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THE IMPACT OF LEAD PRODUCTION ON THE NATURE OF THE DISTRIBUTION OF SLAG WASTE IN THE ENVIRONMENT

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Abstract. The development of industrial production leads to environmental pollution, and pollution is carried out intensively, especially in cities where industrial enterprises are located. Intensive pollution of the main components of the environment with harmful substances, including heavy metals, has led to the formation of a biogeochemical region in many regions of Kazakhstan, characterized by excessive accumulation of pollutants. In this regard, research on assessing the health status of the population living in an ecologically unfavorable region is becoming the most urgent problem today. Hazardous to public health and even longer side effects of waste by polluting atmospheric air, soil, groundwater, open water bodies, agricultural products of plant and animal origin are demonstrated. The list of chemicals, compounds found in industrial waste is quite large. They depend mainly on the raw materials used, the technology used, the order of production, among others. There is practically no state waste management system in the Republic of Kazakhstan, which includes monitoring, storage, processing and disposal of industrial and household waste. More than 20 billion tons of production and consumption waste, including 6.7 billion tons of toxic waste, have accumulated on the territory of Kazakhstan. As a result, soil, underground and surface waters in many regions have been heavily polluted by industrial waste.

Keywords: Atmosphere, diagram, map, air, hydrometeorology, residue

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ҚОРҒАСЫН ӨНДІРІСІ ҚОЖ ҚАЛДЫҚТАРЫНЫҢ ҚОРШАҒАН ОРТАҒА ТАРАЛУ СИПАТЫНА ӘСЕРІ

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Аннотация. Бұл мақалада өнеркәсіптік өндірістің дамуы қоршаған ортаның ластануына әкеліп соқтыратыны, әсіресе өнеркәсіптік кәсіпорындар орналасқан қалаларда ластану қарқынды жүзеге асырылатыны анықталған. Қоршаған ортаның негізгі компоненттерін зиянды заттармен, оның ішінде ауыр металдармен қарқынды ластау Қазақстанның көптеген өңірлерінде ластағыштардың артық жинақталуымен сипатталатын биогеохимиялық облысының қалыптасуына әкелді. Осыған байланысты, экологиялық қолайсыз аймақта тұратын халықтың денсаулық жағдайын бағалау бойынша зерттеулер бүгінгі күні ең өзекті мәселе болып отыр. Атмосфералық ауаны, топырақты, жер асты суларын, ашық су айдындарын, өсімдік және жануар текті ауыл шаруашылығы өнімдерін ластау арқылы қалдықтардың халықтың денсаулығына қауіпті және уақыт бойынша одан да ұзақ жанама әсері көрсетіледі. Қалдықтардың қауіптілігі олардың құрамында барлық үш фактор болуы мүмкін: химиялық, биологиялық және физикалық, олар адам денсаулығына зиянды әсер етеді. Өнеркәсіптік қалдықтарда кездесетін химиялық заттардың, қосылыстардың тізімі өте көп. Олар өнеркәсіпте синтезделетін және өңделетін, өндірілген пайдалы қазбаларда кездесетін және алынған өнімдерде болатын барлық нәрсе болуы мүмкін. Қалдықтардағы химиялық заттардың концентрациясы оннан, жүзден, мыңыншы миллиграммнан 1 кг-ға 1 тонна немесе одан да көп ондаған килограмға дейін өзгеруі мүмкін. Олар негізінен қолданылатын шикізатқа, қолданылатын технологияға, өндіріс тәртібіне және басқаларға байланысты. Қазақстан Республикасында өнеркәсіптік және тұрмыстық қалдықтарды мониторингтеуді, сақтауды, қайта өңдеуді және кәдеге жаратуды қамтитын қалдықтармен жұмыс істеудің мемлекеттік жүйесі іс жүзінде кемде-кем. Қазақстан аумағында 20 миллиард тоннадан астам өндіріс және тұтыну қалдықтары, оның ішінде 6,7 миллиард тонна улы қалдықтар жинақталған. Нәтижесінде көптеген аймақтардағы топырақ, жер асты және жер үсті сулары өнеркәсіптік қалдықтармен қатты ластануға ұшырағандығы анықталған.

