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Assessment of Air Quality in Brazzaville: Measurement of Some Automobile Pollutants

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Abstract

Atmospheric pollution is currently a real public health problem because of its potentially harmful effects on the environment as well as on human health. Several studies conducted in America, Europe, Asia, and Africa have established a significant link between air pollution and cancer, infertility, cardiovascular and respiratory morbidity, and mortality. This study aims to measure some automotive pollutants (CO, CO_2, NO_2, and SO_2) by a selective and colorimetric method using a measurement system on Dräger reagent tubes coupled to a Dräger Accuro sampling pump in order to do a quantitative assessment of air quality in the nine districts of Brazzaville. The results obtained during this study revealed high concentration levels of pollutants (CO, CO_2, NO_2, SO_2), all above the standards recommended by the WHO. The results obtained during this study made it possible to categorise Brazzaville as a polluted city.

Keywords

Air Quality, Automobile Pollutants, Brazzaville

1. Introduction

In recent years, air pollution has been at the heart of all debates because of its potentially harmful effects on the environment as well as on human health. It is, to date, a real public health problem that causes an estimated 4.9 million premature deaths per year around the world [1]. The "Law on Air and the Rational

Use of Energy" (LAURE), adopted in 1996, defines atmospheric pollution as "the introduction by man, directly or indirectly, into the atmosphere and into confined spaces, substances having harmful consequences, likely to endanger human health, harm biological resources and ecosystems, influence climate change, damage material goods, or cause excessive odour nuisance".

Because of its complexity, this scourge arouses the interest and attention of all. As a result, several studies conducted in America, Europe, and Asia show that this pollution is primarily attributed to human activities, whether industrial, domestic, agricultural, or urban [2] [3]. This has led to the establishment of the "ESCAPE project" in Europe and has made it possible to find a significant association between short- and long-term exposure to suspended particles and mortality from natural causes and morbidity and mortality from cardiovascular causes, particularly in terms of coronary events [4] [5]. These findings led the International Agency for Research on Cancer to classify diesel engine exhaust gases as carcinogenic to humans in 2012. These gases are notably responsible for lung and bladder cancer [6].

Globally, the impact of this pollution challenges politicians to the point where it has given rise to certain activities such as the Conference of the Parties (COP), organised every year and whose main missions are the creation of a global carbon tax system, an end to dependence on coal, a phase-out of fuels, and an end to investments in the grey or brown economy.

It has been reported that the impacts of said pollution on human life keep increasing over time, from 4.3 million deaths per year in 2016 to 7 million deaths per year in the world in 2021, including 88% in low-income countries [7] [8].

In addition, in 2019, more than 90% of the world's population lived in areas where concentrations of pollutants exceeded the reference thresholds set by the WHO (OMS) on air quality in 2005 for long-term exposure to $PM_{2.5}$. This led to the WHO revising air quality guidelines in September 2021 to even lower concentrations than previously believed [7].

About developing countries, serious problems of air pollution exist mainly in large cities. Some limited studies have been carried out in the urban areas recently to assess the effects of vehicles on ambient air quality [9] [10].

Like the other continents, Africa is also confronted with this pollution and its harmful effects, in particular on the climate, with global warming, on the health of populations, and with the appearance or even aggravation of non-communicable diseases [8]. According to one air quality modelling study, air pollution may cause at least an estimated 780,000 premature deaths annually in Africa [11], and a significant number of diseases (co-morbidities) are known to be worsened by chronic exposure to air pollution, like asthma, lung cancer, and chronic obstructive pulmonary disease [12].

The Republic of Congo, one of the most urbanised countries in sub-Saharan Africa, is no exception. Indeed, nearly 70% of the population lives in the four main cities of the country. This accelerated urbanisation is unfortunately taking

place in disregard of urban master plans and sanitation master plans [13]. Air pollution is observed during the hours of heavy automobile traffic and in the evening at sunset. 90% of the motor vehicles circulating in the country are second-hand from Europe, often without a catalytic converter or other gas purification devices. These vehicles use gasoline produced by the "National Refining" Company (CORAF) with a lead content equal to 0.1 g/L [13]. Due to the insalubrity into which the cities and villages of the Congo are plunged, the epidemiological picture is dominated by diseases due to environmental degradation, in particular malaria, which represents the first cause of morbidity with 54% of the causes. Consultation in the general population [13]: acute respiratory infections (ARI) are the second most common reason for consultation in children under 5 after malaria. During the same year, 1.201 cases of pneumonia, including 40 deaths, were reported to hospitals in Brazzaville. For other acute respiratory infections, 48.942 cases, including 321 deaths, have been reported. In 2003, in Brazzaville, ARI accounted for 33% of all reasons for consultation in "Integrated Health Centres" and 29.8% of causes of death recorded in hospitals for children under 5 years old.

