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ANALYSIS OF AIR POLLUTION DYNAMICS IN KYIV UNDER MARTIAL LAW CONDITIONS (2023)

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Abstract

The level of atmospheric pollution depends not only on the volume of emissions but also on meteorological conditions such as wind direction and speed, temperature inversions, solar radiation, and precipitation. These factors influence the dispersion, movement, and transformation of air pollutants, causing spatial and temporal fluctuations in the concentration of harmful substances. The terrain and urban planning also play a significant role. Even with identical emission levels, air pollution can vary severalfold depending on weather conditions. Therefore, effective efforts to combat air pollution require consideration of the region's climatic and geographical characteristics, as well as systematic monitoring and forecasting.

Keywords

Air Pollution Index (API), Nitrogen Dioxide (NO₂), Formaldehyde, Sulfur Dioxide (SO₂), Phenol, Air Monitoring, Environmental Situation, Maximum Permissible Concentrations (MPC), Seasonal Dynamics.

Objective

The aim of this study is to analyze the dynamics of atmospheric pollution in the city of Kyiv in 2023 under martial law conditions. Particular attention is given to assessing the levels of major and specific air pollutants, identifying seasonal variations in their concentrations, mapping the spatial distribution of environmental pressure, and detecting the most problematic areas of the capital. The study seeks to provide a well-founded overview of the city's atmospheric environmental state in order to support future risk forecasting for public health and to improve air protection measures.

Scientific Novelty

For the first time under the conditions of full-scale military aggression, a systematic analysis of the state of atmospheric air in the city of Kyiv was conducted, taking into account the limited access to official statistics. The study is based on large-scale monitoring data encompassing over 80,000 samples from 16 stationary observation posts, which enabled the identification of spatial and seasonal patterns in the distribution of major and specific pollutants.

The novelty lies in the detection of stable local zones with the highest pollution levels (such as Demiiivska Square and central transport hubs) and in the comparison of Air Pollution Index (API)

indicators over time with previous years. Special attention is paid to the impact of martial law on the city's environmental situation, particularly changes in the structure of pollution sources, seasonal fluctuations, and the behavior of photochemically active compounds.

The results of the study provide a detailed ecological profile of Kyiv for the year 2023 and serve as a basis for further modeling of health risks and the development of adaptive environmental protection measures under crisis conditions.

Essence of the Study

Against the backdrop of ongoing military aggression by the Russian Federation and the introduction of martial law in Ukraine, the publication of official statistics in many areas—including environmental monitoring—has been significantly restricted. Nevertheless, atmospheric air monitoring in the capital continued to be carried out by the Borys Sreznevskiy Central Geophysical Observatory. In 2023, air sampling was conducted at 16 stationary observation posts located across eight districts of the city, with over 81,000 samples analyzed in total.

The monitoring covered both primary and specific air pollutants, including suspended particles, sulfur dioxide, nitrogen monoxide and dioxide, formaldehyde, phenol, and heavy metals. Throughout the year, the maximum permissible concentrations (MPC) for many of these substances were consistently exceeded. On average, nitrogen dioxide exceeded its daily MPC by a factor of 2.3, formaldehyde by 1.4, sulfur dioxide by 1.5, and phenol by 1.2.

The most critical pollution levels were recorded in areas with high traffic density and developed infrastructure—such as Demiiivska Square, Dovzhenko Street, Sklyarenka Street, Kaunaska Street, as well as Bessarabska and Halytska Squares. These zones consistently showed the highest concentrations of harmful substances. In contrast, the lowest levels of pollution were recorded in a relatively favorable ecological area along Nauky Avenue.

Seasonal pollution dynamics clearly reflected the link between the heating season and elevated sulfur dioxide levels, as well as between the summer months and increased concentrations of formaldehyde and phenol—substances formed through photochemical reactions.

According to the Air Pollution Index (API), the level of air pollution in Kyiv in 2023 remained high, with peak values recorded in May–June (reaching up to 10.0 conventional units). Only during October to December was a slight decrease observed, lowering pollution levels into the “elevated” category.

Compared to 2022, the overall Air Pollution Index (API) remained virtually unchanged (7.7 versus 7.6 conventional units), although some changes in the structure of pollutants were observed: a slight decrease in nitrogen dioxide, nitrogen monoxide, and formaldehyde levels was recorded. At the same time, the concentration of sulfur dioxide increased significantly.

Thus, the year 2023 confirmed the persistence of high levels of atmospheric air pollution in the capital, particularly in areas with heavy traffic and dense urban development. Issues of systematic monitoring, adaptation of urban infrastructure, and strengthening of air quality protection measures remain pressing under the conditions of wartime.

Conclusions

In 2023, the level of atmospheric pollution in Kyiv remained consistently high, as confirmed by the Air Pollution Index (API), which fluctuated throughout the year between 7.0 and 10.0 conventional units, with peak values recorded in May–June. The primary air pollutants remained nitrogen dioxide, formaldehyde, sulfur dioxide, phenol, and nitrogen monoxide—classified as hazard classes II and III—which regularly exceeded maximum permissible concentrations (MPCs).

