ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ
Satbayev University

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Satbayev University

SERIES
OF GEOLOGY AND TECHNICAL SCIENCES

1 (445)

JANUARY – FEBRUARY 2021

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

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«ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы».

ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: ***геология және техникалық ғылымдар бойынша мақалалар жариялау.***

Мерзімділігі: жылына 6 рет.
Тиражы: 300 дана.

Редакцияның мекенжайы: 050010, Алматы қ., Шевченко көш., 28, 219, 220 бөл.,
тел.: 272-13-19, 272-13-18,
http://www.geolog-technical.kz/index.php/en/

Типографияның мекенжайы: «NurNaz GRACE», Алматы қ., Рысқұлов көш., 103.

«Известия НАН РК. Серия геологии и технических наук».

ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420**, выданное 29.07.2020 г.

Тематическая направленность: ***публикация статей по геологии и технических наукам.***

Периодичность: 6 раз в год.
Тираж: 300 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, ком. 219, 220, тел.: 272-13-19, 272-13-18,
http://www.geolog-technical.kz/index.php/en/

Адрес типографии: «NurNaz GRACE», г. Алматы, ул. Рыскулова, 103.

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.

ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Owner: RPA "National Academy of Sciences of the Republic of Kazakhstan" (Almaty).

The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420**, issued 29.07.2020.

Thematic scope: ***publication of papers on geology and technical sciences.***

Periodicity: 6 times a year.
Circulation: 300 copies.

Editorial address: 28, Shevchenko str., of. 219, 220, Almaty, 050010, tel. 272-13-19, 272-13-18,
http://www.geolog-technical.kz/index.php/en/

Address of printing house: «NurNaz GRACE», 103, Ryskulov str, Almaty.

N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224-5278
Volume 1, Number 445 (2021), 52 – 57 **https://doi.org/10.32014/2021.2518-170X.8**

UDC 595. 14 (574. 3 + 574. 2)

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STUDY OF THE EFFECT OF HEAVY METALS ON SOIL COVER AND METHODS OF THEIR BIOREMEDIATION CONTROL

Abstract. The article provides information on literature and patent information on the analysis of heavy metals formed during the extraction and processing of various types of raw materials for the production of non-ferrous metals and chemical products. The influence of heavy metals on the environment and living organisms, fauna and flora, as well as people living in different industrial regions of Kazakhstan is shown. Migration of heavy metals in the soil cover hydrosphere and atmosphere is shown. Based on the analytical review, the goals and objectives of the study are outlined, the chemical composition of raw materials for the main heavy metals formed in solid and dust - like production waste, and for technological processing in the production of lead and zinc in the East Kazakhstan and Turkestan regions is shown. Information is provided on the presence of heavy metals in the soil and their purification by various bioremediation methods. The data of soil analysis on the territory of the Turkestan region in recreation areas of people and in non-ferrous metallurgy enterprises nearby to the mining complex are presented. The dependence of the distribution of heavy metals and the chemical composition of the analyzed samples taken in various points of the Turkestan region and the city of Shymkent is shown. Data on the maximum content of heavy metals in the soil at which experimental worms die are established.

Key words: soil, heavy metals, worms, control, dust and gas mixture, maximum permissible concentrations, phytoremediation, cleaning.

Introduction. The problem of utilization, deep processing of technogenic waste and raw materials containing heavy and other metals in the industrial regions of the Republic of Kazakhstan, as well as cross-border countries of the world is an urgent task.

Soil cover is the most important formation of the globe, which is very important for the life of humanity and the environment. This is due to the fact that the soil cover is the main source of food. In the form of plant and animal origin, not only in the Republic of Kazakhstan, but also in other States. In addition, the most important property of the soil is its fertility, which ensures the quality and quantity of agricultural products. The natural fertility of the soil cover is regulated by the supply of nutrients, which can be affected by various factors - impurities and soil pollutants.

The authors ' work [1] established that lead pollution occurs mainly due to the burning of gasoline (60%) in motor transport, the production of non-ferrous metals (22%), iron, steel and ferroalloys (11%), as well as other factors.

According to the authors ' work [2], it is noted that in some soils the increase in chromium is almost 2 times, lead is 1.8 times, copper, vanadium and nickel is 1.4 times, and zinc is 1.2 times.

