Vol. 9, No. 3, 2024

IMPROVEMENT OF THE SCHEME OF NEUTRALIZATION OF DUST EMISSIONS INTO THE ATMOSPHERE

Nataliia Latsyk, Ihor Petrushka

Lviv Polytechnic National University,
12, S. Bandery Str., Lviv, 79013, Ukraine
nataliia.v.latsyk@lpnu.ua

https://doi.org/10.23939/ep2024.03.144

Received: 15.07.2024

Abstract. Emissions of industrial enterprises in their structure are mostly aerodisperse systems, in which the dispersed phase is organic and inorganic dust or fine droplets, and the dispersion phase is a gas-air mixture. This mixture may comprise several contaminating gaseous components. In many cases, the components of the exhaust gases have an additive effect or are capable of transforming into more dangerous compounds, which in the conditions of background concentrations characteristic of most industrialized areas makes them dangerous even at relatively low concentrations in emissions. This problem is exacerbated by changes in industrial infrastructure, the convergence of industrial and residential areas, as well as the emergence of new toxic substances with an insufficiently studied effect.

At present, dust is becoming one of the priority pollutants that must be considered when organizing monitoring of the surrounding air. Atmospheric monitoring of dust pollution of the air, being a complex modern task, allows us to determine the actual data on air quality, dust concentration, and trends in its change, and assess the degree of damage caused to human health.

We conducted a detailed analysis of the literary data and proposed an influence scheme of fine dust on the environment and ways to improve the neutralization scheme of pollutants on the biosphere, in particular the atmosphere.

Keywords: finely dispersed cement dust, neutralization, trapping, environmental safety.

1. Introduction

Since atmospheric air is the most mobile area of the biosphere, pollutants along with air masses are transported over long distances and can affect the ecological situation of entire regions, disrupting the balance of ecological cycles of the main biogenic substances in all components of the ecosystem. Gas-dust emissions of industrial enterprises are characterized by multicomponent, large volumes, and the presence of various hazard classes pollutants, in the interaction of which synergistic effects may occur. This leads to a decrease in the level of environmental safety. The technogenic impact of gas and dust emissions of industrial enterprises can cause the degradation of ecosystem components and affect the state of environmental safety of atmospheric air directly, as well as other environmental components during the migration of pollutants. Thus, this impact extends to the environmental safety system as a whole. According to the intensity of the impact and the nature of the process of transferring pollutants, zones of direct (core) and indirect impact are distinguished, which differ in the intensity and limits of impact on the environment and humans (Shmandiy, 2003; Cheliadyn, 2011; Bakharev, 2005; Mokin, Varchuk, 2013; Gurets, 2009).

Accordingly, the decomposition principle can be applied to subsystems in the environmental safety system and to subsystem components. The environmental safety system includes subsystems that characterize the level of environmental safety in various environmental components: environmental safety of atmospheric air, environmental safety of the hydrosphere; and environmental safety of the lithosphere (Pliatsuk, Gurets, 2016; Gurets, Pliatsuk, 2013). Each component of the environmental safety system is

For citation: Latsyk, N., Petrushka, I. (2024). Improvement of the scheme of neutralization of dust emissions into the atmosphere. *Journal Environmental Problems*, 9(3), 144–149. DOI: https://doi.org/10.23939/ep2024.03.144

interconnected with others and is a complex and multi-level system, which is characterized by certain functions, characteristics, ability to develop and improve. Continuous degradation of the environment begins with the degradation of one component and gradually covers all the others. That is why the interaction of small systems in a large system should be considered comprehensively.

The boundary of indirect impact covers areas that are exposed to pollutants during their transfer by air flows and migration in environmental components. The boundary of this zone is determined by the natural and climatic conditions that affect the dispersion of pollutants, as well as urban conditions if the distribution of pollutants within the city is considered.

The relationship between the quality of atmospheric air and the state of environmental safety is established when assessing the technogenic load on the environment.