Түйін сөздер: атмосфера, диаграмма, карта, ауа, гидрометеорология, қалдық

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ВЛИЯНИЕ ПРОИЗВОДСТВА СВИНЦА НА ХАРАКТЕР РАСПРЕДЕЛЕНИЯ ШЛАКОВЫХ ОТХОДОВ В ОКРУЖАЮЩЕЙ СРЕДЕ

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Аннотация. Развитие промышленного производства приводит к загрязнению окружающей среды, особенно в городах, где расположены промышленные предприятия и интенсивно осуществляется выброс загрязняющих веществ. Интенсивное загрязнение основных компонентов окружающей среды вредными веществами, включая тяжёлые металлы, привело к образованию биогеохимических зон, характеризующихся избыточным накоплением загрязняющих веществ во многих регионах Казахстана. В этой связи исследования по оценке состояния здоровья населения, проживающего в экологически неблагополучных зонах, являются крайне актуальными. Загрязнение атмосферного воздуха, почвы, грунтовых вод, открытых водоёмов, а также сельскохозяйственной продукции растительного и животного происхождения оказывает опасное и длительное побочное воздействие на здоровье населения. Список химических веществ и соединений, содержащихся в промышленных отходах, весьма обширен. Они могут включать всё, что синтезируется и перерабатывается в промышленности, содержится в добываемых полезных ископаемых и образуется в готовой продукции. Концентрация химических веществ в отходах варьируется от десятых, сотых, тысячных долей миллиграмма на 1 кг до десятков килограммов на 1 тонну и более. Их содержание зависит от используемого сырья, применяемых технологий, особенностей производства и ряда других факторов. В Республике Казахстан практически отсутствует государственная система обращения с отходами, включающая мониторинг, хранение, переработку и утилизацию промышленных и бытовых отходов. На территории страны накоплено более 20 млрд тонн отходов производства и потребления, в том числе 6,7 млрд тонн токсичных отходов. В результате почвы, грунтовые и поверхностные воды во многих регионах подвергаются значительному загрязнению промышленными отходами.

Ключевые слова: атмосфера, карта, воздух, гидрометеорология, промышленные отходы, загрязнение

Introduction. To assess the impact of pollution sources on the environment, we first present a diagram illustrating the dispersion of harmful substances released into the atmosphere from a single pollution source. It is essential to determine the distance over which these harmful substances disperse until their concentrations reach the maximum permissible levels in the atmospheric air. Additionally, an analysis of the hydro meteorological conditions and the influence of local terrain on dispersion patterns at the same distance is required. This study also evaluates the extent to which emissions of the same harmful substances from neighboring industrial facilities contribute to the overall concentration levels in the atmosphere.

The radius of distribution of harmful substances, as depicted in the dispersion diagram, is determined by multiple factors, including the characteristics of the pollution source, hydro meteorological conditions, and terrain features (Bitmanov et al, 2022:1). Wind direction and speed play a crucial role in the dispersion of harmful substances released into the atmosphere from pollution sources. Wind speed significantly influences atmospheric pollution levels, as adverse meteorological conditions can lead to sharp increases in contamination. When wind speed is minimal, a phenomenon known as environmentally hazardous wind occurs. This type of wind prevents the vertical dispersion of pollutants, instead forcing them to remain near the surface, leading to high concentrations of heavy metals in both the atmosphere and soil of the affected region. However, the threshold for environmentally hazardous wind varies depending on the characteristics of each pollution source.

In general, when wind speed exceeds 2 m/sec, pollutants released into the air mix with a larger atmospheric layer and dissipate, reducing their concentration to within maximum permissible concentrations (MPC). It is important to note that wind speed influences the dispersion of pollutants from point sources, whereas large, unstructured pollution sources—such as slag waste storage facilities at metallurgical plants—behave differently. Due to the fine dispersion and low temperature of the waste, low wind speeds (environmentally hazardous winds) do not significantly affect their dispersion in the atmosphere (Solomentseva et al, 2022:2). At very low wind speeds, fine particulate matter rises to high altitudes, where it can travel long distances before settling. Conversely, larger particles remain closer to the ground, leading to localized pollution with high concentrations of residue. Therefore, higher wind speeds are essential for the effective dispersion of slag residues over long distances, preventing the accumulation of heavy pollutants in the immediate vicinity of pollution sources. The expansion of industrial production has significantly contributed to environmental pollution, particularly in urban areas with a high concentration of industrial enterprises. Intensive contamination of key environmental components—such as air, soil, and water—by hazardous substances, including heavy metals, has led to the formation of biogeochemical zones in several regions of Kazakhstan. These areas are characterized by an excessive accumulation of pollutants, posing serious risks to ecosystems and human health. Given these challenges, research aimed at assessing the health status of populations residing in ecologically unfavorable regions has become an urgent scientific and public health priority.

