

RESULTS OF THE AEROSOLFD PROJECT ON HOW AIR PURIFIERS CAN IMPROVE AIR QUALITY AT METRO STATIONS

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ABSTRACT

Air quality at metro platforms is influenced by train-induced particle resuspension, abrasion processes, and complex airflow patterns. Within the Horizon Europe project AeroSolfd, we assessed how filtration solutions and optimized purifier placement can reduce PM exposure in (semi-)closed underground stations. CFD simulations were applied to identify zones of high particle concentration and guide the placement of air purifiers, followed by a month-long demonstration at a Lisbon metro station using both scientific-grade instruments and distributed low-cost sensors.

The AeroSolfd measurements confirmed two characteristic PM zones predicted by CFD: an HVAC-supported cleaner zone and a high-exposure zone where the ventilation system has limited effect. Scientific grade instruments were placed in one location, while low-cost sensors enabled detailed spatial mapping. To compare similar use cases with and without air filtration, a detailed test plan was developed and optimized during the campaign. Duration of one operation mode could be one full day, half a day or two hours thereby also accounting for weekdays and weekends or holidays.

In this conference paper, results of the data analysis are presented and challenges to obtain solid values for evaluating filtration efficiency based on measuring particle concentrations at metro stations are discussed. The results demonstrate the potential of well-placed air purifiers and hybrid operation with a stationary HVAC system to improve air quality at the platform.

KEYWORDS:

Air Filtration, Cleaner Urban Air, PM2.5, low-cost sensors, CFD

INTRODUCTION

Good air makes a great journey. Experiencing good indoor air quality at the platform of a metro station would be appreciated by commuters waiting for the train. Currently there is no regulation for air quality underground at metro stations. Nevertheless, good indoor air quality levels would be preferred. HVAC systems provide fresh air for the stations but can be limited in capacity or only cover parts of the platform. Trains coming and departing intrude particles and mix up the air. The rush hours and schedule of trains add a time effect over the day. The architecture and installations at the platform affect the local air quality distribution and can limit the options for installing additional air purifiers. In the Horizon Europe Innovation Action AeroSolfd, such air purifiers have been developed as retrofit filtration solutions for metro stations and evaluated at metro stations in Lisbon.

AeroSolfd is a Horizon Europe Innovation Action supported by the European Commission under grant agreement No 101056661. The consortium (*Figure 1*) from nine European countries collaboratively developed market-ready retrofit solutions to immediately improve air quality in urban areas by effective filtration to reduce transport-related emissions such as (1) tailpipe particle emissions of Euro 6c and earlier petrol vehicles and (2) brake emissions of busses and (3) pollution in (semi-)closed environments like at metro stations.

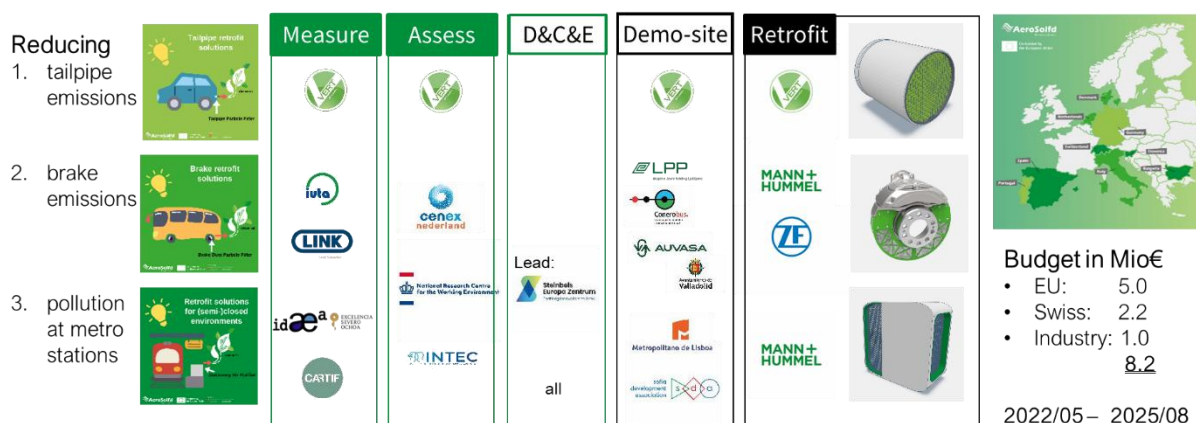


Figure 1 - Overview AeroSolfd consortium: partners, major tasks, budget and duration.

