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Research Article

Monitoring and Control of Particulate Matter in Urban Area in Douala-Cameroon Town

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This study focused on the content of fine particle air pollution in the city of Douala. Several studies have analyzed pollution problems due to road traffic in Douala, Cameroon. Particle concentration levels are higher in heavy traffic than in light traffic. The population's exposure to air pollution in cities is higher near roads. Several studies have analyzed pollution problems due to road traffic in Douala, Cameroon. In this city, the traffic density at the intersections is indeed higher. Thus, the question is as follows: Are these traffic areas hotspots of increased PM exposure levels? To determine it, four particle size fractions (PM_{10}, $PM_{2.5}$, PM_5, and PM_1) were collected using an "OC300 Gas and Dust Particle Laser Detector" for three months at different traffic locations (roundabouts or/and crossroads). Statistical analysis of the data shows very high concentrations at most measurement sites. PM concentrations at the different measurement sites are around 35.69-68.08 μg m^{-3} for PM1, 50.72-99.13 μg m^{-3} for $PM_{2.5}$, 54.11-111.22 μg m^{-3} for PM_5, and 57.97-119.25 μg m^{-3} for PM_{10}. Exceedances of WHO daily guidelines for $PM_{2.5}$ (45 μg m^{-3}) and PM_{10} (15 μg m^{-3}) were found during the measurement campaign, indicating that crossroads are the pollution hotspots in urban areas. Occupation of the roadsides for various economic activities (painting, restaurants, donut shops, etc.) is common in Cameroon, increasing health risks for people working around the roadside. Thus, crossroad locations are areas where the level of exposure to PM_x is the highest on road traffics.

1. Introduction

Daily life is interconnected to environmental change and air quality [1]. Today, pollution is one of the world's most important issues. In recent years, air quality concerns have become one of the most important problems to be solved for the capital city of Cameroon, Douala. It is located 19 m altitude at sea level and has geographic coordinates, 4°02′53″N and 9°42′15″E. It has a hot and humid climate base of the active Mount Cameroon volcano at an altitude of 4100 m. Douala city covers around 210 km^2 and has a population of around 4.2 million [2].

Particulate refers to solid and colloidal microparticles produced during direct and open combustion. Particulates are one of the pollutants of most concern since they are hazardous. Particulates consist of both organic and inorganic substances. PM is classified as an air pollutant [2, 3]. Fine particulate ($PM_{2.5}$) and coarse particulate (PM_{10}) are

the two most prevalent kinds of particulate matter, with aerodynamic dimensions of 2.5 μm and 10 μm, respectively [3, 4]. With special focus on particulate matter, the secondary PM consists of significant portions of sulfates and nitrates, which are due to chemical transformation of SO_2 and NOx. Of these pollutants, the PM is one of the most critical, responsible for the largest healthy and economic damages, and also affects visibility and weather condition. Fine particles ($PM_{2.5}$) are mainly from combustion sources such as vehicles, diesel engines, and industrial facilities. Coarse particles are directly emitted from activities that distract the soil including travel on roads, construction, mining, open burning, and agricultural operations. Other sources include windblown dust, pollen, salts, brake dust, and tire wear [2, 5–7]. The main causes of ambient air pollution are pollutants that are emitted into the atmosphere by stationary sources like coal-fired power plants and steel mills as well as mobile sources such as cars, trucks, and ships. Burning biomass fuels such as wood, coal, straw, dung, and charcoal in home cook stoves primarily contribute to household air pollution in low-income countries, primarily affecting women and children [8]. Natural gas combustion, wood-burning stoves, fireplaces, incense, candles, aerosol sprays, and volatile cleaning products are all causes of indoor air pollution in high-income countries. Inefficiently ventilated houses with poor design amplify household air pollution [9]. The most well researched aspect of air pollution is particulate matter (PM) that has a number of significant health consequences [10].

