



UDK: 628.51:504

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CHEMICAL CHARACTERIZATION OF PARTICULATE MATTER (PM_{2.5}
AND PM₁₀) IN URBAN AIR

<https://doi.org/10.70728/a.series.v08.i02.007>

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Abstract. Urban air pollution is a critical environmental and public health issue, particularly due to fine particulate matter (PM). This study aimed to chemically characterize PM_{2.5} and PM₁₀ in an urban environment. Air samples were collected over a 30-day period from three urban locations using filter-based samplers. Gravimetric analysis was applied to determine mass concentration, while spectrophotometric and atomic absorption spectrometry techniques were used for chemical analysis. The average concentrations of PM_{2.5} and PM₁₀ were found to be $28.6 \pm 6.4 \mu\text{g}/\text{m}^3$ and $54.2 \pm 11.7 \mu\text{g}/\text{m}^3$, respectively. Sulfate and nitrate ions dominated the chemical composition, and trace metals such as Pb and Zn were detected at notable levels. The results indicate that urban particulate matter exceeds WHO guideline values and poses potential health risks.

Keywords: particulate matter, PM_{2.5}, PM₁₀, chemical composition, urban air pollution

Annotatsiya. Shahar havosining ifloslanishi, ayniqsa mayda dispers zarrachalar (PM) tufayli, atrof-muhit va jamoat salomatligi uchun dolzarb muammo hisoblanadi. Ushbu tadqiqotning maqsadi shahar muhitidagi PM_{2.5} va PM₁₀ zarrachalarining kimyoviy tarkibini aniqlashdan iborat bo‘ldi. Havo namunalari 30 kun davomida shaharning uchta hududidan filtrli namuna olgichlar yordamida yig‘ildi. Massa konsentratsiyasini aniqlash uchun gravimetrik tahlil, kimyoviy tarkibni aniqlash uchun esa spektrofotometrik va atom-absorbtsion spektrometriya usullari qo‘llanildi. PM_{2.5} va PM₁₀ ning o‘rtacha konsentratsiyalari mos ravishda $28,6 \pm 6,4 \text{ mkg}/\text{m}^3$ va $54,2 \pm 11,7 \text{ mkg}/\text{m}^3$ ni tashkil etdi. Kimyoviy tarkibda sulfat va nitrat ionlari ustunlik qildi, shuningdek Pb va Zn kabi iz

metallari sezilarli miqdorda aniqlandi. Natijalar shuni ko‘rsatdiki, shahar havosidagi zarrachalar miqdori JSST tavsiya etgan me‘yorlardan yuqori bo‘lib, sog‘liq uchun potentsial xavf tug‘diradi.

Kalit so‘zlar: mayda dispers zarrachalar, PM_{2.5}, PM₁₀, kimyoviy tarkib, shahar havosining ifloslanishi

Аннотация. Загрязнение городского воздуха является серьёзной экологической и медико-социальной проблемой, особенно из-за мелкодисперсных частиц (PM). Целью данного исследования было химическое определение состава частиц PM_{2.5} и PM₁₀ в условиях городской среды. Отбор проб воздуха проводился в течение 30 дней в трёх городских точках с использованием фильтровальных пробоотборников. Для определения массовой концентрации применялся гравиметрический метод, а для химического анализа — спектрофотометрия и атомно-абсорбционная спектрометрия. Средние концентрации PM_{2.5} и PM₁₀ составили соответственно $28,6 \pm 6,4$ мкг/м³ и $54,2 \pm 11,7$ мкг/м³. В химическом составе преобладали сульфат- и нитрат-ионы, также были обнаружены следовые металлы, такие как Pb и Zn, в значительных количествах. Полученные результаты показывают, что концентрации взвешенных частиц превышают рекомендованные нормы ВОЗ и представляют потенциальный риск для здоровья населения.