Figure 1 shows the setup of the AeroSofld project. The project started in May 2022 and finished August 2025. The demo-sites play a key role. This enabled the project partners to measure real emissions or derive a meaningful measurement cycle for a test rig, like brake emissions of buses in urban transport. Including citizen science and setting up a framework for social and environmental LCA provided the base for an overall risk assessment of the solutions. This in combination with disseminations and publication is essential for preparing a market uptake. The major results of the project are – besides ongoing scientific publications – available as public deliverables: <https://doi.org/10.3030/101056661>.

This FILTECH conference paper focuses on how air purifiers can improve air quality at metro stations. It is limited to the technical content related to filtration and in particular measuring exposure and filtration efficiency.

SETUP AND METHODOLOGY

During the AeroSolfd project measurements at two metro stations in Lisbon have been carried out. The first measurement campaign at Alto dos Moinhos station provided a good base and learnings for setting up the final measurement campaign at Quinta das Conchas station. Due to the train activities, supply with outdoor air and the architecture of the station itself, the situation is complex. Hence, it is important to measure spatial and temporal distribution of particle concentration while monitoring outdoor particle concentration levels. Scientific grade instruments are preferred, but expensive and cannot be placed everywhere in the station. The best position was behind a fence in a corner at the end of the platform (Figure 2). Low-cost sensors are easier to be placed in the station and can complement the scientific grade instruments.



Figure 2 – Placement of scientific grade instruments at the end of the platform.

For PM mass measurements, a sequential high-volume sampler (HVS, Model CAV-A/MSb, MCV) with a PM_{2.5} inlet (PM1025/UNE model, built to European Norm EN 14,907) was used, along with a real-time light-scattering laser photometer (DustTrak DRX, Model 8533, TSI). In addition, up to 24 PM-sensors (SEN54, Sensirion) were distributed across the station to assess PM spatial distribution.

Before placing the sensors and the air purifiers, a CFD simulation was setup and run to assess the particle concentration levels along the station. Results are provided in Figure 3. The picture on the left side shows that the station has two zones of different level of particle concentration. This matches well with the installation of the HVAC system at this station in the blue zone, lowering exposure level there. In the right picture a reduction of the exposure level is noticeable across the station but dominant in the previous red zone. Besides, the simulation indicated that an effect of the air purifiers should be possible to detect, as in a stationary simulation without trains running a decay of the concentration is observed within few minutes of simulation time.

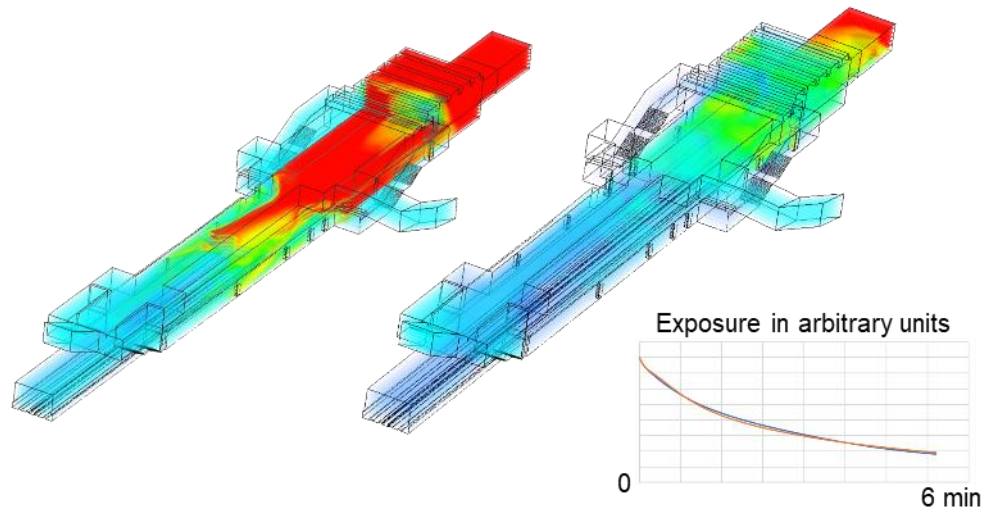


Figure 3 – Results of CFD simulation (left) without and (right) with air purifiers in operation. Particle concentrations are in arbitrary units and range from higher (red) over yellow and green to lower (blue). The curve shows that a decay should be noticeable within a few minutes.

