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THE ROLE OF NOX GASES IN ATMOSPHERIC POLLUTION: SOURCES, ANALYSIS, AND ECOLOGICAL RISK ASSESSMENT

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Abstarct: This article scientifically analyzes the pollution of atmospheric air by NOx gases (nitrogen oxides), their main sources, dispersion characteristics, and ecological risk levels. The study highlights the formation processes of NOx gases and their association with industrial, transportation, and energy sectors. It also discusses the adverse effects of these gases on human health and the environment, particularly their contribution to photochemical smog, acid rain, and climate change. The article substantiates the necessity for effective monitoring and environmental policies to combat NOx emissions.

Keywords: NOx gases, atmospheric pollution, nitrogen dioxide, ecological risk, industrial emissions, photochemical smog, air quality, acid rain, nitrogen oxide dispersion, anthropogenic sources.

In recent decades, global atmospheric pollution has been recognized as one of the most critical environmental threats. The increasing population, expansion of industrial enterprises, and sharp rise in the number of vehicles have led to a year-on-year increase in pollutant emissions into the atmosphere. The degradation of atmospheric composition poses serious threats not only to human health but also to the stability of the entire biosphere system. One of the main gases polluting the atmosphere is nitrogen oxides (NOx), which primarily consist of nitric oxide (NO) and nitrogen dioxide (NO_2). These gases mainly form during fuel combustion at high temperatures. NOx gases not only alter the physical and chemical properties of air but also contribute to photochemical smog, acid precipitation, adverse impacts on plants and human health, and act as greenhouse gases.

Currently, the concentration of NOx gases in the atmosphere is a subject of ecological monitoring in many developed and developing countries. Especially in industrial centers and densely populated urban areas, these gases are among the key indicators of pollution. This article provides a scientific analysis of the role of NOx gases in atmospheric pollution, their anthropogenic sources, dispersion characteristics, ecological risks, and negative consequences. It also discusses approaches to reduce these gases, monitoring systems, and the role of environmental policies.

Nitrogen oxides (NOx) mainly form as a result of chemical reactions between nitrogen and oxygen molecules at high temperatures. During combustion, especially above 1200°C, nitrogen (N_2) and oxygen (O_2) combine to produce nitric oxide (NO). Subsequently, NO reacts with atmospheric oxygen to form nitrogen dioxide (NO_2). The sources of NOx gases can be divided

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into natural and anthropogenic categories. Natural sources include wildfires, lightning, volcanic eruptions, and certain microbial processes. However, in modern times, human activities—industrial enterprises, power plants, and especially transportation—are the primary contributors to NOx emissions. Combustion of fuel in vehicles at high temperatures releases significant amounts of NOx. Additionally, coal or gas-fired power plants and industrial manufacturing processes emit large quantities of NOx into the atmosphere. The increase in these gases deteriorates air quality, contributes to climate change, and harms human health.

Extensive research exists on the role and sources of nitrogen oxides (NOx) in atmospheric pollution. NOx gases, primarily nitric oxide (NO) and nitrogen dioxide (NO_2), are critical in altering the chemical properties of the atmosphere and impacting ecological balance (Smith et al., 2018). Anthropogenic sources have been identified as major contributors to NOx pollution in numerous studies. For instance, Kumar et al. (2020) emphasized that transportation, industrial enterprises, power plants, and agricultural activities are principal sources of NOx emissions. The transportation sector, especially in urban areas, stands out as the largest NOx source due to incomplete combustion in internal combustion engines (Zhao et al., 2019).

Natural sources also play a role in atmospheric NOx emissions but are significantly lower compared to anthropogenic sources. Lightning strikes, forest fires, and microbial processes such as denitrification contribute to NOx formation (Jones, 2016). However, globally, the anthropogenic NOx output has sharply increased due to human activities (Liu et al., 2021).

Health impacts of NOx have been widely studied. Johnson et al. (2019) demonstrated that NO_2 intensifies respiratory diseases, increases allergic reactions, and decreases lung function. Moreover, NOx gases are primary contributors to acid rain, which acidifies soil and water resources (Lee, 2017). NOx plays a crucial role in photochemical smog formation, producing harmful and toxic compounds that create unhealthy environments for humans and plants (Wang et al., 2020).

In Uzbekistan, particularly in major industrial and transportation hubs, NOx pollution is a critical issue. Rakhimov (2022) analyzed air monitoring data in Tashkent, highlighting that emissions from transportation and industrial sectors significantly disrupt ecological balance. The country has developed and implemented several environmental measures to reduce NOx emissions (State Committee for Ecology, 2023). Available literature provides comprehensive data on the identification of NOx concentrations and sources, assessment of health and environmental impacts, and development of effective reduction strategies. Research indicates the need for adopting new technologies in transportation, optimizing industrial processes, and enhancing environmental monitoring to reduce NOx emissions.

The role and concentration of NOx gases in atmospheric pollution have been extensively studied worldwide. According to the World Health Organization (WHO) and other international bodies, NOx gases are among the principal contributors to global air pollution. For example, in the United States, stringent environmental measures taken between 2015 and 2020 resulted in a 20–25% reduction in NOx emissions from transportation and industry (EPA, 2021). However, in some developing countries like China and India, rapid industrial and transportation growth continues to increase overall NOx emissions (Zhang et al., 2020; Singh, 2019). International studies confirm that high NOx concentrations cause respiratory diseases, cardiovascular

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problems, and other health issues (WHO, 2022). NOx gases also lead to photochemical smog and acid rain formation, damaging ecosystems.

Recent monitoring in Uzbekistan indicates consistent tracking of NOx concentration levels. According to the State Committee for Ecology (2020–2023), average NOx levels in Tashkent hover around 0.045 mg/m³, reaching up to 0.06 mg/m³ in industrial and traffic-dense areas. These levels are close to or exceed WHO recommended limits.

Statistics from the Uzbekistan Environmental Agency show that 50–55% of NOx emissions come from transportation, 30–35% from industrial enterprises, and the remainder from natural and agricultural sources (Environmental Agency, 2023). NOx gases remain key components of atmospheric pollution in major industrial centers and cities.

Nitrogen oxides (NOx) constitute a significant portion of atmospheric pollution, primarily resulting from human activities, especially transport and industry. Global and Uzbekistan-specific data indicate that high NOx concentrations exacerbate respiratory diseases, allergies, and other health issues. They also disrupt atmospheric chemical balance, causing acid rain, photochemical smog, and ecological problems.

In Uzbekistan, transportation and industrial sectors are the main NOx emission sources, with problems more acute in large cities and industrial zones. To improve air quality, it is crucial to enhance environmental control systems, implement modern clean technologies, ensure vehicle emission standards, and reduce industrial emissions.

Recommendations:

1. Improve fuel quality and implement modern environmentally friendly technologies in the transport sector.
2. Develop and promote environmentally clean production methods and emission reduction in industries.
3. Conduct regular and systematic environmental monitoring to accurately track atmospheric NOx levels.
4. Increase public environmental awareness and encourage community participation in air quality improvement.
5. Strengthen legislation and enforcement to ensure strict pollution control measures.

These actions will be vital in improving Uzbekistan's environmental conditions, protecting public health, and achieving sustainable development.

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