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The transformation of the mobile forms of the copper in the seasonally frozen soils of the Arkhangelsk region

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Abstract

Studied the accumulation, migration and transformation of the mobile forms of copper in different types of soil in Arkhangelsk. In urban soils, as opposed to natural, not only changes the relationship of transformational forms, but the nature of the relationship of copper with soil components. The influence of technogenic to consolidate copper in the soil and on its possible transition conditions change to the neighboring environment.

Keywords: *copper, kulturozem, replantozem, urbanozem, transformational form.*

Introduction

In the extremely difficult ecological situation prevailing in many parts of the world, geochemical cycles of heavy metals (hereinafter - TM) in the biosphere are determined not so much by the natural redistribution of how human activities [8, 2004]. At present, the relevance of the study of metal compounds in soils and their transformation mechanisms is increasing due to the need for adequate assessment of contaminated soils, prediction of their change, finding ways to improve them [10, 1998].

TM are among the number of the priority pollutants. According to the pollution of TM soils are the bio-geochemical barrier that absorbs the fine materials and gases from the atmosphere, while clearing the other neighboring environment.

In the atmosphere and hydrosphere is a periodic self-cleaning of pollutants, the soil is almost does not have that ability, and TM accumulate in the upper humus layer. Particularly vulnerable soil in the north, exposed to the cold climate and permafrost, the period they do not have self-cleaning.

TM well adsorbed the layers of soil, their connections for a long time retain high mobility and the toxic properties. Being a man-made substances storage, soil can become a secondary source of air pollution, plants and natural water, which can cause the growth of environmentally harmful effects [9, 2003].

Copper belongs to the group of TM and metalloids (II hazard class). Copper – is one of the biologically important, essential trace elements. Her role in the life of living organisms is very diverse. The copper content in organisms ranging from 10-15 to 10-3%. The main role of copper in the tissues of plants and animals - participate in enzyme catalysis. Copper is an activator of a number of reactions and is part of the copper-containing enzymes (primarily oxidase) that catalyzes the reaction of biological oxidation. Copper-containing protein plastocyanin is involved in the process of photosynthesis, i.e. improves the chlorophyll content in leaves. Copper affects the nitrogen metabolism: in her presence of nitrate reeducates activity increases. It is well known that this element has a high complex-forming ability. Lack of copper in soils affects the synthesis of proteins, fats and vitamins in the plants. However, excessive concentrations of copper are harmful to them. Contamination of soil with copper alters the active functioning of the soil microbial community structure and composition of the soil microbial complexes, which results in a decrease in their species diversity and the dominance of a small number of species [5, 1989].

The feature of the pollution of land cover in the industrial city is that a relatively small area comprises a large number of different sources [9, 2003]. Sources of heavy metals in urbo-geo systems city divided into natural (igneous and sedimentary rocks, rock-forming minerals) and man-made. In this flow of HM in soil and vegetation are a variety of ways: emissions into the atmosphere, with the flow of sediments and sewage, with the products of the decomposition of organic residues and microbial synthesis, direct revenue from the business (fertilizer, pesticide use, storage and disposal of household and industrial waste).

Soils and plants are involved in the small circulation of substances (including TM): root system has escrowed properties (stores and distributes incoming material) through root exudates,

the litter of leaves and death of the plant these elements into the soil again. It should be noted that the substances formed by the decomposition of the organic residues and directly secreted by plant roots, have a very high mobilizing capacity, that is, have a direct effect on the hard compound in the soil, converting them into a digestible form.

In the city of Arkhangelsk, the main sources of pollution are the power generation, fuel, timber, woodworking and pulp and paper industries, major rail, aviation and highways.

From stationary sources in the first place Arkhangelsk CHP, coal boilers of making a major contribution to the anthropogenic atmospheric pollution copper. Releases to the environment occurs through anthropogenic dispersal. In the air the bulk TM comes from chimneys and vents, as well as accidental releases into the atmosphere. Most of the precipitates in the vicinity (1-2 km) of enterprises and other sources, some of the pollutants carried by the atmosphere at a distance of 10-15 km, a certain percentage goes to the upper atmosphere and spread over many hundreds or thousands of kilometers [8, 2004]. TM is an important source of transportation. It was found that not only serves as a combustion source of pollution, but also the use of organo-metallic antiknock as an additive in the fuel can also contribute to emission of copper in the atmosphere [10, 1998]. Thus, the pathways of copper in soil and vegetation are different, so its compounds in the soil and in plants can vary widely according to the forms properties: the mobility and migration capacity, instruments fixing soil components.

