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ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ

БАЯНДАМАЛАРЫ

ДОКЛАДЫ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН

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ANALYSIS AND IMPACT OF LEAD-CONTAINING WASTE FROM LEAD PRODUCTION ON HUMAN LIFE AND THE ENVIRONMENT

Abstract. As a result of the activities of the lead plant, about 2 million tons of waste in the form of lead-containing slags were accumulated. Lead production slags contain a large number of toxic heavy metal compounds, such as lead, zinc, osmium, and cadmium, which are dangerous sources of environmental pollution. Due to the open storage of slags, there is an excess of the maximum permissible concentrations (MPC) of lead: near the plant, the concentration of lead is more than 3000 mg/kg in the soil, with a MPC of 3.2 mg/kg. Lead and zinc compounds are dangerous to humans due to their significant toxicity and ability to accumulate in the body. Lead poisoning ranks first among professional intoxications. Waste water containing zinc compounds is not suitable for irrigation of fields, the negative effect of zinc compounds on microorganisms and microfauna of the soil reduces its fertility.

The article presents the results of scientific studies of lead slag, conducted by scanning electron microscopy and X-ray microanalysis, performed on a scanning electron microscope (SEM) JEOL-6490 LV (Manufacturer: JEOL, Japan). The results of the thermal analysis of samples on the derivatograph of the F. Paulik, J. Paulik and L. Erdey system in the air environment, in the temperature range of 20-1000°C. are presented.

According to the results of research, it was found that lead slags contain a sufficiently high amount of non-ferrous metal compounds: lead oxide up to 0.7 % and zinc oxide up to 8.5 % of the weight amount of slag, which makes the process of recycling toxic waste from lead production technically and economically feasible.

Keywords: waste, lead waste, toxic compounds, lead and zinc compounds, environmental pollution, toxic waste processing, waste disposal.

Introduction. In the territory of the South Kazakhstan region (now the Turkestan region), in the city of Shymkent in the period of the 30s of the last century, a lead plant for the production of lead operated and as a result of the company's activities, about 2 million tons of waste in the form of lead production slags accumulated [1-3]. Even after the closure of the plant, the remaining waste in the form of slags is a source of environmental pollution of the soil, groundwater and air. The environmental assessment revealed a huge excess of the maximum permissible concentrations (MPC) of lead in the soil near the former lead plant: currently, near the plant, the concentration of lead is more than 3000 mg/kg in the soil at a MPC of 3.2 mg/kg due to open storage of slags. According to research done by content analysis of lead compounds in the plants growing near the storage of slag was exceeding 1.83-8.13 times [4-8]. Environmental damage to long-term storage of slag is seriously dangerous when the slag is found in an acidic environment (earth pH<4). Contamination of the soil cover of the city of Shymkent with lead compounds and other metals contained in waste slags leads to the entry of harmful chemical compounds into the human body. Lead compounds negatively affect the human nervous system, which leads to a decrease in intelligence, causes changes in physical activity, hearing coordination, and negatively affects the cardiovascular system, leading to heart disease [9]. Among professional intoxications, lead takes the first place, and there is a tendency to increase it. Among the workers affected by lead exposure, about 40% are women. Lead is particularly dangerous for women because it has the ability to pass through the placenta and accumulate in breast milk. As a rule, the highest concentration of lead in the atmospheric air is observed in winter, which is associated with additional emissions of fuel combustion products into the atmosphere. Unfavorable weather conditions during this period of the year also contribute to the accumulation of lead in the lower atmosphere. Lead enters the body through the gastrointestinal tract and respiratory system and is then carried by the blood throughout the body. Moreover, the inhalation of lead dust is much more dangerous than the presence of lead in food. Lead compounds also accumulate in the bones, partially replacing the calcium in the phosphate. Getting into the soft tissues-muscles, liver, kidneys, brain, lymph nodes, lead causes a disease – plumb. Like many other heavy metals, lead (in the form of ions) blocks the activity of certain enzymes. The authors [10-11] found that the activity of enzymes decreases by 100 times with an increase in the concentration of lead in the blood by 10 times – from 10 to 100 micrograms per 100 ml of blood. At the same time, anemia develops, the hematopoietic system, kidneys and brain are affected, and intelligence decreases. This has a negative impact on the health of the population, especially children, who are most susceptible to lead poisoning. Lead can easily enter the body with drinking water if it has come into contact with metal: in the presence of carbon dioxide, soluble bicarbonate slowly passes into the solution. It is enough that there is only one milligram of lead in a liter of water – and drinking such water becomes very dangerous. From the atmosphere to the soil, lead enters most often in the form of oxides, where it gradually dissolves, passing into hydroxides, carbonates or the form of cations [12]. The main source from which lead enters the human body is food, along with the important role played by the inhaled air, and in children also ingested lead-containing dust. Inhaled dust is approximately 30-50% retained in the lungs, a significant proportion of it is absorbed by the blood stream. Absorption in the gastrointestinal tract is generally 5-10 %, in children-50 %. Calcium and vitamin D deficiency increases the absorption of lead in the gastrointestinal tract. On average, the human body absorbs 26-42 micrograms of lead per day. This ratio may vary. About 90 % of the total amount of lead in the human body is in the bones, in children 60-70% [13]. In addition to lead, lead production slags contain zinc compounds, which also adversely affect the environment: wastewater containing zinc is not suitable for irrigation of fields, and the negative effect of zinc on microorganisms and microfauna of the soil significantly reduces its fertility. Many manifestations of zinc intoxication are based on the competitive relations of zinc with a number of other metals. Thus, a significant decrease in the total level of calcium in the blood serum was found in residents of nearby areas [14]. Excessive intake of zinc in the body was accompanied by a drop in the calcium content not only in the blood, but also in the bones, while the absorption of phosphorus was disrupted; as a result, osteoporosis developed. The toxicity of zinc oxide is explained by its catalytic activity. Zinc can be a mutagenic and oncogenic hazard. Thus, due to the great harm to the health of the population of the adjacent areas of Shymkent, the problem of recycling of lead production slags is very acute and urgent [15-17].