To analyze and assess the degree of real danger of air pollution, it is recommended to use the statistical data of the survey results available in the city, which include:

- public health (physiological reaction of the body, morbidity of the population);
- condition of green plantations (biological productivity, accumulation of harmful substances in the bark and leaves);
- determination of the pollution danger level (harmfulness).

These results are summarized using known standard and normative techniques. These include:

- methods for calculating the average annual air pollution (based on the works of M. E. Berland, E. Yu. Bezugoloy, S. S. Chicherina and others);
- criteria and methods for assessing the danger of air pollution to public health (based on the works of K. A. Bushtueva, M. A. Pinigin, V. M. Prusakova, Yu. M. Zhavoronkova and others);
- criteria for assessing the risk of air pollution for vegetation (based on the works of R. Gudarin, G. M. Ilkun, V. S. Nikolaevsky, etc.);
- methods for assessing the socio-economic damage from air pollution (based on the works of O. F. Balatsky and others).

Assessment of the technogenic load on the environment in case of air pollution by emissions of industrial enterprises as a whole includes the processes of identification, assessment and forecasting of the negative impact on the environment and/or human health as a result of the functioning of industrial production. These processes can pose a danger to the population and the environment after reaching a certain value, which is called the “threshold of man-made load” or “threshold of man-made impact”.

The value of the threshold of man-made load is based on the concept of the ecosystem stability or the criticality of its state or its individual links and levels, if there is no reserve of strength. The principle of the threshold effect on biological systems is understood not at all as the threshold of any changes in ecosystems during man-made exposure, but as the biota reaction going beyond the usual physiological fluctuations observed during homeostasis.

The threshold effect of action on grouping (biogeocenosis) is considered and evaluated by the final, integral effect on the entire system. We are talking about the threshold of harmful action, which leads to the release of ecosystem reactions beyond the limits of normal physiological “systemic” fluctuations, and not about the threshold for the manifestation of individual biological reactions. Determination of anthropogenic actions permissible for the ecosystem (against the background of natural variability of its state) is based on the concept of ecological reserve of this system and the interval of permissible fluctuations of its state.

The choice of the threshold characteristic of man-made load is explained by the need for environmental rationing, which does not contradict the sanitary and hygienic rationing and the concept of maximum permissible concentrations (MPC), but to some extent complements them, strengthening the current standards. Assessment of man-made load includes successive stages of general analysis of environmental object pollution as a result of stationary sources emissions (Pliatsuk, Gurets, 2016).

The entry of pollutants into the environment to a certain extent is the main motive for the separate design of urban construction projects and industrial enterprises. However, today industrial and residential buildings exist nearby, actively influencing each other, especially in historically formed industrial regions of the country (Gurets, Pliatsuk, 2013).

When considering the environmental safety of industrial cities, the concept of the urbosphere is introduced (Gurets, 2009). The urbosphere is an important part of the urban environment, where there is a significant impact of anthropogenic factors on the environment. The main components that affect the urbosphere include:

1. Thermal radiation: The earth's surface and various installations (thermal, energy) emit heat, creating a heat cap over the city. This can increase the local temperature and affect the microclimate of the city.

2. Air pollution: Gaseous and aerosol waste from technological processes can create fog and smog, which impairs air quality.

3. Wind mode: Wind changes depending on the landscape features, altitude and structure of the city. This can affect the dispersion of pollutants and air temperature.

The size of the urbosphere and its impact on the environment can vary depending on the terrain, building characteristics and level of industrial activity. The height of influence can reach up to 5 km, and geographically it covers not only urbanized areas, but also natural forest park areas of the city (Gurets, 2009, Vinarsky, 1975; Bondar, Statiukha, 1976; Statsoft, 2007).

The biosphere environmental safety system includes subsystems that characterize the level of environmental safety in environmental components: environmental safety of atmospheric air, environmental safety of the hydrosphere; environmental safety of the lithosphere. Each of the components of the environmental safety system is interconnected with others and is a complex and multi-level system, which is characterized by certain conditions, characteristics, ability to develop and self-improvement.