Communication mechanism for TM with soil components, and on how to retrieve it, two groups of compounds (Table 1):

1) compounds, in which copper is retained on the surface of the soil particles with organic and mineral components of soil in the exchange and specifically adsorbed state, are grouped in a loosely tied copper compounds. This group of compounds of copper is the most important from an environmental point of view, since it is in this form of copper enters the plant and migrates to other neighboring environment;
2) compounds, in which copper is firmly fixed in the structure of primary and secondary minerals, sparingly soluble salts of organic and sustainable and organic copper compounds are grouped in a tightly bound compounds [1, 2006].

Table 1

Transformation forms of cope in the soil

Group	Forms of compound cope	Examples
Loosely connected com-	Water-soluble compounds	$CuCl_2$; $Cu(NO_3)_2$; $[Cu(OH)_2CO_3]^{2}$; $[CuOH]^{+}$; $[CuHCO_3]^{+}$; $[CuCl_4]^{2-}$ and etc

pounds	Link exchanges	
	Specifically adsorbed on the surface of the solid phases	
Hard connected compounds	Soluble compounds	CuS, $CuCO_3$; $Cu_3(PO_4)_2$; Cu_2SiO_3, CuO, Cu_2O; $Cu(OH)_2$; $(CuOH)_2CO_3$; Cu_2SiO_4; $Cu(HPO_4)$ and etc.
	Compounds, hard connected with compounds	
	Connected with organic substances	Humates, fulvates and complexes of heteropolar salts: $[Cu(OH)_2]$ФК, $GK(COOCu)_n$, $FK(COOCu)_n$, chelated copper compounds
	Cope in the minerals	Turquoise $CuAl_6[PO_4]_4(OH)_8 \cdot 5H_2O$, bornite Cu_5FeS_4, chrisokolla $(Cu, Al)_2H_2Si_2O_5(OH)_4 \cdot nH_2O$

Objects and methods of the research work

For the chemical analysis were taken three types of soil (urbanozem, replantozem, kulturozem) residential landscape, located in the central part of the city of Arkhangelsk. As a control (reference standards) for urban soil was selected natural turf low-power light loamy soils formed on dry meadow near the village Babonegovo Primorsky district of the Arkhangelsk region. This choice was dictated by the fact that the process of soil formation takes place in Arkhangelsk on turf, not by podzol type characteristic of the region. Description of plots is given in Table 3 [6, 2006].

Selection, storage and transportation of soil samples were carried out in accordance with GOST 17.4.4.02-84 [3, 1984]. Definition of mobile forms (hereinafter - PF) of copper in soils was carried out extraction-photometric method on how to GOST 50683-94 [2, 1994], using the predecomposition of the organic matrix of the soil.

To highlight the transformation forms of copper was chosen combined method of fractionation (Table 4), using the most common method of fractionation of metals Tessieru (1979), together with parallel extraction [6, 2008, 2, 1994]. Mobile (acid soluble) forms of copper were extracted from the soil with nitric acid.

To assess the level of contamination of soil copper concentration ratios used (K0, Kk), defined as the ratio of the actual content of the analyze in the test point to its content in a similar environment to the background area or PDK:

$$K_0 = \frac{\tilde{N}_i}{\ddot{I}\ddot{A}\hat{E}}, \; K_к = \frac{\tilde{N}_i}{C_{\hat{o}}},$$

where Ci - the maintenance of the chemical elements in the sampling points; Sf - the average maintenance of the element in a similar environment in the background section.

The data obtained statistically treated by the conventional methods in Excel. To study the structure of the relationship parameters studied using correlation analysis.

The discussion of the results

Studies have shown that the total maintenance (SC) of copper in natural soil is 14-23 mg / kg (depending on the horizon), which does not exceed PDKVS = 53 mg / kg (Co <1). In urban soils, it ranges from 38.4 (PP № 40) to 84.0 mg / kg (IP number 60). PCB № 60 exceeding the PDKVS (Co> 1), and QC for the studied PP >> 1 (2,7-6,0). This suggests anthropogenic soil contamination to the pollutants. PF copper content in all soils exceeds PDKPF = 3 mg / kg (Co >> 1). Calculation of the biogeochemical indicators is presented in Table 2.

