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IMPROVING ENVIRONMENTAL MEASURES FOR THE PROTECTION OF ATMOSPHERIC AIR IN CEMENT PRODUCTION ENTERPRISES

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Abstract. This article analyzes the impact of cement production enterprises on atmospheric air and examines environmental measures aimed at reducing this impact, using the Kattakurgan Cement Plant as a case study. The study considers dust and gas emissions, organized and unorganized emission sources, secondary dust generation caused by vehicle movement, the role of green protective belts, and the need to introduce a digital environmental monitoring system. The results indicate that, although the existing filter and aspiration systems at the plant demonstrate high efficiency, transport-related dust, open storage areas, and insufficient digitalization of continuous monitoring remain significant environmental risk factors. The article substantiates practical recommendations for paving internal roads with asphalt or concrete, regularly wetting road surfaces, limiting vehicle speed, transporting dust-generating materials in covered form, establishing green protective zones, and introducing online monitoring of PM10, PM2.5, SO_2, NO_2, and CO.

Keywords: cement plant, atmospheric air, dust and gas emissions, PM10, PM2.5, environmental monitoring, green protective belt, environmental safety, Kattakurgan Cement Plant.

Introduction. Atmospheric air pollution is one of the most urgent environmental problems of the present period, directly associated with industrialization, urbanization, the expansion of transport systems, and the growth of construction-material production. In global practice, industrial enterprises, especially cement production facilities, are considered important anthropogenic sources of dust-gas mixtures, fine particulate matter, nitrogen oxides, sulfur compounds, carbon monoxide, and other harmful substances [1; 2]. In cement production, the stages of raw material extraction, crushing, drying, burning, clinker cooling, cement grinding, storage, and packaging are characterized by a high probability of dust formation, which negatively affects atmospheric air quality [3].

Scientific literature notes that cement dust contains calcium oxide, silicon dioxide, aluminum oxide, iron oxide, and other mineral components. When these particles enter the atmosphere, they can create environmental risks not only within the enterprise area but also in nearby settlements, depending on wind direction and meteorological conditions [4]. Fine particulate fractions such as PM10 and PM2.5 are particularly dangerous to human health because they may penetrate the respiratory tract and contribute to bronchitis, asthma, allergic diseases, cardiovascular disorders, and the aggravation of other chronic illnesses [5; 6].

International approaches to atmospheric air protection emphasize the implementation of best available techniques, improvement of filter and aspiration-system efficiency, control of unorganized emission sources, reduction of transport-related dust, establishment of green protective zones, and organization of continuous environmental monitoring systems as key

measures for reducing industrial dust and gas emissions [7; 8]. Therefore, environmental management at cement plants should not be limited to the installation of technological filters alone; rather, it should rely on comprehensive control of all dust-generating processes within the production area.

In Uzbekistan, reducing the impact of industrial enterprises on atmospheric air, ensuring environmental safety, and protecting public health are among the priority areas of state environmental policy. The Law on Environmental Expertise, Environmental Impact Assessment and Strategic Environmental Assessment, as well as regulatory documents aimed at improving the environmental impact assessment mechanism, define the need for business entities to comply with environmental requirements, reduce pollutant emissions, and organize environmental monitoring [9; 10]. This increases the need to develop and implement scientifically based environmental measures at cement production enterprises.

The analysis carried out using the Kattakurgan Cement Plant as a case study shows that the enterprise has filter and aspiration systems designed to capture dust in the kiln system, clinker cooler, cement mill, and packaging department. However, environmental risk is not limited to organized emission sources. Vehicle movement, open areas, and raw-material and finished-product loading and unloading processes within the enterprise also represent unorganized sources that may cause secondary dust pollution. During dry and windy seasons, dust lifted from internal roads increases the concentration of PM10 and PM2.5 particles and has a negative effect on the ecological condition of the area surrounding the plant.

For this reason, the present article examines the improvement of environmental measures for atmospheric air protection using the Kattakurgan Cement Plant as an example. The study analyzes existing technological protection facilities, transport-related dust, dust from open areas, green protective belts, the digital environmental monitoring system, and the organization of environmental auditing. The main purpose of the article is to scientifically and practically substantiate a set of comprehensive environmental measures aimed at reducing the negative impact of cement production enterprises on atmospheric air.

Materials and methods. The object of the study was the activity of the Kattakurgan Cement Plant and the system of environmental measures aimed at reducing its impact on atmospheric air. The subject of the study consisted of dust and gas emissions generated during cement production, transport-related dust, organized and unorganized emission sources, green protective zones, and environmental monitoring systems.

The research employed analytical, comparative, environmental assessment, systems-approach, and practical recommendation development methods. On this basis, the current environmental condition of the Kattakurgan Cement Plant, its production processes, the main factors affecting atmospheric air, and its technological protection facilities were examined. In addition, PM10, PM2.5, SO_2, NO_2, and CO were analyzed as key indicators for assessing atmospheric air quality. Based on the results obtained, practical recommendations were developed for reducing transport-related dust, wetting internal roads, limiting vehicle speed, establishing a green protective belt, and introducing an online environmental monitoring system.