Concerned about the effects of air pollution, which are still underestimated in our country, and given the non-existence of a permanent air quality monitoring network as well as the lack or even non-existence of data on this, we have devoted ourselves to conducting this study, with the objective to quantitavely assess the quality of the ambient air for certain automobile pollutants (NO_2, CO_2, SO_2, CO) in nine districts Brazzaville.

2. Methods

2.1. Description of the Study Site

This study was carried out in Brazzaville, the political capital of the Republic of Congo, which extends from north to south over an area of 264 km^2. It represents the most populated city in the country, with 2.552.813 inhabitants in 2021. It has nine districts with a population density of 9.670 inhabitants per km^2.

2.2. Data Collection Details

To achieve the objectives set in this study, our measurements were carried out at different sites in the districts of Brazzaville: roundabouts and intersections. For each district, three samples were taken per site during the two seasons and over two years (2020 and 2022), *i.e.*, a total of 108 samples for the nine districts. The parameters of air quality measured include NO_2, SO_2, CO, and CO_2 concentration. **Figure 1** below shows the map of the different points where the concentrations of pollutants were determined.

2.3. Sampling Equipment

The equipment used for this purpose consisted of gas detection tubes, or Dräger tubes (**Image 1**), coupled to a Dräger Accuro pump sampling pump (**Image 2**).