All urban soils contaminated to varying the degrees of mobile copper (Kc >> 1 on all PP), and the image number kulturozem> urbanozem> replantozem. This is due to the age of building area. Kulturozemy - the oldest soils, which are formed on the site of the old gardens, so the period of provision of technological impacts and the accumulation of copper in the soil will be maximized.

PF share of copper for natural soil ranged from 79.14 to 92.40%, for urban soils from 85.52 to 99.33%, which is mainly contained copper in soils in the PF, is its "potential" reserves.

The fractional composition PF copper was evaluated by determining the proportion of each form obtained using selective extracts from the total number of FS.

TABLE 2

Bio-geo-chemical criteria assessment of the soil cover

Indicators	Type of soils											
	Natural soil			PP № 40			PPN№ 60			PP № 3		
	$A_д$	A_1	B	Uha3	Uina1	L	Uha2	U↓↑a 2	DUa3	$A_д$	A_1	B
****BC, mg/kg	14,0	15,0	23,0	38,4	44,0	43,0	56,7	45,0	84,0			
K_o(BC)	0,2	0,3	0,4	0,6	0, 8	0,8	1,1	0,8	1,4		*НД	
$K_к$(BC)		*НД		2,7	3,1	3,1	4,1	3,2	6,0			
**PF, мг/кг	11,1	13,9	19,1	32,8	41,1	42,1	56,0	44,7	73,6	84,7	67,7	76,5
W (PF), %	79,1	92,4	83,3	85,5	93,4	97,8	98,8	99,3	87,6			
W (***NF), %	20,9	7,6	16,7	14,5	6,6	2,2	1,2	0,7	12,4		*ND	
K_o(PF)	3,7	4,6	6,4	11,0	13,7	14,0	18,7	14,9	24,5	28,2	22,6	25,5

*ND – NO DATA; **PF – MOBILE FORMS; ***NF – UNMOBILED FORMS; ****BC – GROSS CONTENT.

Table 3

*Agrochemical indicators of the researched soils **

№ PP, Location	Level	Mechanical level of the structure	Type of the soils	indicators									
				***BC (Cu), mg/kg	pH wa-ter	Clay, %	**** OG, %	***** GK, %	****** ФК, %	***BC (Ca), mg/kg	***BC (Fe), mg/kg	***BC (Al), mg/kg	***BC (Mn), mg/kg
Control (Arkhangelsk, Konetsgore)	Ad	Leg.sugl . + sand	Natural soil	14,0	7,28	**НД	5,2	0,5	0,2	74,8	0,2	0,34	106,5
	A_1	Leg.sugl .		15,0	7,28		4,0	0,4	0,2	72,4	0,3	0,20	96,0
	B_1	Heavy sugl.		23,0	7,34		1,5	0,1	0,1	71,6	0,3	0,34	73,8
3 (Arkhangelsk, Petrovskiy Park)	Ad	Leg.sugl .	Culturozem	**НД	7,07	22,0	13,1	1,8	0,6	154,2	0,2	0,06	201,5
	A_1	Middly sugl.+ humus			7,68	9,0	10,4	1,3	0,6	107,5	0,2	0,02	177,8
	B_1	Leg.sugl . + humus			7,80	17,0	6,6	0,6	0,4	144,8	0,2	0,02	221,7
60(Arkhangelsk, Street. Loginova, and Troizkiy street	Uh a2	Sandy loam + humus	Urbanozem	56,7	7,40	19,0	12,2	1,1	0,6	129,8	0,2	0,02	297,4
	U↑↓a 2	Sandy loam		45,0	7,30	16,0	8,4	0,4	0,5	193,4	0,3	0,03	271,4
	DU a3	Sandy loam		84,0	7,44	8,0	3,3	0,2	0,2	232,4	0,1	0,04	203,3
40 (Arkhangelsk, Komsomolskaya str., 36)	Uh, a3	Sandy loam	Replantozem	38,4	7,52	12,0	**НД				0,3	0,03	7,1
	Uih, a1	sand		44,0	7,08	10,0					0,3	0,01	21,4
	L	Sandy loam		43	7,68	5					0,3	0,01	25,8

** NA - NA; *** Sun - the total content of the element; **** OG - organic matter content; ***** GC - content of humic acids ****** FC - the content of fulvic acids. Abbreviations: lay down. sugl. - Light loam; cord. sugl. - Heavy clay; media. sugl. - Medium loam.

