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The Content of Heavy Metals in the Soil in Aktobe City

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ABSTRACT

For hygienic assessment of anthropogenic pollution of the environment, the state of depositing environments is important, including soil. A particularly strong problem of soil pollution includes industrial cities, such as Aktobe. Soil pollution not only affects the environment but is also having a negative impact on human health. The article presents the results of a study of contaminants in the soil of different districts of Aktobe. Soil samples were taken in five different locations around the city, at different remoteness from Aktjubinsk ferro-alloy plant. Plant is specialized in the production of low-carbon and high-carbon ferrochromium, ferrovanadium, ferrosilicochromium, ferrotitanium, commercial lime. The experiment was conducted in accordance with Methodological recommendations "Organization and procedures for analytical control of soil pollution".The obtained data indicate a high content of heavy metals in adjacent to Aktobe Ferroalloy plant site. High concentrations of zinc, copper, cobalt, nickel, vanadium and lead were identified. The obtained results can serve as a theoretical source for future research in the field of negative influence reduction of industrial enterprises on the environment.

KEYWORDS
Heavy metals; contamination; environment; clark; maximum permissible concentration.

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Introduction

Currently, the environment of the person changes associated with the impact of scientific and technological revolution, human activities. High concentrations of many chemical elements and compounds from technogenic processes currently detected in all environmental media: air, water, soil, plants (Yang et al., 2014; Valipour et al., 2012; Luo et al, 2015).

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Soil - the outer part of the crust. The principal property of soil fertility. It is associated with soil quality, including the content of simple elements, power, pollution (Sungur et al, 2015; Schwarzenbach, Gschewend & Imboden, 1993; Matveev et al., 2016). Therefore, the soil is of great hygienic importance, and is:

1) the main factor in the formation of natural and synthetic provinces, playing a leading role in the emergence and prevention of endemic diseases;

2) an environment that ensures the circulation of the external environment-people used in national economy of chemical and radioactive substances, and exogenous chemical substances entering the soil from emissions from industrial enterprises, aviation and transport, sewage, etc., and in connection with this factor affecting the health of the population (Yang, 2014; Valipour, 2012).

A huge impact on the levels of soil contamination have emissions in atmospheric air of harmful substances that are deposited close to sources of pollution and accumulate in the surface horizons of the soil cover, causes its rapid anthropogenic transformation (Curran-Cournane, 2015; Sungur et al., 2015; Schwarzenbach, Gschewend & Imboden). Therefore, the main principle of analysis of contamination of soils with heavy metals is to determine the extent of the excess of metal contents in soil samples of the studied areas in comparison with MPC, the background level and Clark.

In the industrial regions of Kazakhstan, significant hotspots of anthropogenic disturbances and soil pollution are distributed (Mynbaeva & Imanbekova, 2011; Iskakov, 2008). One of the industrial centers of the country is the city of Aktobe (the administrative centre of Aktobe region), with a population of 387.8 thousand people (2014), which is located in the North-Western part of Kazakhstan, on the left bank of the Ilek river. Average month temperature (coldest month) in January is -15,7˚C, with absolute minimum of -48˚C and an absolute maximum of +2˚C. In July (hottest month) the average temperature is about +22,5˚C, with an absolute maximum of +43˚C and with an absolute minimum of +4^{0}C (figure 1). Average value of wind direction is presented in Figure 2. Therefore, the wind direction at the Western rhumb is 15%, South - 14%, Northeast, East – 13%, Southeast – 12% and North -5% of the total wind direction.