Ключевые слова: взвешенные частицы, PM_{2.5}, PM₁₀, химический состав, загрязнение городского воздуха

Introduction. Air pollution in urban environments has become a major environmental and public health concern as a result of rapid urbanization, industrial development, and increasing traffic density. These factors contribute to the deterioration of air quality and expose urban populations to complex mixtures of airborne pollutants.

Particulate matter (PM), particularly PM_{2.5} and PM₁₀, is considered one of the most harmful air pollutants because of its ability to penetrate the respiratory system. However, the adverse effects of particulate matter are influenced not only by its concentration but also by its chemical composition. Atmospheric particulate matter consists of a heterogeneous mixture of inorganic ions, trace metals, and carbonaceous components originating from various anthropogenic and atmospheric processes.

Chemical characterization of particulate matter provides essential information about pollution sources, atmospheric transformation mechanisms, and potential health risks. Identifying key chemical components such as sulfates, nitrates, ammonium, and metal species allows a more comprehensive assessment of urban air quality.

Therefore, the present study focuses on the chemical characterization of PM_{2.5} and PM₁₀ in urban air. By analyzing the major inorganic ions and trace metals associated with particulate matter, this research aims to enhance understanding of the chemical nature of

urban aerosols and contribute scientific evidence to support environmental monitoring and air pollution mitigation strategies. [1,7,10]

MATERIALS AND METHODS.

Sampling Sites and Period

Particulate matter samples were collected over a 30-day period conducted during January–February to represent typical winter atmospheric conditions in an urban setting. Three distinct sampling sites were selected to capture spatial variability: a roadside location influenced by heavy traffic emissions, a residential area with moderate anthropogenic activity, and a mixed-use zone affected by both traffic and domestic sources. At each site, sampling was performed every second day, resulting in 15 sampling events per location.

Sampling Procedure and Filter Types

Airborne particulate matter, including both PM_{2.5} and PM₁₀ fractions, was collected using standard low-volume samplers equipped with filter holders. Each sampling event had a duration of 24 hours, providing daily average PM concentrations. Teflon (polytetrafluoroethylene, PTFE) filters were chosen for mass concentration determination due to their stability and compatibility with gravimetric analysis, while quartz fiber filters were used for subsequent chemical analyses because of their inert properties and suitability for extracting water-soluble ions and trace elements. Prior to sampling, filters were conditioned for 24 hours in a temperature- and humidity-controlled chamber (20–23 °C, 40–50% relative humidity) to equilibrate and reduce background variability, following widely accepted protocols for particulate sampling studies to minimize contamination and sampling artifacts.

Particulate Matter Mass Determination

Gravimetric analysis was performed to obtain particulate mass concentrations. Filters were weighed before and after sampling using a high-precision analytical balance under controlled environmental conditions. The net mass gain on each filter was used to calculate the volume-normalized PM_{2.5} and PM₁₀ concentrations based on the total sampled air volume (expressed in µg/m³). This approach aligns with established reference methods for PM mass assessment.

Chemical Analysis

Water-soluble inorganic ions were extracted from the quartz filters using deionized water. The resulting extracts were analyzed using UV–Visible spectrophotometry, a widely employed technique for quantifying common ionic species such as sulfates, nitrates, and ammonium due to its sensitivity and specificity for selected ion detection. The method detection limits (LOD) for ionic species ranged from 0.05 to 0.1 µg/m³, depending on the ion and analytical wavelength.

Trace metal concentrations were determined using Atomic Absorption Spectroscopy (AAS) after acid digestion of filter samples. AAS is a well-established analytical method for quantifying metal elements in environmental samples and is frequently utilized in

particulate matter characterization studies to assess anthropogenic emissions of metals such as Pb, Zn, and Cu. The method detection limits (LOD) for metal analysis were approximately: Pb(0.005 µg/m³), Zn(0.01 µg/m³), Cu(0.008 µg/m³).

