GLOBAL CLEAN AIR

Methodology for a proof of concept hyperlocal monitoring in the Mexico City metropolitan area

Executive Summary

In September 2020, Environmental Defense Fund (EDF) and the Government of Mexico City began a collaboration to explore the potential of innovative technologies and analytical tools to provide additional support to the city's efforts to tackle air pollution.[1] This collaboration has been built on the solid experience and capabilities of Mexican institutions, as well as on EDF's international track record, particularly the best practices and lessons learned through the Global Clean Air Initiative.

The first step in this collaboration was the development of a methodology for a proof of concept of hyperlocal air quality monitoring in Mexico City. The goal of this proof of concept project is to demonstrate how new technological innovation can increase understanding of air pollution problems, and by complementing Mexico City's Atmospheric Monitoring System (SIMAT), provide a basis for driving a new generation of effective, high-impact measures for improving air quality and protecting health of the most vulnerable.

The development of this methodology was based on the current best available information on technologies and good practices in this field. In particular, it has been grounded in EDF's experience on similar projects around the world, incorporating insights from specialists in related aspects and systematized recommendations provided by EDF's *Making the Invisible Visible: A Guide to Mapping Hyperlocal Air Pollution to Drive Clean Air Actions*.[2] The methodology was developed through a collaboration between Mexico City's Secretariat of Environment (SEDEMA), the Government of the State of Mexico's Secretariat of Environment (SMA), the Environmental Commission of the Megalopolis (CAMe), the Secretariat of Environment and Natural Resources (SEMARNAT), the Mario Molina Center for Strategic Studies on Energy and Environment (CMM) and Environmental Defense Fund, within the framework of the Global Clean Air Initiative.[3] In addition, an Advisory Committee composed of experts from universities, research centers, non-governmental organizations and state environmental agencies provided feedback and recommendations along the development process, and a consultation process with national and international specialists and key stakeholders informed the methodological design.

The objective of the proof of concept is to conduct a deep characterization of air quality in a selected area in Mexico City by using innovative technologies and analytical tools. This will allow reliable and timely data to be obtained, with a high spatial and temporal resolution to improve understanding of the local air pollution as a basis for designing, adopting and implementing effective clean air solutions. The methodology for this proof of concept includes the general design of a hyperlocal monitoring network to be deployed in a specific area of Mexico City; it addresses specific monitoring requirements proposed by the environmental authorities and offers guidelines

[1] https://www.edf.org/media/iniciativa-de-innovacion-de-aire-limpio-lanzada-por-autoridades-mexicanas-y-environmental
[2] https://www.edf.org/media/new-edf-guide-mapping-hyperlocal-air-quality-drive-clean-air-action
[3] Information about EDF's Global Clean Air Initiative can be found at the following link: https://www.globalcleanair.org/about-edfs-global-clean-air-initiative/

and recommendations for operation and maintenance, data management, information dissemination and engagement of key stakeholders to catalyze actions.

Local information to design and implement community level clean air solutions

The recent advent of microsensor systems for measuring air pollutants is opening new horizons to supplement reference technologies and expand air quality monitoring at unprecedented spatial and time scales — thereby expanding opportunities to obtain useful data for improving air quality management. Microsensor-based systems are small, lightweight and have lower power consumption. Some of the disadvantages in terms of service life, precision and performance can be mitigated by means of calibration methods and correction algorithms.

Among the cities that have made significant progress in using microsensors for hyperlocal air quality monitoring are London (United Kingdom); Los Angeles (United States); Beijing (China); and Medellin (Colombia). As the C40 city network[4] notes, the pilot phase of the Breathe London project "demonstrated that an extensive network of expensive regulatory air quality monitors is not the only way cities can better understand hyperlocal air pollution and gain the knowledge needed to inform air quality management planning."[5]

Mexico City's atmospheric monitoring network — the backbone of the air quality management system and the assessment of compliance with Mexican air quality standards — has been in place for more than thirty years. Its robust infrastructure, site density and technical performance puts it in high international recognition. This system has supported Mexico City’s significant progress in improving air quality over the past several decades. However, there are still significant challenges that require reliable and timely information at a hyperlocal scale to improve the understanding of problems and identify new solutions. There is an opportunity to apply innovative tools and new information to enhance the identification, evaluation and prioritization of actions in order to make more informed decisions and strengthen implementation of sound solutions.

