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Morphogenetic characteristics of chernozem leached in mining enterprises pollution conditions

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Abstract
The article presents the results of comparative studies on the uncontaminated (virgin) leached chernozem soil in terms of heavy metal contamination due to zinc plant operations. Study object location is given. The territory under the influence of plant emissions is devoid of vegetation. Everywhere on the soil surface there are manifestations of deep erosion processes and continuous erosion of the topsoil. Soil cuts with morphogenetic descriptions, physical, physico-chemical and biological characteristics of the soil were laid at the objects. The soil cover under the influence of pollution has undergone degradation and led to transformational processes of particle size distribution, humus content, absorbed bases, the elemental composition of the food regime of the soil, as well as on the vital activity of the soil biota.

Keywords: soil, heavy metals, humus, soil - ecological functions, soil biota, plants, granulometric composition of the soil

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INTRODUCTION

Due to the historical development associated with the predominance of the mining industry of non-ferrous metallurgy ehe East Kazakhstan region is one of the most ecologically unfavorable regions in the Republic. The main enterprises of the mining and metallurgical complex are located in the zone of the most dense river network. Due to technical need the largest heat power industry enterprises are located here. This location means that all pollutants with gaseous, liquid and solid waste from industrial enterprises inevitably fall into the river network, the soil, causing environmental damage to both biocenoses and the population of the region. At the same time, the soil and vegetation cover of the territories is disturbed and sometimes their complete destruction occurs. These areas are infertile, often toxic, not overgrown for a long time, exposed to erosion and degradation processes with the deterioration of the environment causing significant damage to human health. In this case, an imbalance occurs in the functioning of the biosphere which is the main component of the existence of life on earth.

In the East Kazakhstan region at the beginning of 2015 the technologically disturbed lands amounted to 12,602 thousand hectares, the waste land - 5,120 thousand hectares. At the end of 2015, the technologically disturbed lands increased by 182 thousand hectares and amounted to 12,784 thousand hectares. Used lands were 5,134 hectares which increased by 14 hectares (Data of the Agency of land … 2015).

In order to protect the environment and the full functioning of the biosphere one of the main and targeted measures for the return of disturbed land to agricultural use and the improvement of the habitat of industrial regions is their reclamation. The study of soil formation processes and ecosystems of disturbed lands is of scientific interest in theoretical and practical terms. The soil cover under the influence of the mining industry is subject to pollution. Pollution has an impact on soil properties as physical, physico-chemical, chemical and biological.

MATERIALS AND METHODS

The object of the research are the territories under the influence of emissions from the enterprises of the mining processing industry in the East Kazakhstan region, and influence of the zinc plant on the surrounding landscapes (**Fig. 1**).

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Fig. 1. Location of the study area

Fig. 2. Object of study

Research methods. Reconnaissance detour of the territory was done in order to determine the general soil-ecological state of the object of study. The nature of the manifestation of the negative effects of zinc plant emissions on the surrounding natural systems, sources of pollution and manifestations of erosion processes were determined. Comparative soil-ecological method as control, polluted version, and field methods with the laying of soil sections and the selection of soil samples for laboratory and analytical studies were used (**Fig. 2**). Determination of physical, chemical properties of the soil is performed by generally accepted methods in soil science.

- a method of laying cuts with a description of the location, topography, vegetation and morphogenetic features of the soils was used during a comparative morphological characteristic of chernozem soils under the conditions of anthropogenic impact of a zinc plant;
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- total humus by the method of Tyurin I.V (1965).

- determination of total nitrogen by the I.G. Kjeldahl method, micromethod;
- gross phosphorus by Ginzburg and Shcheglova;
- gross potassium by Smith;
- hydrolyzable nitrogen by the method of Tyurin and Kononova;
- mobile phosphorus by the method of Kirsanov A.T.
- mobile potassium by the method of Peyve J.V.;
- soil pH by potentiometric method;
- determination of carbonates by gasometric method;
- determination of the absorption capacity by the method of Bobko E.V. and Askinazi D.L. in the modification of Grabarov P.G. and Uvarova Z.A.;
- determination of soil particle size distribution by the pyrophosphate method of Kachinsky N.A. (1959);
- microaggregate soil analysis by the method of Kachinsky N.A.

