	1,4	3,9
4	Admiralty park	12,9	3,4	50,5	48,6	62,0	36,0	337,5	556,1	1,9	18,1
5	Petrov park	17,9	2,2	24,1	0,7	30,0	8,5	364,3	36,2	3,9	0,3
6	Vosstaniya st. (district "Mayak")	8,4	0,3	20,1	7,5	18,0	3,8	325,4	94,5	7,3	2,1
7	Gagarin-Korolev st.	10,6	0,8	20,1	8,2	19,0	4,0	258,6	103,8	4,0	5,0
8	Gagarin st., "Behetle" shop	41,4	12,3	47,7	32,1	32,0	15,0	338,2	393,4	6,4	5,3
9	Publishers park	26,9	5,6	-	14,4	16,0	56,0	290	394	5,7	1,9
10	Ibragimov prospect	12,9	1,7	6,8	1,2	36,2	16,0	234	990	1,9	2,0
11	Volgogradskaya st.	15,7	1,7	4,5	4,7	18,0	67,5	245	150	6,7	2,4
12	Levchenko st., DK "Polymer"	7,8	1,7	20,0	7,3	18,0	15,0	44,6	47,6	3,5	1,0
13	Levchenko st., "Magnet" shop	10,1	1,1	18,6	8,7	19,0	8,5	254	37,7	1,5	1,1
14	The crossroads of Vosstaniya st.	15,7	2,8	1,0	-	7,8	3,5	418	383	3,9	4,0
15	The park at the administration of a Porokhovoy plant	18,5	1,7	6,1	7,1	18,0	7,5	258	101	8,8	1,4
16	The park near lake Khorovoye I	3,4	0,3	18,8	8,2	30,0	3,0	56,1	28,4	2,3	0,9
17	The park near the Youth center	29,7	14,0	68,6	97,9	36,0	30,0	455	622	9,9	11,8

It is characteristic of urban soils to differ greatly in content of available nutritious elements to feed plants. In the upper layer 0-5sm contents of easily hydrolyzed nitrogen varies in wide range: from 43,7 to 3,4 mg/100g of soil, mobile phosphorus – from 68,6 to 1,0mg/100g, mobile potassium – from 62,0 to 7,8mg/100g of soil. Contents of manganese and copper are also subject to great variations both in 0-5sm and 15-25sm.

Nevertheless, these meanings do not exceed the maximum allowable concentration (MAC and OAC) of heavy metals both for urban and background soils of the given region.

The meanings of biological activity (enzymological urease activity) of the studied samples of soils of parks and gardens of Kazan are presented in fig.1-3.

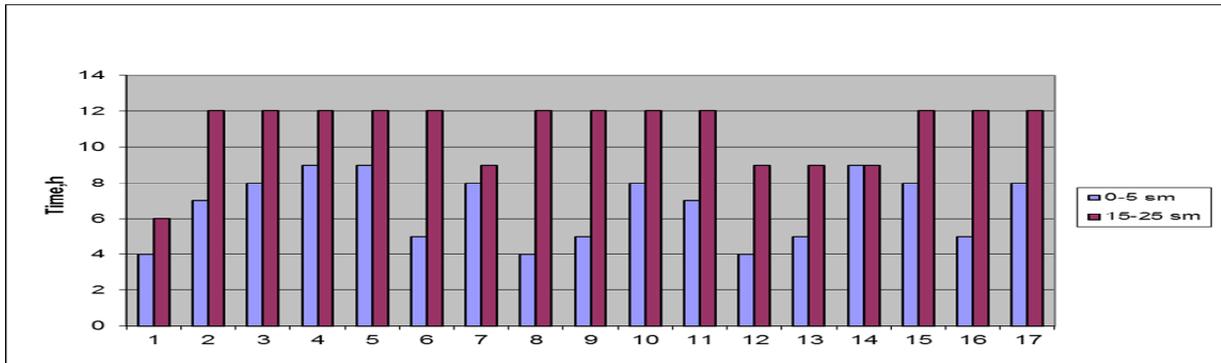


Fig.1 Activity of enzyme of urease in hours in soil-like bodies in parks and gardens of Kazan

The results of research of activity of urease illustrate that the contents of enzymes in layers 0-5sm and 15-25sm are subject to vary significantly. The highest activity of enzyme of urease is characteristic of upper layers (0-5sm) in all studied samples, so the speed of degradation of model substance (urea) in them was 4-8 hours. In the layer 15-25sm it was considerably less, pH

was 10-11 in more than 12-14 hours; in these layers the process of degradation of model substance (urea) was much slower.