Problem statement. To determine the chemical composition of lead production slags, the results of scanning electron microscopy and X-ray microanalysis of lead production slag, performed on a JEOL-6490 LV scanning electron microscope (SEM) (Manufacturer: JEOL, Japan). The results of the thermal analysis of samples on the derivatograph of the F. Paulik, J. Paulik and L. Erdey system in the air environment, in the temperature range of 20-1000°C are presented. The research was conducted at the Institute of Metallurgy and Enrichment of NAS RK, Almaty and the Institute of geological Sciences named after K. I. Satpayev.

The study of the material composition was carried out on a loose slag material, externally black in color, with a size from 2 to 6 mm. A heavy fraction was isolated from the sample, according to which polished artificial anschlyphs (briquettes) were made. The anschlyphs were studied under a LEICA DM 2500P microscope. Along with this, the sample was studied under a microscope in immersion fluids, and as a result, samples were selected for further research.

Scanning electron microscopy of slag is performed on a JEOL-6490 LV scanning electron microscope (SEM) (Manufacturer: JEOL, Japan) to measure the scale factor of the video image by obtaining an image of the surface of an object with high spatial resolution, as well as for elemental analysis and elemental mapping at small magnifications (figure 1).

578 – lead slag

Element	Weight class %	Atomic %
O	33.15	56.22
Na	2.44	2.88
Mg	1.86	2.08
Al	2.68	2.70
Si	10.90	10.53
S	1.54	1.30
K	0.86	0.60
Ca	11.04	7.47
Mn	0.49	0.24
Fe	27.40	13.31
Ni	0.06	0.03
Cu	1.25	0.53
Zn	3.93	1.63
As	0.17	0.06
Ag	0.00	0.00
Ba	1.93	0.38
La	0.00	0.00
Au	0.00	0.00
Pb	0.30	0.04
Results	100.00	