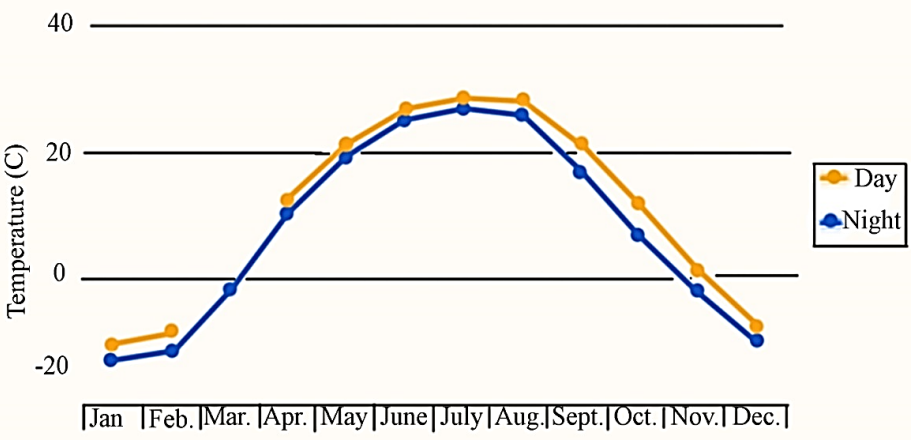

Figure 1. Average temperature

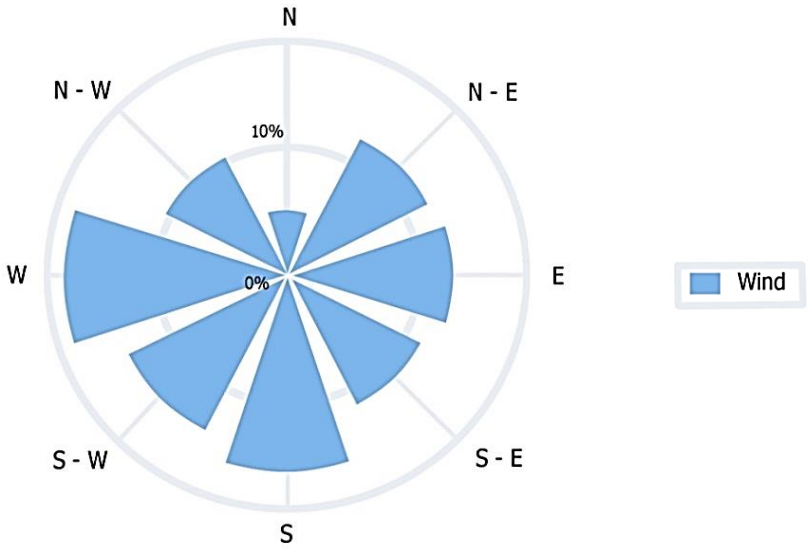

Figure 2. Wind diagram

According to the environmental rating of International Academy of ecology, Aktobe is among the seven most polluted cities of Kazakhstan. Companies that determine the level of pollution of atmospheric air, are 5 organizations: JSC "CNPC-Aktobe", LLP "Kazakhoil Aktobe" UMG "Aktobe", JSC "INTERGAS Central Asia", branches of JSC "TNC "Kazchrome", Aktobe Ferroalloy plant (AFP) and Donskoi GOK (GGOK), which have 42% of emissions of pollutants into the atmosphere. Actual emissions for 2014 amounted to 121,8 thousand tons (National report on the state of the environment and natural resources use for the period of 2011-2014). A considerable share of the total amount of pollutant emissions from road transport (40.6 per cent). In order to reduce the load on the atmosphere of the city from the emissions of road transport in 2014 completed the construction of the road "Northern bypass of Aktobe", the construction of a draw bridge in the 11th district of Aktobe, improvement of pavement, etc., which helped to relieve the Central part of the city from transit transport and to reduce emissions at individual sites Aktobe (National report on the state of the environment and natural resources use for the period of 2011-2014).

According to LLP "Eco-Operating" the city of Aktobe, in the soil samples, selected in different districts, the lead content was in the range of 0.1-0.2 MPC, chromium of 0.04-0.3 MPC and zinc 0,3-0,7 MPC, copper 1,0-1,3 MPC and cadmium of 0.6 and 2.3 MPC. In the area of school №16, the cadmium content was 1.6 MPC and copper of 1.1 MPC. On site, street Turgeneva, cadmium content amounted to 1.2 MPC, and copper of 1.1 MPC. Near the railway station in the soil samples the content of all determined heavy metals were in the normal range. By results of RSE "Kazgidromet" researches in 2013, soil samples of Aktobe city in selected districts, the lead content was in the range of 0.04-0.2 MPC, chromium is 0.02-0.1 MPC and zinc 0,2-0,5 MPC, cadmium 1,0-3,3 MPC, copper 0,01-1,7 MPC. In all areas of the city the concentration of lead, chromium and zinc did not exceed the permissible norm. In different parts of the city in the spring of the contents of cadmium and copper were as follows: - in the areas of school №16 and Turgenev