The final placement of the low-cost sensors and the eight air purifiers is illustrated in Figure 4. The air purifiers are distributed across both platforms, whereas more units are in the red zone. In addition to sensors along the platform, one sensor has been placed in the atrium and one the ducting of the HVAC system to assess effects of changes in the outdoor particle concentration.

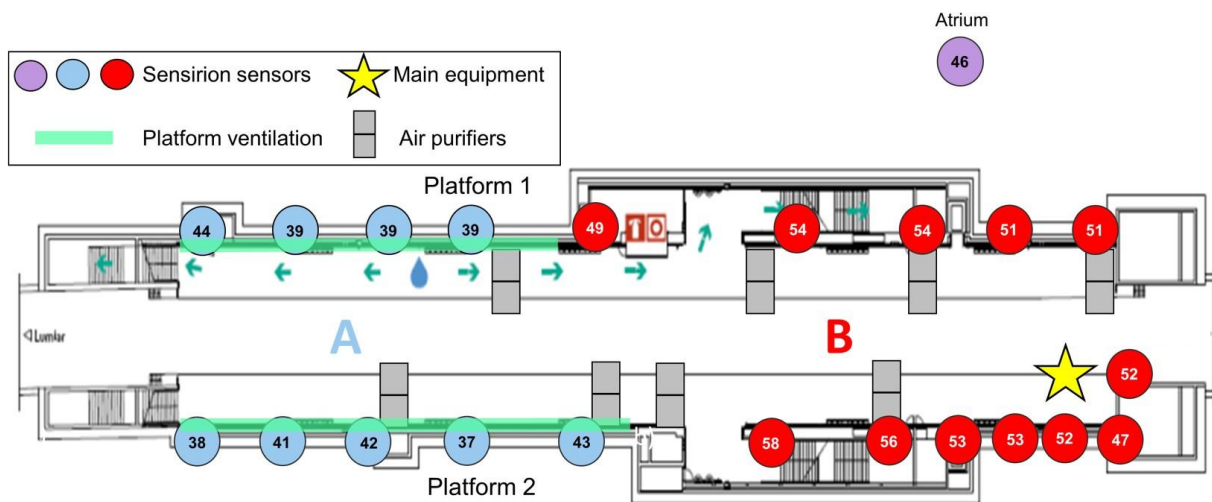


Figure 4 – Placement of sensors and air purifiers at the station.

The objective of the onsite demonstration was to assess how air purifiers can reduce the exposure level to airborne particles at a metro station. Consequently, a test plan was defined to compare measurements with and without air purifiers running. A variety of setups (full day on/off, half day on/off and even two hours on/off) were defined; some with the station HVAC system running, some without. The focus was less on the absolute concentration level than on how the air purifier operation mode affected the local exposure level as measured by the low-cost sensors.

RESULTS

First results and a more detailed description of the setup and methodology are published by Agathokleous et al. (2026). In this conference paper we summarize and discuss these results from a filtration perspective.

The particle concentration changes over time and is highly affected by the workday or weekend schedule of the trains. There is a rush hour in the morning. The HVAC ventilation at the station is running only from 7:00 to 20:00 and turned off overnight.