These laboratories biogeochemical studies at the department of chemistry and chemical ecology NArFU named after MV.Lomonosov.

Table 4

The combined scheme of the fractional soils of the zinc compounds [6, 2008; 11, 2006]

Indicator	Way of finding	
	Experimental	Estimated (the difference between the content of heavy metals in the extracts)
1	2	3
1. Maintenance of metals in the exchange form :		
– Total	1н ААБ, pH = 4,8	
– Easy to exchange	0,05 M $Ca(NO_3)_2$	
– Difficult to exchange		1н ААБ – 0,05 M $Ca(NO_3)_2$
2. Metal maintenance associated with carbonates, and in separate phases:		
– Loosely linked	2,5 % CH_3COOH	
3. Metal maintenance associated with the non-silicate compounds of Fe, Al, Mn:		
– Total	0,04 M $NH_2OH \cdot HCl$	
– Loosely linked		(1н HCl – 1н ААБ) – 2,5 % CH_3COOH
– Tightly linked		0,04 M $NH_2OH \cdot HCl$ – (1н HCl – 1н ААБ –2,5 % CH_3COOH)
4. Metal maintenance associated with organic matter:		
– Total	30 % H_2O_2	
– Loosely linked		1 % ЭДТА в 1н ААБ – 1н ААБ
– Tightly linked		30 % H_2O_2 – 1 % ЭДТА

Natural soil

In natural soil PF distribution in the soil profile is uneven. The second horizon is sharply increased the share of the Fermi surface (from 79.1 to 92.4%), which may be associated with a slight grading of the soil horizons and the effect of washing water regime. In the subsurface PF content decreased (83.3%) due to the occurrence of a mechanical barrier at the second and third of the soil horizons. In natural soil predominate form of copper associated with the non-silicate compounds of Fe, Mn, Al (72,2%), and copper are associated with soil organic matter (41.2%) (Picture 1). Exchange forms can be submitted free copper ions and copper held by electrostatic forces on the clay and other minerals, organic matter and amorphous compounds soluble copper complex compounds with inorganic anions or organic ligands of different strength [6, 2008, 11, 2006]. In natural soil exchange forms are present in the soil horizon Hell (0.19 mg / kg) in the form of mobile difficult to exchange compounds with organic matter (r = 0,75) and clay minerals (r = 0,97). Specifically adsorbed form of copper available in view of the fact that the analyzed soil is noncalcareous.

Copper is associated with non-silicate compounds of Fe, Mn, Al, - is occluded copper cations in amorphous compounds or adsorbed on the surface [11, 2006]. By binding copper and non-silicate compounds Fe, Mn, Al (72,2%) is its accumulation in the natural soil. The copper in the form of fixed difficult to exchange compounds Fe (r = -0,92) and easy to exchange compounds Mn and Ca (rMn = -0,98, rCa = -0,96). Education PF copper able to migrate to the neighboring environment, will be due to the formation easy to exchange compounds with Fe (r = 0,75), difficult to