The hazardous effects of industrial waste on public health, along with its long-term environmental consequences, are evident in the contamination of atmospheric air, soil, groundwater, surface water bodies, and agricultural products of both plant and animal origin (Ikramov et al, 2023:3). The primary concern is that industrial waste may contain a combination of chemical, biological, and physical pollutants, each of which poses significant risks to human health. The composition of industrial waste is highly diverse, encompassing a wide range of chemicals and compounds. These substances may originate from industrial synthesis and processing, be present in extracted minerals, or accumulate in manufactured products. The concentration of chemicals in waste can vary considerably—from trace amounts in milligrams per kilogram to several kilograms per ton or more. The specific chemical composition depends on multiple factors, including the raw materials used, technological processes, and production methods. A critical issue in the Republic of Kazakhstan is the absence of a comprehensive state waste management system that would enable the monitoring, storage, processing, and disposal of both industrial and household waste. The lack of such a system exacerbates the environmental and health risks associated with uncontrolled waste accumulation. More than 20 billion tons of industrial and household waste, including 6.7 billion tons of toxic waste, have accumulated across the territory of Kazakhstan. As a result, extensive contamination of soil, groundwater, and surface water bodies has been documented in multiple regions, posing significant environmental and public health risks.

The relationship between environmental conditions and public health in the Republic of Kazakhstan is becoming increasingly urgent each year. Environmental pollution and its impact on human health are closely correlated, as indicated by data on morbidity rates, pollutant emissions from stationary sources, the discharge of contaminated wastewater into water bodies, the accumulation of toxic waste, and public access to safe drinking water. According to environmental monitoring data, pollution levels in many cities within the monitoring network continue to exceed sanitary and hygienic standards. In 2017, the highest levels of air pollution (Air Pollution Index, Ali) were recorded in Almaty (Ali = 12.6), Shymkent (Ali = 11.2), Aktobe (Ali = 9.5), Ust-Kamenogorsk (Ali = 7.2), Temirtau (Ali = 8.6), and Ridder (Ali = 9.0). High pollution levels in Ust-Kamenogorsk, Shymkent, Aktobe, Ridder, and Temirtau were primarily attributed to emissions from non-ferrous and ferrous metallurgy enterprises, while unfavorable climatic conditions in Almaty exacerbated pollution dispersion. The quality of drinking water also remains a serious concern, particularly in Astana, Kyzylorda, and Turkestan regions. In Kyzylorda region, the proportion of non-compliant water samples reached 5.1% for sanitary and chemical parameters and 5.3% for microbiological indicators. For decentralized water sources, these figures were 23.4% and 6.5%, respectively. Between the first half of 2018 and 2023, reports have documented an increasing incidence of socially significant diseases with confirmed diagnoses, further highlighting the urgent need for environmental and public health interventions.

Materials and methods of research. In the general morbidity structure of the adult population in the studied settlements, respiratory diseases are the most prevalent. Since 2020, there has been a sharp increase in the incidence of pneumonia, bronchitis, vasomotor, and allergic rhinitis among adults, with allergic rhinitis continuing to rise in subsequent years. This trend has been linked to high levels of environmental pollution, particularly contamination with lead and other heavy metal compounds.

In highly polluted areas, such as the Kazygurt microdistrict, the incidence of pneumonia in children was recorded 1.9 times higher from 2018 to 2020 compared to a relatively favorable area (Kaitpas microdistrict). Since 2020, the incidence of pneumonia in children under 14 years of age in the Kazygurt microdistrict has increased sharply. By 2021, 183 cases of pneumonia in children were registered in Kazygurt, which was 1.9 times higher than in Kaitpas. Although a slight decline in pneumonia cases has been observed since 2021, morbidity rates in 2023 still remain 1.6 times higher than in the less polluted area.

A similar trend is seen in adult pneumonia cases. In 2021, a 20-fold increase in incidence was observed in Kazygurt. While there was a gradual decline in the following years, pneumonia incidence rates remained significantly elevated compared to Indomitable microdistrict, being 8.5 times higher in 2022 and 7.6 times higher in 2023, as illustrated in Figures 1 and 2.

When analyzing the frequency of various respiratory diseases, it is important to highlight the high prevalence of chronic bronchitis, which remains the leading condition among respiratory illnesses.