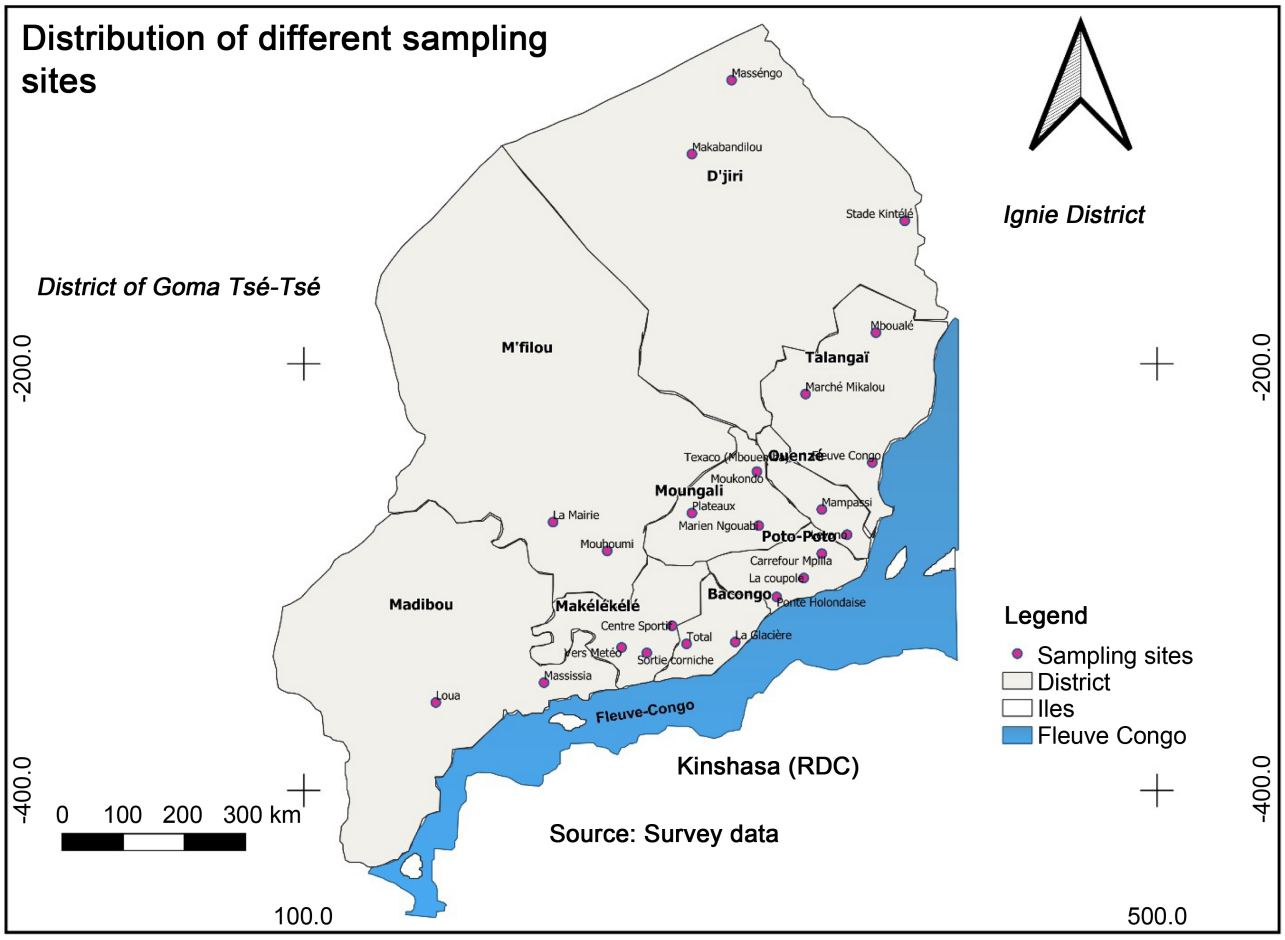

Figure 1. Mapping of pollutant measurement sites.

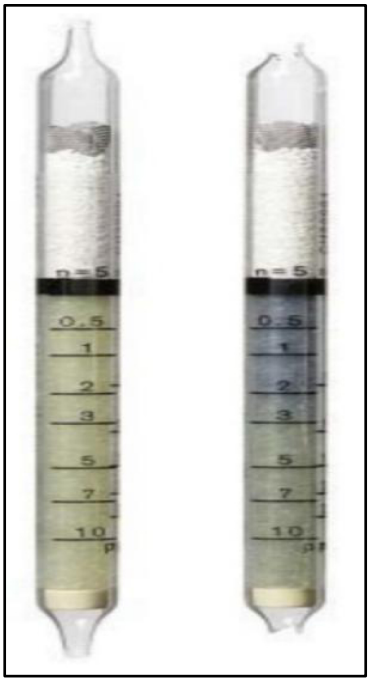

Image 1. Dräger tube.

Image 2. Dräger accuro pump.

2.4. Assessment of Pollutants

An air sampling campaign for the quantitative assessment of the concentrations of gaseous automobile pollutants (NO_2, SO_2, CO, and CO_2) in the ambient air was carried out in the nine districts of Brazzaville in 2020 and 2022, with two samples for each year, one in the rainy season and the other in the dry season. Sampling was carried out using an exhaustive method. In this study, the samples were taken using the point method using a measuring system on Dräger reagent tubes (Image 1), coupled to a Dräger Accuro sampling pump (Image 2). In order to avoid their degradation, the tubes were kept in the containers and stored in the refrigerator, the recommended temperature being between 0 and 10˚C. These tubes were then transported to the various sites by car in coolers. The equipment was placed at a distance of 1.5 m from the street for all the pollutant measurement sites. The pump uses a bellows system, and before any sampling, two tests were carried out to assess the quality of the pump. The method for measuring the concentration of pollutants is based on a colorimetric reaction (in the Dräger tube) that takes place in the presence of specific pollutants. Dräger reagent tubes, or gas detection tubes, are filled with chemical reagents that absorb and react with the measured target gases or vapours. After suction of the air by the pump, the reading was taken immediately in a bright place, sheltered from direct sunlight, on white paper from the scale engraved on the tube, and in comparison with a tube not used. In the absence of standards and regulations on air quality in Congo, our results were assessed according to the WHO 2021 air quality standards.

3. Statistical Analysis

Data has been processed using Excel 2016 software (Microsoft Corporation, USA). This tool was used for the statistical analysis and conception of graphes. The CSPRO 4.1 software was also used for data entry.

4. Results

During this campaign, the CO concentrations measured during the rainy season

were lower than those measured during the dry seasons, with peaks in Makélékélé, Poto-Poto, Ouénzé and Talangai, all of which were above WHO standards (2022). We also observe an increase in the concentration of CO in the 2022 rainy season compared to the 2020 rainy season. There is also a sharp increase in the concentration of CO between the 2020 dry season and the 2022 dry season (Figure 2).