Soil, ground. Methods for laboratory determination of particle size distribution (grain) and microaggregate composition. GOST 12536-2014.

Gross forms of Pb, Cd, Cu, Zn (ST RK ISO 11047-2008 p.3, ST RK ISO 11466-2010 State Standard of the Republic of Kazakhstan November 6, 2008 No. ST RK ISO 11047-2008 “SOIL QUALITY. Determination of cadmium content, chromium, cobalt, copper, lead, manganese ...)

Mobile forms of Pb, Cd, (RD 52.18.289-90 (KZ.07.00.03250-2015) Guidelines. MWR of the mass fraction of mobile forms of metals (copper, lead, zinc, nickel, cadmium, cobalt, chromium, manganese) in soil samples by atomic absorption analysis)

Mobile forms of Cu, Zn according to the method of Krupsky and Alexandrova in the modification of CRIAS, GOST R 50686-94. All determinations were carried out on a Contr AA300 Atomic Absorption Spectrometer, Germany, 2012, AA-6200 Atomic Absorption Spectrophotometer, Japan, 2003.

RESULTS AND DISCUSSION

A number of factors of different genesis and degree of manifestation affect the ecological state and health of the population in the town Ridder. They can be combined into several groups. First of all, a group of natural factors stands out to which natural-climatic and geological conditions should be attributed. Secondly, a group of technogenic factors among which the production activities of industrial enterprises and transport emissions play the greatest role. Among the main industrial pollutants is Ridder zinc and lead plants. Production facilities are located in the city within the industrial area. The activity of mining and processing enterprises is important in shaping socio-economic conditions, and they inevitably have a negative impact on the environment and on public health. In this regard, the study of the influence of various factors on the environment and the adoption of measures to reduce adverse effects are relevant.

Fig. 3. Plot without vegetation

Fig. 4. Washout the soil in the Tikhaya River

In the zone of influence of the Ridder zinc plant emissions one should especially note bare spaces without plants subjected to erosion processes. The soil cover is devoid of vegetation (**Fig. 3**). In some places, willow shrubs and vein grass are preserved. On the surface of the slope with a gradient of 15-20 ° there are deep gullies and furrows formed to the river. There is a washout of the upper soil layers in the Tikhaya River (**Fig. 4**).

The impact of emissions from a zinc plant is over long distances. The range of emissions in a circle is 2 km, according to the wind rose to the east of the plant towards the “round mountain” and the city. The mountain is devoid of vegetation and is cut by deep erosion grooves, gullies, ditches and aryks. A continuous washout of the upper layers of chernozem soil occurs (**Fig. 5**).

Fig. 5. Eroded sites

Fig. 6. Layout of soil cuts

Fig. 7. Section 1 – Deposit, leached chernozem

On the site devoid of vegetation and surface soil washout as well as on the site of the deposit the soil sections were made. Comparative characterization with a description of the morphogenetic properties of the soil and the selection of soil samples for laboratory and analytical studies were done. Let us give morphogenetic descriptions of leached chernozem on a deposit and the soil polluted by emissions from mining enterprises (**Fig. 6**).

Pedon 1 was laid on a deposit on leached chernozem on a wavy relief of the foothill plain (50º21'24"N; 83º28'11"E). The area of the laying of the section was north-west of the zinc plant in 1.5 km. (**Fig. 7**). The vegetation is corroded by animals. The surface of the

