Air quality monitoring during urban regeneration activities: the case of MUSA Open-air laboratory at University of Milano-Bicocca

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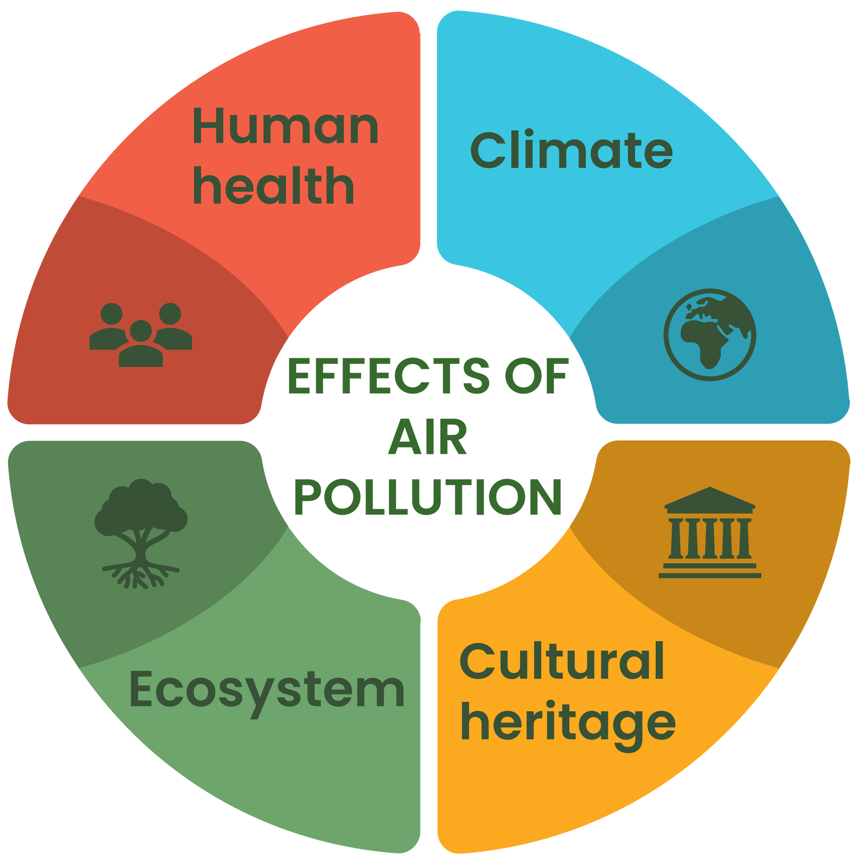
Introduction

Air pollution represents one of the major risk factors for human health, estimated to cause millions of premature deaths worldwide every year, has profound effects on the entire ecosystem, from the climate-altering effect to direct consequences on soil and vegetation, and affects anthropogenic materials (such as cultural heritage and IT infrastructure).

Regulations on air pollutants set limit values not to be exceeded to ensure public health. However, these limits only apply to outdoor environments, leaving indoor environments, where people spend most of their time, yet unregulated.

As indoor and outdoor environments are strongly interconnected, both must be considered when assessing air quality.



MUSA – Multilayered Urban Sustainability Action

- Spoke 1 (Urban) of the MUSA ecosystem focuses on innovation of processes and products and the development of strategies for urban regeneration, making cities more sustainable and responsive to the needs of today's citizens. In this perspective, the redevelopment of *Piazza della Scienza* aims to renew the urban and architectural context, offering better living spaces and green coverage.
- The square is one of MUSA's living laboratories, where more than 50 sensors will be installed to monitor numerous parameters, such as square temperature, *air quality*, noise impact of human activities and biomonitoring.

- The aim of this work is the close monitoring of air quality during redevelopment works of *Piazza della Scienza*, assessing the impact of the construction site to ensure the livability of planned spaces and protect the health of citizens.

Methodology

Particulate matter (PM) and nanoparticles (NPs) concentrations were monitored during both the pre-work (May – June 2023) and the construction phase (July 2023 – now) by establishing 11 sampling spots on the university campus, divided between indoor and outdoor environments (figure 1).

Sampling was carried out by coupling research-grade instrumentation with low-cost and portable sensors (figure 2):

- OPC-N3 (Alphasense)
- Portable Aerosol Spectrometer Model 1.107 (GRIMM)
- Aerosol Dosimeter Partector 2 (NANEOS)
- NanoScan SMPS Nanoparticle Sizer 3910 (TSI)

This setup ensures an accurate assessment of air quality of the selected environments, while allowing performance evaluation and data calibration of the low-cost devices.

These sensors will be an integral part of the open-air lab in Piazza della Scienza, providing continuous monitoring of pollutants and making the data collected easily accessible by the public.