Air pollution has variable degrees of a consequence on cardiovascular disease around the world. Air pollution no longer kills as many people from cardiovascular disease as it used to in high-income countries because of the major reduction in pollution carried about by laws, regulations, and technological advances. Air pollution levels in the US have dropped by 70% since the Clean Air Act was adopted in 1970 [11]. On the other hand, pollution is frequently hazardous and is getting worse in some regions in low- and middle-income countries. In many developing countries, the proportion of cardiovascular deaths linked to pollution is much greater than the proportion linked to smoking and other behavioral and metabolic risk factors [12]. Short-term (from hours to days) alterations in $PM_{2.5}$ levels are associated with increased risks of myocardial infarction, stroke, and cardiovascular death [9, 13]. The probability of these events increases by 0.1–1.0% for each transient elevation in $PM_{2.5}$ levels of 10 g/cm^3 [9]. There have also been dose-related increases in risk with nitrogen oxides (NOx) and sulphur oxides (SOx), although not usually with ozone, according to certain studies [14].

Various scientific studies on air quality have proliferated in Africa and throughout the world, thanks to the use of mobile and low cost measurement devices: in Gabon [15], in Senegal [16], in Cameroon [2], and in Sri Lanka [17]. The World Bank's Clean Air Initiative in Sub-Saharan African Cities program is responsible for the first air quality studies in Cameroon. The first studies on PM in Cameroon were those by Antonel and Chowdhury [6], in three cities for 9 days every 24 hours in the dry season. The daily mean concentrations in Bafoussam, Bamenda, and Yaoundé for $PM_{2.5}$ were 67 ± 14, 132 ± 64, and $49 \pm 12\,\mu g{\cdot}m^{-3}$ and for PM_{10} 105 ± 29, 141 ± 107, and $65 \pm 21\,\mu g{\cdot}m^{-3}$, respectively. Studies in West Africa have reported high $PM_{2.5}$ and PM_{10} concentrations in several cities, Accra, Ghana [18]; Dakar, Sénégal [19]; and Bamako, Mali [6]. In addition, measurement of $PM_{2.5}$ concentrations at an urban area in Dakar from June 2008 to May 2009 was greater than the WHO guideline [20]. The mean $PM_{2.5}$ concentration in Nigeria, specifically Enugu State, ranges from 1.67 to 12.16 $\mu g{\cdot}m^{-3}$. In Dakar, Senegal, PM_{10} and $PM_{2.5}$ concentrations range from 120 to 180 $\mu g{\cdot}m^{-3}$ and from 25 to 48 $\mu g{\cdot}m^{-3}$, respectively [21].

African countries have substantial air pollution problems due to the uncontrolled increase in the size of cities, the number of organized urbanized areas, the increase in population trends, manufacturing activities, and the poor road traffic system, and especially the lack of measuring stations [22]. The majority of the car fleet in Douala, one of Cameroon's largest cities, is mainly composed of old vehicles with old and inefficient combustion technologies [23]. Increasingly, in Africa and around the world, mobile measurement devices are becoming more and more common in air quality research, due to their ease of use, low cost, and light weight [2, 24, 25]. In this study, OC-300 Gas and dust particle detector were used to detect particles in air, for 04 particle channels: 1.0 μm, 2.5 μm, 5 μm, and 10 μm [2].

The objective of this work is to get an idea of the level of fine particles in the city of Douala and then compare the concentration levels with the Cameroonian air quality standards. Data were also analyzed with Statistical Package for Social Sciences (SPSS) version 22 and Microsoft Excel.

2. Materials and Methods

2.1. Study Area. This study was conducted in a fast-growing city, Douala situated in Littoral region of Cameroon (4°02′53″N and 9°42′15″E, 19 m above the sea) (Figure 1). Douala is a coastal city located at the bottom of the Gulf of Guinea which shares almost 65 km of coastline with the Atlantic Ocean. It has a hot and humid climate base of the active Mount Cameroon volcano at an altitude of 4100 m; however, Douala city covers around 210 km^2 and has a population of around 4.0 million in 2020 [2]. Table 1 presents the different measurement sites and their geographical coordinates.

