ЭКОЛОГИЯ ПОЧВ

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L.M. Kalimoldina[1*], G.S. Sultangazieva[1], M.Sh. Suleimenova[1]

CONTAMINATION OF SOILS WITH HEAVY METAL IN THE URBAN AREA OF ALMATY

[1]Almaty Technological University, 100, Tolebi Str., Almaty, Kazakhstan,
**email: Kalimoldina.laila@mail.ru*

Abstract. Heavy metals refer to special pollutants, monitoring of which is obligatory in all environments. In this regard, the study of soil contamination with heavy metals is one of the urgent issues. The research results showed that the amount of heavy metals in samples from sites located along the Tashkent tract was several times higher than the norm. The study of anthropogenic impact on soil microbiota is a necessary element of any biomonitoring study. Heavy metals already rank second in terms of danger, inferior to pesticides and well ahead of such well-known pollutants as carbon dioxide and sulfur. In the future, they may become more dangerous than nuclear power plant waste and solid waste. Contamination with heavy metals is associated with their widespread use in industrial production. Due to imperfect cleaning systems, heavy metals get into the environment, including soil, polluting and poisoning it.

Key words: soil, heavy metals, concentration, contamination, maximum permissible concentration.

INTRODUCTION

One of the main problems of the modern world is the impact of heavy metals on the environment. The spread of heavy metals in the living environment is intensively taking place not only in natural conditions, but also by anthropogenic means. These include production waste, transport, chaotic use of fertilizers, which contain heavy metals, and general urbanization. Residual substances emitted from transport smoke of the highway, which is located on the territory of Almaty city, have been polluting the environment for many years. The main ones are the degree of distribution of heavy metals into the air, soil and water. Heavy metals spread in the air in the direction of the wind, and in the soil, passing to the middle layers, they are transported to the plant organism through plant roots.

An important role in the process of anthropogenic changes in soils is played by their contamination with technological waste. The main group of pollutants includes heavy metals, the main part of which enters the lower layers of troposphere with emissions from industrial enterprises, migrating by air and settling into soil surface layers. The position of polluting metals in space is quite complex and depends on many factors. However, even in any case, the soil is the main accumulator of technogenic part of heavy metals. Any type of industrial pollution of soils with heavy metal is estimated by increased concentration of metal compared to the initial natural concentration, to which plant and animal organisms have long adapted.

The soil largely determines the microelement composition of growing plant. Currently, the study of accumulation of heavy metals in soil and their passage through the nutrient chain is one of the important issues, since they have a long-term toxic effect on all living organisms, including the human body [1].

The purpose of our research work is to identify harmful substances in soil composition in anthropogenically contaminated zones. Environmental protection- the first issue, that is put before scientists, determination of the total and active concentration of heavy metals in soil. The second point is the development of simple and sufficiently reliable models for distribution of pollutants in order to predict the level of

pollution of natural objects. Thirdly, scientifically justified neutralization and rationing of heavy metals aimed to prevent the negative consequences of pollution. In general fractions in the form of dust (0.001 -0.005 μm) of heavy metals that spread differently into the air, very small particles (0.001-0.005 μm) and medium-level fractions in different places make up about 34-54 % compared to large-sized fractions. According to scientific data, in trophic relations, human body takes 40-50 % of toxic substances from food, 20-40 % from water, 20-40 % from air. Heavy metal ions, entering this way are the main cause of occurrence of various diseases in the human body. In technogenically polluted areas, diseases of stomach are in the first place, diseases of respiratory system are in the second place, and diseases of circulatory system are in the third place. Therefore, purification of the environment from heavy metal ions and its preservation, apparently, is an urgent relevant issue [2].

Heavy metals, when entering the environment in large quantities, result in poisoning the soil. These metals include lead, zinc, cadmium, mercury, molybdenum, manganese, nickel, tin, cobalt, titanium, copper, vanadium. These elements are not destroyed by the process of self-purification of ecosystems when released into the environment. They accumulate in soil, pass to plants and then enter into biological circulation. The biological chain: soil-plant-human, soil-water-human and soil-atmospheric air penetrate the human body, causing various diseases.