cadmium concentrations of 1.5-2.0 MPC, copper of 1.3 MPC; - in areas around the airport and the train station, the concentration of copper was 1.1 and 1.7 of the MPC; in the district of the Aktobe ferroalloys plant cadmium concentration of 3.3 MPC (On the state of environment of the Republic of Kazakhstan, 2013; National report on the state of the environment , 2014; The standards of maximum permissible concentrations of harmful substances, 2004). Iskakov (2008) identified territories (AFP) where the chromium concentration exceeded 10 g/kg (the limit is determined by spectral analysis of the content). 50% of the area of the surveyed plot of the CR content exceeded 8 g/kg (80 MPC EU, 100 times more than Clark). The average content of chromium in the soil of the city - 931±112,0 mg/kg. The average content of lead was 78.1±11,25. The average nickel content in soil at 1.0-1.5 times higher than the MPC. In the area of AFP can also be detected abnormality in the content of cobalt, respectively, to 500 and 150 mg/kg soil (Iskakov, 2008). Thus, these different sources have different performance, which requires careful study of the soil of the city of Aktobe the content of heavy metals. The excess concentration, which can affect the health of animals and humans.

Aim of the Study

To determine the content of heavy metals (zinc, copper, cobalt, nickel, vanadium, lead) in soil of different districts of the city of Aktobe.

Research questions

How far does the level of pollution exceed the maximum permissible norm?

Method

Theoretical basis of research are works of domestic and foreign researchers in the field of ecology. The study used general scientific methods of statistical and comparative analyses, tabular methods of data visualization. In addition, the experiment was conducted in the course of which were definite indicators of soil pollution.

Sampling of soil was conducted on the territory of the Aktobe ferroalloys plant - point No. 1 (AFP – is located in the northeastern part of the city, the products are low-carbon and high-carbon ferrochromium, ferrovanadium, ferrosilicochromium, ferrotitanium, commodity lime, occupies a total area of 367.5 hectares), in the yard of school № 16 on point No. 2 (the distance from the AFP 1 km), at the intersection of Turgenev and Skulkin – point No. 3 (3 km), train station in Aktobe – point No. 4 (7 km) and the area around the airport to point No. 5 (10 km), on the determination of the content in the soil zinc, copper, cobalt, nickel, lead and vanadium. Point sampling of the soil are determined at various distances from AFP, taking into account wind roses (at the locations of the environmental posts in accordance with the approved plan of Aktobe regional territorial administration, environmental protection, and harmonization with the Ministry of environment protection of Kazakhstan).

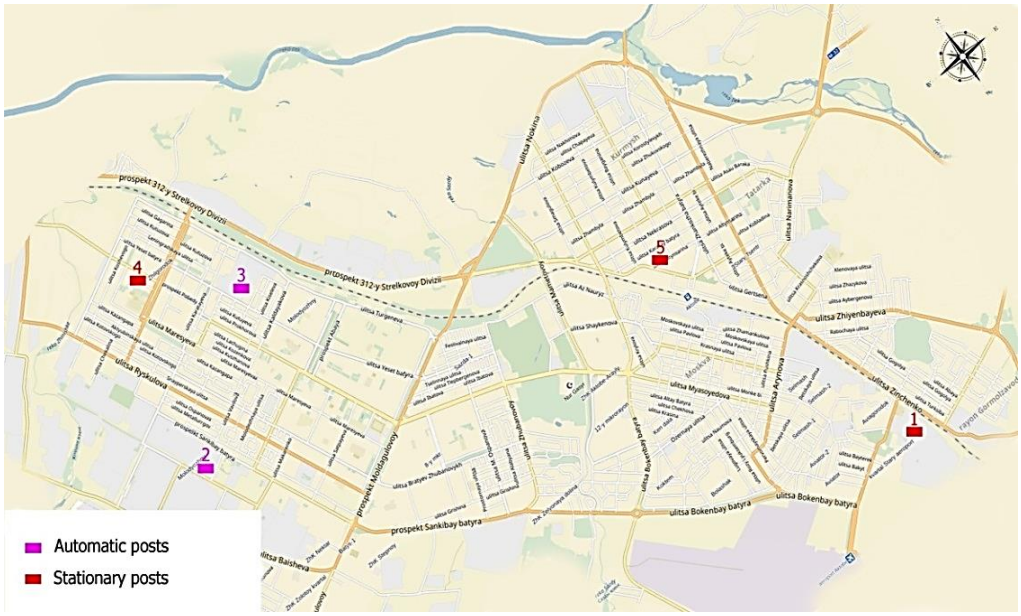

Figure 3. The sampling of soil

Soil samples were made in the spring and autumn periods in 2014 and 2015 in accordance with the guidelines, "Organization and procedure of analytical control of soil pollution" (Union Standard "Protection of nature"). Samples from these zones are selected from a depth of 0-10 cm of topsoil in accordance with All Union State Standard (Union Standard "Protection of nature"). Determine the level of heavy metals in the soil was performed by atomic absorption spectral analysis.