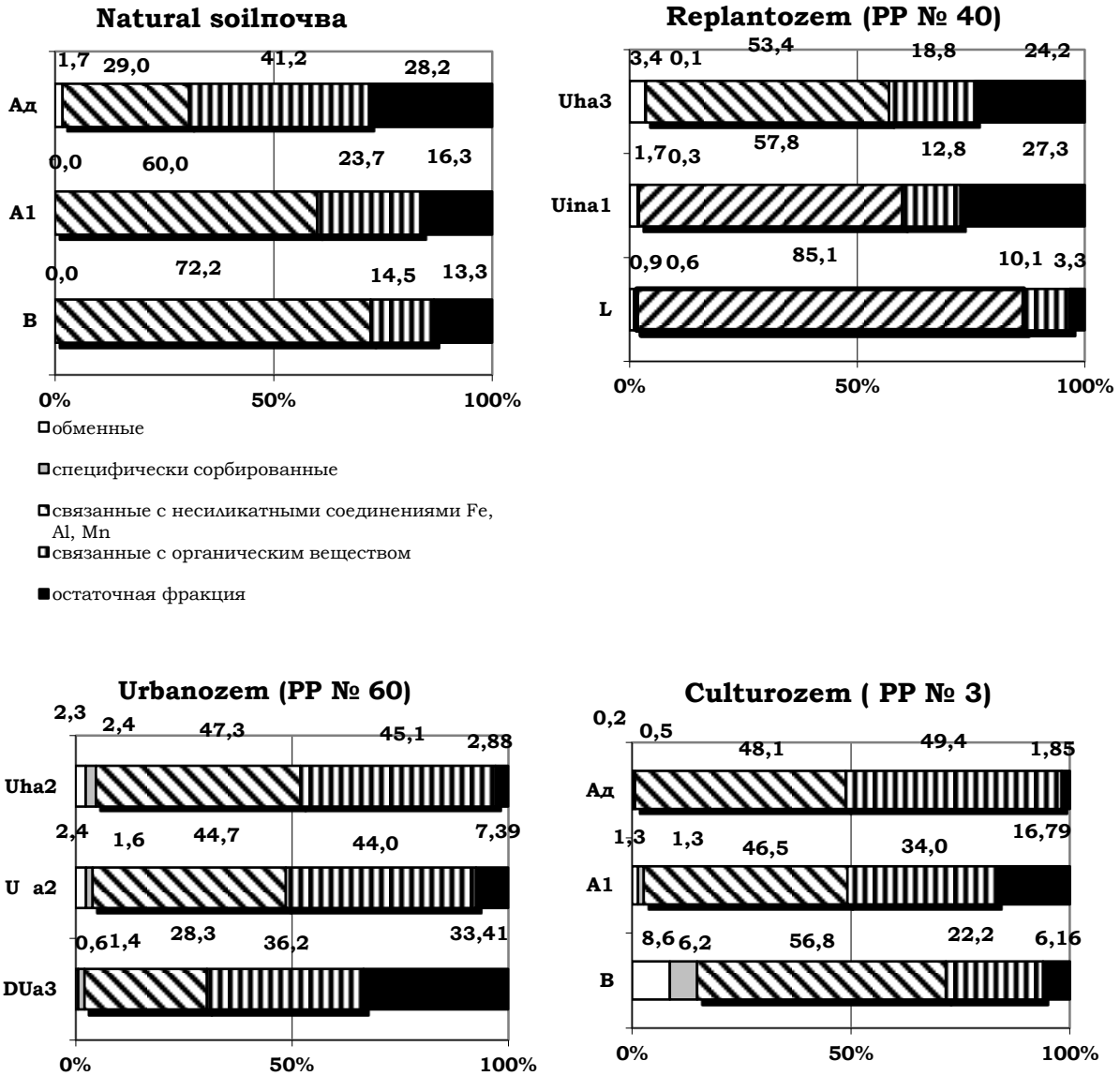
exchange compounds with Mn and Ca (rMn = 0,88, r = Ca 0,99), in lesser extent, in the form of compounds with difficult to exchange Al (r = 0,42).

Copper, having some amphoteric properties, in an acidic medium is in the form of cations Cu2 +, and in alkaline medium in the form of hydroxy-[Cu (OH) 4] 2 -. Change in the reaction medium of the soil solution may increase or decrease the mobility of the element. For example, reducing the soil pH of the solution to pH = 7 easy to exchange copper compounds will move into insoluble forms difficult to exchange (r = 0,87).

Copper is associated with organic matter retained in the soil by the complication reactions with chelation to organic matter or organic matter associated with Fe3 +, Al3 +, Ca2 +, oxides and hydroxides of Fe, Al and clay minerals, as well as the part of the living matter and detritus. Down the soil profile, a decrease of copper forms associated with organic matter.

Larger part of the residual fraction of copper (~ 1/3), the content of which decreases down the soil profile. This fraction can be a secondary source of pollution with copper.

Replantozem – is the soil and technical education in the fresh lawns and yards of the new buildings created by the mixing peat and sand in the regeneration area. Their thickness is filled with debris. They are formed as a backfill and on Pogrebnaya natural soils. The share exchange forms of copper in replantozem above ~ 4 times than natural turf soil. Number of this form decreases down the soil profile. Exchange forms of copper are easily movable and difficult to exchange forms with clay minerals (r = 0,99, r = 0,58, respectively). An inverse relationship between the content easy to exchange forms of copper and pH of the soil solution (r = -0,61). Consequently, the action of the alkaline barrier manifested in its consolidation.