Table 1. Morphological features of the soils profiles investigated

Pedon	Horiz.	Depth (cm)	aColour	bTexture	cStructure	dBoundary	eCons.	fEff.	gRoots
P1	A_1	0-27	10YR5/3	SIC	ST,sbk,f	C	HA	n	f&E
	A_2	27-61	10YR5/3	SIC	abk,f,3	G	SHA, PM,F	n	f&E
	B	61-79	5YR5/1	SIC	abk,f	C	SH, PM,F	n	1,f&E
	BC	79-97	10YR5/1	SIC	abk, & pr	U	SH	n	1,f&E
	C	97-145+	7.5Y7/1	SIC	sbk,m,3	U	H,F	n	0,E
P2	A	0-25	10YR3/3	SCL	gr&sbk,f&m,3	C	H	n	1,
	B	25-56	10YR3/1	SIC	gr& sbk&m,3	G,P	CH	n	1,f&E
	B_1	56- 81	7.5Y6/1	SIC	gr& sbk,	C	CH	n	1,f & E
	BC	81-96	7.5Y5/2	SISC	abk,f,1	C	H	n	1,f & E
	C	96-115+	7.5YR4/3	SISC	abk,3	nd	H	n	0, E,I

[a]Munsell dry colour.
[b] Texture: L=loam; CL Clay-loam; SL= silt-loam; SCL= sandy-clay-loam; SI=dust; SC=sandy clay
[C]Structure. *Type:ST=strong,* sbk=subangular blocky; abk=angular blocky; pr=prismatic; *Size:* f=fine; m=medium; *Grade:* 1=weak; 2=moderate; 3=strong; nd=not described;
[d]Boundary: C=clear , G=gradual,U=unknown,…form W,I=passing to soil horizon is wavy uneven
[e]Consistence:H=hard, SH=slightly hard, PM,F=thin porous,…………………………
[f]Effervescence: n=none
[g]Roots:0=absent, 1=few, f=fine,
E=the tunnels of earthworms
I=Insect nests

Fig. 8. Section 2. Leached Chernozem (Zinc Plant)

territory is covered with zoogenic formations in the form of anthills, burrows of jerboas. The vegetation consists of herbs and grasses (yarrow, dandelion, reed grass) cover of 70%. The leached chernozem was used as a control. Morphological features of the soils profiles investigated (**Table 1**).

Pedon 2 was laid in 250 m from the zinc plant eastward on a strongly eroded surface of the slope, on the left bank of the Tikhaya River (50º20'51"N; 83º29'00"E). The site has willows preserved in places, but significant areas of land were without vegetation cover.

There was no vegetation on the surface. On the surface of the slope with a gradient of 15-20 ° to the river deep gullies and furrows were formed. There was a washout of the upper layers of the soil in the river (**Fig. 8**). Description of soil Pedon 2 (**Fig. 8**).

A characteristic feature of the soil cuts is the abundance of soil zoological fauna activity traces which are filled with soil from the upper horizons. This gives spotting to soil profiles. The cuts were laid during the period of heavy autumn precipitation, as a result of which the profile was saturated with moisture. The surface of the fallow area is represented by formations of intensive zoogenic activity in the form of anthills, burrows, and field mice. Earthworms are found as well. Rich vegetation cover with 70% projective cover formed a good sod layer.

The descriptions of soil profiles are very different in their characteristics. First of all, these sections differ in the thickness of horizons. So, the soil section 1 has a dark gray color, which is characteristic of a well-pronounced thick sod layer and an abundance of roots of various sizes. The taproot penetrates into the lower horizons which are not in the soil horizon of the section 2. In this horizon, there are passages of earthworms and single earthworms. They differ in structure. In the soil of the fallow area, the structure is solid and difficult to break up into separate lumps, whereas the section of the polluted and deprived vegetation section of the horizon A differs in color, so dark gray acquires a brown tint from decayed plant roots. Washout topsoil is clearly seen. The soil structure is fragile, lumpy and granular which easily disintegrates. It should be especially noted that, despite the abundance of earthworm moves and their coprolites, in describing the section, not a single earthworm was encountered. There are ants the representatives of the mesofauna. We believe that the reason for the lack of earthworms is the soil pollution by emissions of a zinc plant and the deterioration of their habitat.