The study was carried out in the accredited testing laboratory of the Department of laboratory-analytical control of the Aktobe regional territorial administration of environmental protection.

Data, Analysis, and Results

The level of soil contamination in the spring period 2014-2015 in the city of Aktobe is listed in Table 1. As it can be seen from Table 1, the content of Zn in soil on the territory of the AFP (point No. 1) to 2014 is 1.2 MPC("The maximum allowable concentrate chemicals in soils", 1997). and in 2015 – 2,14 MPC. In 2015, the point No. 3 – 1, 1 MPC and the point No. 5 – 1.2 MPC. The Cu content in the point number 1 – make up of 2.13 and 2.25 MPC, respectively in 2014 and 2015 With Content from 0.68 to 0.82 MPC. Ni at points 3,4 of ranged from 1.03 to 1.2 MPC. Levels of V ranging from 0.5 (point No. 1) to 0.87 (point No. 5) EQS. The content of Pb exceeded at all points in 2104 and 2015. Most were determined in points №№ 2,3 – 1.2 to 1.6 MPC.

Table 1. The content of metals in soil samples in the spring of 2014 and 2015 (mg/kg)

№	The place of sample taking	Metal content											
		Zn		Cu		Co		Ni		V		Pb	
		2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
1	AFP Territory	28,1	49,3	70,3	74,5	3,9	4,0	3,0	3,1	74,0	80,0	39,3	41,0
2	The courtyard of the school №16	18,9	20,2	20,0	24,7	3,9	4,0	3,9	4,0	109,1	110,0	38,8	39,0
3	Crossing of the Turgenev street and Skulkin street	15,3	24,3	13,1	23,5	3,4	3,5	4,1	4,9	111,0	112,0	49,1	52,0
4	Railway station area	10,5	18,6	13,3	21,9	4,0	4,1	4,6	4,7	109,1	117,0	33,4	34,5
5	The Area Around The Airport	6,1	27,4	7,8	15,4	3,6	3,7	3,1	3,0	127,0	130,0	32,5	32,7
6	MPC	23,0	23,0	33,0	33,0	5,0	5,0	4,0	4,0	150,0	150,0	32,0	32,0

Table 2. The content of metals in soil samples in the autumn of 2014 and 2015 (mg/kg)

№	The place of sample taking	Metal content											
		Zn		Cu		Co		Ni		V		Pb	
		2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
1	AFP Territory	32,4	50,5	71,3	76,4	4,0	4,7	3,1	3,6	75,0	95,0	40,0	43,0
2	The courtyard of the school №16	19,0	21,0	20,1	31,2	4,0	4,1	4,0	4,4	110,0	111,0	38,0	40,0
3	Crossing of the Turgenev street and Skulkin street	14,2	29,6	14,7	27,5	3,5	4,0	4,9	5,0	112,0	112,0	50,0	54,0
4	Railway station area	10,6	19,3	13,7	28,5	4,1	4,2	4,7	4,7	117,0	117,0	34,0	35,0
5	The Area Around The Airport	5,8	28,8	7,92	20,5	3,7	3,9	3,0	3,1	130,0	132,0	32,1	33,0
6	MPC	23,0	23,0	33,0	33,0	5,0	5,0	4,0	4,0	150,0	150,0	32,0	32,0

From Table 2, it is seen that the concentration level of Zn in 2014, point No. 1 amounted to 1.4 MPC at other points of the exceedances were observed. In 2015, the content of Zn in the point No. 1 was 2.2 MPC in points No. 3, 5 and 1.3 MPC. The excess Cu was observed only in the point No. 1 is 2.2, and 2.3 MPC, respectively in 2014 and 2015 the co Content as in the spring period did not exceed the MPC. Ni at points 3,4 of ranged from 1.2 to 1.3 MPC. As in the spring period level V did not exceed the MPC, although as the distance from point # 1 element content increased from 0.5 to 0.9 MPC. As well as in the spring in soil samples the concentration of Pb exceeded the maximum permissible concentration at all points – from 1,003 to 1.7 MPC. The content of the element was at the point No. 3 is 1.6 and 1.7 MPC, respectively in 2014 and 2015.