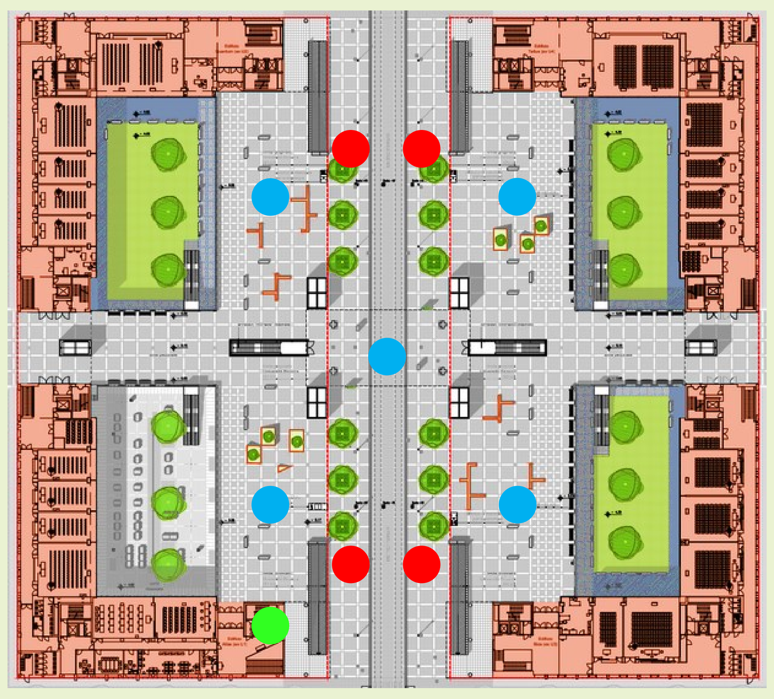


Figure 1. Map of the Bicocca campus in Piazza della Scienza and related sampling points. Outdoor environments in red, indoor environments in blue, in green the atmospheric chemistry laboratory, reference point (start and end) for each measurement.

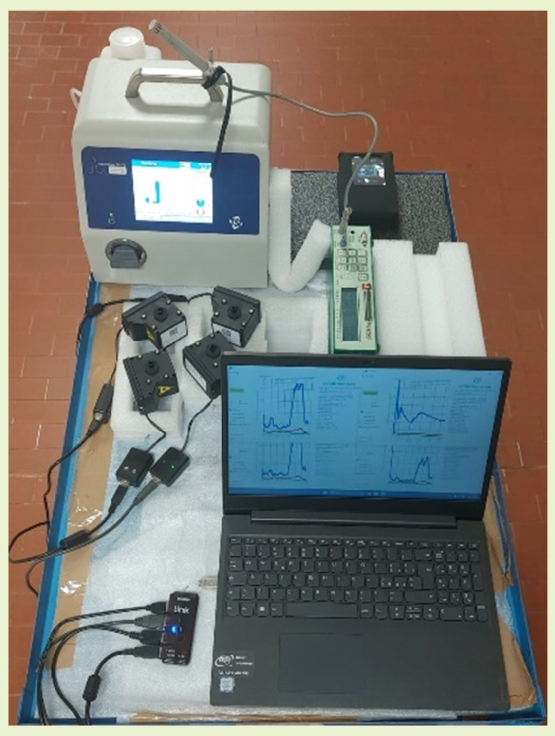
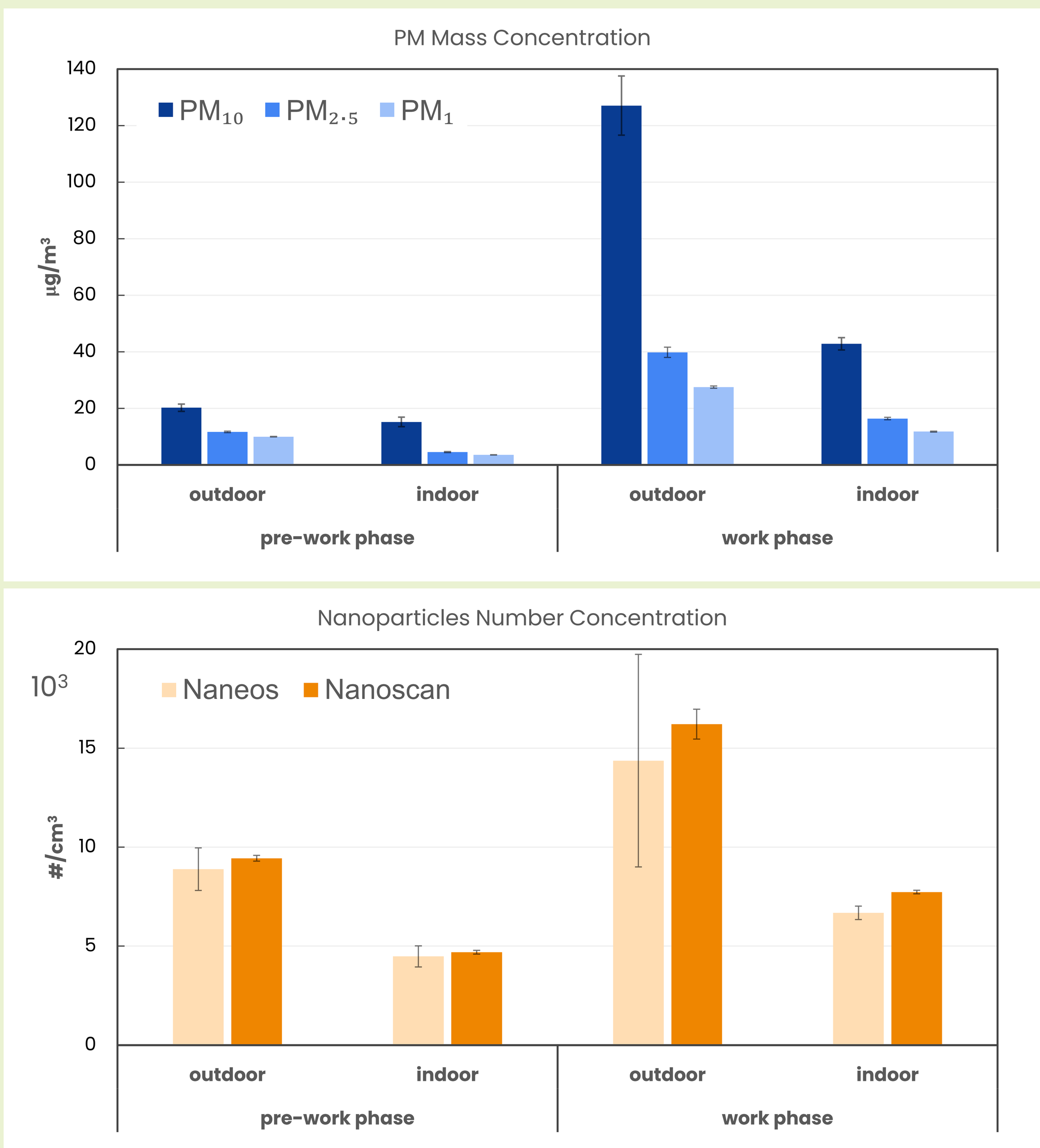