As a result of carried out research it has been proved that the activity of urease in upper layers of soil-like bodies of parks and gardens is not the same (fig.2).

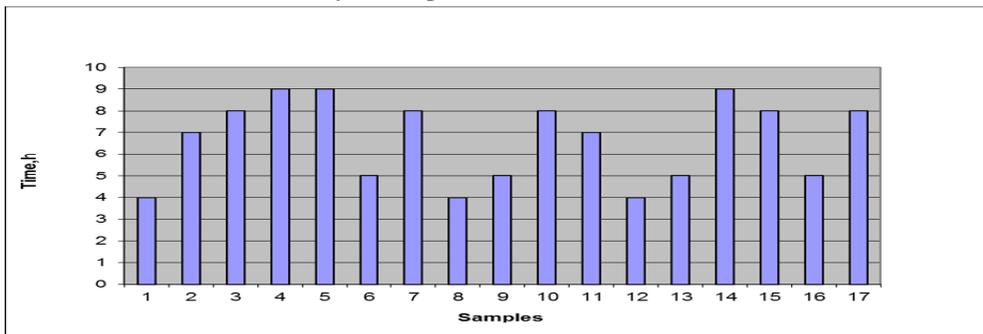


Fig.2. The activity of the enzyme of urease in layer 0-5sm of soil-like bodies (time/hours of achieving pH=10)

In cases 1, 6, 7, 9, 12 it was the highest. There pH reached the maximum meaning (10-11) in 4-5 hours of the experiment in degradation of the model substance. In cases 2,10,15,17 the level of the activity of urease was lower (pH 10 was

reached in 7-8 hours of the experiment). In cases 4, 5, 14 the speed of the growth of urease activity was the lowest. There pH 10 was reached only in 9-10 hours of the experiment.

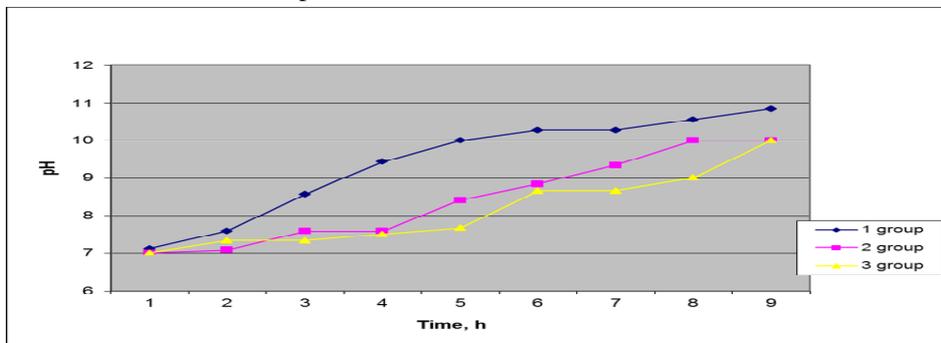


Fig.3. The dynamics of the growth of urease activity in studied samples (grouping according to anthropogenic pressure)

As a result of the research on the dynamics of changes in environment under the influence of degradation of the model substance in samples of soil-like bodies of parks and gardens of the city of Kazan there were defined three sets of results (fig.3): with the high speed of degradation the model substance (4-5hours), medium (7-8 hours) and prolonged (9 and more hours). Judging by the given results it can be considered that the least biological activity of soils corresponds to the most quantity of hours of transformation of carbamide.

4.DISCUSSION

The chemical qualities of soils are very important characteristics while studying the level of degradation of soils of urban territories. As is shown in a number of articles, [10, 11, 12, 13] soils of big cities as a rule undergo degrading changes of the major physiochemical and morphological qualities. It concerns transformation of acid-alkaline conditions of soil solution, content of organic substance.