[4] C40 is the network of the world's megacities committed to addressing climate change. C40 helps cities collaborate effectively, share knowledge and drive meaningful, measurable and sustainable actions on climate change. Mexico City is a prominent member of this network.
[5] https://www.c40knowledgehub.org/s/article/Breathe-London?language=en_US

Methodology for a proof of concept hyperlocal monitoring network for Mexico City

The objective of the proof of concept is to conduct a deep characterization of air quality in a selected area in Mexico City by using innovative technologies and analytical tools. This will allow reliable and timely data to be obtained, with a high spatial and temporal resolution to improve understanding of the local air pollution as a basis for designing, adopting and implementing effective clean air solutions.

The following proof of concept monitoring requirements were defined based on the information needs from air quality authorities and the features offered by microsensors:

Air quality monitoring:	• Obtain information for characterizing and assessing air pollution problems at a community level in a selected area of study.
Characterization of emission sources:	• Provide key information to identify, characterize and assess the impact of emissions from local sources of hyperlocal-scale pollution, including the generation of inputs for the application of source attribution techniques.
Identification of control measures and actions:	• Provide high spatial and temporal resolution data for the design, monitoring, evaluation and implementation of strategies and actions to improve air quality and reduce greenhouse gas emissions at the community level.
Health impact assessment:	• Provide data for the subsequent application of health impact assessment methodologies at community level.
Communication and participation:	• Improve communication to the public about the situation of air quality at community level, raise citizen awareness for air quality and involve them in the development of management policies and in supporting actions to improve air quality.