Figure 2. Instrument setup for air quality monitoring on the campus. Instruments were mounted on a cart for easier movement between the sampling locations.

Results

An increase in PM and NPs concentrations can be observed during the construction phase, in both indoor and outdoor environments.

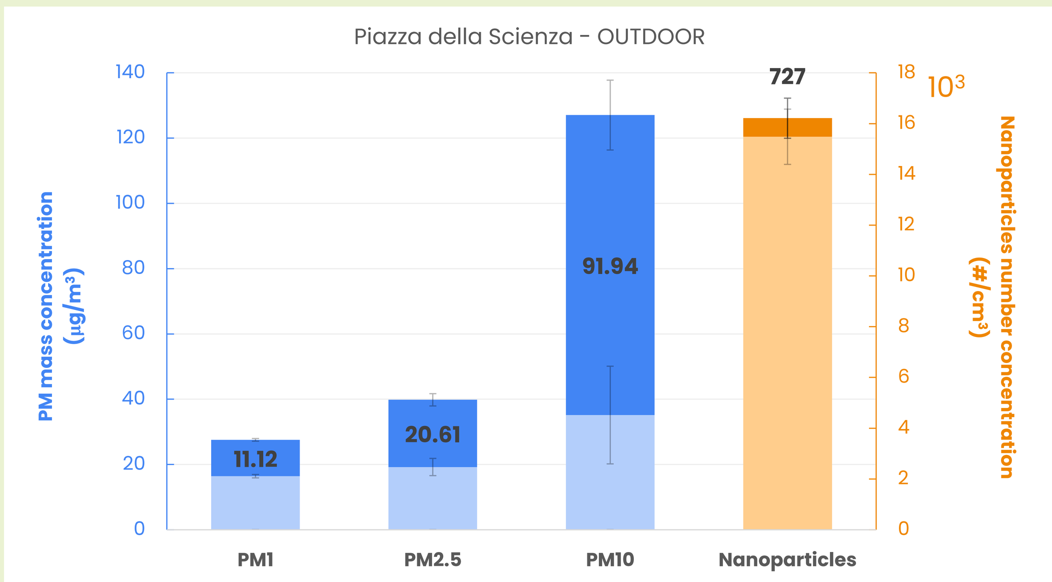
Average concentrations for all measurements of each phase is showed in the graphs below:



Graph 1. Average concentration and 95% confidence interval of PM (above, OPC Grimm data) and nanoparticles (below) for outdoor and indoor sampling spots for both the pre-work and the construction phase.