Table 2. Granulometric composition (data in %) of the soil samples.*

Pedon	Horiz.	Depth (cm)	mm					
			1.0-0.25	0.25-0.05	0.05-0.1	0.01-0.005	0.005-0.001	<0.001
P1	A1	0-27	1.8	8.8	27.6	12.0	14.4	35.4
	A2	27-61	1.0	1.1	32.4	19.1	17.0	29.4
	B	61-79	1.4	5.5	29.9	10.4	15.8	37.0
	BC	79-97	1.2	4.1	31.8	11.6	14.5	36.8
	C	97-145+	1.4	5.6	31.0	11.5	14.5	36.0
P2	A	0-25	1.8	10.7	31.8	13.4	19.3	23.0
	B1	25-56	0.3	3.8	24.4	16.9	19.4	35.2
	B2	56- 81	0.1	3.7	28.2	9.5	17.4	41.0
	BC	81-96	0.04	24.3	12.9	3.3	15.8	43.7
	C	96-115+	0.2	2.7	26.1	10.8	19.9	40.3

*The calculation of the ratio of fractions was carried out according to the Kaczynsky classification (1958)

The idea of the structural levels of the soil physical state is based on the relationship of the constituent elements of the soil mass. At the lowest levels, such elements are elementary soil particles, the ratio of which in the soil determines its particle size distribution (Shoba 1999). The granulometric composition is one of the most important indicators of the physical condition, as well as important genetic and agrochemical characteristics of the soil. Soil fertility is significantly associated with the granulometric and structural-aggregate composition. As a result of a long history of the territory formation the granulometric composition of the soil reflects all the stages of its development, and also determines the technological properties of the soil: hardness, adhesion to tillage implements, density. The granulometric (mechanical) soil composition (GSC), that is the relative content of various sizes particles in it, is of great agronomic importance. It allows solving the issues of soil treatment, selection of cultivated crops, to establish the timing of agricultural work. GSC significantly affects water-physical, physico-mechanical, air, thermal properties, redox conditions, absorption capacity, accumulation of humus in the soil, the number of available nutritional element. It is established that the soil of a heavier granulometric composition contains more silt (clay) fraction. The same number of nutrients per 100 g of soil accounts for a larger sample of silt (Utkaeva 2002).

According to the granulometric composition the leached chernozem of the fallow area is characterized as heavy loamy, sandy-silty, sandy (**Table 2**). The granulometric composition shows the aggregation process, i.e. a decrease in the clay fraction and an increase in microaggregates of coarse dust and fine sand. The particle size analysis showed the movement of dust fractions (<0.01mm) to the lower horizon. The process of ligation is a characteristic process for zonal soils.

The soil aggregates of the contaminated experimental site are not water resistant and are subject to both erosion processes and the technogenic impact of pollutants. So, the territory of the experimental field is subjected to erosion processes.

Soil contamination with heavy metals leads to the destruction of soil aggregates and the formation of finer fractions. That leads to weighting and compaction of the soil. The granulometric composition of the upper soil horizons of the experimental plot is characterized as heavy, coarse silty clay (**Table 2**). The movement of fine fractions into subsequent horizons leads to the initial process of forming a more compacted illuvial horizon.

The integral component of the soil which determines its ecological functions and properties is a system of humic substances. Soil organic matter determines the water, heat, air, nutrient regimes of the soil, its physical properties and structural-aggregate composition, buffer properties and features of the soil-absorbing complex. Soil humus also performs a number of biospheric functions: it is a depot of carbon and ash elements; accumulates significant reserves of biochemically bound solar energy; determines the spectral reflectivity of the soil, therefore regulates climatic processes; involved in maintaining biodiversity, creating a habitat for pedobionts. Humus is considered the main indicator of soil fertility, since it accumulates nitrogen, phosphorus, potassium and other plant nutrients. These elements are transformed into forms that are available for nourishing plants and microorganisms with the mineralization of humus (Biryukova and Orlov 2004). Due to the interaction of microorganisms, nutrients such as calcium, magnesium and potassium are absorbed by the soil and removed from the water supply system. Soil microbes decompose organic pollutants and play an important role in the nitrogen cycle, making nutrients available to plants in the required amount.