Continuous degradation of the environment begins with the degradation of one component and gradually covers all the others. That is why the interaction of small systems in the general system should be considered in a complex way (Alentum, 2009; MVV No. 081/12-0161-05, 2005).

2. Results and Discussion

For a detailed assessment of the air pollution impact value for an individual settlement in which the source of pollution is located, it is necessary to take into account: natural and climatic factors; degree of settlement development and factors that are directly related to the emission source (Fig. 1).

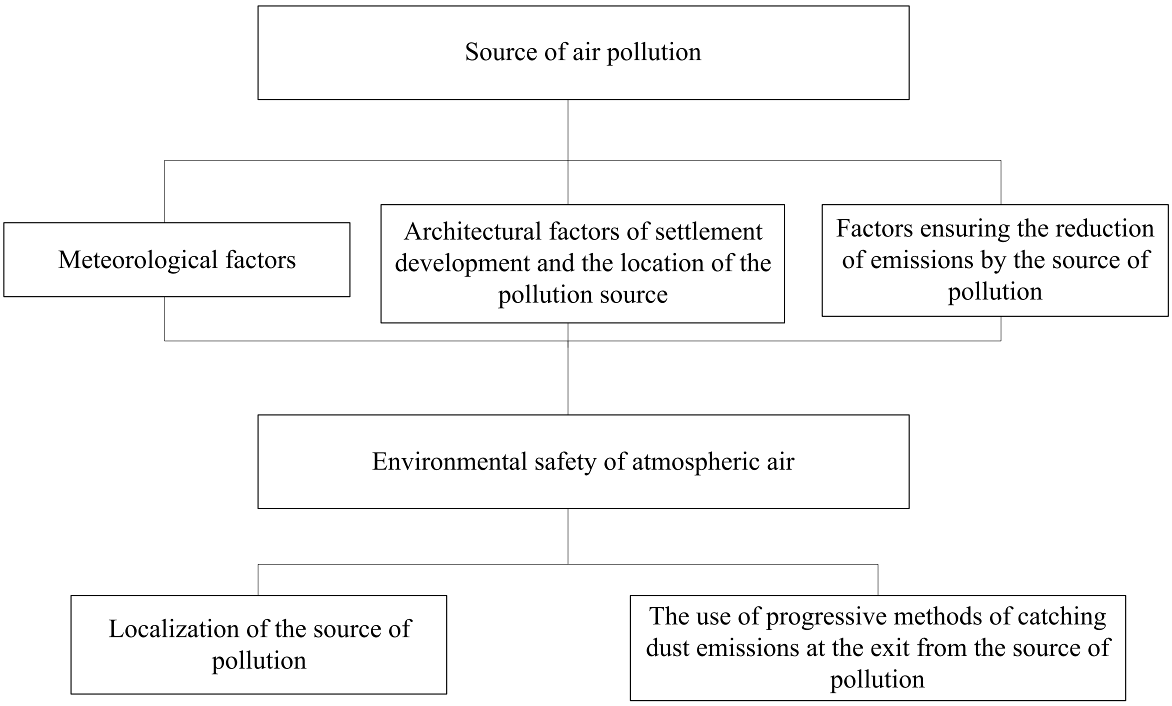

Fig. 1. Scheme for ensuring environmental safety of atmospheric air when exposed to industrial enterprises

The subsystem that focuses on the impact of industrial pollution sources on the quality of atmospheric air is a component of this system. The components of this subsystem can be classified as follows: meteorological conditions that affect the transport and dispersion of pollutants (average wind load direction, temperature stratification, solar radiation); terrain; density and height of development: remoteness of the enterprise from residential areas, landscaping of the territory of the settlement, the state of sanitary protection zones of the enterprise; environmental safety management services (emission control), characteristics of emission sources (height, diameter of pollution particles, their aggressiveness to the environment), process characteristics, volume, temperature of pollutants, concentration and properties of pollutants, environmental processes (gas treatment systems, gas treatment equipment).

