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AIRESVIEWER: INTEGRATION OF CONTINUOUS MONITORING, EMISSION INVENTORIES, AND ATMOSPHERIC DISPERSION MODELING IN A DIGITAL AIR QUALITY MANAGEMENT PLATFORM

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Abstract: The digital transformation of air quality management requires integrated approaches capable of connecting environmental monitoring, operational records, emission inventories, and atmospheric dispersion assessments. This study presents the architecture of AiresViewer, an integrated digital platform designed to centralize, process, validate, and analyze environmental and operational information. The methodology combines continuous data acquisition, monitoring network management, field operational records, automated reporting, fugitive particulate emission quantification, georeferenced emission inventory development, and atmospheric dispersion modeling within a unified workflow. The architecture integrates AiresViewer, StationFlow, OperaViewer, AiresReport, AiresRAMP, AiresEmission, and AiresFlow, connecting measured environmental conditions, operational activities, emission sources, and modeled atmospheric impacts. The results demonstrate the feasibility of establishing a continuous and traceable information chain that improves analytical consistency and supports more integrated and data-driven air quality management.

Keywords: air quality monitoring, emission inventory, atmospheric dispersion modeling, environmental data management, fugitive emissions.

INTRODUCTION

Air quality management relies on heterogeneous datasets generated by continuous monitoring networks, meteorological observations, operational activities, emission inventories, and atmospheric dispersion models. These datasets support pollutant assessment, emission characterization, regulatory evaluation, and environmental decision-making. However, they are frequently processed through independent tools and databases, limiting interoperability, traceability, and the efficient transformation of environmental and operational information into decision-support information.

The increasing volume and complexity of environmental data require digital solutions capable of connecting measurement, validation, operational management, emission characterization, modeling, and reporting within a unified framework. In addition to environmental measurements, information on equipment performance, maintenance, calibration, and field activities is relevant for assessing the reliability and context of monitoring data. Similarly, direct quantification of fugitive emissions can provide an additional connection between measured particulate concentrations and emission inventories.

In this context, this study presents the architecture of AiresViewer, an integrated digital air quality management platform developed to connect continuous environmental monitoring, operational records, emission characterization, automated reporting, fugitive emission quantification, emission inventory development, and atmospheric dispersion modeling. The objective is to evaluate how the integration of these components can establish a continuous workflow for environmental assessment, traceability, and decision support.

METHODS

The methodology was structured as an integrated digital workflow covering environmental data acquisition, operational management, data validation, reporting, emission characterization, and atmospheric dispersion assessment.

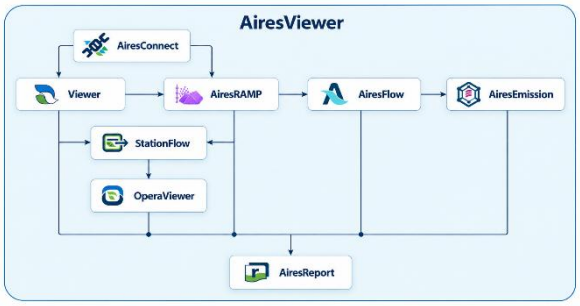


Figure 1. Integrated workflow of the AiresViewer platform for air quality data management, emission inventory development, and atmospheric dispersion assessment.

The different components share a centralized data structure, allowing information generated throughout the environmental management process to remain connected and traceable.

AiresConnect acquires and standardizes monitoring data from air quality analyzers, meteorological sensors, and dataloggers, storing measurements in a centralized database with preliminary quality checks. AiresViewer organizes georeferenced environmental data and provides tools for visualization, statistical analysis, and traceable validation of monitoring records.

Operational information is incorporated through StationFlow and OperaViewer. StationFlow monitors the operational status of monitoring stations, identifying equipment and communication anomalies and recording occurrence histories. OperaViewer complements this operational layer by managing field records, including Daily Operational Reports (RDOs), maintenance plans, and calibration plans. The integration of environmental measurements with operational records provides additional context for evaluating data availability, equipment performance, and field activities.

Validated monitoring data are consolidated through AiresReport, which generates standardized technical reports directly from the managed database, reducing intermediate manual processing. This establishes a connection between data validation and technical reporting while preserving consistency between the analyzed and reported information.

For emission characterization, AiresEmission provides a georeferenced structure for registering and quantifying atmospheric emission sources. In addition, AiresRAMP addresses fugitive particulate emissions from diffuse sources by combining upwind and downwind monitoring with vertical concentration profiling and meteorological measurements. The platform calculates effective emission rates for diffuse sources and provides temporal, spatial, and source-specific information that can support emission inventories and control actions.

The emission information generated and managed by AiresEmission, including information derived from fugitive emission monitoring, is connected to AiresFlow for atmospheric dispersion assessment. The modeling workflow uses source characterization, meteorological inputs, terrain information, and receptor configurations to generate concentration fields and georeferenced dispersion maps. The results can subsequently be evaluated together with measured air quality data, emission sources, and operational information, completing the integrated workflow from measurement and field operations to emission characterization, dispersion assessment, and decision support.