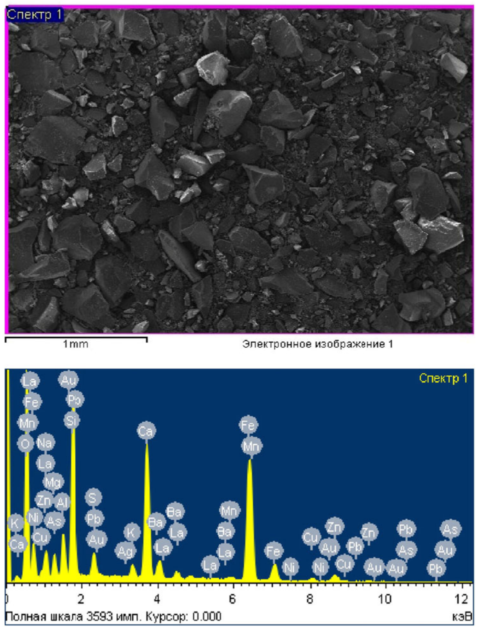

Figure 1 - Scanning electron microscopy and X-ray microanalysis of lead slag

The thermal analysis of slag samples was carried out according to the data of DTA and TGA measurements. Thermal analysis of the powder sample of the slag sample was performed on a Q-1000/D derivatograph of the F. Paulik, J. Paulik and L. Erdey system of the company "MOM" (Hungary, Budapest). The survey was carried out in air in the temperature range 20 to 1000°C heating mode - dynamic (dT/dt = 10), the reference substance, calcined Al_2 O_3, weighed samples of 500 mg from valuable scale weight change of the sample is 500 μv. The studies revealed the following parameters: the sensitivity of the balance 100 mg, the sensitivity of other measuring systems of the device: DTA = 250 μV, DTG = 500 μV, TG = 500 μV T = 500 μV.

The method used is based on the recording by the device of changes in the thermochemical and physical parameters of the substance that can be caused during its heating. The thermochemical state of the sample is described by the curves: T (temperature), DTA (differential thermoanalytic), TG (thermogravimetric) and DTG (differential thermogravimetric), the latter curve is a derivative of the TG function.

The optimal thermochemical parameters obtained during high-temperature treatment of the test system allowed us to reveal the nature of the destruction of thermally active components.

The composition of the powder sample was identified by the morphologies of the thermal curves and the obtained numerical values of the intensities of endo-and exothermic effects, using the thermogravimetric readings of the TG lines associated with them.

The results of the analysis were compared with the data given in the atlases of thermal curves of minerals and rocks and compared with the descriptions of the thermal behavior of monomineral samples described in other reference sources and accumulated in the data bank of the laboratory that conducted these studies.

A sample of slag in the dynamic heating mode on (DTA-, DTG -, and TG-) curves in different temperature ranges left a series of effects caused by endo - and exothermic reactions, as shown in figure 2 and their quantitative values in table.

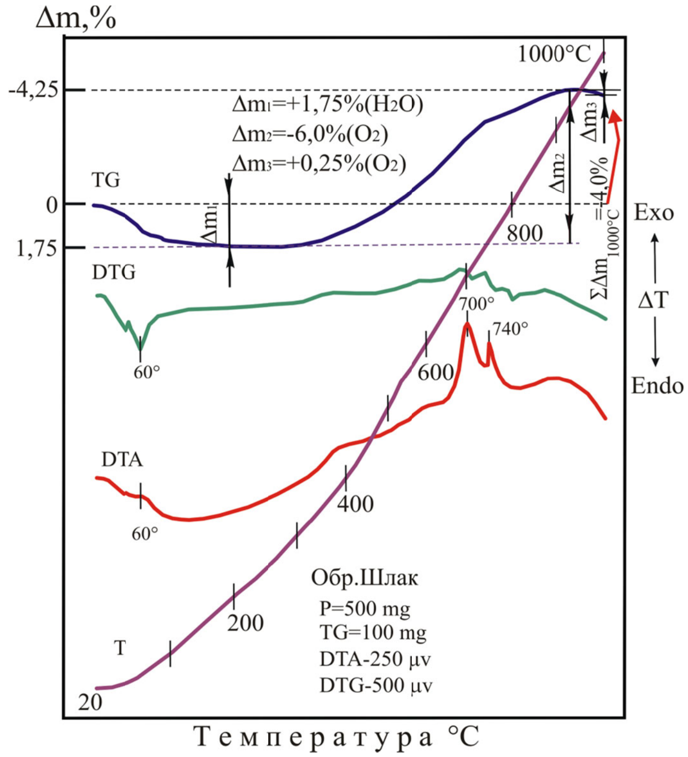

Figure 2 - Derivatogram of the slag sample

Sequence of quantitative values of weight loss of volatile components

Weight Loss Sequence	Weight loss, in %	Volatile components	Decomposition temperature range, °C
Δm_1	1,75	H_2O	20-200
Δm_2	-6,0	$-O_2$	280-930
Δm_3	0,25	O_2	930-1000
$\Delta m_{1000°C}$	4,0	H_2O, $-O_2$, O_2	20-1000