Picture1. Mass fraction of the transformation forms of copper in the soils of Arkhangelsk

Specifically adsorbed compounds – the copper particles are held by covalent and coordination bonds. The share of the specifically adsorbed forms of copper that are primarily associated with carbonates of calcium and magnesium, low (0,12-0,59%). Perhaps this kind of consolidation going on anthropogenic inclusions (debris, asphalt, etc.). The high degree of correlation between the calcium content and the amount of specifically adsorbed forms of copper (r = 0,95) confirms the literature data [1, 2006] that can be attached to the copper carbonates of calcium and magnesium in the form of loosely related compounds. Clay minerals are involved in the formation easy to exchange forms of copper, capable of migrating to the neighboring environment (r = 0,99). In replantozem, as in the natural soil, copper is presented mainly in the form of forms associated with the non-silicate compounds of Fe, Mn, Al. Their content increases down the soil profile (from 53.4 to 85.1%). Accumulation of copper is in the form of compounds with difficult to exchange Mn and Fe (rMn = -0,97; rFe = -0,86), as easy to exchange connections to Al (r = -0,94). Compound Fe,

Mn (rFe = 0,73; rMn = 0,90) are involved in the formation of mobile forms. The copper content is associated with organic matter, less than in natural soil (~ 2-fold), the amount of this form decreases down the soil profile. In contrast to the natural soil profile down to a sharp decrease in the residual fraction (from 24.2 to 3.3%).

Urbanozem – is the soil outdoor lawn and yard area of the modern building. Can be formed in soils of different origin and the cultural layer, characterized by a kind of salty substrate humus mixed with man-made particles. The share exchange forms in urbanozem low (2,34-0,61%), the presence of exchange forms in the upper levels associated with either copper intake from outside, either by transforming other forms of copper. Exchange forms of copper are easily movable and difficult to exchange compounds with organic matter of the soil, and is equally as with humic and fulvic acids (rFK = 0.99, rGK = 0.93), with clay minerals (r = 0,98) . There is evidence of a weak inverse relationship between the content of exchange forms of copper and pH of the soil solution (r = -0,51). Consequently, the action of the alkaline barrier manifested in its consolidation. Compared to the natural soil and the share replantozem by the specifically adsorbed forms. Calcium compounds will form with copper easy to exchange mobile connection (r = 0,66), which with increasing pH of the soil solution will dissolve (r = 0,75) and migrate to the neighboring environment. Content of forms related to non-silicate compounds of Fe, Mn and Al, less than replantozem. Down the soil profile, a decrease of copper in the form unlike replantozem and natural turf soil. Compounds of Al and Ca (rAl = -0,86, rSa = -0.87) are involved in binding copper in the form of light and difficult to exchange compounds, compounds Fe (r = -0,72) - as easy to exchange connections. Mn compounds are also involved in the formation of mobile difficult to exchange forms of copper (r = 0,98), are able to migrate to the neighboring environment. Dependence on pH is similar as for specifically adsorbed forms (r = 0,87). Due to the fact that there is a layer of urbanozem "urbik" copper is more concerned with the organic matter (as opposed to natural soil and replantozem), the form of copper easy to exchange fixed mainly on the FC (r = -0,75). Movable difficult to exchange form on GC (r = 0,91), on the contrary, are more mobile than the FC (r = 0,74). In urbanozem, in contrast to the control, the percentage of residual forms is reduced, but down the profile of her sharply, reaching a maximum in the soil horizon L.

Kulturozem – is an urban fruits soils, botanical gardens, old gardens. Formed in the old town, characterized by a high humus horizon, the presence of humus layers torfo-kompostnyh capacity of more than 50 cm, growing on the lower part of the alluvial soil profile, the cultural layer or soils of different origin. Content exchange forms down the soil profile increases. In contrast to all other types of soil copper will be secured equally to FC and SC (rFK = -0.97, rGK = -0.96) in the