MATERIALS AND METHODS

For conducting the research, we used an I-160M laboratory ionomer, which is designed to measure temperature in laboratory conditions, automatically converts electronic input signals from primary pH-converters or to information measurement signals displayed on automatic digital indicators of the recovery of aqueous solutions, as well as analog and digital output signals. The device measures pH, as well as redox potential (eh), temperature (T) of monovalent and bivalve anions and cations (hereinafter referred to as ion activity, pX), as well as ion concentration (Cx) in aqueous solution (in accordance with approved measurement procedures).

This device is intended for use in laboratories of industrial enterprises and research institutions in various sectors of the national economy. The device consists of a measuring transducer (hereinafter referred to as the transducer) and a set of measurement accessories. The device is based on potentiometric method for measuring pH (pH) and eh of controlled solution. The operation of converter is based on conversion of electronic system and other sources of EMF into proportional voltage, followed by conversion into a digital code and an analog output signal. When measuring pX (pH) or eh solutions, electrode system is used, which is consisting of measuring and auxiliary electrodes. For this, various concentrations of lead were prepared and their potentials were determined. In the methods of phototurbidimetry and nephelometry, the element to be detected is converted into weakly soluble compound, and this compound must form a stable dispersion system during formation.

Soil samples were taken from the study sites from depth of 25 cm. Concentration of heavy metals and trace elements in soil samples has been determined in accordance with the guidelines for determination of heavy metals in soils and crop products suitable for agriculture [2].

Determination of sulfate ions in soil composition by turbidimetric method. Based on the basis of the method, Td = Td + V/Vk, using this formula we determined Td - turbidity of sulfate ions, Td - turbidity degree, V - volume of sulfate ions.

As turbidity value of soil solution increases, sulfate concentration decreases, and the degree of turbidity increases. The turbidity of solution has changed at different concentrations, as shown in the graph (figure 1).

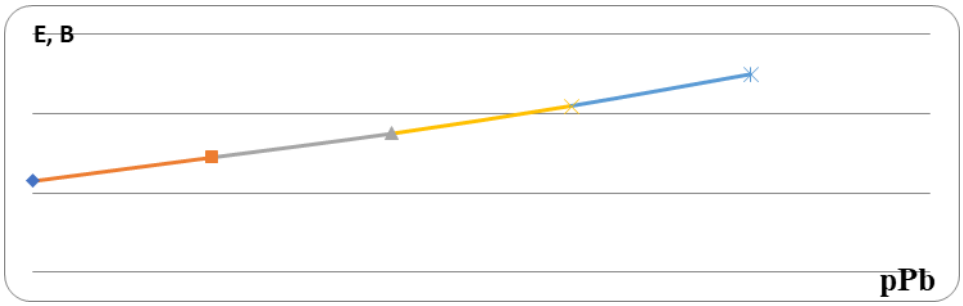

Figure 1 – Correlation between different lead concentrations and potentials

RESULTS AND DISCUSSION

To determine the amount of distribution of heavy metals in soil, we selected study sites where observations were made. On the territory of Almaty, study sites have been identified:

- study site No.1 - adjacent areas of Raiymbek avenue (Tashkentskaya st.);
- study site No.2 - botanical garden located in the central area of the city;
- studysite No.3 - settlement "Altyn Orda" 2 km from the city

For this purpose, soil is taken from a depth of 30-35 cm per 1 square meter of land. The soil was taken from the surface, middle and lower layers and completely mixed (table 1).

