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ENVIRONMENTAL ASSESSMENT IN A DEMOLITION AREA: AIR QUALITY MONITORING NETWORK DESIGN AND OPERATIONAL MONITORING

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Abstract: An integrated assessment of air quality in industrial areas requires the combination of emissions inventory, mathematical modeling, and environmental monitoring. In this study, emission sources associated with material handling, exposed areas, vehicular traffic, heavy equipment, crushing, and stationary combustion during demolition activities were evaluated. The results indicated a predominance of fugitive sources for particulate matter and a low relative contribution of the assessed activities to the consolidated ambient concentrations observed.
Keywords: air quality, AERMOD, monitoring network, demolition, particulate matter.

INTRODUCTION

Air quality assessment in industrial areas can be performed by integrating the characterization of emission sources, emission quantification, atmospheric dispersion modeling, and monitoring of ambient concentrations. Emission inventories constitute a fundamental step in this process, as they organize emissions by source, location, and reference period and provide input information for atmospheric dispersion models. (European Environment Agency, 2019; Kuenen et al., 2022).

Emission estimates can be obtained from emission factors associated with source activity, operational information, and process characteristics. Established references, such as the EMEP/EEA Air Pollutant Emission Inventory Guidebook and AP-42 – Compilation of Air Pollutant Emission Factors, provide methodologies and factors applicable to different source categories, including industrial processes, combustion, vehicles, and particulate matter sources (European Environment Agency, 2019; U.S. EPA, 2026).

Air Emission Inventories have been presented with higher spatial and temporal resolution, combined with atmospheric models capable of representing in greater detail the relationship between emissions, meteorology, and ambient concentrations. (Zhou et al., 2017; Kuenen et al., 2022). In addition, contemporary approaches have integrated inventories, numerical models, and surface observations, expanding the capacity for air quality assessment and forecasting (Baklanov and Zhang, 2020).

Atmospheric modeling, however, should not be considered in isolation. Comparing simulated concentrations with monitoring observations makes it possible to assess the consistency of the results and understand the relative contribution of sources. Atmospheric dispersion models complement monitoring networks by providing additional spatial coverage and enabling the assessment of different emission scenarios, while observational data provide the necessary reference for evaluating simulations (Baklanov and Zhang, 2020; European Environment Agency, 2019).

In this context, the present study presents an integrated assessment of atmospheric emissions, pollutant dispersion, and air quality in an industrial area undergoing demolition activities. The study includes the development of an inventory of the main emission sources, the application of mathematical modeling to estimate their contribution to atmospheric concentrations, the design of the monitoring network based on the Figures of Merit and Spheres of Influence methodologies, allowing the identification of priority locations for the installation of monitoring points, and the analysis of air quality monitoring results by comparing observed concentrations with those estimated by the model and with national standards.

The objective is to characterize the main emission sources, quantify their contribution, assess the spatial distribution of modeled concentrations, and compare these results with observed concentrations and national air quality standards, providing an integrated interpretation of the atmospheric conditions in the assessed area.

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METHODS

2.1 Source characterization and development of the emissions inventory

Initially, potentially emitting sources associated with the assessed activities were identified, classified, and spatially mapped, following the principles of the EMEP/EEA Air Pollutant Emission Inventory Guidebook (European Environment Agency, 2019). The sources were classified as exposed areas, crushing, stationary combustion, equipment operation, material transfer and handling, and traffic routes.

2.2 Estimation of emission rates

Emission rates were calculated based on the activity level and the emission factors applicable to each source, incorporating, where relevant, operational parameters and the efficiency of control measures:

$$E = A \times FE \times (1 - \eta)$$

where E represents the emission rate or load, A corresponds to the activity level, FE is the emission factor applicable to the source, and η represents the efficiency of the control measure (European Environment Agency, 2019; U.S. EPA, 2026). The results obtained in the source inventory are presented in Figure 1.

Emissions were spatially distributed according to the location of the sources, especially in the case of diffuse and linear sources, whose spatial distribution influences the modeling results.

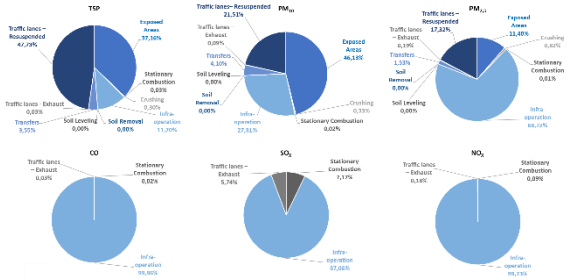


Figure 1. Source inventory results

2.3 Atmospheric dispersion modeling setup

The inventoried sources, their physical characteristics, and respective emission rates were entered into the atmospheric dispersion model to estimate their contribution to pollutant concentrations in the surroundings of the assessed area. A regular receptor grid with 500 m spacing was used, totaling 961 receptors, complemented by discrete receptors at points of environmental interest.

The results were evaluated based on the maximum concentrations corresponding to the applicable reference periods for each pollutant. For NO_2, evaluation based specifically on the 99th percentile was adopted.