As a rule, urban soil substances possess slightly alkaline and alkaline reaction of soil solutions [14,15,16]. The meanings pH of water extraction depend on many corresponding factors and to some extent are an indicator of the level of the chemical degradation of soil and content of nutritious substances.

The discovered increased alkalinity of the lower layers (15-25 sm) of soil in comparison to upper layers (0-5 sm) must be connected with the fact that there is regular renovation of the surface layers of soil bodies of lawns with "fresh" material and the more polluted ground happens to be buried (covered) that indirectly proves the anthropogenic pollution.

In comparison to zone soils the studied soil-like urban bodies are characterized with high variation of content of organic substance, available nutritious elements (N, P₂O₅, K₂O) and heavy metals. Gradual deviation from background meanings can indicate significant transformation of the qualities of soils within boundaries of urban territories.

Thus, gradually increased meanings of actual acidity and high level of variants of content of organic carbon, available forms of nutritious elements for plants and heavy metals in soils of parks and gardens as well as absence of regularity of their content characteristic of zone soils indicate of their considerable chemical degradation.

According to the point of view of some authors [3,17,18], biosystems of urban soils nowadays are subject to considerable structural transformation which in the first place is redistribution of biological activity in the depth of soil profile. In this connection special attention is attracted to the biochemical qualities of soils and their enzymological activity and its connection with different kinds of pollution and changes of soil microbiota under the influence of negative ecological processes of the urban environment.

Enzymological activity of soils connected with transformation of compounds of major biogenic elements is a graphic indicator. According to some authors [19,14], implication of methods, stating enzymological activity is very effective in evaluation of ecological condition of soils, especially when the ability to resist anthropogenic influence is meant.

One of these indicators is urease activity as one of graphic diagnostic criteria. As this enzyme possesses a strong specific activity, disintegrates only urea, sensitively responds to the changes of external environment and is its good indicator.

It is considered that transformed soils achieve the highest meaning of pH in the shortest period of time (5-8 hours). Rapid growth of urease activity and its high level in some of studied samples must indicate the strong resistance of this enzyme against inhibitory factors wide spread in urban conditions (pollution of soils with heavy metals and petroleum products) and the ability of such soils to self-purification. It is possible that microcombination (mainly urea bacteria) participating in degrading of urea and producing the enzyme of urease preserves certain natural ecological niche

and occupy new ones, which have obvious anthropogenic character.

As some authors state, the activity of the enzyme of urease depends firstly on the reaction of soil solution and the content of organic substance [20]. It is stated that with the increase of pH up to slightly alkaline meanings and with the increase of content of the organic substance urease activity increases and it is especially characteristic of unspoiled soils [21].

In our research there has not been discovered any co-relational connection between urease activity of soils and pH of environment, coefficient factor is -0,14. It enables to make a conclusion that there is no dependence of urease activity of the studied samples of urban soils from their acid-alkaline conditions. Co-relational dependence between urease activity and content of organic carbon was defined as slight one, coefficient factor makes 0,37, that also enables to make conclusion of low dependency of urease activity from content in sample of organic substances. So enzymologic activity must be considerably transformed in urban conditions, in anthropologic surface bodies with disturbed soil profile, to which the studied samples belong.

5.CONCLUSION

Soil bodies of parks and gardens of Kazan do not correspond their original analogs in concern of the studied chemical qualities. Their chemical qualities have been greatly transformed. They are characterized by slightly alkaline and alkaline reaction of the medium and high variety of content of organic substance in them. Indicators of enzymological (urease) activity are subject to considerable variation, the highest activity of the enzyme of urease is characteristic of the upper layers (0-5 sm) of the studied samples of soil. Enzymological (urease) activity of the studied soil-like bodies do not depend on pH medium and content in them of organic carbon.

Chemical and biological qualities of urban soils undergo changes, are considerably different from the complex of qualities of original soils, that is

why it is necessary to work out new methods and approaches of their study to evaluate their state and condition and forecast their influence on urban environment.

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