Table 1- Concentration of heavy metals in soil (mg/kg)

Soil study site	Soil environme	Lead	Copper	Zinc	Cadmium
		32 mg/kg	33 mg/kg	55 mg/kg	1,0 mg/kg
No. 1 - areas adjacent to Raiymbek ave. (Tashkentskaya st.)	pH-8,2	445,72±6,74	136,45±4,64	169,26±4,85	10,71±1,42
No. 2 - Botanical Garden	pH-8,3	318,16±5,23	110,35±3,92	90.96±4.10	2,88±0,86
No. 3 - the settlement "Altyn Orda" 2 km from the city	pH-8,0	27,66±2,45	23,15±2,32	26,54±2,80	-

According to the results of study site No. 1, it was found that lead concentration in soil was 14 times higher than maximum permissible concentration (MPC), and amounted to 445.72 mg/kg. At the study site No. 2, the amount of lead was 318.16 mg/kg, which was 10 times higher than the MPC. At study site No.3, lead concentration was 27.66 mg/kg, i.e. did not exceed MPC (control samples).

Analysis of data on copper in soil showed that in the zone of Raiymbek avenue (Tashkentskaya street, site No.1), its concentration was 136.45 mg/kg, which is 4.2 times higher than the MPC. Taking into account that the established maximum concentration of copper in soil is 33.0 mg/kg. At the study site 2 (Botanical Garden), 110.35 mg/kg of copper was detected, which is 3.3 times

higher than the MPC. In the control sample, the amount of copper was 23.15 mg/kg, i.e. does not exceed the maximum permissible concentration [3].

In the soil along Raimbek Avenue, the highest accumulation of zinc 169.26 was observed which exceeds the MPC 3 times. In soil sample taken in the Botanical Garden, it is much less - 90.96 mg/kg, but there is also an excess of MPC by 1.6 times. Zinc concentration in soil sample of Altyn Orda is 2 times less than MPC.

Cadmium concentration in the area adjacent to Raiymbek Avenue is 10.7 times higher than MPC. On the territory of the Botanical Garden, cadmium concentration is much lower, exceeding the MPC by 2.8 times. Cadmium was not found in the Altyn Ordy soil sample.

According to the results of table 2, in soil selected in the Botanical Garden, cadmium concentration in soils decreases as the distance decreases in other study sites. The deviation is observed in comparison with the nearest places, cadmium concentration decreases within 47.8-100 %

Table 2 - Cadmium concentration in soils of Almaty city, mg/kg

500 m		1000 m		1500 m		2000 m		500-2000 m
n	%	n	%	n	%	n	%	P
0,667	100	0,550	82,4	0,351	52,6	0,316	47,3	0,70
0,213	100	0,176	82,6	0,95	65,2	0,102	47,8	0,97
0,566	100	0,538	80,7	0,99	61,7	0,283	42,4	0,99
0,136	100	0,103	75,7	0,999	56,6	0,057	41,9	0,999

Table 3 shows that zinc concentration in soils decreased in terms of distance in other soil study sites, at study site of Raimbek Ave., the greatest accumulation of zinc 28.0 mg/kg was observed. The decrease of zinc concentration in the soil sample in the area of Altyn Orda was observed in the range of 18.8-100 % compared to the nearest sites.

Table 3 –Concentration of zinc in soils of Almaty, mg/kg

500 m		1000 m		1500 m		2000 m		500-2000 m
n	%	n	%	n	%	n	%	P
64,4	100	50,9	79,0	37,5	58,2	24,1	37,4	0,999
46,2	100	40,1	86,7	34,1	73,8	28,0	60,6	0,95
64,7	100	61,0	81,6	41,5	55,5	16,0	21,4	0,99
70,1	100	65,8	57,1	34,7	30,0	21,7	18,8	0,999

Table 4 shows that in soil sample of the Altyn Orda region, concentration of copper in soils decreases compared to other study sites. The deviation was observed in comparison with the nearest sites, zinc concentration decreases within 36.1-100 %.