However, ongoing efforts to reduce heavy metals in oil-contaminated soils do not produce the desired results in terms of their content in the soil cover.

Anthropogenic sources of heavy metals are mining and processing of minerals and raw materials, the combustion of fuel of vehicles and technical means of agriculture, wastewater, and oil spill and oil, ferrous and nonferrous metallurgy [3-16]. Based on this the role of soil cover on the life and productivity of terrestrial ecological systems is of great importance.

For example, contamination of soil cover, which is an important component of photosynthetic processes in plants with heavy metals, has two negative features:

- intake from the soil to plants, from plants to the human and animal bodies, causing serious diseases and reducing vital activity, due to the toxicological effects of agricultural products containing harmful components;

- accumulating in the soil in large quantities, they change the physical, chemical, biological and other properties of the soil cover, violating its fertility and the main importance for the agro-industrial complex.

Therefore, the object of research is the ecological safety of densely populated territories of industrial regions, cities and localities with agricultural land to ensure the normal life of fauna and flora.

The subject of the study is soil contamination with such heavy metals as lead, arsenic, copper, cadmium, zinc, and the possibility of their bioassay by bioremediation method.

It is known that heavy metals have a significant impact on the deterioration of the structural and agrochemical properties of the soil. This leads to an increase in spore-bearing fungi, bacteria and, in many cases, to the death of plants. When heavy metals get into water, they cause irreparable damage and upset the balance of the ecological system, participating in redox processes, due to the variable valence, complexing properties change.

The danger of the influence of heavy metals on humans and animals is manifested not only in the direct impact of high concentrations and accumulation in the body, but also in the fact that they are difficult to remove and have a Toxicological effect with the possibility of abnormal diseases and poisoning.

Studies by a number of authors of scientific papers [5-7,14-16] revealed the environmental impact of metals such as Pb, Zn, Wi, Cu, W, Co, etc., carried away from the sources of formation by migration along with dust and gases.

For example, the Mangistau region of the Republic of Kazakhstan is one of the regions with a rather tense radioecological situation. This is due to the extraction and processing of radioactive raw materials used for energy, industrial, medical and research purposes. Radioecological conditions are determined by the degree of saturation of dangerous objects of natural and man-made origin. Dangerous man-made radioecological objects include sinkholes over the site of underground nuclear explosions Sayotes, Koshkar ATA tailings storage, places where radioactive waste is buried at Mangystau nuclear power plant industrial sites, uranium quarries and waste from the oil industry.

Soil analysis of these regions based on soil maps of the Mangistau region allowed us to establish that the main factors that affect the degree of their ecological disturbance are the prevailing types of soil pollution and salinization. Indicators for soil bonitet of the region are very low, which is due to the low content of humus in zonal soils and the presence of negative signs, such as salinity, salinity, crushed stone, and only in certain areas of the region used for irrigated arable land, the bonitet score is higher [17].

The analysis of literature and patent information finds that contamination of areas located close to industrial enterprises in the mining of non-ferrous metallurgy and processing them on lead and zinc, the value of heavy metals and degree of contamination they have different indicators. This is due, in our opinion, to the direction of the prevailing wind and the presence of the MPC level of heavy metals above acceptable standards, which is common for industrial regions and the soils of nearby cities and towns.

To reduce the content of heavy metals, patent information on methods for determining, disposing of, and cleaning contaminated soils from heavy metals was collected and analyzed [13-20]. The authors of [15] conducted research to determine heavy metals in the human body, from the influence of dust and gas emissions and wastewater from the enterprises of JSC Kazzinc (Ust - Kamenogorsk lead - zinc plant) and JSC UKTMP (Ust - Kamenogorsk titanium - magnesium plant), located within the city of Ust - Kamenogorsk, East Kazakhstan region of the Republic of Kazakhstan.

Based on the literature and patent analysis of the available information, studies were conducted to determine the contamination and presence of heavy metals in the soil on the territory of the former Shymkent lead plant and Achisay mining and processing plant located in the Turkestan region.

Analysis of soil contamination with heavy metals in industrial regions of the mining and processing complex of non-ferrous metallurgy enterprises was carried out by selecting point representative soil samples weighing at least 15 kg from the survey sites to a depth of 20 cm from a square hole.