In the chernozem soil deposits, the humus content in the 0-27 cm layer was 6.9% with a sharp decrease in the lower horizons. The comparative characteristic of the soil of a polluted area by aggressive plant emissions differs in the amount of organic matter. Thus, the total amounts of humus in the upper horizon were 4.7%. Total humus loss because of zinc plant emissions was 32%. The activities of the plant contributed to the intensive manifestation of negative effects in the form of deep erosion processes and partial erosion of the soil humus horizon (**Table 3**).

Nitrogen, phosphorus and potassium are traditionally attributed to the main elements of the soil by which plants are provided. Their content in the soil horizons

Table 3. Soil agrochemical characteristics

Place of selection	Depth, cm.	Humus, %	Total nitrogen, %	Hydrolyzed nitrogen, mg / kg	Phosphorus		Potassium	
					Gross, %	Mobile, mg / kg	Gross, %	Mobile, mg / kg
Deposit, leached chernozem, P-1	0-27	6.9	0.196	50.4	0.2	44	1.69	200
	27-61	2.19	0.154	44.8	0.144	25	1.81	180
	61-79	1.62	0.14	42	0.064	16	2.06	190
	79-97	1.11	0.126	39.2	0.092	12	2.06	190
	97-145	1.38	0.098	33.6	0.12	3	2.06	190
Zinc Plant Experimental Site. P-2	0-25	4.7	0.25	49.0	0.20	40.0	0.25	350.0
	25-56	4.1	0.21	33.6	0.18	17.0	0.25	260.0
	56-81	2.8	0.14	36.4	0.13	10.0	0.25	240.0
	81-96	1.9	0.13	36.4	0.12	5.0	0.19	260.0
	96-115	1.2	0.10	36.4	0.13	10.0	0.25	240.0

Table 4. Content of absorbed bases in soils

Place of selection	Depth, cm.	Absorbed base, mEq.				
		Ca	Mg	Na	K	Сумма
Deposit, leached chernozem, P-1	0-27	13,25	2,75	0,27	0,18	16,45
	27-61	17,5	3	0,37	0,12	20,99
	61-79	18,75	3,25	0,37	0,18	22,55
	79-97	18,25	3,5	0,37	0,18	22,3
	97-145	17,75	3,25	0,37	0,12	21,49
Zinc Plant Experimental Site, P-2	0-25	6,8	5,3	0,1	0,3	12,4
	25-56	21,0	2,0	0,1	0,1	23,2
	56-81	22,5	1,8	0,2	0,1	24,6
	81-96	23,5	1,5	0,3	0,1	25,5
	96-115	22,5	2,0	0,2	0,1	24,8

determines not only fertility, but also the degree of stability and self-restoration of ecosystems.

The content of nutrients such as nitrogen, phosphorus and potassium in the soil can be a diagnostic characteristic of changes occurring under the influence of man-made pollution. The study of the total content of the mobile forms of these elements, their migration ability in the soil profile as well as their seasonal dynamics made it possible to identify the features of the soils of the industrial landscape depending on the level of anthropogenic impact. The content of nutrients in soils subject to significant anthropogenic impact has not been studied enough and is assessed ambiguously. Some authors point to a decrease in the content of nutrients in polluted soils, in particular, nitrate and ammonium nitrogen (Kolomyts et al. 2000, Tsvetkov and Tsvetkov 2003). Others note a high content of nutrients relative to the background, especially mobile phosphorus and exchangeable potassium (Popova et al. 2012).

The soil does not provide a high amount of available forms of nitrogen and mobile phosphorus. The content of mobile potassium in 0 - 20 cm layer is 423.0 mg / kg. In the soil profile decreased amount of mobile potassium is observed (**Table 3**).