Discussion and Conclusion

Table 3. Clarks of chemical elements in urban soils, mg/kg

Element	Symbol	Alekseenko V. A.(2013)	Aktobe city		
			Max.	Average	Min.
Zinc	Zn	158	50,5	22,5±11,7	5,8
Copper	Cu	39	76,4	29,8±23,1	7,8
Cobalt	Co	14,1	4,7	4,0±0,3	3,4
Nickel	Ni	33	5,0	4,0±0,7	3,0
Vanadium	V	54,5	132,0	109,5±16,8	74,0
Lead	Pb	104,9	54,0	39,6±6,9	32,1

Compared to cercami in urban soils (Alekseenko V. A., Lavrov, 2012; .18.19] in Aktobe the average content of V exceeds 2.0 times, and maximum content of 2.4 times (table 3). The content of other investigated metals did not exceed clark.

From table 4 it is seen that compared with the known kurkami (Kasimov & Vlasov, 2015; Taylor, 1964) in Aktobe exceeds the average content of V and Pb, and the max content of Cu, V and Pb.

Waste management at AFP's happening in terms of a system of environmental management ISO 14000: 2004 in accordance with the regulations "On waste management". This regulation establishes the procedure for collection, storage, utilization and accounting of waste production (Saspugaeva, Akshabakova & Satova, 2013).

AFP has 3 basic electric steel melting shops and eight subsidiary providing basic. Enterprise AFP TNC "Kazkhrom" is located on 3 sites:

- site No. 1 – Plant ferrosplavov;
- site No. 2 – the Quarry "Sholaksay-South";
- platform No. 3 – Residence of JSC "TNC Kazchrome".

The company has landfills for waste disposal of production and consumption: a room with an area of 47 ha and the area of construction waste (ACW) with an area of 1.78 hectares In the room are dumping slag on ACW – production-construction waste (Saspugaeva, Akshabakova & Satova, 2013).

However, soil in the city of Aktobe remains significantly contaminated, which has a negative effect on the environment and on the health of the residents of the city.

Table 4. Clarks of chemical elements in the upper continental crust, mg/kg (Kasimov & Vlasov, 2015).

№	Element	A. P. Vinogradov (1962)	A. A. Beus et al. (1976)	D.M. Shaw et al. (1976)	S.R. Taylor, S.M. Mclennan (1985)	K.H. Wedepoht (1995)	S.Gao et al. (1998)	R.L. Rudnick, S.Gao (2003)	Z. Hu, S. Gao (2008)	N. A. Grigoriev (2009)	Aktobe city	
1	Zn	83	51	52	71	52	70	67	75	75	Max.	50,5
											Average	22,5
											Min.	5,8
2	Cu	47	22	14	25	14,3	32	28	27	39	Max.	76,4
											Average	29,8
											Min.	7,8
3	Co	18	7,3	12	10	11,6	17	17,3	15	17	Max.	4,7
											Average	4,0
											Min.	3,4
4	Ni	58	26	19	20	18,6	38	47	34	50	Max.	5,0
											Average	4,0
											Min.	3,0
5	V	90	76	53	60	53	98	97	106	121	Max.	132,0
											Average	109,5
											Min.	74,0
6	Pb	16	16	17	20	17	18	17	-	17	Max.	54,0
											Average	39,6
											Min.	32,1

Implications and Recommendations

The content of Zn in the soil at the point No. 1 exceeded the MCL in the spring and autumn to 2.2 times. In 2015, points №№3,5 exceeded MPC by 1.3 times. The Cu content in the point No. 1 was 2.3 MPC. In point number 1 exceeds clark, including 2 times Clark in urban soils. The content of Ni in points 3,4 of ranged from 1.2 to 1.3 MPC. The concentration level of V did not exceed the MPC, although as the distance from point # 1 element content increased from 0.5 to 0.9 MPC. However, there is excess known the Clarks and the excess of the Clark in urban soils 2.4 times (max). The content of Pb exceeded at all points in 2104 and 2015. Most were determined in points №№ 2,3 – 1.2 to 1.6 MPC. Exceeding the Clarks was 2.7 times. Compared with the spring period of autumn, the metal content was slightly increased in 2014 and 2015.

Thus, in the soil of the city of Aktobe the content of Zn and Cu exceed the maximum permissible concentration at point No. 1 (the territory of the AFP), Ni at points 3,4 of Pb at all points. It is noted the excess of the Clarks on the contents of V and Pb. In turn, sagrestia soil has a negative impact on human health.

The results of this article can be used as a theoretical source for further research for improving soil quality.

Disclosure statement

No potential conflict of interest was reported by the authors.

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