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Data Analytics Application of NOM-172-Semarnat-2019: Mexico City Case Study

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Abstract— **With the implementation of the guidelines contained in the Mexican standard NOM-172-SEMARNAT-2019, for obtaining and communicating the Air Quality and Health Risks Index, a unique method of calculation and dissemination guidelines was officially recognized to be applied by state or municipal governments responsible for monitoring air quality, this led to significant progress in access to information and health protection. This work has as one of its purposes to provide an accessible tool of very low cost so that monitoring studies can be carried out in other cities of the Mexican Republic using mobile networks of census of pollutants (using free software tools for a Geographic Information System, as well as free interactive data visualization software). Additionally, it was considered useful to make a distribution (areas of influence) using the Voronoi methodology in order to place this distribution only as a reference standard for the installation of future monitoring stations.**

Keywords—Geographical Information System, Data Visualization, Air pollution, Air Quality and Health Risks Index, Voronoi methodology

I. INTRODUCTION

Spatial analysis is a core GIS technology, which primarily includes buffer zone analysis, overlap analysis, and web analysis. The analysis of the buffer zone defines different widths of damping according to the different attributes of the objects to form a changing buffer zone of width, for example, analyze and display the service zone of the pollutant processing equipment, reflect the impacts of pollution sources on the environment and humans [5].

Currently, the Government of Mexico City is committed to monitoring air quality and communicating the results to the population and that this information is more useful if it is linked to health expressed in the levels of risk associated with air quality. In this way, the general population will be able to effectively use the information provided to implement protective measures.

One of the major problems that arise in large cities, associated with high demographic concentration, is that corresponding to air pollution. Indeed, as a consequence of the phenomenon of private or public human transport, mobility has led to an increase in the concentration of polluting particles. Thus, it is an element of strategic safety to be able to monitor the levels of pollution that can constitute elements harmful to human health in modern cities.

In Mexico City, air pollution has gained remarkable relevance, due to the health implications of the population. In 2019, the Mexican standard NOM-172-SEMARNAT-2019 [1] was formalized, in order to establish the guidelines for obtaining and communicating the air quality and health risk index.

In this paper, an analysis of the available data of the main pollutants is presented [3], focusing on the days of environmental contingency declared in the course of 2022 (May 3, 4, 6 and 21), in order to verify the concordance of the data of Air Quality Monitoring Network with the standard NOM-172-SEMARNAT-2019. Indeed, based on the data provided by Secretariat of Environment of Mexico City, and using a set of free software tools, we proceeded to analyze the concordance of air quality monitoring stations in Mexico City, based on the guidelines established by the NOM-172-SEMARNAT-2019 standard.

Given the importance for human health of having permanent monitoring of air pollutants, a system called THE AIR QUALITY MONITORING NETWORK was implemented in Mexico City.

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The Secretariat of Environment of Mexico City has four subnetworks that make up the afore mentioned network:

1.- Automatic Atmospheric Monitoring Network (RAMA).
2.- Network of Meteorology and Solar Radiation (REDMET).
3.- Atmospheric Deposit Network (REDDA).
4.- Manual Network of Atmospheric Monitoring (REDMA).

These networks are basically responsible for the permanent monitoring of the main pollutants [2] in accordance with international guidelines such as: CO, NO, NO_2, NO_X, O_3, PM2.5, PM10, PMCO and SO_2. The standards for the monitoring stations of the air quality of the different pollutants were established considering the measurement at an average altitude of 2,240 meters above sea level [7].

II. METHODOLOGY

Based on the data provided by the AIR QUALITY MONITORING NETWORK [3] and using the equations and tables provided in the NOM-172-SEMARNAT-2019 standard [1], the reference framework was established for the elaboration of the calculations corresponding to the evolution of the different pollutants in the periods prior to the days of environmental contingency. In fact, using free software tools, the information was given a structure, to facilitate its analysis and that this constituted a contribution to demonstrate that anyone interested in air quality can access and carry out an analysis and propose alternative solutions to the air pollution problem in Mexico City.

Considering the limitations of Excel to visualize information by means of pivot tables [4] and given the size of the sample of data to be processed: 949,488 rows, and 4 columns. For a better analysis of the information and recognition of it, the Tableau Public software was used, finding: a) 949,488 rows (01/01/2022 12:00:00 a.m. to 31/05/2022 23:00:00 p.m. and 01/06/2022 12:00:00 a.m.); (b) 4 columns (date, id_station, id_parameter, value) of the pollution values ("value") reported by the air quality monitoring stations 614,705 records presented non-zero values and 334,783 records presented null values.

Equations for calculating the weighted moving average concentration: The following equations show the specifications used in the different analyses that were performed for the contaminants: PM10, PM2.5, O_3, NO_2, NO, SO_2 and CO.