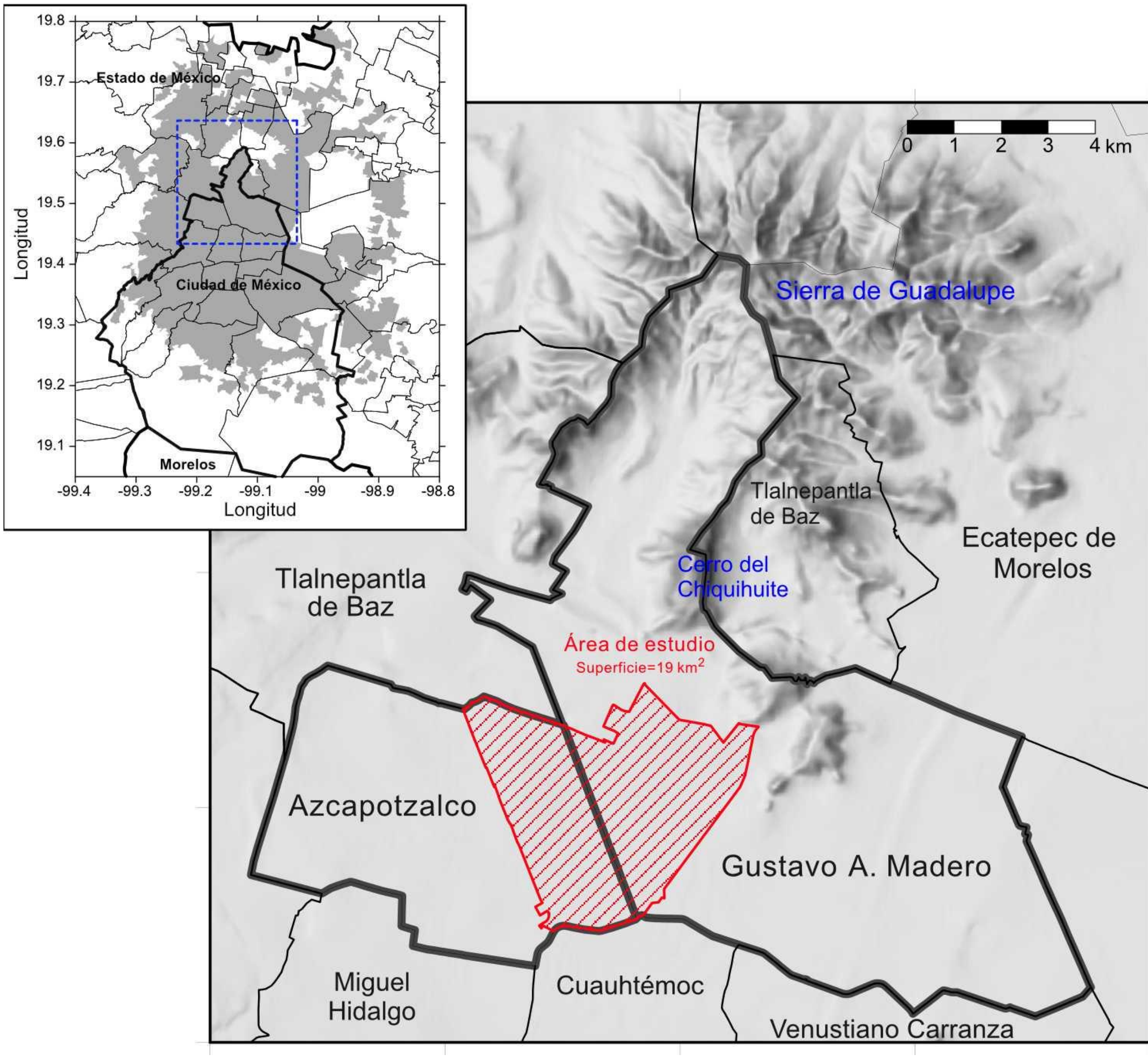

Figure RE1. Location of the study area. The map in the upper left corner shows the selected study area in the Metropolitan Zone of the Valley of Mexico, while the enlarged map displays this location in terms of the local jurisdictions involved.

The selected study area is a polygon of approximately 19 km^2 in the northern part of Mexico City. It is an area of high environmental complexity (see Figure RE1). The selection of the study area was the result of a coordinated review with environmental authorities of the different government jurisdictions involved in the air quality management. The study area was explicitly selected for the coexistence of a mix of major pollution sources (industrial facilities, transportation hubs and freight and passenger roadways) with vulnerable groups exposed to air pollution in multiple hospitals, schools, parks and sport centers, in an area with high population density with diverse socioeconomic backgrounds. Also, the selection took into consideration the availability of local infrastructure to place the microsensor monitoring sites and the proximity to existing SIMAT reference sites.

The proposed area is bounded to the east by Av. Insurgentes Norte, to the west by the avenues Ferrocarril Central y Maravillas, to the south by the Circuito Interior and to the north by avenues

Acueducto, Miguel Bernard and Poniente 152. The area is characterized by a high industrial activity and a dense roadway network for public transport and the movements of raw materials and goods which connects Mexico City with the rest of the metropolitan area. The study area has a relatively high population density and is in a region that experiences not only local emissions, but also regional transport of air pollutants. Five main pollution hotspots were identified based on map analysis, a field visit and existing information about emission sources in the area. These hotspots include: a major industrial corridor (Corredor Industrial Vallejo); a major urban transport hub (named CETRAM Indios Verdes); another urban transport hub near La Raza Medical Center; the North Intercity Bus Terminal; and an outdoor food preparation and sale area in a vicinity of a major a hospital cluster.
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The target pollutants for this proof of concept include: particulate matter with diameter less than 2.5 micrometers ($PM_{2.5}$), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2) and tropospheric ozone (O_3). These pollutants were selected in consultation with the Advisory Committee to address the proof of concept monitoring requirements. A set of performance specifications for both air quality and meteorological sensor devices was proposed based on the monitoring requirements as a basis for technology selection.

For air quality sensors, specifications were proposed for bias, accuracy, comparison with reference equipment, detection limits, response time, measurement frequency, interference, sensor expiration, measuring interval, baseline deviation, stability against weather changes and recovery time after electrical failure. For meteorological sensors, specifications were defined for temperature, relative humidity, wind direction, wind speed, barometric pressure and precipitation.