2.2. Air Pollution Campaign. In order to quantify the pollution levels in our study area, we used the roadside measurement method, which makes it possible to measure emissions in a hot spot (road) and over a given period. Thus, our data collection campaign took place from January 6 to February 26, 2023, in the city of Douala. The data were measured at each intersection on a daily basis throughout this period. Data collection was therefore carried out using two devices: the laser dust particle detector and the air quality analyzer; all fixed on a 1.50 m bracket and took place from 07:00 to 20:00 (Figure 2). Data

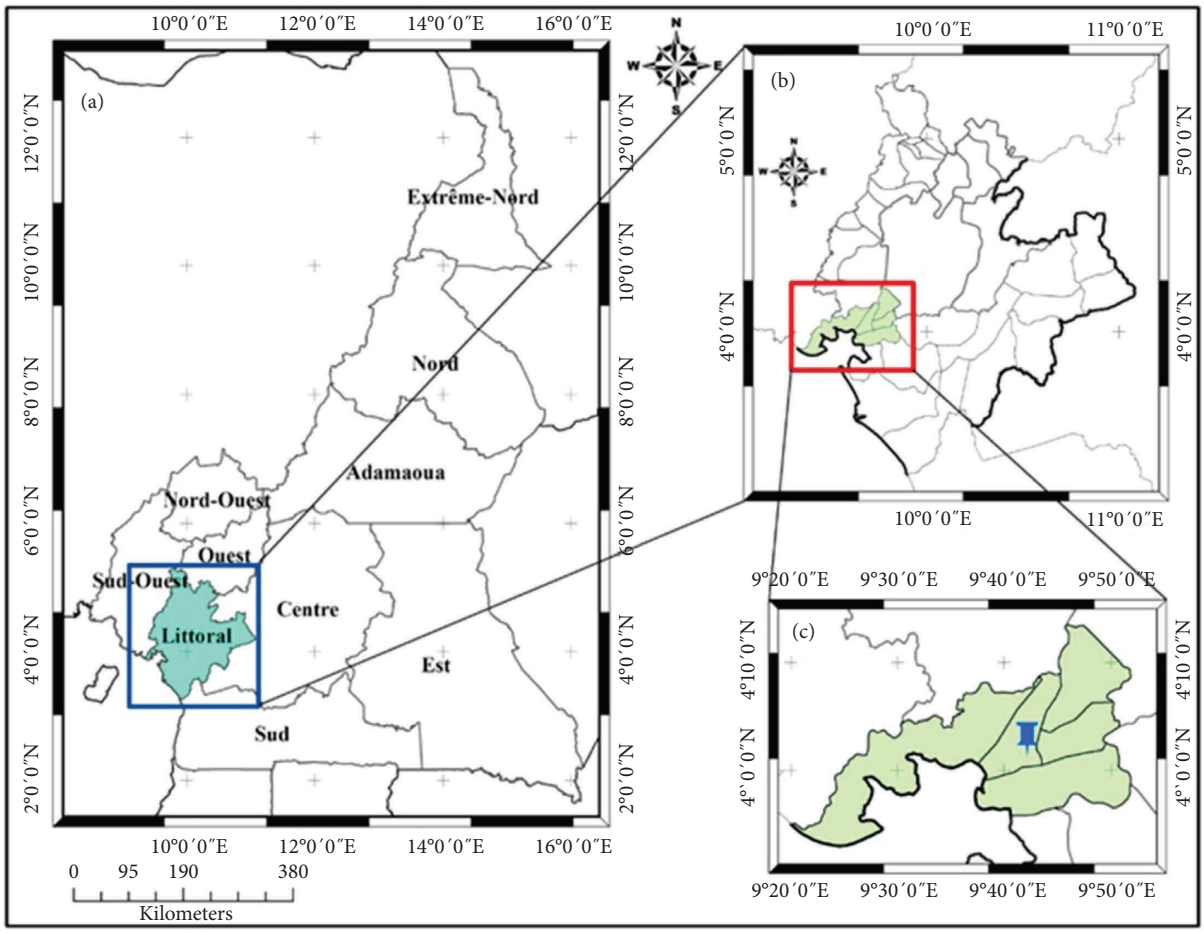

Figure 1: Study area.

Table 1: Description of measurement sites.