Table 4 - Copper concentration in soils of Almaty, mg/kg

500 m		1000 m		1500 m		2000 m		500-2000 m
n	%	n	%	n	%	n	%	P
-	100	8,4	76,0	6,67	-	-	-	-
7,15	100	7,08	99,0	6,78	60,3	5,84	52,8	0,99
25,7	100	20,23	78,7	14,76	94,8	6,27	87,6	0,96
2,88	-	-	-	-	57,4	9,29	36,1	0,999

Table 5 shows the data obtained during the research work on heavy metal contamination of soils in Almaty. The settlement "Altyn Orda", which is located 2 km from the city, there was a decrease in lead in the range of 58.9-100 % compared to the nearest sites.

Table 5 –Concentration of lead in soils of Almaty, mg/kg

500 m		1000 m		1500 m		2000 m		500-2000 m
n	%	n	%	n	%	n	%	P
6,19	100	5,90	95,3	5,53	89,3	4,89	78,9	0,99
0,93	100	0,76	81,7	0,59	63,4	0,42	45,1	0,96
8,72	100	4,22	48,3	1,83	20,9	1,54	17,6	0,99
0,73	100	0,63	86,3	0,53	72,6	0,43	58,9	0,999

The data obtained as a result of conducting studies on the level of heavy metals concentration, and sampling of soil at various distances in Almaty city, are presented. Soil contamination with heavy metals was especially often observed near the highway, as evidenced by the result of this work [4].

Thus, according to the research results, it was found that at different distances (500-2000 m) in the territory of Almaty, the adjacent areas to the south of Raiymbek avenue (Tashkentskaya street); botanical garden, to the east of the city; "Altyn Orda", 2 km south of the city, concentration of detected heavy metals in soils is at different levels. In accordance with this, in soils of the same region, heavy metals fluctuate in different concentrations.

The danger of the increased concentration of heavy metals in soil and atmosphere is also associated with their active absorption and accumulation in plants, which has negative effect not only on plant vital activity, but also poses a serious threat to human and animal health.

According to the results of statistical analysis, there is a direct correlation between soil and plants. Morphopathogenesis of leaves and all plants was observed in the zone of ventilation distribution of harmful residual substances. Leaf damage manifested itself as necrosis with a change in shape and color, as well as chlorosis, yellowing, loss of turgor properties, color change, fall after change or minor external damage. In heavily polluted areas, industrial dust also has a significant negative impact on plants. Large dust particles (5-10 m/km) mechanically affect the above-ground plant organs. Dust, along with damage to buds, flowers, leaves (cutting down), damages the bark of the trees, causing its cracking and falling. Purified wood loses water and begins to fade, the function of potassium is disturbed, that is, the viability of the whole plant organism decreases [5].

Plants contaminated with cadmium in the entire atmosphere amount to 20-60 %. Cadmium which enteres through the atmosphere can pollute the flora.

Lead mainly enters plants through the roots or even through the leaves. Atmospheric lead can reach 40 % compared to the content of vegetation in the area of highways.

The main amount of lead is concentrated on vegetative organs, and 4-7% of plant composition accumulates in the reproductive organs. The impact of heavy metals on plants and their response are subject to the well-known "dose-effect" correlation, which often has a two-phase character. This means that, at low concentrations, heavy metals can have a stimulating effect on plants (in relation to certain physiological processes and indicators), while higher doses cause an inhibitory effect, which increases as active

concentration increases. In certain cases, it can even end in the plant death.

Depending on the source of pollution (natural or technogenic), there are noticeable differences in the profile distribution of heavy metals in soil.

According to research data, concentration of heavy metals in soil is very high in comparison with the control zone. The concentration of heavy metals in soil, except for zinc, is much higher than in the studied areas (table 6).