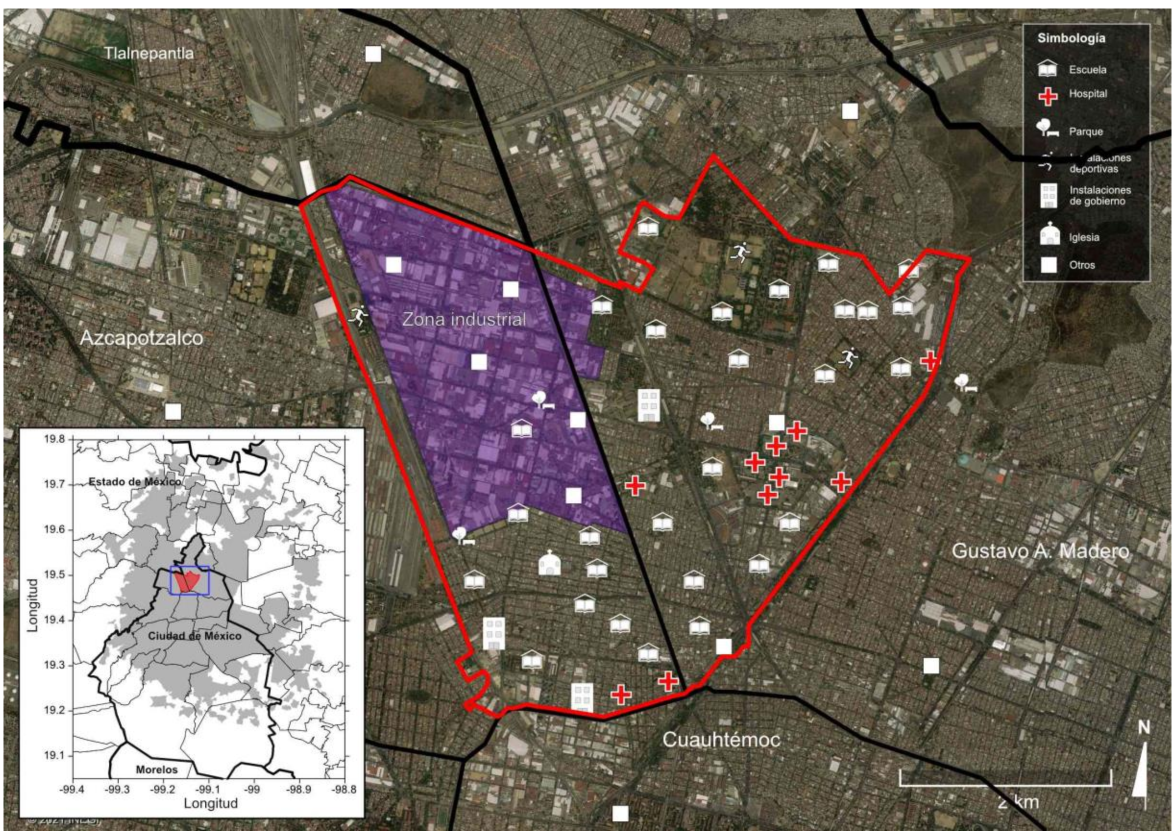

Figure RE2. Proposed location for the installation of monitoring sites.

The Figure RE2 shows the proposed location for stationary monitoring sites. Each icon represents the point where microsensors could be placed targeting hospitals, schools, parks, sports facilities, and churches — locations where individuals that may be more susceptible to pollution, such as the sick, elderly and children, gather or spend extend periods of time. The siting of each stationary site was proposed considering some characteristics that might improve spatial resolution and reduce local effects, such as height, distance to obstacles, interferences, safety and access. The proposed network configuration includes 56 stationary sites located near hotspots and at different places within the residential area, giving priority to schools and hospitals.

In addition to the microsensor stationary sites, this methodology proposes to make the existing air quality monitoring supersite at the SIMAT laboratory facility (located near the center of the polygon) available and fully operational. It also proposes the installation of eight weather stations in strategic sites of the project study area.

While the microsensor network described above will provide data about air quality inside the study area, another six existing air quality reference monitoring sites located in the vicinity of the polygon will enable comparisons with background concentrations to observe air pollution dispersion and transportation patterns, as well as possible impacts from microlocal and external sources.