As with CO, NO_2 concentrations were all above WHO standards (2021); the highest were recorded in the 2021 dry season, with peaks in the 2021 dry season in Ouénzé, Poto-Poto, and Makélékélé (Figure 3).

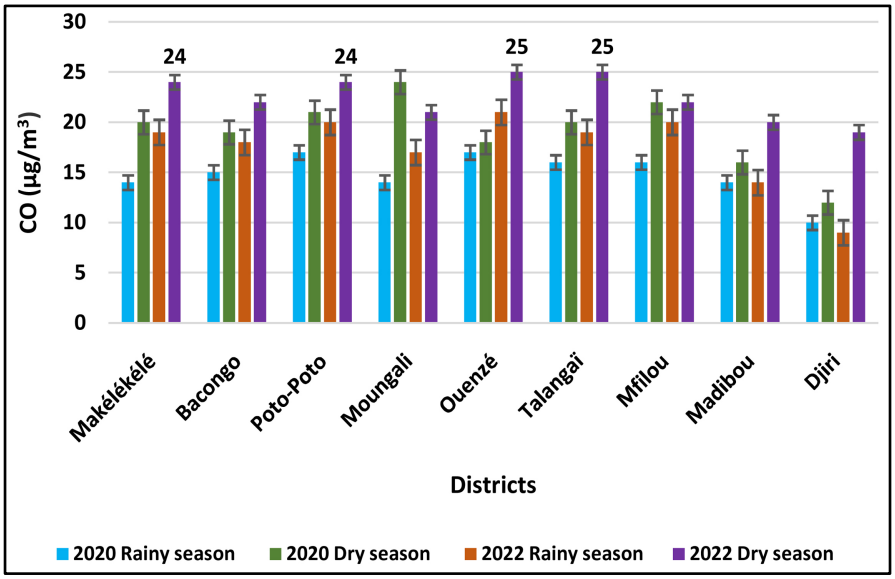

Figure 2. Distribution of CO concentrations by district Legend: S. rain: rainy season; dry season: dry season.

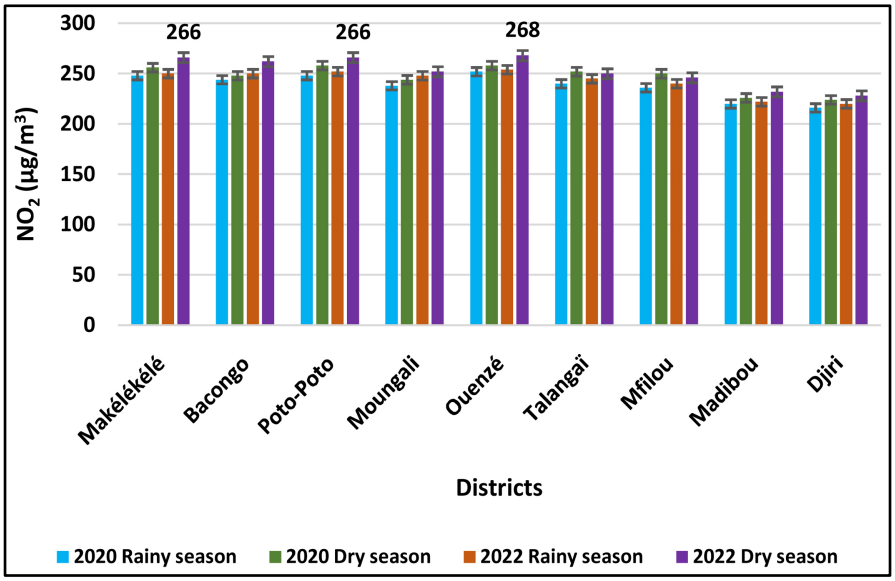

Figure 3. Distribution of NO_2 concentrations by district Legend: S. rain: rainy season; dry season: dry season.