There are two groups of measures for environmental protection at an industrial enterprise:

1. Modernization of technological equipment is necessary to prevent harmful substances from entering exhaust gases through improvement of technological processes.

2. Improvement of exhaust gas purification systems: the use of high-efficiency gas cleaning equipment to achieve regulatory indicators of the concentration of pollutants on the discharge from the pipe. This includes both commissioning new gas treatment plants and upgrading existing gas treatment systems at minimal cost if possible.

Taking into account the above, air quality management in the system of settlement – industrial enterprise will be presented in the form of a scheme (Fig. 2). Improvement of gas purification systems will be one of the links in ensuring the environmental safety of the atmospheric air of settlements.

Thus, ensuring the environmental safety of the atmospheric air of the settlement, which is located within the anthropogenic impact of the enterprise, is based on the factors presented in Fig. 2, while it is necessary to take into account the fact that dispersed particles as a result of precipitation fall into the soil. At the same time, as previously noted, the impact on the lithosphere and hydrosphere will depend on the degree of toxicity and the speed of propagation in the soil environment or aquatic environment, and this depends on factors such as: the type of soil and meteorological conditions of the region (average temperature, river flow speed, wind load speed).

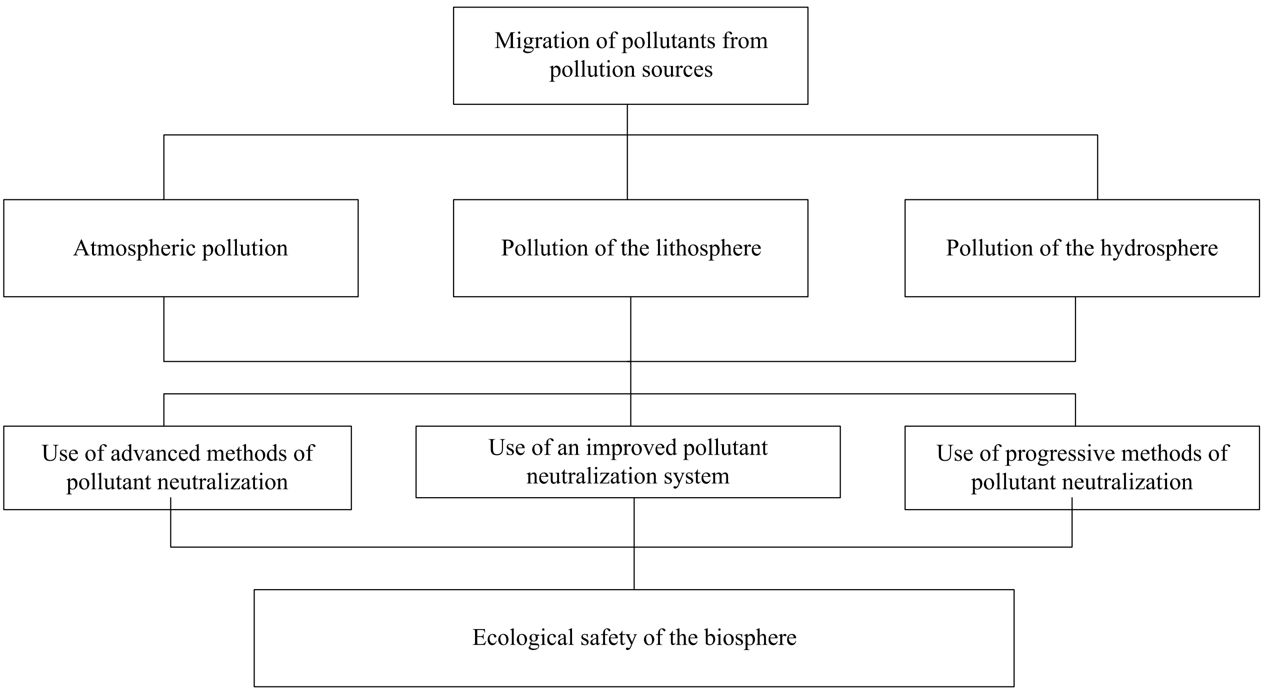

Fig. 2. Ensuring the environmental safety of the atmosphere with the complex action of polluters