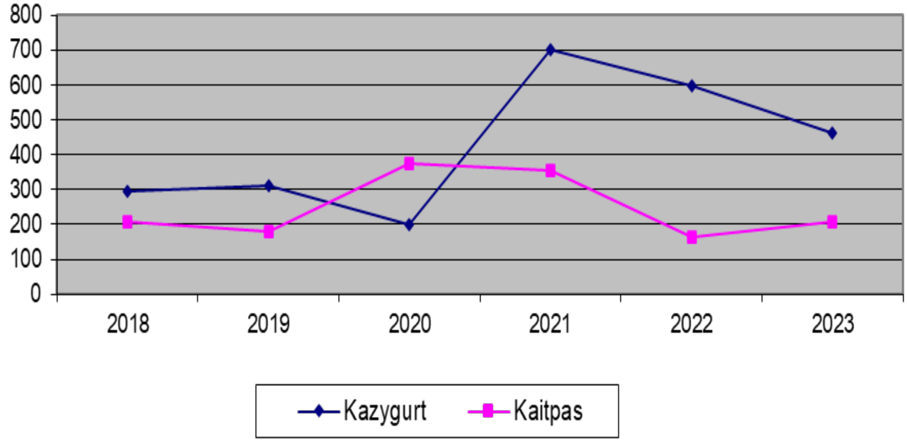

Figure 1- Relative incidence of pneumonia

Children's bodies are more vulnerable to environmental factors compared to the adult population. In the overall structure of respiratory diseases among children under 14 years of age, the incidence of bronchitis in the contaminated area showed a sharp increase in 2021—rising 11 times compared to the previous year and 14 times higher than in the less polluted area.

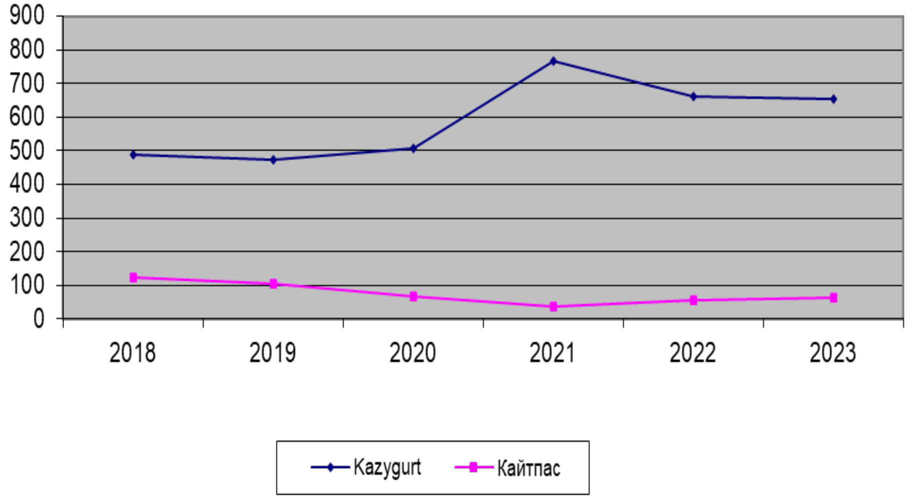

Figure 2 – Relative incidence of pneumonia in adults in the studied areas per 100,000 people

The highest incidence of bronchitis in adults in the Kazygurt microdistrict was recorded in 2021, with 1,977 cases. This figure was 24 times higher than in the Kaitpas microdistrict. Although a downward trend has been observed in subsequent years, morbidity rates remain significantly elevated, as shown in Figures 3 and 4.

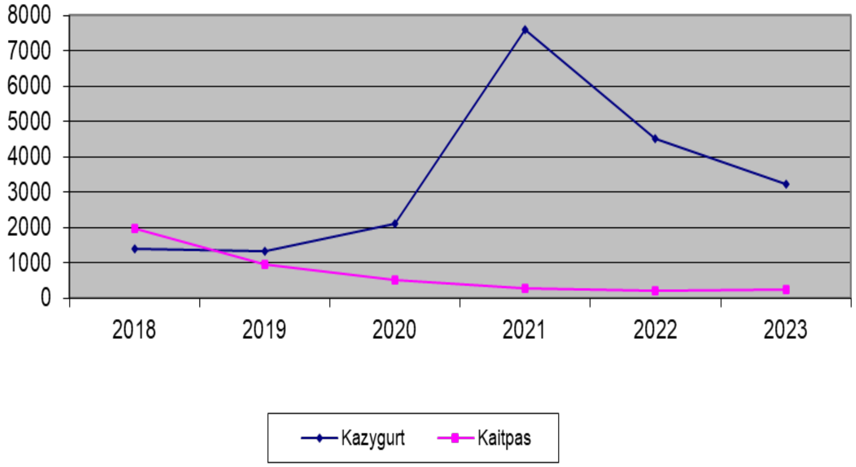

Figure 3 – Relative incidence of bronchitis in adults in the studied areas per 100,000 people