To ensure the highest quality data collection, calibrations would be performed before and during the field measurements. Sensor devices would be calibrated by co-location at the reference monitoring site and the network performance would be maintained using transfer standards. The current data acquisition and management system used by SIMAT would be upgraded to obtain sensors' data. For data visualization, the creation of an interactive dashboard similar to that developed for the *Breathe London* pilot project would allow the dissemination of preliminary data. For data validation and transformation, we have included recommendations based on EDF's best practices and previous experiences.

Finally, the proof of concept would include activities for developing capabilities for the understanding and use of data by both government and key stakeholders. Engagement of local authorities, local neighboring organizations, groups associated with local parks, schools of different levels of education, as well as hospitals and health centers, would allow the building of a standardized basic knowledge about the local air quality and develop abilities to access and use local air quality information.

Expected results for the benefit of air quality management

Once implemented, the proof of concept hyperlocal monitoring project is expected to contribute to increasing the knowledge about the problem of air pollution, which is necessary to improve the planning and management of air quality in Mexico City. The expected outcomes include:

- Supplementing the regulatory monitoring network with capabilities for hyperlocal monitoring using innovative technologies and analytical tools.
- Integration and systematization of reliable databases on the spatial and temporal distribution of air quality at community level, complementing existing data from SIMAT.
- Upgrading data processing software and analytical tools at Mexico City's air quality monitoring system to take full advantage of hyperlocal data management and maximize its dissemination.

- Identifying prominent sources of pollution and assessing their air quality contribution based on the data obtained in the project.
- Obtaining data at hyperlocal scale to enable improved methodologies for health effects assessment in overburdened communities, considering aspects of equity and environmental justice.
- Offering useful data for the identification, evaluation and prioritization of the emissions reduction from localized hotspots.

Time and investment

The project described here has been designed to be implemented in 24 months according to the following phases:

- **First phase:** Evaluation of technology performance. The time frame for this phase would be eight months, including the performance evaluation of various options of microsensor systems for the target pollutants.
- **Second phase**: Technology acquisition, and network deployment and initial operation. The timeframe for this phase would be 14 months after the first phase.
- **Third phase**: Overall assessment of the proof of concept. A detailed evaluation of the proof of concept will be conducted based on the established monitoring goals, aiming to assess its overall performance and identify major lessons learned and recommendations for future development. This phase will collect information from the previous phases and is scheduled to conclude two months after the second phase.

It should be highlighted the operation of the network may continue depending on the needs of the environmental authorities.

The scale of the proof of concept described can be scaled based on available resources and expected scopes. For example, it could start with the acquisition of sensors for $PM_{2.5}$ monitoring for which some devices have demonstrated good correlations when compared against reference instruments and offers lower costs than a multi-pollutant measurement system. In addition, PM sensors have longer lifespans than gas sensors (up to three years).

This gradual development scheme could begin with the evaluation of one or two of the initial monitoring objectives (e.g. monitoring at places where vulnerable groups congregate, such as schools or hospitals). As additional resources are allocated, more monitoring objectives can be evaluated, adding sensors for measuring gaseous pollutants and growing the network with additional sites. The definition of a lower scope project can follow the same reasoning presented in the full proof of concept outlined in this document.

It is also important to emphasize that microsensor-based technologies are rapidly evolving. This, coupled with performance improvements and reductions in acquisition and operation costs, suggests that cost of hyperlocal monitoring systems will be lowered in the near future.

Sustainability

As part of the development of the project, we considered a strategy for ensuring the viability of the project in the short- medium- and long-term. Some of the recommendations to explore include:

1. Establish a formal collaboration between the various agencies involved in the air quality management at the city, for joint deployment and operation of a hyperlocal air quality monitoring network.
2. Identify and raise complementary resources from national and international donors and other sources, inviting them as project partners.
3. Engage civil society groups and other interested stakeholders to participate in the acquisition, operation and maintenance of microsensors part of the network. Similar approaches have been deployed in the second phase *Breathe London* and the experience with the *Citizen Scientist* project in Medellin.
4. Maximize the value of the hyperlocal air quality monitoring network by providing useful inputs on meteorological data to other systems that monitor the city's environmental performance and climate risk management, like the Citizen Scientist project in Medellin.
5. Require all new infrastructure projects in Mexico City to incorporate, as part of their evaluation and monitoring, hyperlocal air quality measurements.