FINDINGS AND ARGUMENT: INTEGRATION OF ENVIRONMENTAL DATA FOR AIR QUALITY ASSESSMENT

The implementation of the AiresViewer architecture demonstrates that integrating environmental monitoring, operational management, emission characterization, and atmospheric dispersion modeling enables a continuous and traceable workflow for air quality assessment. By connecting these components through a common data structure, the platform links environmental measurements with the operational context in which the data are generated and managed.

The first outcome is the transformation of monitoring measurements into validated environmental information. AiresViewer provides visualization, statistical analysis, and traceable validation, while StationFlow adds information on equipment and communication status. OperaViewer further extends this traceability by incorporating field operational records, including maintenance and calibration planning and Daily Operational Reports. This combination provides a broader context for interpreting data quality and network performance.



Figure 2. AiresViewer interface for integrated visualization, analysis, and validation of continuous monitoring data.

The second finding is the integration of emission characterization and fugitive emission quantification. AiresEmission provides the georeferenced structure for atmospheric emission inventories, while AiresRAMP adds real-time quantification of fugitive particulate emission rates from diffuse sources. By connecting concentration measurements, meteorological conditions, source location, and calculated emission rates, the architecture provides information that can support both emission inventories and operational control of diffuse sources.

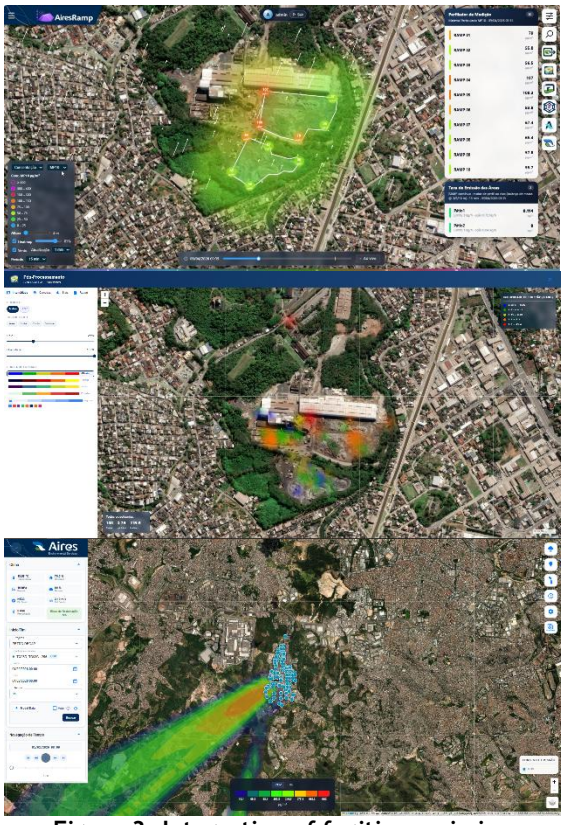


Figure 3. Integration of fugitive emission quantification, emission inventory, and atmospheric dispersion assessment through AiresRAMP, AiresEmission, and AiresFlow

The third outcome is the connection between characterized emissions and atmospheric dispersion assessment. AiresFlow uses the available source and environmental information to generate concentration fields and georeferenced dispersion results. These results can be evaluated together with monitoring data and operational information, enabling a more comprehensive interpretation of atmospheric scenarios.

The integrated architecture therefore extends beyond data visualization by connecting environmental measurements, operational records, field activities, emission sources, and atmospheric dispersion results. Compared with fragmented workflows, this approach reduces information discontinuity and establishes a structured chain in which each component contributes to environmental assessment while maintaining connections with the common data structure.

Table 1. Comparison between conventional fragmented workflows and the integrated AiresViewer approach.

Stage	Conventional	Integrated
Monitoring & validation	Independent systems	Centralized and traceable
Operational management	Manual control	StationFlow + OperaViewer
Reporting	Manual preparation	Automated reporting
Fugitive emissions	Separate measurements	AiresRAMP quantification
Emission inventory	Separate inventories	AiresEmission
Dispersion	Independent modeling	AiresFlow

CONCLUSIONS AND RECOMMENDATIONS

This study demonstrates that integrating continuous monitoring, operational records, emission characterization, fugitive emission quantification, automated reporting, and atmospheric dispersion modeling provides a structured approach to air quality management. The AiresViewer architecture establishes a continuous information chain connecting environmental measurements, equipment and field activities, emission sources, and modeled atmospheric impacts, improving traceability and consistency throughout the assessment process.

The effectiveness of the integrated approach remains dependent on the quality and representativeness of monitoring, operational, emission, and meteorological information. Future developments should focus on expanding automated data quality procedures, strengthening comparisons between monitored and modeled concentrations, and integrating additional predictive and operational decision-support capabilities.

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