Note: to figure 2 and to table: the minus sign (-) for the value of Δm2 indicates the introduction of atmospheric oxygen into the system. This sign is the opposite of the sign applied to the weight loss parameter.

Within low temperatures (20-200°C) in the studied system, an endothermic effect was observed with a weight loss of Δm1 equal to 1.75% of the sample weight, shown in figure 2, table 5. Many powder samples contain atmospheric water, which is carried into the atmosphere in the specified temperature range. In this case, the main part of the evaporated molecular water can be attributed to the dehydration of the powder slag particles adsorbed-H_2O. After the sample dehydration process, the enthalpy of the system in the range of 200-280°C practically does not change, which is caused by the lack of weight loss in this temperature range. It should be noted that in the range of 280-930°C, the thermogravimetric curve (TG) steadily shifts upwards - in the direction of increasing the mass of the sample, which is caused by the introduction of atmospheric oxygen into the system. The increase in mass is accompanied by the rise of the DTA curve line, which, in the range of 640-800°C, formed clearly pronounced exothermic peaks at 700 and 740°C. The processes that caused the introduction of heat into the system are associated with the oxidation of the ferrous components of the sample. Iron oxides enriched with oxygen are usually formed within the marked temperature limits. These high-temperature peaks are caused by the transition of iron oxide from the lower level of acidity to the higher level. At a higher temperature (930°C), the increase in the mass of the sample reaches its limit (Δm2=-6%). And further heating of the sample (up to 1000°C) leads to a decrease in its mass by 0.25%.

The results of laboratory studies showed the content of lead and zinc in the in the form of oxides, the quantitative content of lead reaches 0.3 % and zinc – 3,93% of the total amount.

Conclusion. According to the results of thermal, X-ray fluorescence semi-quantitative analyses, scanning electron microscopy and X-ray microanalysis of lead slag, it was revealed that the slag of lead production contains a significant amount of toxic compounds that are dangerous sources of environmental pollution. Lead slags contain a sufficiently high amount of non-ferrous metal compounds: lead oxide up to 0.7 % and zinc oxide up to 8.5 % of the weight of the slag, which makes the process of recycling toxic waste from lead production technically and economically feasible.

Further processing and disposal of toxic slags of lead production will lead to an improvement in the ecological state of the environment and reduce the negative impact on human health. At the same time, a significant contribution is made to the development of the system of rational use of natural resources.

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ҚОРҒАСЫН ӨНДІРІСІНІҢ ҚҰРАМЫНДА ҚОРҒАСЫН БАР ҚАЛДЫҚТАРЫН ТАЛДАУ ЖӘНЕ АДАМНЫҢ ТІРШІЛІК ӘРЕКЕТІНЕ ЖӘНЕ ҚОРШАҒАН ОРТАҒА ӘСЕРІ

Аннотация. Қорғасын зауытының қызметі нәтижесінде құрамында қорғасын бар қождар түрінде 2 млн. тоннаға жуық қалдықтар жинақталды. Қорғасын өндірісінің шлактарында экологиялық ластанудың қауіпті көзі болып табылатын қорғасын, мырыш, осмий, кадмий сияқты ауыр металдардың улы қосылыстары көп. Қождарды ашық сақтауға байланысты қорғасынның шекті рұқсат етілген концентрациясының (ШЖК) артқаны байқалады: зауыттың жанында қорғасын концентрациясы ШРК 3,2 мг/кг кезінде топырақта 3000 мг/кг артық құрайды. Қорғасын мен мырыш қосылыстары оның уыттылығы мен организмде жинақталу қабілетіне байланысты адамдар үшін қауіпті. Қорғасынмен улану кәсіби интоксикациялар арасында бірінші орын алады. Құрамында мырыш қосылыстары бар ағынды сулар алқаптарды суаруға жарамсыз, мырыш қосылыстарының микроорганизмдер мен топырақ микрофаунасына теріс әсері оның құнарлылығын төмендетеді.