To account for seasonal variability, data obtained were normalized on data from the ARPA reference station of Milano Pascal.

This allowed us to highlight the impact of construction site in Piazza della Scienza in terms of PM and nanoparticle concentrations.



Graph 2. Average outdoor concentration and 95% confidence interval for the construction phase. The darker portion of the bars show the calculated impact (in µg/m³ for PM and #/cm³ for NPs) of the construction site on the measured concentrations.

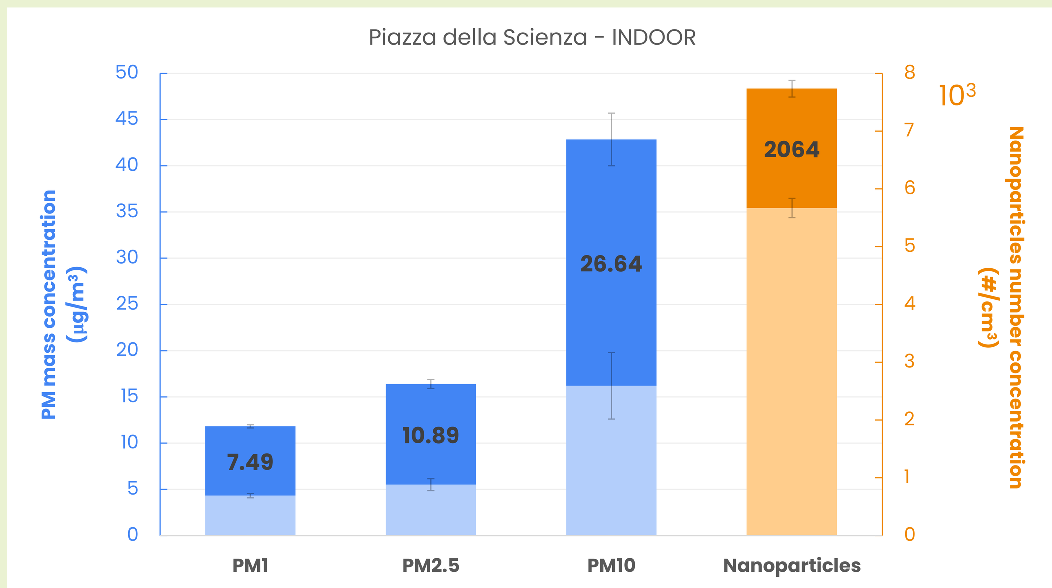
The construction site impact on air quality, for the outdoor environments studied, can be observed mainly in the coarse phase, with a contribute of over 90 µg/m³ on the total PM_{10} concentration. The impact is lower when considering the $PM_{2.5}$ fraction (>20 µg/m³) and the PM_1 fraction (>11 µg/m³), while for the total number of nanoparticles the increase in concentration attributable to the construction site is negligible compared to the total measured value.

This highlights how redevelopment works on the square mainly concern the release of coarse particles into the atmosphere.

The impact of the construction site on indoor environments was derived by calculating an infiltration factor from the measured concentrations and applying it to ARPA reference data in the formula proposed by Sangiorgi et al. (2012):

$$C_{in} = F_{inf} * C_{out} + C_{ig}$$

where C_{in} and C_{out} are the measured indoor and outdoor concentrations respectively, F_{inf} is the fraction of PM infiltrating from outside and C_{ig} is the indoor generation contribution.



Graph 3. Average indoor concentration and 95% confidence interval for the construction phase. The darker portion of the bars show the calculated impact (in µg/m³ for PM and #/cm³ for NPs) of the construction site on the measured concentrations.

The opposite trend is observed indoors, with the impact of the construction site being proportionately less significant for the coarse phase; while finer particles, with higher infiltration rate, show a greater impact on total concentrations due to the construction site. As expected, indoor concentrations are lower in absolute value, but strongly influenced by the infiltration of outdoor air, which favours the introduction of finer particles.

Future steps

- Air quality monitoring in Piazza della Scienza will continue through the post-construction phase, assessing the impact of the redesigned environments and the planting of new green areas.
- Low-cost sensors for continuous monitoring of pollutants will be installed in fixed positions throughout the university's indoor and outdoor environments, ensuring greater spatial and temporal coverage of air quality data. Real time Black Carbon (BC) measurements will also be set up on the university campus, deploying both low-cost and reference aethalometers.
- In the future, different interdisciplinary activities will be performed, such as the quantification of emission through field monitoring and sampling campaigns during and after the plaza regeneration, by using the ELPI+ instrument size spectrometer (figure 4) for real-time particle measurements, and the toxicological assessment through laboratory experiments with advance in vitro models at real exposure scenarios and doses.

Figure 4. Dekati ELPI+ (Electrical Low-Pressure Impactor) particle size spectrometer.

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