Measurement sites	Geographic position
Rond Point Deido	4°3′50.472″N; 9°42′23.649″E
Douche Akwa	4°2′34.374″N; 9°42′10.778″E
Tradex Ndokotti	4°2′37.811″N; 9°44′35.364″E
Marche Central	4°2′12.138″N; 9°42′21.236″E
PK14	4°4′44.216″N; 9°47′35.297″E
Tradex Yassa	4°0′1.588″N; 9°48′19.294″E
Carrefour Agip	4°5′3.012″N; 9°43′11.445″E
Marche Bonamoussadi	4°5′32.846″N; 9°44′15.414″E

collection was carried out manually (air quality analyzer) during regular time intervals (30 min) for a daily total of 26 data. On the other hand; the data were recorded by the device (OC-300 Gas and dust particle laser detector) at the rate of one data (average of the measurements) per minute for a total of 780 data per working day. The data were then extracted using a computer in the form of an Excel spreadsheet file. Once the data have been collected, these, respectively, underwent statistical preprocessing using the Excel software which allowed us to calculate the average concentrations of pollutants in each intersection during the entire period of fieldwork and thus to group its data by slice hourly. Then, we carried out a statistical processing using the statistical analysis software SPSS which allowed us to quantify the average pollution peaks of each intersection according to the time slots.

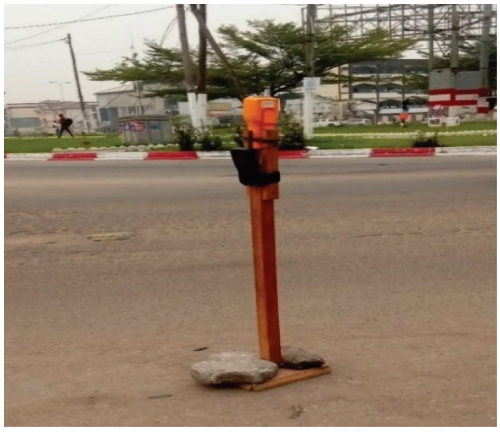

Figure 2: OC-300 Gas and dust particle laser detector in a measurement point during the data campaign.