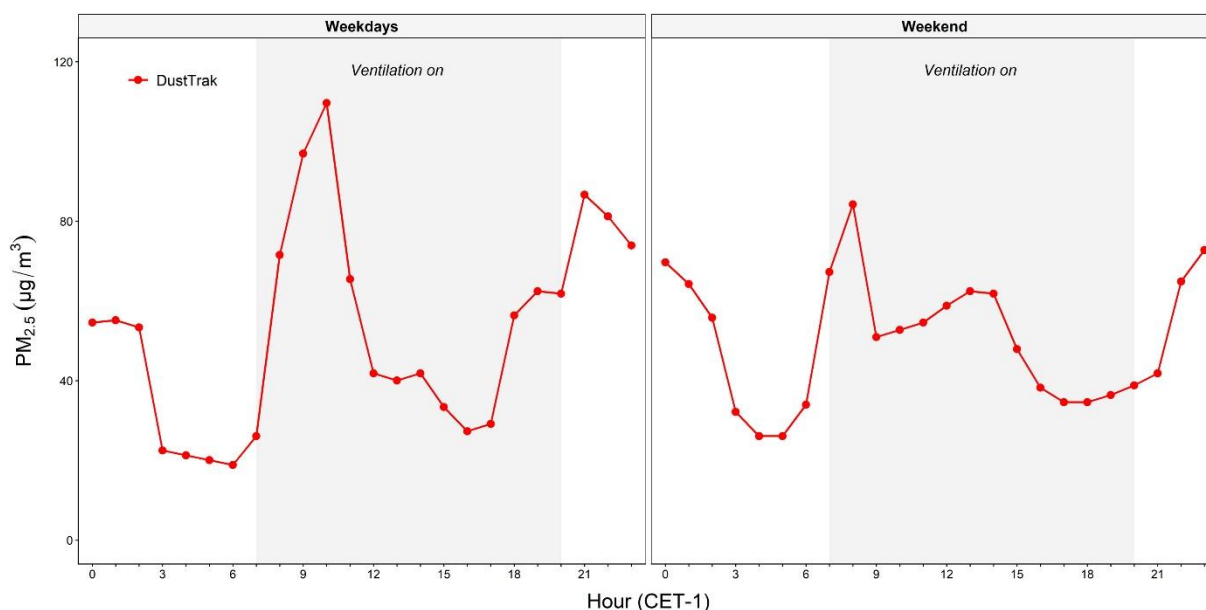


Figure 5 – “Median hourly PM_{2.5} concentrations for several 24-hour baseline (BL) days at Quinta das Conchas metro station, clustered in weekdays (Monday to Friday) and weekend (Saturday and Sunday). Corrected data from DustTrak, located on the edge of sector’s “B” platform, inside the protective cage.” (Agathokleous et al., 2026)

Calculating a filtration efficiency or reduction potential of the air purifiers requires comparing measurement with and without air purifiers in operation. The temporal change of the particle concentration and a difference between weekdays and weekend add constraints. Running one weeklong measurement without air purifiers and the next week with air purifiers in operation would create a reasonable large number of data but at the end compare apples with oranges as outdoor conditions can change. Instead, we selected a shorter time frequency of at the beginning a day and later two hours without and with air purifiers running and alternated the slots every day. This provided enough data for a solid comparison while keeping the other parameters in a narrower range of changes.

Filtration efficiency or reduction potential is a relative value for a given setup as dividing the particle concentration measured with air purifier running by the particle concentration measured without air purifiers running. The question is what values to use. Low-cost sensor values typically require a correction to match the values measured with scientific grade instruments. However, if this correction is not just a factor but has an offset, then this offset will affect filtration efficiency. If the correction is just a factor, then the division of the two values will eliminate the correction factor. Consequently, for calculating filtration efficiency, we used the raw data of the low-cost sensors.

The filtration efficiency has been calculated for two exemplary cases: a station with an HVAC system and a station without an HVAC system installed. For the first case we compared the measurements from 8:00 to 10:00 (Figure 6) and for the second case we compared data from 20:00 to 22:00 (Figure 7). As expected, running an air purifier reduces the local particle concentration. In the hybrid operation with the HVAC system, the reduction effect is nominal up to 30 % in the blue zone, but PM_{2.5} levels do not change much as already reduced by the ventilation system. However, in the red zone a reduction of 40 % and significant change of PM_{2.5} level is observed. In the case without HVAC system running, the reduction in the blue zone is up to 78 % and in the red zone up to 48 % and in the same range as in the other case. However, the values in the blue zone clearly show how air purifiers can improve air quality in the absence of an HVAC system.