The amount of absorbed bases in the soil of the experimental plot is 16.2 mEq. Calcium predominates in the composition of absorbed bases. The amount of absorbed bases of soil section 2 is 12.0 - 25.47 mEq. The decrease in the amount of absorbed bases should be explained by the manifestations of erosion processes (the phenomenon of erosion of the upper horizon) and the influence of heavy metals in complexation and the displacement of absorbed bases (**Table 4**).

Soils are a natural reservoir of heavy metals in the environment and the main source of pollution of adjacent environments, including higher plants. Heavy metals are found in the soil in the form of various chemical compounds. In the soil solution, they are present in the form of free cations and associates with the components of the solution. Most of these are fragile compounds called weak complexes. In the solid part of the soil, heavy metals are in the form of exchangeable cations and surface complex compounds; in the structures of clay minerals as impurities, in the form of their own minerals stable sediments of poorly soluble salts (Kolesnikov et al. 2000, Stroganova et al. 2005). Heavy metals entering the soil surface accumulate in the soil column, especially in the upper humus horizons and are slowly removed during leaching, plant consumption, and erosion. The first half-removal period for various heavy elements varies considerably. It takes a very long period of time: for zinc, from 70 to 510 years; cadmium from 13 to 110 years; copper from 310 to 1500 years and lead from 770 to 5900 years (Strogonov and Myagkova 1996).

Vernadsky pointed to the close relationship between the elemental chemical composition of organisms and the crust (Vernadsky 1922). It is well known that in the same plants the content of chemical elements may be different. It depends on the unequal concentrations in the soil of their mobile compounds. In order to preserve elements concentrations favorable for life plants have a certain protective system. But, in spite of the presence of such a system when the ions of chemical elements are excessively supplied from the soil the plants degrade and die.

A specific feature of emissions from non-ferrous metallurgy enterprises is the simultaneous presence of

Table 5. Content of gross and mobile forms of heavy metals, mg / kg*

Place of selection	Depth, cm.	Zn		Cu		Pb		Cd	
		Gross, MPC 50	Mobile, MPC 23	Gross, MPC 35	Mobile, MPC 3	Gross, MPC 30	Mobile, MPC 6	Gross, MPC 5	Mobile, MPC 2
Deposit, leached chernozem, P-1	0-27	359.6	119.5	44.8	1.1	84.0	13.4	2.0	0.7
	27-61	124.8	21.3	31.2	0.5	26.1	1.8	0.8	0.0
	61-79	86.4	43.3	31.2	0.1	15.8	0.9	1.2	0.1
	79-97	87.2	2.6	27.6	0.6	13.9	0.9	0.0	0.0
	97-145	146.8	1.3	34.0	0.7	83.0	6.6	0.8	0.1
Zinc Plant Experimental Site, P-2	0-25	36440	16695	1427	320	3020	1625	180	92
	25-56	560	280	52	24	2240	920	6	4
	56-81	1200	310	51	20	1480	960	6	4
	81-96	120	60	51	24	760	490	5	3
	96-115	480	230	56	26	1880	1180	6	4

*(MPC= maximum permissible concentration according to the maximum permissible concentration (MPC) of chemicals in the soil is Hygienic standards GN2.1.7.2041-06RF)

large quantities of heavy metals in them. The most dangerous for the environment are groups of toxicants from heavy metals that accumulate in the soil and plants.

According to the results of our research in the area of the zinc plant, it was established that the content of gross lead in the upper 10-cm layer of soil exceeds the MPC by 1.68 times; zinc by 25.46 times; copper by 1054.6 and cadmium by 440.9 times. Especially, the middle and lower parts of the site are heavily polluted, since the territory has a large slope towards the Tikhaya River. Geochemical anomalous regions contain a significant amount of chemical elements in the soil. Many plant species are adapted to such conditions, but when plants and the environment are affected by man-made emissions from mining and processing plants the soil cover is deprived of plant and tree cover in large areas. Emissions from non-ferrous metallurgy are transferred over long distances. Accumulation of heavy metals in the soil and plants at a distance of 10–15 km and further from the source of pollution is noted (**Table 5**).