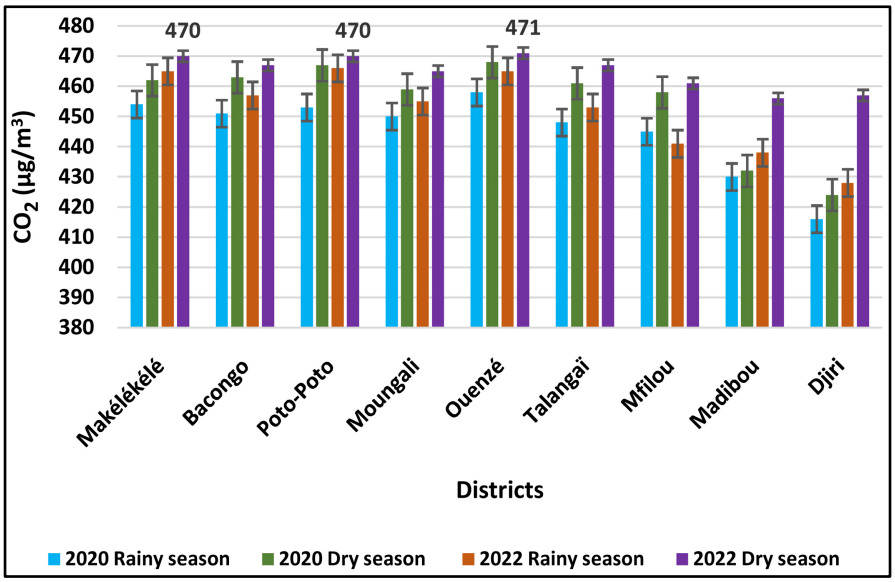

Figure 4. Distribution of CO_2 concentrations by district Legend: S. rain: rainy season; dry season: dry season.

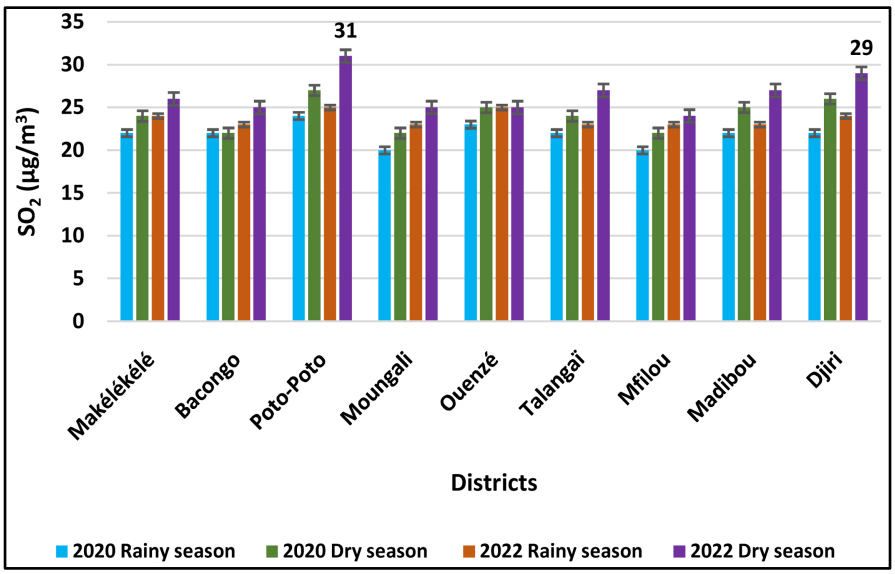

Figure 5. Distribution of SO_2 concentrations by district Legend: S. rain: rainy season; dry season: dry season.

During this study, we noted CO_2 concentrations above WHO standards (2021) in all districts, with peaks in Ouénzé, Potopoto, and Makélékélé. We also noted a sharp increase in CO_2 concentration at Djiri (Figure 4).

With regard to SO_2, concentrations above WHO standards (2021) were also noted in all districts, with peaks in Poto-Poto and Djiri (Figure 5).