Table 6 - Concentration of heavy metals in soils, mg/kg

Heavy metals	Concentration, mg/kg								
	500 meters		1000 meters		1500 meters		2000 meters		500-2000 м
	n	%	n	%	n	%	n	%	P
Cu	11	100	5,0	70	5,0	50	3,0	30	0,999
Cd	0,3	100	0,1	66,6	0,1	33,3	0,05	16,6	0,95
Pb	4,1	100	2,7	60	2,7	54	2,0	40	0,99
Zn	30	100	15,0	53,3	15,0	50	12,0	40	0,999

Heavy metals - is group of non-ferrous metals, which density exceeds the density of iron (7.874 g/cm^3). These include zinc, lead, tin, manganese, bismuth, copper, mercury, antimony, nickel, cadmium. Therefore, concentration of heavy metals in the environment should not exceed the MPC [6].

Phytoremediation is the most important method of soil purification from heavy metals. Phytoremediation is cost-effective, and environmentally friendly compared to other physical and chemical methods. Depending on soil conditions and metal concentrations, plants account only 5 % of the cost of other solar energy cleaning methods. In this regard, the study of metal-saving activity of natural plant species in Kazakhstan is relevant and timely, and identification of the most effective plant species for phytoremediation of contaminated soils a promising direction.

For the phytoextraction method, it is necessary to clean the contaminated soil from heavy metals by increasing concentration of metal in biomass and aerial part of the plant, and conducting effective agronomic measures, taking into account physical and chemical properties of each heavy metal, biological characteristics of plants. Mowing and removing the plant green mass, in which a large amount of metal ions has accumulated in soil, results in biological purification of soil. The rate of absorption of heavy metal from soil by the plant also depends on pH, soil density, redox reactions, concentration of organic substances in it, and concentration of other metal ions.

For toxic metals such as lead, the limiting factor is poor solubility, mobility, and vascular absorption of its salts. The only way to increase solubility of heavy metal salts is reduction of the pH, that is, soil acidification, concentrating lead at the roots [7].

CONCLUSION

Soil contamination with heavy metals is associated with intensive development of production and motor transport, as well as the fact that soil is not the only source of plant pollution. Plants can also be polluted with heavy metals through the atmosphere. High concentration of heavy metals in soil leads to disappearance of plant species which are sensitive to them and decrease in vegetation in a certain area.

Soil contamination with heavy metals was especially often observed near the highway, as evidenced by the results obtained in this work.

In connection with the increased number of vehicles in the environment, the "technogenic zones" appear. Due to the large amount of heavy metals in nature, only plant species which are resistant to these conditions, remain. The adaptability and natural selection of plants to extreme chemical conditions in the environment is determined by biochemical and physiological variability of organisms within populations. Under the influence of heavy metal, the cells of the root meristem zone are destroyed, and further zones of stretching and formation of root hairs. In strong and prolonged exposure to heavy metals. In regions which are contaminated with heavy metals, plant resistance increases, and intolerant and sensitive species die completely. The issue of cleaning the soil, which is contaminated by their specific components, has not yet been solved. As a result of research work, the following goals were achieved:

- ways of heavy metals entry into the soil are determined;
- methods of determining heavy metals in soil are considered;
- amounts of distribution of heavy metals in soil at selected research sites where observations were done, were determined.

It is shown that the increased migration of chemical elements in biosphere affects the need to reduce concentration of heavy metals in soil, which pollute the wildlife components.

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ТҮЙІН

Л.М. Калимолдина[1*], Г.С. Султангазиева[1], М.Ш. Сулейменова[1]

АЛМАТЫ ҚАЛАСЫНЫҢ ҚАЛА АЙМАҒЫНДАҒЫ ТОПЫРАҚТАРДЫҢ АУЫР МЕТАЛДАРМЕН ЛАСТАНУЫ

[1]Алматы технологиялық университеті, Казақстан. Алматы қаласы, Төле би көшесі, 100, email: kalimoldina.laila@mail.ru