Plants are one of the most sensitive indicators of anthropogenic changes in the environment. They show a change in the environmental situation under the influence of various factors and therefore are widely used in assessing environmental pollution. The vegetation cover is under a powerful man-made press of pollutants coming from the air and polluted soils. Some of them are necessary for metabolic processes in plants, but an increase in their concentration becomes toxic to plants, other metals, such as Pb, Cd, etc., are toxic even in low concentrations (Baker 1981). Lead excess associated with an excess of metal in the soil leads to slower respiration, suppression of photosynthesis, as well as an increased content of cadmium in plant tissues, reduces the flow of essential trace elements such as Zn, Ca, P, S. External symptoms of the lead negative effect of are the appearance of dark green leaves, twisting of old leaves, stunted foliage (Ilyin and Syso 2001). Near the zinc plant (1 km) the accumulation of these metals in the soil is so great that the cultivation of any crops for animal feed or for eating them is dangerous for human and animal health.

Heavy metals are strongly sorbed and interact with the soil humus and form poorly soluble complex compounds. Thus, there is their accumulation in the soil. Along with this, in the soil under the influence of various factors there is a constant migration of substances falling into it and transporting them over long distances (Mishkevich and Kovalchuk 1988). Heavy metals entering the soil from the emissions of enterprises are firmly bound in the upper layer. The maximum content of metals in soils is observed at distances of 1–3 km from sources pollution (Sadovnikov 1984). Cereals are less resistant to its excess, legumes are resistant. The least resistant to pollution by lead plants are maple species, bulb onions and cocksfoot. Lead concentration above 10 mg / kg dry weight is toxic to most cultivated plants. A number of authors have established easy absorption of such ions as Cd, Br, Cs by plants. While Pb enters the plants more slowly than other heavy metals and is transported to ground organs (Bashmakov 2009, Voskresenskaya and Polovnikova 2009).

Different plants concentrate a different number of microelements in themselves in most cases, selectively. Thus, copper is absorbed by plants of the family Caryophyllaceae, cobalt - Peppers. A high coefficient of biological absorption of zinc is typical for dwarf birch and lichen; nickel and copper for Veronica and lichen. Different plant species have a different ability to accumulate lead, which is widely used to reduce the adverse effects on urban phytocenoses and their use as promising accumulators such phytoremediates. Rationing of the content of heavy metals in the soil and plants is extremely difficult because of the impossibility of fully taking into account all environmental factors. So, changing only the agrochemical properties of the soil (medium reaction, humus content, degree of saturation with bases, particle size distribution) can reduce or increase the content of heavy metals in plants several times. There are conflicting data even on the background content of some metals. The results given by researchers sometimes differ by 5-10 times (Erdyneeva et al. 2016, Kozybayeva et al. 2015, Mensah et al. 2017, Petrovskaya et al. 2016, Zaitseva et al. 2016, 2018).

Our data show that at the site in shrub vegetation (lower part of the study area) Pb exceeds the MPC by 1241 times; Zn by 781; Cu by 11 and Cd 2695 times. In the middle part of the site in poplar plants the Pb content exceeds the MPC by 1580 times; Zn by 317; Cu by 5 times and Cd 1345 times. In the upper part of the plot in pine plants Pb exceeds MPC by 670 times, Zn by 298 times, Cu by 5 times and Cd 1197 times. Studies on the content of heavy metals showed that in plants growing in control plots located 25 km to the north of the plant, the excess of the content of heavy metals in herbs: Pb is 2.8 times, Zn 3.3 times, Cu 0.6 times and Cd 3.3 times. In shrubs, Pb was 5.8 times, Zn was 3.6 times, Cu was 0.4 times and Cd was 7.7 times. When the content of lead in the soil was 100-500 mg / kg, the twisting of old leaves was observed. On the experimental plot, the planted crops show weak crown lining and damage to the edges of the foliage plate under the influence of atmospheric toxic emissions (Beiseyeva and Abuduwali 2013, Kozybayeva et al. 2015, 2017, Muslim et al. 2016).