Мақалада растрлық электрондық микроскопия және JEOL-6490 LV растрлық электрондық микроскопта (РЭМ) орындалған рентгендік микроаналдау әдістерімен жүргізілген қорғасын өндірісінің қожын ғылыми зерттеу нәтижелері (өндіруші: "JEOL" фирмасы, Жапония), сондай-ақ Axios рентгенофлуоресцентті толқын-дисперсиялық спектрометрінде орындалған рентгенофлуоресцентті жартылай сандық талдау нәтижелері (өндіруші: "PANalytical B. V." фирмасы, Нидерланды) ұсынылған. F. Paulik, J. Paulik және L. Erdey жүйесінің дериватографында, 20-1000°С температура депазонында сынамаларды термиялық талдау нәтижелері келтірілген.

Зерттеу нәтижелері бойынша қорғасын қождарында түсті металдар қосылыстарының жеткілікті жоғары мөлшері бар екендігі анықталды: қорғасын оксиді 0,7%-ға дейін және мырыш оксиді қождың салмақтық мөлшерінің 8,5%-на дейін, бұл қорғасын өндірісінің улы қалдықтарын кәдеге жарату процесін техникалық және экономикалық тұрғыдан орынды етуге мүмкіндік береді.

Түйін сөздер: қалдықтар, қорғасын қалдықтары, улы қосылыстар, қорғасын және мырыш қосылыстары, экологиялық ластану, улы қалдықтарды қайта өңдеу, қалдықтарды кәдеге жарату

З. Багова [1], К. Жантасов[1], Г. Туребекова[1], Б. Сапаргалиева[2]

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АНАЛИЗ И ВЛИЯНИЕ СВИНЕЦСОДЕРЖАЩИХ ОТХОДОВ СВИНЦОВОГО ПРОИЗВОДСТВА НА ЖИЗНЕДЕЯТЕЛЬНОСТЬ ЧЕЛОВЕКА И ОКРУЖАЮЩУЮ СРЕДУ

Аннотация.В результате деятельности свинцового завода накопилось около 2 млн. тонн отходов в виде свинецсодержащих шлаков. Шлаки свинцового производства содержат большое количество токсичных соединений тяжелых металлов, таких как свинец, цинк, осмий, кадмий, которые являются опасными источниками экологического загрязнения. Из-за открытого хранения шлаков наблюдается превышение предельно допустимых концентраций (ПДК) свинца: вблизи завода концентрация свинца составляет более 3000 мг/кг в почве при ПДК 3,2 мг/кг. Соединения свинца и цинка представляют опасность для человека в связи с его значительной токсичностью и способностью накапливаться в организме. Свинцовое отравление занимает первое место среди профессиональных интоксикаций. Сточные воды, содержащие соединения цинка, не пригодны для орошения полей, отрицательное влияние соединений цинка на микроорганизмы и микрофауну почвы снижает ее плодородие.

В статье представлены результаты научных исследований шлака свинцового производства, проведен-ными методами растровой электронной микроскопии и рентгеновского микроанализа, выполненные на растровом электронном микроскопе (РЭМ) JEOL-6490 LV (Производитель: фирма «JEOL», Япония), а также результаты рентгенофлуоресцентного полуколичественного анализа, выполненные на рентгенофлуорес-центном волнодисперсионном спектрометре Axios (Производитель: фирма "PANalytical B.V.", Нидерланды). Приведены результаты термического анализа проб на дериватографе системы F. Paulik, J. Paulik и L. Erdey в воздушной среде, в диапазоне температур 20-1000°С.

По результатам исследований выявлено, что в свинцовых шлаках содержится достаточно высокое количество соединений цветных металлов: оксида свинца до 0,7 % и оксида цинка до 8,5 % от весового количества шлака, что позволяет сделать процесс утилизации токсичных отходов свинцового производства технически и экономически целесообразным.

Ключевые слова: отходы, свинцовые отходы, токсичные соединения, соединения свинца и цинка, экологическое загрязнение, переработка токсичных отходов, утилизация отходов.

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