Arsenic containing dusts of various stages of lead - zinc production formed during the operation of non-ferrous metallurgy enterprises were studied.

The average chemical composition of raw dusts from different production stages and sampling points is shown in tables 1, 2 and 3.

Table 1 – Average chemical composition of raw materials of the Achisayskoye field

Name of the object	Pb	Zn	Cu	Cd	Bi	As	Sb	Ag	Al_2O_3
Achisayskoe field	18,87	116	3,5	0,041	н/о*	0,64	0,2	615,0	3,5
Note*: n/a detected									

Table 2 – Average chemical composition of dusts of various stages of lead - zinc production

Name of the material	Content of components in %, %							
	Pb %	Zn %	Cu %	Fe %	S %	Sb %	As %	CaO %
Fine dust	39,79	15,19	10,94	3,2	8,3	0,51	1,0	n/d*
Dry cleaning dust	39,9	8,88	2,06	7,87	14,37	0,34	0,37	н/о
Cyclone dust of the mine furnace	32,37	7,987	2,32	9,84	–	0,19	0,65	1,62
Cyclone dust of the sinter shop	38,68	7,32	2,69	9,2	11,74	0,16	0,404	2,54
Converter dust	63,33	3,47	1,82	0,23	n/d	0,66	7,08	n/d
Converter dust from: 6	29,9	1,79	40,82			5,51	n/d	
Note*: n/d not detected								

In the course of the research, the content of the studied heavy metal components exceeded the MPC standards.

Table 3 – analysis of samples from various points of the industrial region of the Turkestan region of the Republic of Kazakhstan

№	Objects	Component content, mg/kg					Method of testing
		Pb	Cd	Zn	Cu	As	
1	Dendro Park Shymkent	4,0	1,0	10,0	0	0	МУ.08-47/203
2	Achisay (Turkestan region)	1287	37	871	344	0,64	
3	Internal overburden generated during mining of brown coals of the Lenger Deposit (Tolebi district)	461	10	871	62	0,59	
4	Industrial Corporation Yuzhpolymetal JSC, Shymkent	1287	37	7164	344	0,68	
	MPC	32,0	0,5-1,0	23	23	2,0	

The elemental and morphological composition of the selected presented samples of point samples from various locations of research objects obtained using the JSM-6490LV electron scanning microscope is shown in figures 1, 2, 3 and 4.

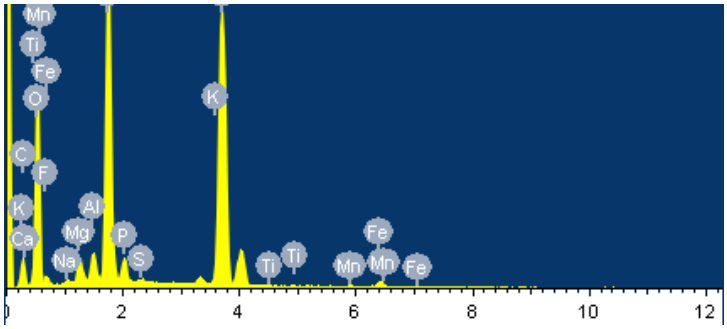

Figure 1 – Chemical composition of spot samples of soil of the Achisai State Production Complex, with content in (%)

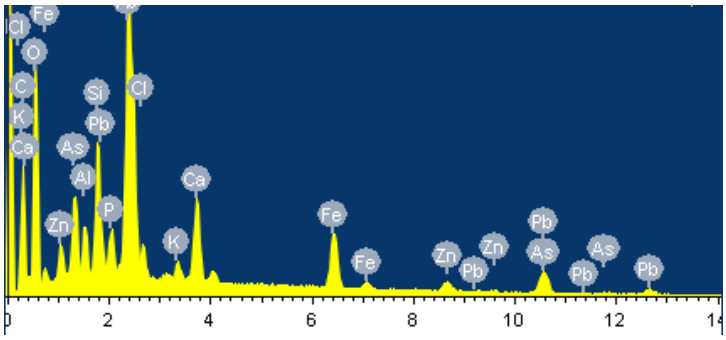

Figure 2 – Chemical composition of spot soil samples, internal overburden rocks formed during the extraction of brown coal from the Lenger deposit (Tolebi district), with a content in (%)