The calculation of the weighted moving average concentration for each pollutant is given by:

$$\bar{C} = \frac{\sum_{i=1}^{N} C_i \, W^{i-1}}{\sum_{i=1}^{N} W^{i-1}}$$

Where:

$$W = \begin{cases} W \; si \; W \geq 0.5 \\ 0.5 \; si \; W \leq 0.5 \end{cases} \quad \text{and} \quad w = 1 - \frac{\text{Cmax} - \text{Cmin}}{\text{Cmax}}$$

$\bar{C}$= Weighted moving average concentration.

N = Number of hours selected in the period.

$\sum$ = Sum of data.

C_i= Hourly average concentration of time i.

i = consecutive hour of measurement.

W = Weighting factor.

w = Weight value.

C_{max} = Maximum hourly average concentration in the period.

C_{min} = Minimum hourly average concentration in the period.

Based on the publication of the NOM-172-SEMARNAT-2019 standard, two types of tables are identified that contain: 1.- Obtaining the AIR AND HEALTH INDEX corresponding to the pollutants (Tables 1 and 2), 2.- AIR AND HEALTH QUALITY INDEX COLOR CODE GUIDE. Two tables representative of the above are shown below (Table 3).

Table 1. AIR AND HEALTH INDEX for sulfur dioxide (SO_2).

Air quality	Associated risk level	24-hour moving average Sulphur dioxide (SO_2) range (as approximate to the 24-hour average) (ppm)
Good	Low	0.008
Acceptable	Moderate	>0.008 and 0.110
Suitcase	High	>0.110 and 0.165
Very Bad	Very High	>0.165 and 0.220
Extremely Bad	Extremely High	>0,220

Table 2. AIR AND HEALTH INDEX for Ozone (O_3).

Air quality	Associated risk level	Eight-hour moving average Ozone (O_3) range (ppm)
Good	Low	0.051
Acceptable	Moderate	>0.051 and 0.070
Bad	High	>0.070 and 0.092
Very Bad	Very High	>0.092 and 0.114
Extremely Bad	Extremely High	>0,114

Table 3. Categories and colors for the AIR AND HEALTH INDEX.

Air quality	Associated risk level	Color	R (Red)	G (Green)	B (Blue)
Good	Low	Green	0	228	0
Acceptable	Moderate	Yellow	255	255	0
Bad	High	Orange	255	125	0
Very bad	Very high	Red	255	0	0
Extremely bad	Extremely high	Purple	143	63	151

III. RESULTS

In this work, the values analyzed correspond to the data provided by Secretariat of Environment of Mexico City in its daily measurements, particularizing the period between one day prior to the environmental contingencies decreed during the month of May 2022 (3, 4, 6 and May 21). Obtaining the following results, by May 2, 2022:

Table 4. Summary of the results of the levels associated with air quality (May 2, 2022).

Pollutant	Air quality	Associated risk level	Weighted Moving Average Interval Limit	Location of the base concentration on the calculated air health scale	Unit	Color
CO	Good	Low	8.75	0.23	PPM	Green
SO_2	Extremely Bad	Extremely High	>0,220	1.390	PPM	Purple
NO_2	Good	Low	0.107	0.018	PPM	Green
O_3	Bad	High	>0.070 and 0.092	0.083	PPM	Orange
PM2.5	Acceptable	Moderate	>25 and 45	30	µg/m3	Yellow
PM10	Acceptable	Moderate	>50 and 75	50	µg/m3	Yellow

In the table above, the colors corresponding to air quality index color code guide are associated according to NOM-172-SEMARNAT-2019.

Air Quality Monitoring Network topology

Considering the fact that air pollution is a space-time (geospatial) problem [6], a map of the distribution of the Environmental Monitoring Network was drawn up (Figure 1), given the information provided by the environment of Mexico City and for a better visualization of the subnetworks, in the topology of these, it was decided to use the Voronoi type technique in order to identify a delimited area of influence of the monitoring stations corresponding to the different subnetworks (Figure 2); It is worth mentioning that due to the framing of Figure 2, the regions external to the analyzed area appear larger than the real one, a limitation of Voronoi that does not affect the analyses carried out.

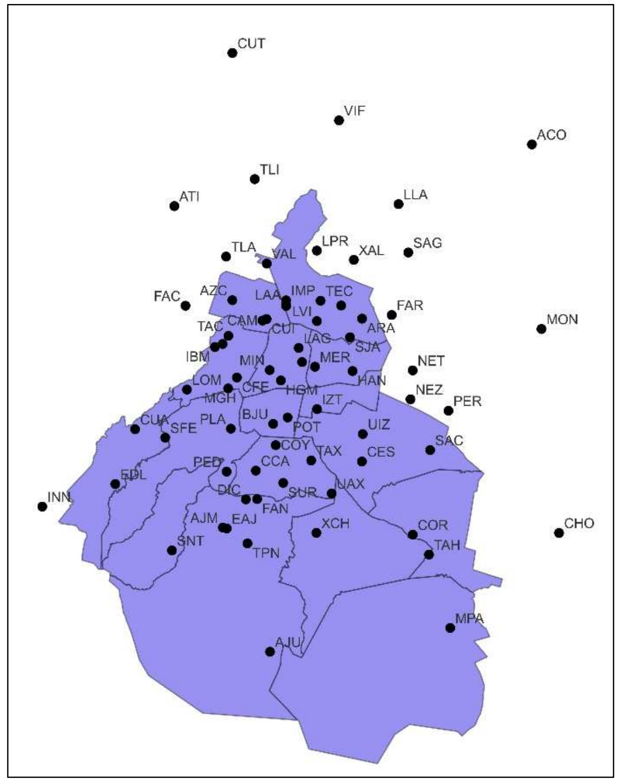

Figure 1: Map location of Air Quality Monitoring Stations in the Mexico City area.