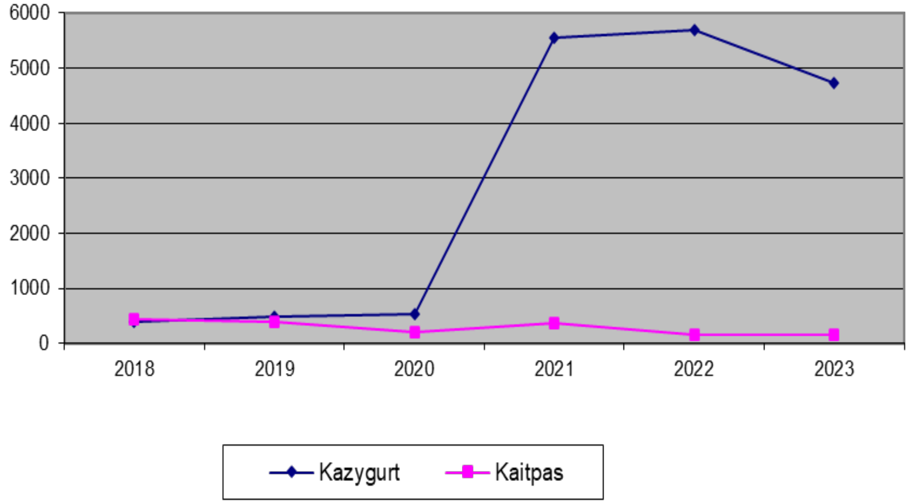

Figure 4 – Relative incidence of bronchitis in children's in the studied areas

Over the past six years, among respiratory diseases, ENT disorders, particularly vasomotor and allergic rhinitis, have been the most prevalent. The relative incidence of vasomotor and allergic rhinitis in children in the studied areas has shown a steady increase from 2018 to 2020. In 2019, 295 children were diagnosed with the disease in residential areas surrounding the lead plant, while by 2021, the number of affected children had risen to 748. In contrast, in the less polluted area, no cases of the disease were recorded in the same year. By 2023, the number of registered cases among children is expected to reach 945.

In the general control area, the lowest incidence rates have been observed in adults over the past six years. Furthermore, starting in 2021, as shown in Figures 5 and 6, incidence rates in both children and adults have declined to zero.

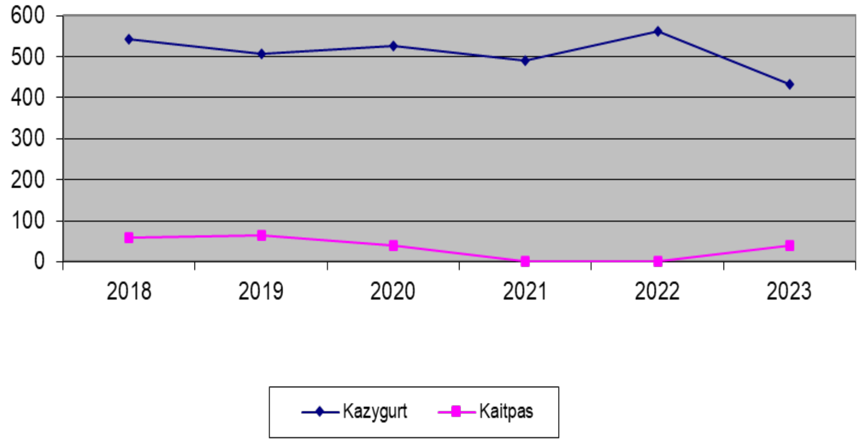

Figure 5 – Relative incidence of vasomotor and allergic rhinitis in adults in the studied areas per 100,000 people

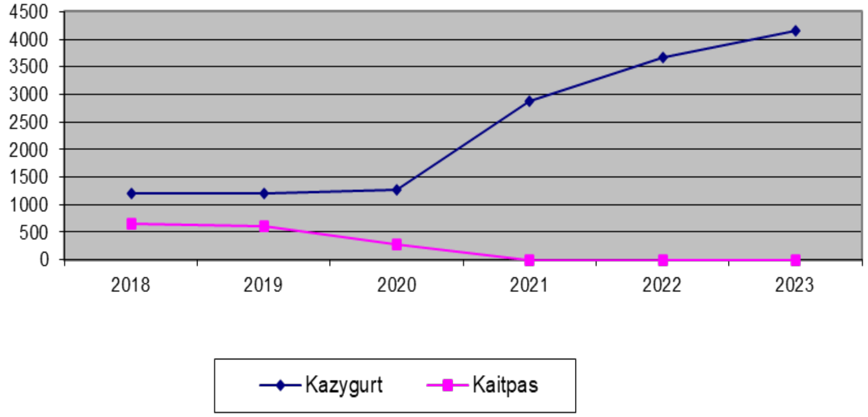

Figure 6 – Relative incidence of vasomotor and allergic rhinitis in adults in the studied areas per 100,000 people