Quality assurance measures included the use of field blanks and laboratory procedural blanks to identify and correct for potential contamination during sampling and analysis. Calibration standards were prepared for ion and metal analyses to ensure analytical accuracy and precision. [4,9,12]

RESULTS.

Particulate Matter Mass Concentration

The average mass concentrations of PM_{2.5} and PM₁₀ across the three urban sampling sites are presented in Table 1. PM_{2.5} exhibited a mean concentration of 28.6 ± 6.4 µg/m³, while PM₁₀ averaged 54.2 ± 11.7 µg/m³. Both fractions exceed the World Health Organization (WHO) 24-hour guideline values of 15 µg/m³ for PM_{2.5} and 45 µg/m³ for PM₁₀, indicating elevated particulate pollution in the study area. Reporting the mean alongside the standard deviation provides a measure of variability across sampling locations and days, which provides an indication of spatial and temporal variability.

Table 1. Average PM concentrations and WHO guideline comparison

Parameter	Mean ± SD (µg/m ³)	WHO guideline (µg/m ³)
PM _{2.5}	28.6 ± 6.4	15
PM ₁₀	54.2 ± 11.7	45

Inorganic Ion Composition

The chemical analysis of PM_{2.5} samples revealed that water-soluble inorganic ions contributed substantially to the overall particulate mass. Sulfate (SO₄²⁻) accounted for 31% of the total measured ions, followed by nitrate (NO₃⁻, 25%) and ammonium (NH₄⁺, 18%). Other ions collectively represented 26% of the measured composition. These results indicate that secondary aerosols, formed via atmospheric chemical reactions, are a major component of urban particulate matter. The ion concentrations are summarized in Table 2.

Table 2. Concentrations and relative contributions of major inorganic ions in PM_{2.5}

Component	Concentration (µg/m ³)	Percentage (%)
SO ₄ ²⁻	6.8	31
NO ₃ ⁻	5.4	25
NH ₄ ⁺	3.9	18
Others	5.7	26

Trace Metals in PM_{2.5}

Trace metal analysis showed that the PM_{2.5} fraction contained measurable levels of lead (Pb: 72 ng/m³), zinc (Zn: 146 ng/m³), copper (Cu: 38 ng/m³), and iron (Fe: 410 ng/m³). The presence of these metals suggests contributions from anthropogenic sources such as

vehicle emissions, industrial activities, and urban dust resuspension. Table 3 summarizes the measured metal concentrations.

Table 3. Mean concentrations of selected trace metals in PM_{2.5}

Metal	Mean (ng/m ³)
Pb	72
Zn	146
Cu	38
Fe	410

Summary of Results

The results demonstrate that urban air in the studied area contains high levels of fine and coarse particulate matter, with chemical composition indicating both primary sources (metals from traffic and industry) and secondary formation processes (sulfate, nitrate, ammonium ions). These findings highlight potential health risks and the necessity for regular air quality monitoring and pollution control measures. [2,3,5,6]

DISCUSSION. The measured PM_{2.5} concentrations indicate a strong anthropogenic influence, with traffic emissions and fuel combustion are suggested as major contributors. The high proportions of sulfate and nitrate ions point to active secondary aerosol formation in the urban atmosphere, which is commonly associated with atmospheric chemical reactions. The presence of trace metals such as Pb, Zn, and Cu further supports the impact of vehicular and industrial activities. Overall, the chemical composition of particulate matter observed in this study aligns with patterns reported in recent studies on urban air pollution in comparable metropolitan environments. These results emphasize the importance of targeted pollution control measures to mitigate health risks and improve air quality. [7,8]

CONCLUSION. This study confirms that urban particulate matter exhibits a complex chemical composition and exceeds recommended air quality standards. The predominance of sulfate, nitrate, ammonium ions, and trace metals highlights both secondary aerosol formation and anthropogenic contributions from traffic-related and industrial sources. These findings underscore the need for continuous air quality monitoring and the implementation of effective pollution control strategies to reduce potential health risks associated with particulate matter exposure. [11]

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