Ауыр металдар - бұл барлық орталарда бақылауды қажет ететін ерекше ластаушы заттар. Осыған байланысты топырақтың ауыр металдармен ластануын зерттеу біздің заманымыздың өзекті мәселелерінің бірі болып табылады. Деректер топырақтағы ауыр металдар мен олардың қосылыстарының шоғырлануы мен ұлғаюын көрсетеді. Бұл

мақалада топырақтың ластану көрсеткіштеріанықталған. Зерттеу нәтижелері көрсеткендей, Алматы трассасының бойындағы, атап айтқанда Райымбек ауданының трактісі учаскелерінде ауыр металдардың мөлшері, нормадан бірнеше есе асып түсті. Топырақ микробиотасына антропогендік әсерді зерттеу кез-келген биомониторингтік зерттеудің қажетті элементі болып табылады. Қазірдің өзінде ауыр металдар пестицидтерден төмен және көміртегі диоксиді мен күкірт сияқты танымал ластаушы заттардан едәуір озып, қауіптілік деңгейі бойынша екінші орында. Болашақта олар атом электр станцияларының қалдықтары мен қатты қалдықтардан гөрі қауіпті болуы мүмкін. Ауыр металдардың ластануы олардың өнеркәсіптік өндірісте кеңінен қолданылуымен байланысты. Тазалаудың жетілмеген жүйелеріне байланысты ауыр металдар қоршаған ортаға, соның ішінде топыраққа еніп, оны ластайды және уландырады. Ауыр металдар арнайы ластаушы заттарға жатады, оларды бақылау барлық ортада міндетті болып табылады. Топырақ-ауыр металл түсетін негізгі орта, оның ішінде атмосфера мен сулы орта.

Түйінді сөздер: топырақ, ауыр металдар, концентрация, ластану, шекті рұқсат етілген концентрация.

РЕЗЮМЕ

Л.М. Калимолдина[1*], Г.С. Султангазиева[1], М.Ш. Сулейменова[1]

ЗАГРЯЗНЕНИЕ ТЯЖЕЛЫМИ МЕТАЛЛАМИ ПОЧВ ГОРОДСКОЙ ЗОНЫ АЛМАТЫ

[1]Алматинский технологический университет, Казахстан. г. Алматы, ул. Толе би, 100, email: Kalimoldina.laila@mail.ru

Тяжелые металлы относятся к особым загрязняющим веществам, наблюдения за которыми обязательны во всех средах. В связи с этим изучение загрязнения почвы тяжелыми металлами является одной из актуальных проблем. Результаты исследований показали, что количество тяжелых металлов в пробах с участков, расположенных вдоль ташкенстского тракта превышено в несколько раз от нормы. Изучение антропогенного воздействия на почвенную микробиоту является необходимым элементом любого биомониторингового исследования. Тяжелые металлы уже сейчас занимают второе место по степени опасности, уступая пестицидам и значительно опережая такие широко известные загрязнители, как двуокись углерода и сера. В перспективе они могут стать более опасными, чем отходы атомных электростанций и твердые отходы. Загрязнение тяжелыми металлами связано с их широким использованием в промышленном производстве. В связи с несовершенными системами очистки тяжелые металлы попадают в окружающую среду, в том числе и в почву, загрязняя и отравляя ее.

Ключевые слова: почва, тяжелые металлы, концентрация, загрязнение, предельно-допустимая концентрация.

INFORMATION ABOUT AUTHORS

Kalimoldina Laila Mautenovna - senior lecturer of the department "Chemistry, chemical technology and ecology", candidate of technical sciences, *e-mail: Kalimoldina.laila@mail.ru*

2 Sultangazieva Gulbaram. Sapina. - Lecturer of the Department of Chemistry, Chemical Technology and Ecology, Master of Agricultural Sciences, *e-mail: gul-2012@mail.ru*

3 Suleimenova Maria Shayakhmetovna - Head of the Department "Chemistry, Chemical Technology and Ecology", Candidate of Chemical Sciences, *e-mail: s.mariyash@mail.ru*