When analyzing the dispersion of harmful substances in the surface layer of the atmosphere, the maximum distance of slag dust propagation is determined based on wind speed and the maximum permissible concentration (MPC). The highest recorded lead aerosol concentration reaches Sfgti = 0.21 mg/m³. The impact of environmental pollution on the socio-economic situation and public health is significant (Sadykov, et al, 2020:4). One of the key principles of waste-free technology is the recovery of valuable components during processing. For instance, the production of glass, cement, clinker, ceramic tiles, aggloporite, and other construction materials involves heating raw materials to 1200–1400°C. At these temperatures, many metals can sublimate in the form of oxides or chlorides. This process requires the selection of appropriate charge additives and the installation of sublimation control devices. Electricity generation from solid fuel combustion remains one of the primary energy sources (Cerny et al, 2017:5).

TPP ash

Waste from coal mining and enrichment

Waste from the pulp and paper industry

Peeled rocks of phosphorite ores

Waste from aluminum production

Research on the synthesis of ash and slag for lightweight concrete has been conducted through sintering processes, which result in the formation of porous materials.

In 1937–1938, S. D. Toporkov conducted pioneering studies in this field. Later, between 1948 and 1951, a group of scientists confirmed the feasibility of producing artificial porous aggregates using thermal power plant ash (Bukunova et al, 2003:6). Numerous studies have demonstrated the extraction of aggloporite from various types of industrial waste:

In 1980, the technology for producing aggloporite from the ash of the Moldavian State District Power Plant was tested at the Dniester plant. The process utilized a condensed suspension with an ash content of 50–60%, with clay schlicker added as a binder. The proportion of clay added was 5–7% of dry ash, along with aluminum slurry. During the sintering process, a porous structure is formed due to moisture evaporation, fuel and organic matter combustion, contact synthesis of individual charge grains, and expansion caused by gas release pressure. The rapid temperature rise in the aggloporitized layer and the short duration at peak temperature further contribute to the formation of a porous aggloporite structure.

L.I. Popov and other researchers determined that the sintering process speed and the quality of the final aggregate depend on both the raw material properties and the preparation and sintering conditions. The most critical factors influencing the process include:

Gas permeability of the layer

Grain composition

Moisture content of the charge

Density of individual granules

Type, quality, and quantity of fuel

Vacuum pressure under the sintering mesh

Results.

The technology and quality parameters of aggloporite production using waste from the lead-zinc concentrator are detailed in the research of R. F. Zabelin.

Characterized by a relatively high alumina content, a high melting point (above 1600°C), and the absence of self-formation during heating, coal concentrator waste serves as an excellent raw material for the production of aggloporite for refractory and acid-resistant concretes. The technical and economic feasibility of aggloporite production from the waste of Donetsk, Kuznetsk, Karaganda, and Ekibastuz coal concentrators, as well as other basins, has been well established (Bukunova et al, 2006:7). The industrial-scale extraction of porous aggregates from coal enrichment waste is actively practiced in many countries, including the United Kingdom, Belgium, the United States, and Australia.

The use of porous aggregates in large-scale construction offers several key advantages:

Reduction in the total mass of buildings and structures under construction.

Increased structural dimensions due to a lower average concrete density.

Lower transportation and installation costs for structural components.

Enhanced thermal insulation properties of the final structures.

At present, a significant amount of natural raw materials and fuel is consumed for the production of artificial porous aggregates. However, technological studies conducted both domestically and internationally have demonstrated that industrial waste from various sectors can be effectively utilized in the production of artificial porous aggregates. In the production of porous aggregates, sintering annealing is the most effective method. This process allows for greater flexibility in the chemical composition of industrial waste suitable for aggregate production, ensures high heating unit productivity, and creates the necessary conditions for full mechanization and automation of the entire production cycle. A key advantage of layer annealing in processing waste and producing porous fillers is the small aggregate size. When using a rotary tube furnace, twice as much liquid fuel is consumed compared to layer annealing, making the dust emissions of a layer-annealing unit 30 times lower than those of a rotary furnace. The layered flow annealing process, which involves pumping air through a layer of granules placed on an annealing mesh, significantly improves production efficiency. This method allows for a yield of up to 1000 kg/m², whereas a rotary kiln achieves only 40 kg/m² per hour. Another major advantage of sintering technology in industrial waste processing is its low thermal inertia. This enables the production of hollow aggregates within 20–30 minutes after combustion, whereas a rotary kiln requires 2–3 hours to achieve the same result. Additionally, air pollution levels from carbon monoxide, nitrogen dioxide, and sulfuric anhydride during layer firing remain within maximum permissible concentrations (MPC). This is because these gases are diluted with a large volume of air during combustion. In contrast, during the release of finished products, a rotary kiln emits up to 120 kg of dust per cubic meter, whereas layer firing of raw materials releases no more than 10 kg of dust per cubic meter (Lukashev et al, 1998:8).