According to the results of analytical data consecutive series of heavy metals accumulation in vegetative organs of grass and tree-shrub plants were built. The data of researchers of the Kazakh Research Institute of Soil Science and Agrochemistry named after U.Uspanov showed that the accumulation and distribution of heavy metals in vegetative organs of willow (leaves - Cu> Fe> Pb> Zn; branches - Zn> Pb> Cu> Fe; roots - Fe> Pb> Zn> Cu) was uniform and birch had the largest accumulation of heavy metals in the roots — Fe> Cu> Zn> Pb (leaves - Zn> Pb> Cu> Fe; branches - Pb> Zn> Fe> Cu). In grassy plants the largest accumulation of heavy metals was observed in litter and roots (0–10 cm layer), their smallest content was in cutting - Zn> Cu> Pb> Fe (litter - Pb> Zn> Cu> Fe; roots 0-10 cm - Fe> Zn> Pb> Cu; roots 10-20 cm Fe> Cu> Zn> Pb) (Kozybayeva et al. 2015, Muslim et al. 2016). These territories are subject to restoration for sanitary and hygienic and environmental protection purposes.

CONCLUSIONS

As a result of the research, it was revealed that the main source of pollution of the experimental plot is a zinc plant. Areal distribution of emissions of zinc and lead plants in a circle was 2 km with a particular influence of the wind rose eastward from the plant towards the city. But the direction of the wind rose varied, occasionally.

Vegetation cover was destroyed on the territory of aggressive emissions from the zinc plant. Soil cover is subjected to strong erosion processes.

The morphological characteristics of leached chernozem on the deposit differed in color, thickness of horizons, fodderiness, and persistent nut-lumpy soil aggregates. The presence of plant roots, single earthworms, a lot of insects and worms filled with dark and brownish-black caprolites made the soil profile variegated and linguistic.

On the polluted site, the soil section did not have a soddy layer. The thickness of the horizons was shortened and the color of the soil was brownish. Structural units were unstable fragile-lumpy - granular easily broke up into small aggregates. The profile was distinguished by the presence of single root residues, the profile contained many earthworm moves filled with caprolites, but the worms themselves were absent due to the pollution of their habitat.

According to the granulometric composition of the chernozem the leached fallow area was characterized as heavy loamy, sandy-silty, and sandy. The granulometric composition showed the aggregation process, i.e. decrease in the clay fraction and increase in microaggregates of coarse dust and fine sand.

Soil contamination with heavy metals led to the destruction of soil aggregates and the formation of finer fractions which also led to weighting and compaction of the soil. The granulometric composition of the upper soil horizons of the experimental plot was characterized as heavy, coarse silty clay.

The content of total soil humus in the studied polluted soil decreased by 32% compared with the soil of the deposit as a result of the impact of plant emissions, lack of vegetation and erosion processes.

The sum of the absorbed bases for chernozem soils of the deposit and the experimental plot was low. Impact of plant emissions traced everywhere. Heavy metals displaced absorbed bases from PWC and formed complexes.

The soil available forms of nitrogen and mobile phosphorus were low whereas the content of mobile potassium was high. In the soil profile a decrease in the content of mobile potassium was observed.

Analytical data allowed determining the content of heavy metals in the soil, both gross and mobile forms. Priority elements of pollution were zinc, lead, copper and cadmium. According to the results of analyzes the content of heavy metals in the leached chernozem soil exceeded the maximum permissible norms in all elements. An increased concentration of heavy metals was noted in the upper layers of the soil.

Studies on the content of heavy metals in plants showed that the greatest pollution of plants occurred in the lower part of the territory, which is closer to the plant and has a subordinate position. The accumulation of heavy metals in various vegetative organs made it possible to construct biological series of the successive absorption of elements and the determination of the characteristics of plants and their tolerance to pollutants.

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