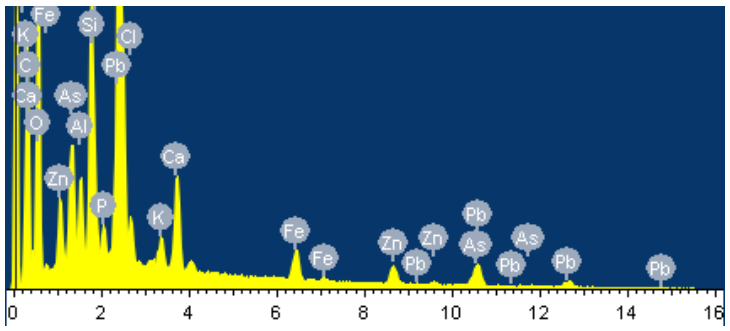

Figure 3 – Chemical composition of point soil samples "Yuzh - polymetal", with content in (%)

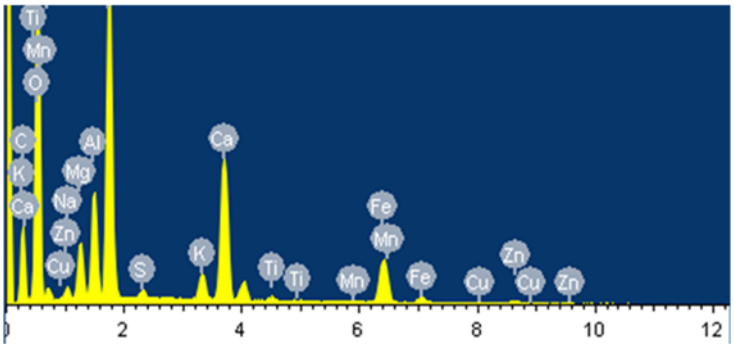

Figure 4 – Chemical composition of spot soil samples (control) Dendropark of Shymkent, with content in (%)

On the basis of the obtained analyzes of point samples using a JSM-6490LV scanning electron microscope, it was revealed that in the soils of the territory of the industrial enterprises under study, the content of heavy metals is above the MPC (Pb - 32.0 g / cm^3, Cd - 0.5 - 1.0 g / cm^3 , Zn - 23 g / cm^3, Cu - 23 g / cm^3, As - 2.0 g / cm^3), which causes irreparable damage to the fauna and flora of the studied regions of the Turkestan region and requires the development of methods for phytoremediation soil control and a method for cleaning soil from heavy metals.

Conclusion. 1. The analysis of patent information on soil cover contamination with heavy metals, such as lead, copper, zinc, vanadium, Nickel, arsenic, cadmium, etc. was carried out in Russian and foreign literature.

The sources of the formation of heavy metals in the Aktobe region have been established - the plants of TNK Kazchrome JSC, in the East Kazakhstan region - 2 enterprises, in the Turkestan region - 2 enterprises of the Achisai State Production Complex and Yuzhpolymetal JSC, excluding motor vehicles.

2. Point samples were taken of land contamination from the plant territory.

The analysis of the morphological and chemical composition of the selected soils was also carried out. Revealed the content of heavy metals in the samples on a scanning electron microscope company JSM-6490LV, the content of heavy metals is above the maximum permissible concentration Pb - 32,0 g/cm^3, Cd - 0,5 – 1,0 g/cm^3, Zn – 23 g/см^3, Cu – 23 g/cm^3, As - 2,0 g/см^3, which requires the use of cardinal solutions for bioremediation. A method for cleaning soil from heavy metals is shown.

