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INDOOR AIR QUALITY AND PARTICLE LEVELS IN EDUCATIONAL SETTINGS

Background/Objective
People generally spend more time indoors than outdoors, yet there is still a lack of regulations addressing particulate matter concentrations in indoor environments. Indoor air quality plays a crucial role in human health, especially in enclosed spaces where individuals, particularly children, are exposed to airborne pollutants for extended periods and are especially vulnerable to air pollution due to their developing respiratory systems and higher exposure levels in these environments. Particulate matter (PM), which includes both fine and coarse particles, has been linked to a range of cardiorespiratory issues, including asthma, bronchitis, and cardiovascular diseases. While significant attention has been given to outdoor air pollution, there is limited information available on indoor air quality, particularly in public indoor spaces such as schools and educational facilities.

This study aims to assess the concentration of various types of particulate matter such as total suspended particles (TSP), PM10, PM2.5 and PM1 across different educational environments. This research seeks to contribute to the growing body of knowledge on indoor air quality in schools, providing valuable insights for policymakers, educators, and facility managers to improve the overall health and well-being of students and staff. Understanding the factors that influence particulate pollution in educational settings can lead to better air quality management strategies, fostering healthier learning environments.

Methods
From March to September 2021, a total of 19 sampling locations were chosen in educational settings across Valencia, Spain. These comprised 8 primary school sites, 6 secondary school sites, and 5 university locations. The air quality measurements were carried out on weekdays using the Fidas® Frog optical aerosol spectrometer, which simultaneously measures TSP, PM10, PM2.5, and PM1. A descriptive statistical analysis was conducted, and the ANOVA test was employed to examine potential differences in particulate levels across the different types of educational facilities.

Results
The mean concentration of TSP in indoor educational spaces was 65.0 (±73.6, standard deviation) μg·m−3 in primary schools, 33.0 (±39.9) μg·m−3 in secondary schools, and 23.7 (±20.0) μg·m−3 in universities. For primary schools, the concentrations of PM10, PM2.5, and PM1 were 39.3 (±37.0), 16.6 (±8.9), and 11.4 (±6.1) μg·m−3, respectively; in secondary schools, they were 20.2 (±19.6), 8.0 (±9.1), and 4.2 (±5.0) μg·m−3; and in universities, 12.6 (±15.4), 7.2 (±4.0), and 4.7 (±3.2) μg·m−3, respectively.

Significant differences in particle levels (TSP, PM10, PM2.5, and PM1) were observed across the different types of educational institutions (primary schools, secondary schools, and universities), with the highest concentrations recorded in primary schools ($p<0.05$).

In 46% of the sampled days, exposure levels found in educational institutions exceeded the World Health Organization ‘s 2021 guideline for PM2.5 short-term exposures (daily mean), and 14% of the sampled days exceeded the short-term exposures guideline for PM10 (WHO, 2021).

Conclusions
This study highlights the urgent need to address indoor air quality in educational settings, particularly in primary schools, where the highest concentrations of particulate matter were observed. The findings show that a significant portion of exposure levels, especially for PM2.5, exceed the World Health Organization’s recommended guidelines for short-term exposure. This poses potential health risks for students, teachers, and staff. The significant differences in particle concentrations across various types of educational institutions emphasize the importance of developing targeted strategies to improve air quality in schools. Implementing

measures such as better ventilation, high-efficiency air filters, and stricter air quality regulations can help create healthier learning environments and protect the well-being of those, particularly children, who spend long hours indoors and are especially vulnerable to air pollution.

Key words
Particles, indoor environments, educational settings

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