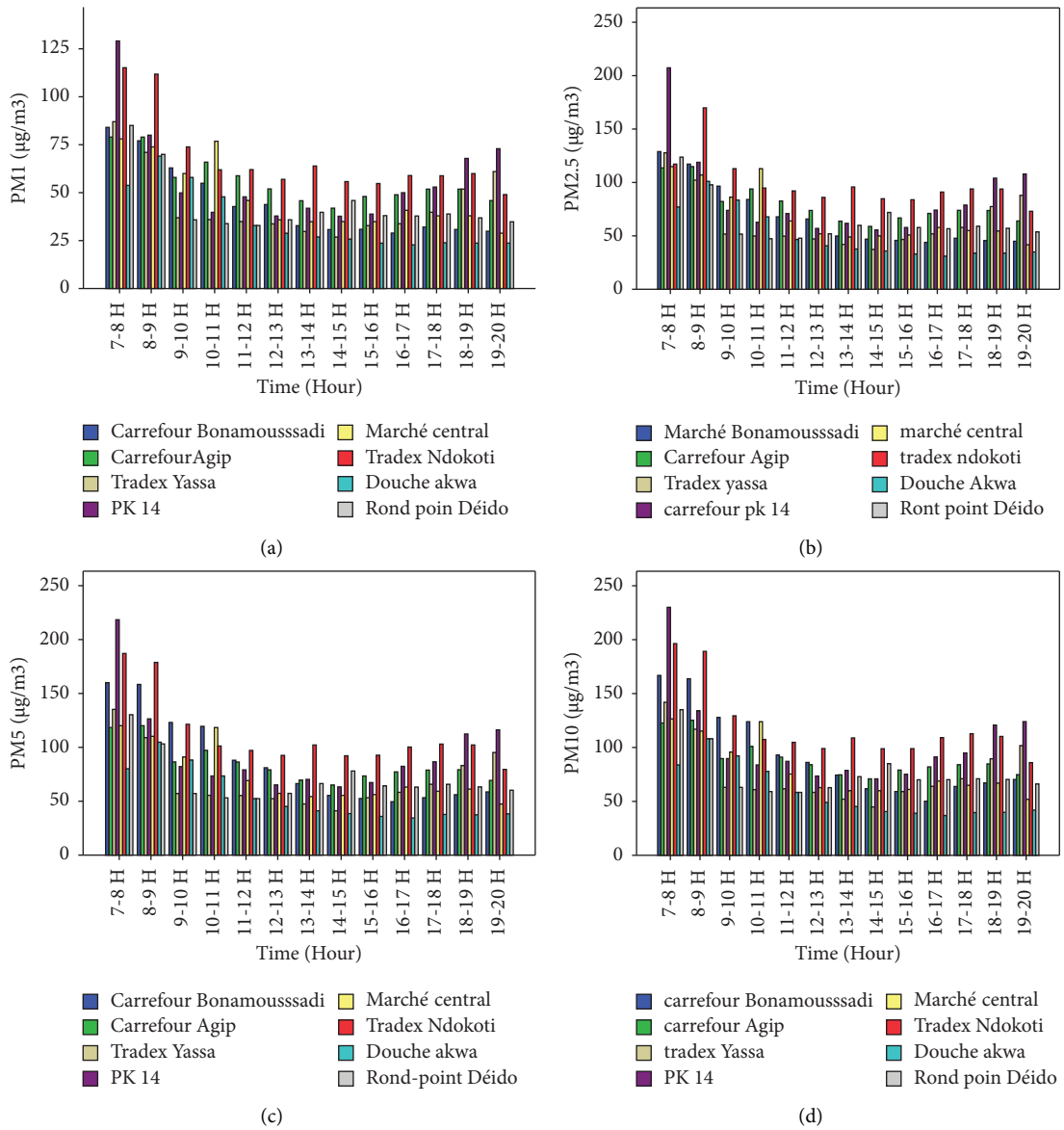

Figure 3: Hourly variation in the concentrations of particulate matter at different measurement sites: (a) PM_1; (b) $PM_{2.5}$; (c) PM_5; (d) PM_{10}.

3. Results and Discussion

3.1. Hourly Variation of PM Concentrations in Different Measurement Sites. Figure 3 shows the hourly variation in the concentrations of material particles at the different measurement sites. For PM_1, the concentrations vary between 24 and 127 $\mu g{\cdot}m^{-3}$ (Figure 3(a)). $PM_{2.5}$ has concentrations that range between 44 and 210 $\mu g{\cdot}m^{-3}$ (Figure 3(b)). PM_5 and PM_{10} are, respectively, between 48–240 $\mu g{\cdot}m^{-3}$ and 50–240 $\mu g{\cdot}m^{-3}$. We find that the concentrations are very high between 07–09 am and 4–8 pm (Figure 3). These different time slots are, respectively, the morning and evening peak hours, which correspond to the period of leaving and the period of returning home for different workers. Several in the city of Douala show that during these periods of the day, the concentration levels are very high. Some measurement sites such as PK14 and Carrefour Ndokotti are the points of high concentration (Figure 3).

3.2. Average Variation in PM Concentrations at Different Measurement Sites. Figure 4 shows the average variations in the concentrations of material particles on the different measurement sites. The measurement points with high PM_1 pollution levels are mainly Tradex Ndokoti, Agip crossroads, Bonamousadi, PK 14, and Central Market with concentrations of 68.08 $\mu g{\cdot}m^{-3}$, 56.03 $\mu g{\cdot}m^{-3}$, 44.87 $\mu g{\cdot}m^{-3}$, 57.46 $\mu g{\cdot}m^{-3}$, and 47.46 $\mu g{\cdot}m^{-3}$, respectively (Figure 1(a)). As for $PM_{2.5}$, the concentrations are between 50.72 and 99.13 $\mu g{\cdot}m^{-3}$; as shown in Figure 3(a), the $PM_{2.5}$ concentrations are higher than the