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АУЫР МЕТАЛДАРДЫҢ ТОПЫРАҚ ЖАМЫЛҒЫСЫНА ӘСЕРІН ЗЕРТТЕУ ЖӘНЕ ОЛАРДЫ БИОРЕМЕДИАЦИЯЛЫҚ БАҚЫЛАУ ӘДІСТЕРІ

Аннотация. Бұл мақалада түрлі-түсті металдар мен химия өнімдерін өндіруге арналған шикізаттың алуан түрлерін алу және өңдеу кезінде пайда болған ауыр металдарды талдау туралы әдебиеттер мен патенттік мәліметтер келтірілген. Ауыр металдардың қоршаған ортаға және тірі организмдерге, фауна мен флораға, сондай-ақ Қазақстанның түрлі өндірістік аймағында тұратын адамдарға әсері көрсетілген. Ауыр металдардың топырақ жамылғысындағы, гидросферадағы және атмосферадағы миграциясы көрсетілген. Аналитикалық шолу негізінде зерттеудің мақсаттары мен міндеттері көрсетілген, қатты және шаңды өндіріс қалдықтарында пайда болатын негізгі ауыр металдарға қатысты Шығыс Қазақстан мен Түркістан облыстарында қорғасын мен мырыш өндірісі кезінде технологиялық қайта бөлу үшін шикізаттың химиялық құрамы көрсетілген. Топырақта ауыр металдардың болуы және оларды түрлі биоремедиация әдістерімен тазарту туралы мәліметтер келтірілген.Түркістан облысының аумағында адамдардың демалу аймақтарындағы және тау-кен кешеніне жақын түсті металлургия кәсіпорындарындағы топырақты талдау мәліметтері келтірілген. Түркістан облысы мен Шымкент қаласының түрлі нүктесінен алынған ауыр металдардың таралуы мен талданатын үлгілердің химиялық құрамының тәуелділігі көрсетілген. Тәжірибелік құрттар өлетін топырақтағы ауыр металдардың максималды құрамы туралы мәліметтер анықталды.

Түйін сөздер: топырақ, ауыр металдар, құрт, бақылау, шаң мен газ қоспасы, шекті рұқсат етілген концентрация, фиторемедиация, тазарту.

А. Д. Байботаева, Г. Д. Кенжалиева, К. Т. Жантасов, М. К. Жантасова, Е. Н. Кочеров

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ИССЛЕДОВАНИЕ ВЛИЯНИЯ ТЯЖЕЛЫХ МЕТАЛЛОВ НА ПОЧВЕННЫЙ ПОКРОВ И МЕТОДЫ ИХ БИОРЕМЕДИАЦИОННОГО КОНТРОЛЯ

Аннотация. В статье приводятся сведения по литературным и патентным данным по анализу тяжелых металлов, образующихся при добыче и переработке различных видов сырья для производства цветных металлов и химической продукции. Показано влияние тяжелых металлов на окружающую среду и живые организмы, животный и растительный мир, а также на людей, проживающих в различных промышленных регионах Казахстана. Показана миграция тяжелых металлов в гидросфере и атмосфере почвенного покрова. На основе аналитического обзора намечены цели и задачи исследования, показан химический состав сырья для основных тяжелых металлов, образующихся в твердых и пылевидных отходах производства, а также для технологической переработки при производстве свинца и цинка в Восточно-Казахстанской и Туркестанской областях. Приводятся сведения о наличии тяжелых металлов в почве и их очистке различными методами биоремедиации. Представлены данные почвенного анализа на территории Туркестанской области: в зонах отдыха населения и на предприятиях цветной металлургии, расположенных вблизи горнорудного комплекса. Показана зависимость распределения тяжелых металлов и химического состава анализируемых проб, взятых в различных точках Туркестанской области и города Шымкента. Установлены данные о максимальном содержании тяжелых металлов в почве, при котором подопытные черви погибают.

Ключевые слова: почва, тяжелые металлы, черви, контроль, пылегазовая смесь, предельно допустимые концентрации, фиторемедиация, очистка.

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www:nauka-nanrk.kz

ISSN 2518-170X (Online), ISSN 2224-5278 (Print)

http://www.geolog-technical.kz/index.php/en/

Редакторы *М. С. Ахметова, Д. С. Аленов, А. Ахметова*
Верстка *Д. А. Абдрахимовой*

Подписано в печать 01.02.2021.
Формат 70x881/8. Бумага офсетная. Печать – ризограф.
12,75 п.л. Тираж 300. Заказ 1.

Национальная академия наук РК
050010, Алматы, ул. Шевченко 28, т. 272-13-19, 272-13-18