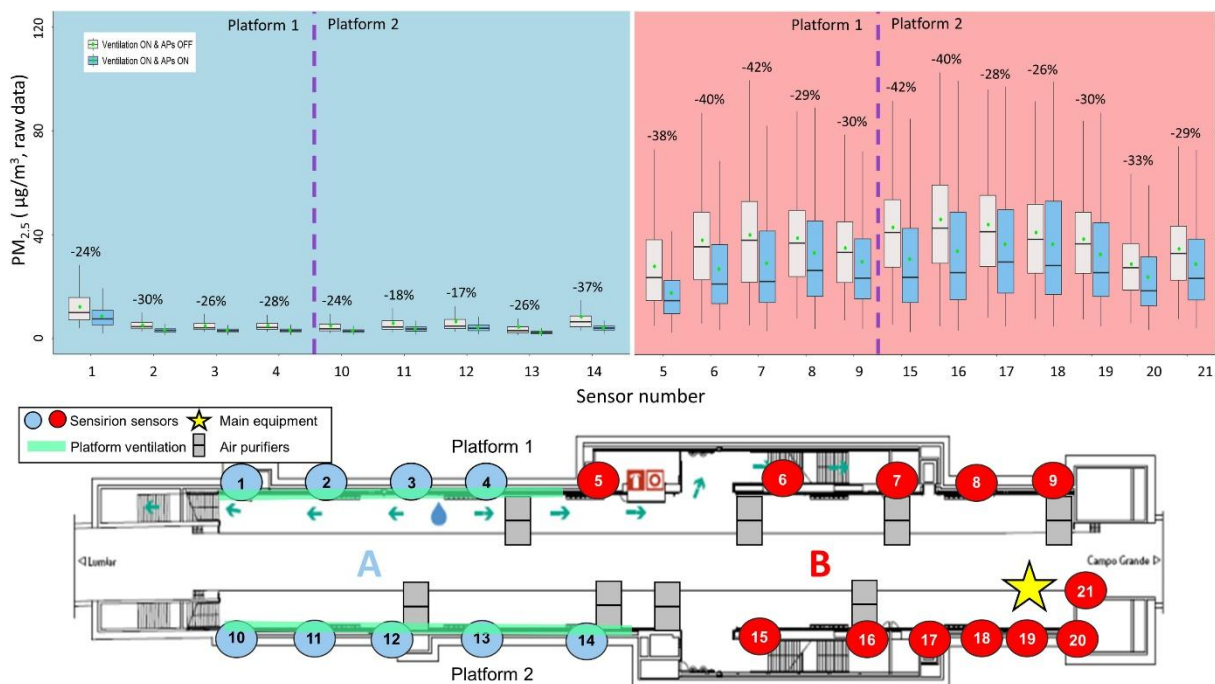


Figure 6 – “Spatial effect of eight air purifiers (APs) operating at maximum air volume flow (AVF) on air pollutant concentrations. The ventilation system was off in both control (also considered as baseline here, BL) and experimental (setup) conditions. Each box represents the interquartile range (25th–75th percentiles), the horizontal black line and green dots inside the boxes indicate the median and mean values, respectively. The whiskers (black vertical lines) extend to 1.5 times the interquartile range below the first quartile (25th percentile) and above the third quartile (75th percentile). Percentages above the boxplots show median concentration differences. The purple dashed line separates platform 1 and 2 sensors. The schematic shows the location of each sensor, per platform, represented by number.” (Agathokleous et al., 2026)