form of light and difficult to exchange connections. With a decrease in pH will be fixing exchange forms (r = 0,70). Down the soil profile is an increase in the proportion of specifically adsorbed forms (unlike the previously reviewed soils). Copper will be fixed in the form of compounds with easy to exchange Ca (r = -0,77). Dependence on pH is similar as in replantozem (r = 0,71). Share forms of copper associated with non-silicate compounds of Fe, Al, Mn, higher than previously considered soil, the content of this form decreases down the soil profile. Formation of mobile copper occurs with compounds Fe, Mn, and Ca in the form of easily-and difficult to exchange compounds (rSa = 0,91, rFe = 0,73, rMn = 0,97), with connections only as Al difficult to exchange connections (rAl = 0,95). In kulturozem, as in other types of soil, down the soil profile decreases copper associated with organic matter. Difficult to exchange form of copper associated with organic matter (rFK = -0.89, rGK = -0.86), are fixed in the soil, easy to exchange - will dissolve and migrate to the neighboring environment (rGK = 0.96, = 0.95 rFK). The distribution of the residual fraction is uneven: maximum concentration observed in the second horizon (16.79%) and the lowest - in the first (1.85%).

Thus, analyzing the distribution of copper in the form of transformation of natural and urban soils, we can draw the following conclusions.

1) Total content of copper in the soil does not exceed the natural PDKVS. For gross content and copper content PF studied soils can be arranged in the following series: kulturozem> urbanozem> replantozem> natural soil. In the absence of excess PDKVS found that intake of copper is man-made, since KK> 1

2) In all the studied soil samples are predominant PF, SF content is low. PF distribution of copper in the investigated soils is humus-accumulative nature (accumulated in the upper layer). Number PF copper in urban soils above: replantozem to ~ 3.5-fold, and for urbanozem, kulturozem ~ 4 times higher than in the natural soil.

3) The maintenance and the distribution of copper in the form of transformation of the natural and urban soils in different ways:

- in natural soil and replantozeme generally predominate forms of copper associated with the non-silicate compounds of Fe, Mn, Al. In kulturozem, urbanozem and commensurate with their share of copper associated with organic matter. In replantozem, kulturozem and, as in the natural soil, the content of these forms increases down the soil profile in urbanozem, decreases. In the natural soil, and replantozeme kulturozeme easy to exchange form copper compounds Fe mobile. The same characteristic shape easy to exchange copper compounds and Mn in replantozem, kulturozem. In natural soil and kulturozem Ca involved in the formation of mobile easy to exchange forms of copper. Securing copper compounds in the form of Fe trudnoobmennyh forms characteristic of natu-

ral soil and replantozem, urbanozem. In urbanozem as in replantozem, copper accumulation is possible by different forms of the compounds Al and difficult to exchange forms compounds Al and Ca;

- the most of the copper is in the form of complexes with organic matter, and in all soils, this form of copper decreases down the profile. In natural soil difficult to exchange mobile forms and mobile easy to exchange form copper FC and SC will dissolve and migrate to the neighboring environment. In urbanozem copper is accumulated by easy to exchange forms on FC, and migrate to the neighboring environment in the form of mobile difficult to exchange forms of HA. Kulturozeme In contrast, the form of copper difficult to exchange participate in its consolidation and moving easy to exchange form of copper will be quite mobile;
- in contrast to the natural soil in urban soils share exchange forms of copper is slightly higher, and they appear in the lower horizons. In replantozem, urbanozem data content and form down the profile decreases, and in kulturozem - increases. In urbanozem, as in the natural soil, the mobile will difficult to exchange form with FC and SC, in kulturozeme copper equally attached to the FC and SC;
- in replantozeme, as opposed to other types of soil is weak alkaline barrier affecting the consolidation of different forms of copper;
- in urban soils observed the emergence of specifically adsorbed forms of copper, but the content is very low. In these forms of urbanozem content decreases down the profile, and in kulturozem and replantozem - increases. Securing copper as easy to exchange forms Ca characteristic replantozema and kulturozema. In kulturozeme urbanozem and increase in pH increases the solubility easy to exchange forms of copper by forming hydroxo. In urbanozem difficult to exchange for copper in the form, on the contrary, an increase in pH leads to a decrease in solubility and transfer to the NF;

Thus, under the influence of the technogenic changes in the number of forms and transformational nature of the connection of copper with soil components, which influences its consolidation and migration? Technogenic influence on the residual fraction is difficult to assess. The results are of ecological importance, as they allow predicting the processes of transformation, migration and accumulation of soil components responsible for binding copper in the seasonal soils, and the possibility of secondary mobilization.

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