Results and discussion. The research results showed that the Kattakurgan Cement Plant has certain technological protection facilities for reducing dust and gas emissions. In particular, cartridge dust filters are used in the kiln system, and their efficiency is estimated at up to 99.9%. Filters installed in the clinker cooler can retain up to 99.95% of dust particles. Aspiration systems are also available in the cement mill and packaging department, where they contribute to a significant reduction in dust emissions. This indicates that technological protection for organized emission sources has been established at a relatively satisfactory level.

However, the analysis revealed that the main problem is related to unorganized emission sources. Secondary dust pollution is generated within the plant area as a result of vehicle movement, open storage areas, and the loading and unloading of raw materials and finished products. During dry and windy periods, the movement of 50-ton trucks, dump trucks, and other heavy machinery causes PM10 and PM2.5 particles to rise into the air. This may increase environmental risk in residential areas located near the plant.

Paving internal roads with asphalt or concrete is an important practical measure for reducing transport-related dust. Such an approach can significantly reduce the level of dust generation. In addition, regular wetting of roads with special equipment during dry seasons, limiting the speed of heavy vehicles to no more than 15 km/h, and transporting dust-generating materials in covered form reduce the secondary resuspension of PM10 and PM2.5 particles.

Green protective belts also play an important role in reducing environmental risk. It is advisable to establish a green protective zone consisting of four to six rows of trees and shrubs around the Kattakurgan plant. In areas exposed to strong prevailing winds, the width of such a belt may be increased to 100-150 m. Trees and shrubs retain dust particles on leaf surfaces, reduce wind speed, and limit the penetration of pollutants into residential areas.

Taking into account the dry and hot climatic conditions of the Kattakurgan area, tree species suitable for local conditions should be selected for the green protective belt. Poplar, Russian olive, elm, mulberry, ash, and local shrub species capable of effectively retaining dust may be recommended. Their environmental advantage is that they are drought-resistant, adapted to local soil and climatic conditions, and capable of retaining airborne dust particles.

Another important direction identified in the study is the need to introduce a digital environmental monitoring system. Online monitoring points for PM10, PM2.5, SO_2, NO_2, and CO should be established within the enterprise area and in nearby settlements. Monitoring points should be placed along the main wind directions at the plant boundary, as well as in settlements with a higher probability of exposure and in control zones. This would allow real-time observation of pollutant concentrations in atmospheric air, detection of exceedances of permissible limits, and prompt adoption of environmental management decisions.

Recommendations. For the Kattakurgan Cement Plant, it is advisable to organize environmental measures according to the following system. It is advisable to organize environmental measures for the protection of atmospheric air at the Kattakurgan Cement Plant on the basis of an integrated system. In this regard, it is necessary not only to operate technological filters and aspiration equipment, but also to reduce dust and gas emissions at all stages of the production process, control unorganized emission sources, regulate transport movement, expand green protective zones, and establish a continuous environmental monitoring system.

No.	Measure area	Specific recommendation	Expected environmental effect
1	Technological protection	Ensure the uninterrupted operation of aspiration and filter systems and introduce a scheduled maintenance plan.	Organized dust and gas emissions are reduced.
2	Transport-related dust	Pave internal roads with asphalt or concrete, wet them every 6 hours, and limit vehicle speed	Secondary resuspension of PM10 and PM2.5 particles decreases.

		to 15 km/h.	
3	Open areas	Store and transport raw materials and dust-generating products in covered form.	Unorganized emission sources are reduced.
4	Green protective belt	Establish a four- to six-row green belt, with a width of 100-150 m on the side exposed to strong winds.	The spread of dust particles into residential areas is limited.
5	Digital monitoring	Introduce online monitoring points for PM10, PM2.5, SO_2, NO_2, and CO.	Exceedances of standards are detected quickly, and management decisions become scientifically justified.
6	Environmental audit	Annually assess filters, fuel consumption, waste generation, traffic intensity, and the condition of green areas.	The environmental management system becomes more stable.

The discussion results indicate that ensuring environmental safety at cement plants should not be limited to the installation of filters alone. Technological protection, regulation of transport movement, reduction of open dust sources, expansion of green protective zones, and introduction of a continuous monitoring system should be implemented in an integrated manner.

CONCLUSION

The analysis conducted using the Kattakurgan Cement Plant as an example demonstrates that the protection of atmospheric air in cement production enterprises requires a comprehensive approach. Although the existing filter and aspiration systems at the plant play an important role in reducing dust and gas emissions, unorganized emission sources, transport-related dust, and dust particles originating from open areas remain environmental risk factors.

According to the study results, reducing negative impacts on atmospheric air requires paving internal roads with asphalt or concrete, regularly wetting road surfaces, limiting vehicle speed, transporting raw materials and dust-generating products in covered form, establishing a four- to six-row green protective belt, and implementing an online monitoring system for PM10, PM2.5, SO_2, NO_2, and CO.

The implementation of these measures will reduce the cement plant's impact on atmospheric air, lower environmental risks in nearby residential areas, and contribute to the ecological sustainability of industrial production.

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