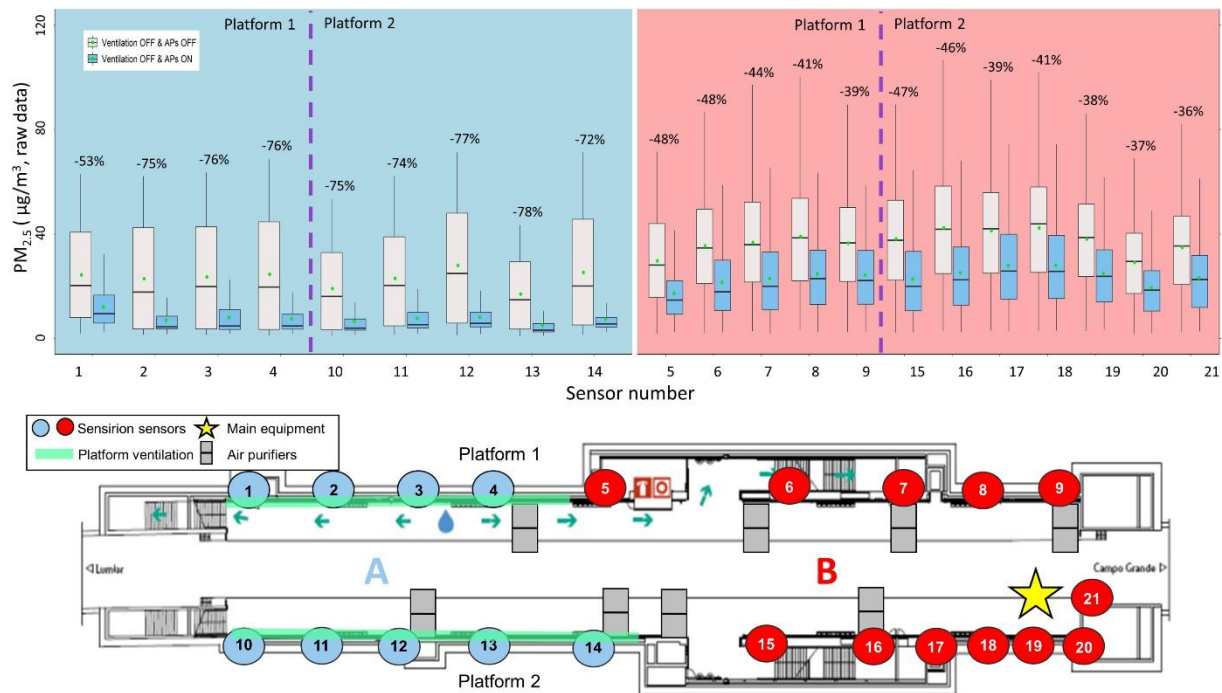


Figure 7 – “Spatial effect of eight air purifiers (APs) operating at maximum air volume flow (AVF) on pollutant concentrations. The ventilation system was on in both control (also considered as baseline here, BL) and experimental (setup) conditions. Each box represents the interquartile range (25th–75th percentiles), the horizontal black line and green dots inside the boxes indicate the median and mean values, respectively. The whiskers (black vertical lines) extend to 1.5 times the interquartile range below the first quartile (25th percentile) and above the third quartile (75th percentile). Percentages above the boxplots show median concentration differences, while asterisks indicate statistical significance ($p = 0.05$). The schematic shows the location of each sensor, represented by number. The purple dashed line separates platform 1 and 2 sensors. The schematic shows the location of each sensor, per platform, represented by number”. (Agathokleous et al., 2026).

CONCLUSION

As part of the AeroSolfd project eight air purifiers and 24 low-cost sensors have been installed at the Quinta das Conchas metro station of Metro Lisboa. An extensive measurement campaign - lasting over one month - was carried out. The AeroSolfd demonstration confirms that targeted deployment of air purifiers, supported by CFD-guided placement, can significantly reduce particulate exposure in complex metro station environments. The results highlight the strong spatial variability of PM concentrations and the importance of distinguishing between HVAC-influenced and high-exposure zones. While existing ventilation systems already lower background levels, the addition of air purifiers provides substantial further reductions – particularly in poorly ventilated areas – reaching up to ~40–50% under hybrid operation and even higher (up to 78 %) in the absence of HVAC.

Overall, retrofit filtration units represent a technically viable option to complement existing ventilation systems and reduce commuter exposure. At the same time, for practical implementation, several aspects require further consideration and additional research, including energy consumption, maintenance, environmental-social LCA considering local energy mix, and viable business models. Successful deployment therefore depends on site-specific assessment, optimized placement, and careful evaluation of operational and economic conditions. Practical recommendations for implementation, operation, and evaluation are summarized in the AeroSolfd best-practice guidelines and associated public deliverables of the project (<https://doi.org/10.3030/101056661>).

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