In Kazakhstan, there is currently no alternative processing of granulated slags from non-ferrous metallurgy for use in building materials. This area presents a highly promising and environmentally sustainable solution, as it addresses the issue comprehensively.

Research conducted by K. B. Beskempirova has revealed that the concentration of various toxic substances in the human body often exceeds permissible limits. This indicates a state of chronic poisoning, though it may not always present clinical symptoms. For example, in the East Kazakhstan region, approximately 700,000 people—more than 70% of the population— are affected by chronic exposure to toxic substances. Although many heavy metals are essential for life, they can also exert significant negative effects on all living organisms, including plants, animals, and microorganisms (Starodumanov, et al, 1999:9).

Research conducted by M.U. Anartaeva on the hygienic working conditions of employees in the Shymkent lead industry has revealed significant occupational and environmental health risks. Despite the implementation of new technological processes, automation, and modern protective equipment, the concentration of industrial dust and harmful substances exceeds maximum permissible concentrations (MPC) by 21 times. This excessive pollution is observed not only within the work environment but also within a 1,500-meter radius outside the plant. Additionally, among women working in lead production, the prevalence of gynecological diseases is 5.35 times higher than in the control group, while the incidence of tumor diseases is 1.5 times higher. Moreover, as work experience increases, the incidence of tumor diseases rises sixfold. For girls born to mothers who worked at EKZ during pregnancy, the health index is recorded at 10.0%, which is 5.4 times lower than the control group (54.0%).

P. E. Kalmenova's research has further highlighted the health impact of lead pollution on children. The incidence of pneumonia in children living near the lead plant is 3.5 times higher than in an ecologically clean area. In Shymkent, childhood pneumonia rates have shown a steady increase each year. Between 2018 and 2021, the incidence of pneumonia in children doubled, reaching 37.5 cases per 1,000 children (McConnell, Doveze et al, 1999:10,11).

An analysis of public health in the Republic of Kazakhstan indicates that health indicators lag significantly behind those of most industrialized countries. Achieving a high standard of public health is closely linked to environmental protection, improved working conditions, and enhanced living standards. One of the key priorities for improving public health in Kazakhstan is the implementation of national policies focused on the prevention of infectious diseases. This includes protecting and strengthening public health, eliminating risk factors, and addressing environmental contributors to morbidity, mortality, and injuries (Chalkley et al, 1998:12).

In recent years, water bodies, particularly rivers, have experienced severe pollution due to intensive human activities. This includes the discharge of industrial, agricultural, and domestic wastewater into surface waters, as well as the emission of coal, petroleum products, and other pollutants into the atmosphere. Wastewater containing metal ions that enter natural water bodies disrupt oxygen balance, harm aquatic ecosystems, and pose serious risks to human health. Among the most toxic metals found in contaminated waters are mercury (Hg), cadmium (Cd), arsenic (As), lead (Pb), and radionuclides, all of which have detrimental effects on both the environment and human health (Nosova et al, 1983:13).

The high variability in the composition of pollutants and the intermittent nature of contamination from man-made sources often make it difficult to fully characterize long-term pollution trends over a year or decade. The quality of water and the ecological state of water bodies are primarily assessed based on metal concentrations. Notably, heavy metal concentrations in bottom sediments are significantly higher than in the water column and are less affected by fluctuations in wastewater discharge. Consequently, the presence of heavy metals in sediments at the bottom of reservoirs and watercourses serves as one of the most objective indicators of a water body's pollution level and self-purification capacity, as influenced by hydrophysical, geochemical, and biological processes (Landrigan et al, 1991:14).

However, bottom sediments in reservoirs have now ceased to function as natural self-purification agents for aquatic ecosystems. This is due to the depletion of ecological reserves that once facilitated water self-purification, as well as the saturation of bottom sediments with pollutants, reaching their environmental capacity limit. Additionally, heavy metals have a high probability of secondary precipitation from bottom sediments, particularly when physicochemical and hydrodynamic conditions of the aquatic environment change. These processes are mainly confined to areas of active silt accumulation.