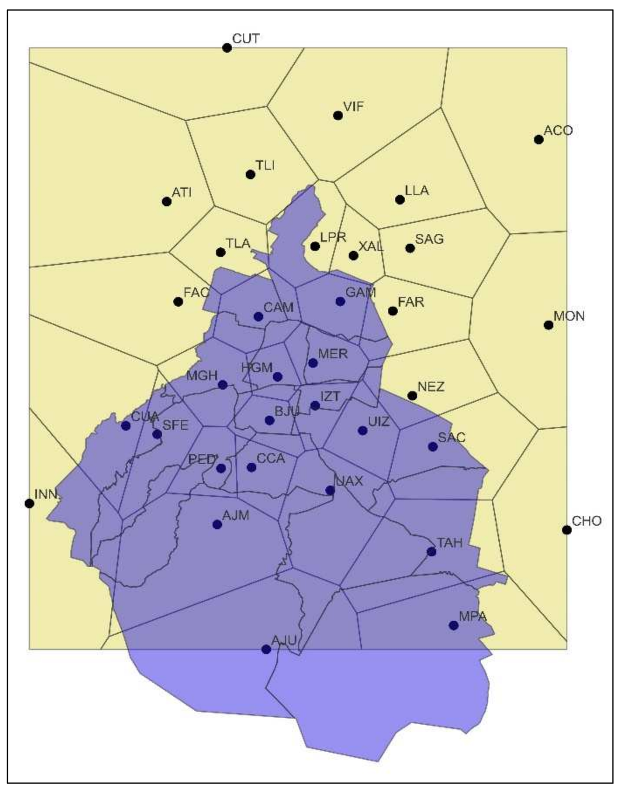

Figure 2: Areas of influence (Voronoi Methodology) obtained for the case of RAMA, showing that the areas of greater population density of the CDMX are significantly covered.

Below are the graphs corresponding to the reported levels of SO_2 and O_3 pollutants (Figure 3), by the stations of the monitoring network (Days 2, 3, 5 and 20 May 2022).

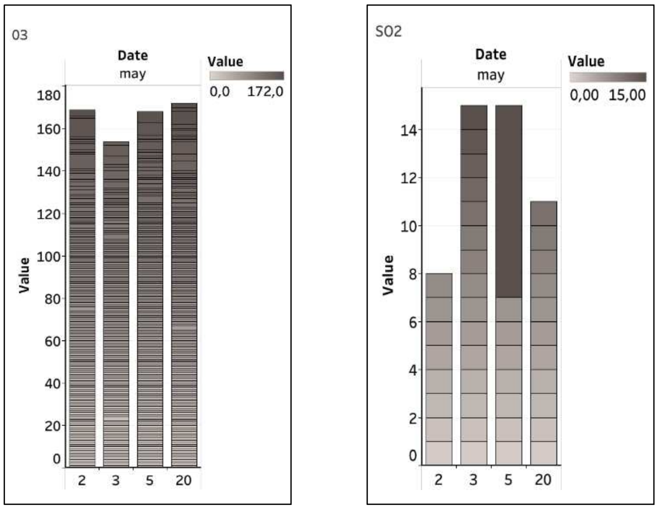

Fig 3. Reported levels of SO_2 and O_3, by the stations of the monitoring network.

IV. CONCLUSIONS

A first result shows that the data published by Secretariat of Environment of Mexico City are consistent with the declaration of environmental contingency of May 3, 2022, emphasizing the pollutants O_3, PM10, PM2.5 and SO_2 as the main trigger is of the contingencies in the Mexico City, despite the fact that missing data were detected (null) at some monitoring stations.

As a result of the analysis of the subnetworks, a marked tendency was observed to cover the northern part of Mexico City, leaving to investigate the need for monitoring of the REDMA, REDMET and REDDA networks.

The work presented was carried out using free software tools, with which there are elements so that anyone who has access to public data by Secretariat of Environment of Mexico City can carry out a timely follow-up of the monitoring of the environmental conditions of the Mexico City, this type of access is currently being promoted in cities in Europe and Asia, where it has even been seen the need to place mobile monitoring stations on the access roads to large cities.

It should be clarified that there are topological distributions of the subnetworks corresponding to: Meteorology and Solar Radiation Network (REDMET), Atmospheric Deposit Network (REDDA) and Atmospheric Monitoring Manual Network (REDMA).

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