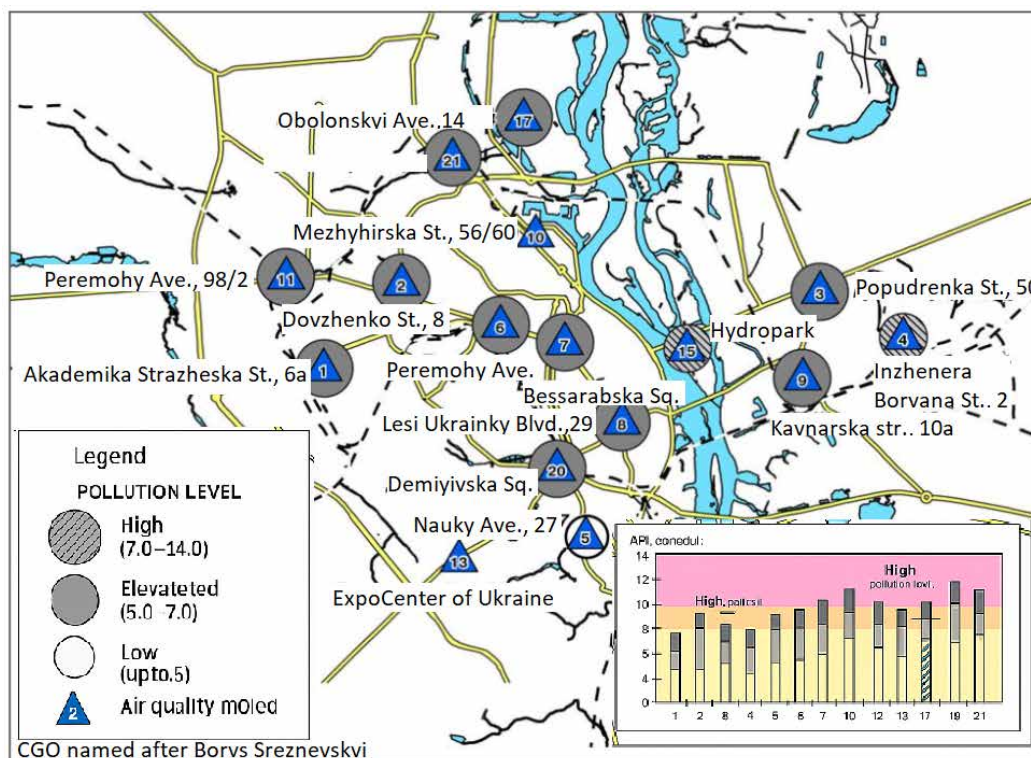


Fig.1. Map of the Monitoring Network Observation Stations of the Borys Sreznevskiy Observatory in Kyiv

The highest levels of pollution were recorded in areas with heavy traffic: Demiivska Square, Bessarabska and Halytska Squares, Beresteiskiy Avenue, and Splyarenka, Dovzhenka, and Kaunaska Streets. The lowest levels were observed in the green zone along Nauky Avenue.

Seasonal trends in pollutant concentrations indicate the influence of the heating season (with elevated SO₂ levels in winter) and photochemical processes (increased formaldehyde and phenol in summer). Compared to 2022, there was no significant improvement in the environmental situation. A slight decrease in the average annual concentrations of some substances (nitrogen dioxide, formaldehyde) was accompanied by a notable increase in sulfur dioxide levels. The concentrations of specific pollutants—ammonia, hydrogen sulfide, hydrogen fluoride and chloride, as well as heavy metals—did not exceed the permissible limits, but their presence in the air requires ongoing monitoring.

The results underscore the need to strengthen environmental monitoring measures, especially under martial law, and to implement adaptive air quality management policies in the urban environment.

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АНАЛІЗ ДИНАМІКИ АТМОСФЕРНОГО ЗАБРУДНЕННЯ У МІСТІ КИЄВІ В УМОВАХ ВОЄННОГО СТАНУ (2023 РІК)

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Анотація

Рівень забруднення атмосфери залежить не лише від обсягів викидів, а й від метеорологічних умов, таких як напрям і швидкість вітру, температурні інверсії, сонячна радіація та опади. Ці чинники впливають на розсіювання, переміщення й трансформацію домішок у повітрі, зумовлюючи просторово-часові коливання концентрацій шкідливих речовин. Важливу роль також відіграє рельєф місцевості та міське планування. Навіть за однакових викидів рівень забруднення повітря може відрізнятись в кілька разів залежно від погодних умов. Тому ефективна боротьба з атмосферним забрудненням потребує врахування кліматичних і географічних особливостей регіону, а також системного моніторингу та прогнозування.

Ключові слова: індекс забруднення атмосфери (ІЗА), діоксид азоту, формальдегід, діоксид сірки, фенол, моніторинг повітря, екологічна ситуація, гранично допустимі концентрації (ГДК), сезонна динаміка.