Currently, several research initiatives are being conducted to improve the ecological state of natural waters and mitigate pollution impacts.

Discussion. According to UNESCO, approximately 320 million tons of river water are transported to the sea annually. This water carries over a ton of iron and 2.3 million tons of lead. Industrial wastewater further intensifies contamination, contributing twice the natural amount of mercury, 12–13 times the amount of lead, copper, and zinc, and 30 times the amount of antimony to river ecosystems. The total inflow of heavy metals into the northeastern Atlantic from industrial and agricultural wastewater reaches 9,096 million tons per year (Makashev et al, 1976:15).

In urban environments, heavy metals in street dust are among the most significant sources of pollutants. This urban dust originates from industrial activity, road traffic, building erosion, and fossil fuel combustion (Mohammadi et al, 2023:16).

Heavy metals pose serious health risks:

Lead (Pb): Affects the central and peripheral nervous system, circulatory system, and kidneys.

Copper (Cu): Causes liver damage.

Cadmium (Cd): Chronic exposure increases the risk of lung cancer and kidney damage.

Mercury (Hg): Can lead to brain damage (Brindhadevi, et al, 2023:17).

The chemical composition of underground waters in the Karazhyra Coal Field (East Kazakhstan region) was analyzed, revealing that the concentrations of strontium, arsenic, titanium, cadmium, manganese, lead, and iron exceed the maximum permissible concentrations (MPC) for underground water by 2 to 16 times. The authors also investigated lead concentrations in the soil across various districts of Shymkent and analyzed the presence of heavy metals in the Badam River water (Snopkova, et al, 1985:18).

The contamination of river basins with heavy metals is a global environmental concern, as these pollutants are transported through river systems, posing significant toxicity risks to aquatic ecosystems (Liu et al, 2023:19). In the Republic of Kazakhstan, there is almost no comprehensive state waste management system that includes the monitoring, storage, processing, and disposal of industrial and household waste. Across the country, more than 20 billion tons of production and consumption waste, including 6.7 billion tons of toxic waste, have accumulated. This situation is primarily due to the use of outdated technologies, low-quality raw materials and fuel, and the reluctance of enterprises to invest in waste disposal and reclamation.

Industrial waste, including toxic waste, continues to be stored in various waste facilities without adherence to environmental norms and regulations. As a result, soil, groundwater, and surface water in many regions are experiencing severe contamination. The constant increase in the volume of stored waste has led to the formation of new man-made landscapes. As the height of mounds and tailing piles increases, they become more significant sources of dust pollution, exacerbating environmental hazards. Due to the low concentration of valuable components in deposits, the production of non-ferrous metals generates significant amounts of industrial waste. These waste materials, accumulated in various types of landfills, occupy large areas and contribute to environmental pollution.

One of the key strategies for the sustainable use of mineral resources and natural resource conservation is the development of advanced technologies for comprehensive waste processing. This includes the implementation of low-waste and waste-free technologies, as well as the utilization of low-grade ores, beneficiation waste, and metallurgical solid waste as raw materials for industrial processing. However, the utilization of waste from this industry in Kazakhstan remains at a low level.

In 2021, the highest levels of atmospheric air pollution within the plant's territory were recorded in the southwest direction, where the concentration of lead aerosols exceeded the maximum permissible concentration (MPC) of 0.0003 mg/m³ by 29.7 times. In other directions, the exceedance was as follows:

Northeast direction: 9.7 times

Southeast direction: 2.7 times

Central region: 10.3 times

The average annual concentration of lead aerosol in the atmospheric air within the plant's territory ranged between 0.002 and 0.0074 mg/m³. The highest annual average concentration was observed in the southwestern part of the plant's territory, reaching 0.0074 mg/m³, while the lowest concentration was recorded in the southeastern part, at 0.0008 mg/m³.

Conclusion

Over the past six years, ENT diseases have remained the most prevalent respiratory conditions, particularly vasomotor and allergic rhinitis. The relative incidence of these conditions among children in the studied areas has shown a steady increase from 2018 to 2020. In 2019, a total of 295 children living near the lead plant were diagnosed with these diseases. By 2021, the number of affected children had risen to 748, whereas in the unpolluted area, no cases were recorded in that year. By 2023, the number of registered cases is projected to reach 945. Additionally, in the general control area, the lowest incidence rates of these diseases among adults were consistently observed over the six-year period.

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