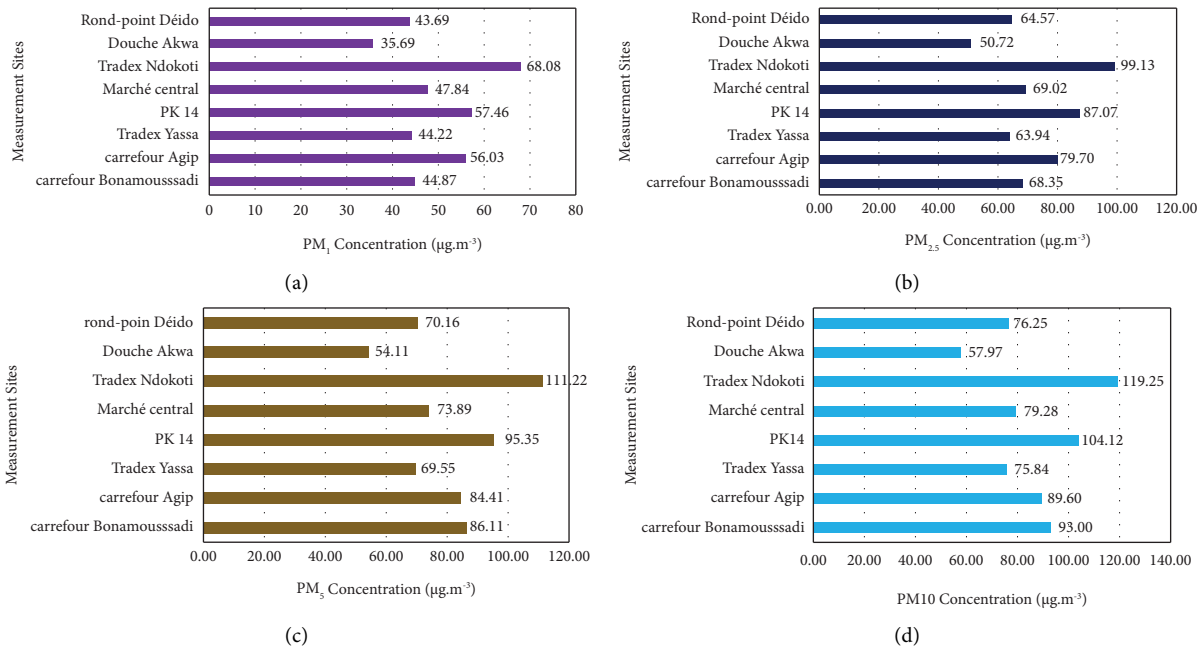

Figure 4: Average variation in PM concentrations at different measurement sites.

WHO guidelines which are located at $15\,\mu g{\cdot}m^{-3}$ [26]. Figure 3(a) shows that PM_5 concentrations are between 54.11 and $111.22\,\mu g{\cdot}m^{-3}$. For PM_{10}, the concentrations are between 57.97 and $119.25\,\mu g{\cdot}m^{-3}$ (Figure 1(d)); the PM_{10} concentrations are higher than the WHO standards which are located at $45\,\mu g{\cdot}m^{-3}$ [26].

We note in this study that the sites of measurements have high pollution due to the strong density of the population and have major roads heavily used as well as important points of agglomerations (PK 14, Carrefour Ndokotti, and Carrefour Agip). The measurement sites with low pollution rates are those of Akwa, Deido Roundabout, Central Market; these are neighborhoods marked by the strong presence of business offices with relatively low population densities and reduced road traffic. In addition, the presence of administrative buildings in this area of the city makes it possible to regulate road traffic and the quality of vehicles, thus reducing the rate of particles emitted. The average concentrations of the various particles are above the level recommended by the WHO, in particular $PM_{2.5}$ and PM_{10}, whose recommended values are, respectively, $15\,\mu g{\cdot}m^{-3}$ and $45\,\mu g{\cdot}m^{-3}$. However, some measurement points reveal values indicating interesting intermediate pollution targets [26]. This is target 2 for measurement sites such as Douche Akwa, Rond-point Deido, Central Market and intermediate target 1 for sites such as Tradex Ndokotti, Carrefour Agip, Bonamoussadi, and PK14. This study is in agreement with the work of Ngo et al. [15], which shows that air pollution is a social phenomenon because the measurement sites located in poor neighborhoods are much polluted compared to those in rich neighborhoods.

4. Conclusion

In this study, we used a portable, easy to use, and easily transportable device to measure four particle sizes in the air in urban areas including PM_{10}, PM_5, $PM_{2.5}$, and PM_1. We have found that pollution levels are higher than those set by the World Health Organization. We also find that intersections represent urban pollution hotspots [27, 28]. In the present study, the authors found that distance to road, traffic density, and pollutants measure are the usual methods to characterize the exposure to traffic-related air and its consequences on respiratory health. No study mentioned the situation about specifically populations around the roundabouts. But the situation in Africa's cities is different regarding the urbanization and the enthusiasm of population to settle along high traffic road and roundabouts. The authors suggest that it would be very useful if research focused on the populations living around the roundabouts in order to determine their possible over exposure to air pollution linked to traffic.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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