5. Discussion

This study, conducted from 2020 to 2022 in the 9 districts of Brazzaville, the capital of the Republic of Congo, focused on a quantitative assessment of the various

automotive pollutants (CO, CO_2, NO_2, and SO_2) and made it possible to assess the quality of air in the agglomerations of Brazzaville. During this study, the concentrations of different pollutants were measured both in the dry season and in the rainy season over the years from 2020 to 2022. In the absence of standards and regulations on air quality in Congo, our results were assessed with reference to the 2021 WHO air quality standards [13]. In this study, the concentrations of CO, CO_2, and NO_2 measured in the nine districts of Brazzaville were all higher than the WHO air quality standards, with peaks observed in Poto-Poto and Ouénzé. The production of these three pollutants is strongly linked to traffic type. Note that the nine districts of Brazzaville are inhabited and active. The concentrations of CO, CO_2, and NO_2 obtained in this study could be justified by the fact that our country, The Republic of Congo, is experiencing strong growth in the car fleet, especially with regard to four-wheeled vehicles. Moreover, due to the phenomena of erosion encountered in Brazzaville, certain areas of this city present difficulties of access, which has favoured the exponential increase in the use of motorcycles (taxi-moto), recognised as major CO emitters at almost 90% [14]. We also note the very important phenomenon of traffic jams during rush hours, but the slower the traffic speed, the more the vehicles emit pollutants. At the same time, the use of old vehicles ("second-hand from Europe") that do not have catalytic converters, the lack of maintenance of these vehicles, and the poor quality of the fuel also accentuate the emission of the said pollutants.

The concentrations of pollutants found in our study were all higher than WHO standards, these results are in agreement with those found by Mama in 2013 in Benin, Nana in 2012 in Burkina Faso [15] [16]. Similarly, we noted in this study high concentrations of SO_2 above WHO standards with a peak of 31 μg/m^3 in Poto-Poto. Our results are in agreement with those reported by [17] in Beirut, they are however different from those obtained by [16] in Benin. This difference could be explained on the one hand, by the fact that SO_2 generally emanates from diesel vehicles, which represent in our country, almost all public transport as well as trucks; on the other hand, by the presence in Poto-Poto of several industries such as FAAKI, SCLOG, BRASCO, and, MAYO, which could also contribute to the emission of these pollutants.

Air pollution has been associated with a variety of health effects, ranging from subclinical outcomes to death. Global estimates of ambient air pollution alone suggest that hundreds of millions of years of healthy life are lost, with the greatest attributable disease burden seen in low- and middle-income countries. The more air pollution they are exposed to, the greater the health impact, especially on people with chronic conditions such as asthma, chronic obstructive pulmonary disease and heart disease, as well as on elderly, children and pregnant women [7]. In Europe, the "ESCAPE project" was set up to study the health effects of long-term exposure to air pollution. The various analyses carried out have made it possible to find a significant association between exposure to suspended particles and mortality from natural causes, cardiovascular morbidity and mortality,

particularly in terms of coronary events and morbidity of the respiratory system [18] [19]. The same results were reported by [10]. Both animal and human epidemiological studies support the idea that atmospheric pollutants cause abnormalities during gametogenesis leading to a decrease in the reproductive capacities of exposed populations. Air quality impacts overall health as well as reproductive function [20], as well as a disruption of sex hormones [21]. At the same time, Yang established an association between air pollution and precocious puberty [22].

In addition, the results of the air analysis revealed that the concentrations of automobile pollutants were higher in 2022 than in 2020, which shows that the level of pollution continues to grow in our country. However, the differences in concentrations observed between the two seasons, with peaks in the dry season, could be explained by the fact that in the rainy season, precipitation causes pollutants to fall to the ground, but also wind currents promote the dispersion of pollutants in the air. While in the dry season the temperature is low, pollutants tend to freeze and accumulate in the air.

6. Conclusion

Air pollution has a negative impact on human health. In this study, concentrations of CO, CO_2, NO_2 and SO_2 are all above the 2005 and 2021 WHO standards for air quality. These results thus make it possible to categorise Brazzaville as a polluted city. This exposes the resident population to the risks of respiratory diseases, cardiovascular disorders, and cancer. This sad reality should challenge the local authorities in order to develop an effective control policy and remedy it. Without this, there will be an increase in morbidity and mortality at the local level.

Recommendations

Several phenomena contribute to the increase in air pollution, and it is clear that in urban areas, car traffic is greatly involved in poor air quality. At the end of this study, the authors can formulate the following recommendations: The Ministry of the Environment should set up a permanent air quality monitoring network, which would make it possible to better manage pollution levels and to decree red zones in real time. The Ministry of Health and Population should promote awareness campaigns and education on the health risks associated with exposure to air pollution. To the government: to widen the road network, which would reduce traffic flows and therefore pollution levels and would also allow diversions to alert zones.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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