The following scientific and methodological principles should be used as the main principles of environmental safety in the case of air pollution caused by exhaust gases from industrial enterprises:

1. The principle of complexity: environmental safety of atmospheric air should be an integral system that considers the factors affecting the quality of atmospheric air and the relationship between the quality of atmospheric air and the state of the environment in general and public health in particular.

2. The principle of sustainable development: development and implementation at industrial enterprises of technological processes and technological equipment that meet international standards and minimize the release of pollutants during the production process.

3. Minimization principle: reducing the concentration of pollutants in the exhaust gases of industrial enterprises by using highly efficient gas cleaning equipment; reducing the concentration of pollutants in the human environment through the introduction of urban planning measures.

To carry out experimental research on the development and improvement of gas treatment equipment, an experiment was planned, which included the following stages:

– Selection and justification of factors: identification and selection of factors that affect the efficiency of the gas cleaning apparatus, such as the free cross section of the apparatus (τ), the gas velocity in the apparatus (m/c).

– A series of experiments: experimental measurements with variation of selected factors (Bondar, Statiukha, 1976; Statsoft, 2007; Alentum, 2009).

– Processing and analysis of results: collecting data from experiments, building regression models to determine the influence of factors on the efficiency of the apparatus.

– Using software products for data processing: using Mathcad 14.0 software products for mathematical analysis, Statistica 6.0 for statistical analysis, and Advanced Grapher 2.2 for data visualization (Koziy et al., 2009; Koziy, Gurets, 2009; Polutrenko, Paranyak, 2015).

The parameters of gas treatment equipment can be evaluated and improved systematically using this approach based on scientific research and analysis of the results obtained.

Experimental studies of the characteristics of the devices were carried out on enlarged models in order to eliminate the phenomenon of large-scale transition. Studies on enlarged models give more reliable results that can be directly used in the design of industrial devices (Alentum, 2009; MVV No. 081/12-0161-05, 2005).

The proposed dust collection system provides improved efficiency of dust cleaning, as well as separate dust collection of fine dust (Petrushka et al., 2022; Serebryansky et al., 2014).

It should be noted that the concentration of industrial enterprises in cities and urban-type settlements creates a difficult environmental situation, especially when they are near residential areas. This requires an integrated approach to the design of cities, where the environmental factor becomes decisive. It is important to provide for the integration of industrial facilities with residential areas in such a way as to minimize the negative impact on the microclimate and quality of the environment.

To ensure the safety and comfort of urban residents, it is crucial to design and control pollutant emissions separately. The implementation of forecasts of the environmental situation, taking into account natural and anthropogenic factors, avoids serious environmental problems in the future and contributes to the sustainable development of urban areas.

3. Conclusions

Prevention of ingress of harmful substances of cement production into the atmosphere has been improved by improvement of exhaust gas purification systems using highly efficient gas cleaning equipment in order to achieve standard indicators of concentration of pollutants on the pipe discharge.

The priority of gas purification processes in the system of environmental safety of the environment and atmospheric air in particular has been established.

The scientific and methodological principles of environmental safety of atmospheric air under the influence of emissions of cement enterprises are formulated: the principle of complexity; the principle of sustainable development; minimization principle.

An integrated system with a cyclone and bag filter in a single design does have the potential to significantly improve dust collection efficiency, especially in the context of cement production. It not only helps to reduce the impact on the environment by reducing emissions of fine dust, but also allows manufacturers to obtain high-quality cement and improve the quality and cost of products.

This approach is also of strategic importance, providing enterprises with competitive advantages in conditions of market competition. The integration of technological and environmental solutions in this way demonstrates the importance of sustainable development in industrial production.

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