2.4 Integration of air quality modeling and monitoring

The final stage consisted of integrating the modeling results with environmental monitoring data. This approach made it possible to distinguish the background concentration from that attributable to the sources represented in the model.

For each receptor assessed, the following were considered:

$$C_{consolidated} = C_{background} + C_{modeled}$$

where $C_{background}$ represents the highest concentration observed in monitoring for the reference period considered and $C_{modeled}$ corresponds to the additional contribution estimated by the model.

The methodology was applied to TSP, PM_{10}, $PM_{2,5}$, SO_2, CO, and NO_2. Monitoring was evaluated according to the reference periods and standards established by the applicable environmental legislation, considering CONAMA Resolution No. 491/2018 for the 2023 data and the evolution of the standards established by CONAMA Resolution No. 506/2024 for subsequent data. 24-hour moving averages were used for TSP, PM_{10}, $PM_{2,5}$, and SO_2, 8-hour moving averages for CO, and hourly averages for NO_2.

Finally, the consolidated concentrations were compared with national air quality standards, allowing both the contribution of the inventoried sources and their relevance relative to background concentrations and applicable environmental limits to be assessed.

FINDINGS AND ARGUMENT

The results of the emissions inventory indicated a predominance of fugitive sources in particulate matter emissions, mainly associated with road dust resuspension, material handling, and machinery operation.

For particulate matter, exposed areas were the main contributors, accounting for 87.57% of TSP, 91.72% of PM_{10}, and 85.86% of $PM_{2,5}$ emissions, while gaseous emissions were predominantly related to equipment operation and stationary combustion.

The inventory included TSP, PM_{10}, $PM_{2,5}$, CO, NOx, and SOx, with emission rates ranging, respectively, from 7.34-9.16 g/s, 2.82-3.90 g/s, 0.51-1.42 g/s, 2.62-26.20 g/s, 2.43-23.43 g/s, and 0.022-0.090 g/s.

The results demonstrate higher magnitudes for CO and NO_x emissions, followed by total particulate matter, while SO_x emissions show significantly lower values. For particulate matter, the expected reduction in rates is also observed as a smaller particle-size fraction is considered, progressing from TSP to PM_{10} and $PM_{2,5}$.

The georeferencing of the sources enabled their proper representation in the dispersion model. In the atmospheric dispersion modeling stage, the regulatory AERMOD model was used, with

meteorological data from 2019 to 2021, SRTM/NASA terrain information, a uniform 500 m grid with 961 receptors, and discrete receptors at strategic points.
The results, combined with the background concentrations obtained prior to the start of the study, made it possible to estimate the consolidated concentrations and supported the design of the monitoring network through the Figures of Merit and Spheres of Influence methodologies, as presented in Figure 2. Four strategic points were defined: one reference station, intended for monitoring pollutants and meteorological variables, and three compact stations for monitoring particulate matter and NO_2.

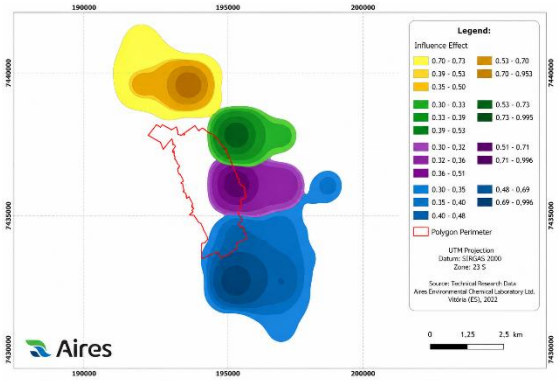


Figure 2. Monitoring network design

The consolidated concentrations ranged from 71.68 to 171.48 µg/m³ for TSP, from 46.37 to 102.59 µg/m³ for PM_{10}, from 12.12 to 25.02 µg/m³ for $PM_{2,5}$, and, for NO_2, from 25.18 to 58.11 µg/m³, considering the 99th percentile.
For SO_2 and CO, maximum values of 13.93 µg/m³ and 0.80 ppm, respectively, were recorded.
All results remained below the air quality standards adopted as reference, established by CONAMA Resolution No. 506/2024.
Environmental monitoring conducted between August 2023 and March 2026 generally confirmed compliance with the environmental standards for the assessed parameters. The isolated occurrence of $PM_{2,5}$ was associated with a local event external to the activities analyzed. The results demonstrate that integrating emissions inventory, atmospheric modeling, background concentrations, and continuous monitoring constitutes an effective approach for assessing and managing air quality in areas undergoing demolition activities.

CONCLUSIONS

The integrated approach combining emissions inventory, AERMOD modeling, and air quality monitoring made it possible to characterize the main emission sources and assess their influence on atmospheric concentrations in the study area. The results indicated a predominance of fugitive sources for particulate matter, while consolidated concentrations remained below the air quality standards adopted as reference.
The modeling, combined with background data, made it possible to identify the areas most influenced by the sources and support the design of a network comprising four strategic points, subsequently used for air quality monitoring. Monitoring conducted between August 2023 and March 2026 generally confirmed compliance with the applicable standards, demonstrating the effectiveness of integrating modeling and field observations for environmental monitoring of demolition activities.

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