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Road traffic-induced particle matter dispersion in a calm wind environment at the main roundabout in Douala, central Africa

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ABSTRACT

Introduction: Road traffic emissions are among the most significant sources of pollution in Douala, Cameroon's economic town, alongside industrial operations. The morning and the evening are two times of the day when traffic is heavier and the winds are also at their calmest. The majority of the non-exhaust Particulate Matters (PMs) produced by autos is re-suspended road contaminants. The purpose of this research is to estimate fine particle dispersion in conditions of calm winds.
Materials and methods: In one of Douala's roundabouts, the Gaussian Plume model is employed to calculate the PM concentration under calm winds conditions. Different vehicle classes (HDV: Heavy Duty Vehicles, LDV: Light Duty Vehicles, PC: Passenger Cars) are used to figure out the amount of PMs they produce. Measurements of ambient fine particle concentrations are made with the OC-300 laser dust particle detector.
Results: The results made it possible to compare actual measurements of $PM_{2.5}$, PM_{10} (300±150 μg/m^3 and 650±150 μg/m^3, respectively) with simulated values ($PM_{2.5}$, PM_{10}: 310 μg/m^3 and 631 μg/m^3, respectively). The difference between in-situ and computed values can range from 10 to 132 μg/m^3. From 6 to 10 AM, the population's exposure to PM pollution is more severe. It has also been demonstrated that there is a significant association between traffic flow and PM Concentration during the dry season (R^2=0.921). With increased traffic flow intensity, particle concentration levels rise.
Conclusion: The concentration threshold stays above the World Health Organization (WHO) limits regardless of the approach. Furthermore, this paper provides important information about Douala's pollution levels.

Introduction

Particulate Matter (PM) is a complex mixture of solid and liquid particles, including dust, dirt, soot, smoke and liquid droplets [1]. The World Health Organization (WHO) has documented the negative effects of air pollution, particularly in metropolitan areas, on human health, and other researchers have documented the regional and

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worldwide repercussions of poor air quality [2, 3]. This collection of data serves as a guide for policymakers who want to take steps to clean up the environment. The majority of these research looked at background pollution levels, or levels of pollutants measured at locations far from any known sources (industrial or automotive). This background pollution also results from long distance transports from the dispersion of pollutants emitted locally heating, road traffic,... [4–6].

In West African countries, Saharan dust is a major contributor to local background pollution. However, the source is unrelated to local economic activity, and the consequences for air quality and human health have received far less attention [7, 8]. Cities in Sub-Saharan Africa (SSA) and other emerging regions have the highest fine particle concentrations on the planet [9]. The dearth of studies in SSA could be explained mostly by the limited data emanating from the region.

In terms of health effects, several epidemiological studies have found that an increase in bient levels of atmospheric particles is linked to both short-term (acute punctual exposure) and long-term (chronic exposure) effects on morbidity and mortality, particularly fine particles (i.e. $PM_{2.5}$), which can more easily enter the lungs and thus are more likely to increase the incidence of respiratory and cardiovascular disease [10, 11]. These small particles can transport hazardous and carcinogenic substances, such as Polycyclic Aromatic Hydrocarbons (PAHs), metals, and soot carbon, that can overcome the physiological barrier and reach the blood vessels and important organs, even at low quantities [12]. In terms of health effects, several epidemiological studies have found that an increase in ambient levels of atmospheric particles is linked to both short-term (acute punctual exposure) and long-term (chronic exposure) effects on morbidity and mortality, particularly fine particles (i.e. $PM_{2.5}$), which can more easily enter the lungs and thus are more likely to increase the incidence of respiratory and cardiovascular disease [10, 11]. These negative effects of PM on human health are particularly pronounced in urban areas because of the high population density, intense anthropogenic activities, and the proximity of local sources of combustion (e.g. road traffic) [13].

There is an urgent need for the comprehensive studies on this scourge. Till date, several reported research works are focused on identification and categorization of pollutants sources, determination of pollutants concentrations and their mode of dispersion in the air. Therefore, with the aim of assessing the effect of these pollutants on the population, in respect of World Health Organization (WHO) guides values, the steady state Gaussian plume dispersion models are applied with calm wind condition to assess air pollution concentrations in Douala city. The Gaussian plume dispersion model is utilized to come up with a realistic description of dispersion because of its simplicity, ease of usage, and reliability. The model represents an analytical solution to the diffusion equation for concentrations of non-reactive contaminants moving through wind-induced advection [14]. The meteorological circumstances (values of wind speed and direction, temperature, and atmospheric stability) fed into the Gaussian plume as inputs are connected to the emission description within the study area.

Due to higher traffic activity, which occurs generally in morning and evening, and calm meteorology made the surrounding air quality worst. The calm wind condition in association with cool air, limit the dispersion of traffic emission during morning rush hour [15, 16]. Using models, different scenarios can be tested in order to reduce or optimize pollutants emissions. These modeling studies can then provide the base to the scientists, needed to develop effective environmental public policies. For a good modeling of the atmospheric dispersion of PMs, it is important to distinguish the spatio-temporal scales in which the consequences of this phenomenon are manifested. It's especially about the scale: the global scale (global) with global warming and the destruction of the ozone layer, the regional (continental) scale with hurricanes and cyclones, the local scale (country) with the degradation of the air quality which is the root cause of public health problems [3, 17].

The objective of this study is to compute PM concentration due to road traffic under calm wind conditions. Based on the main source of fine particles (traffic flow), the PM's emission factor estimation was estimated, for all categories of vehicles. Secondly, to estimate the PMs concentration for the calm wind condition of the city of Douala, in the tropics, which occurs frequently in the morning and evening [18]. Further, to calculate the emissions load of PMs by taking into account parameters of influences.

Materials and methods

Study area

Douala, the economic capital of Cameroon is a city recognized for its growth. This city listed among the most popular cities in Central Africa, with several activities carried out within it, one of the main economic activity is road traffic and maritime. Further, the transfer of goods to other countries of the sub-regions (Chad, Central African Republic, and Republic of the Congo) with its innumerable heavy-duty trucks significantly increases the vehicular emission in the local vicinity. 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 is located 19m 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 is covers around 210 km^2 and has a population of around 4.0 million in 2020 [19]. The Deido roundabout is one of the most used intersections for road traffic in the city of Douala (Fig. 1), it is the crossroad connecting several districts of the city, indicating high density and emission intensive intersection.

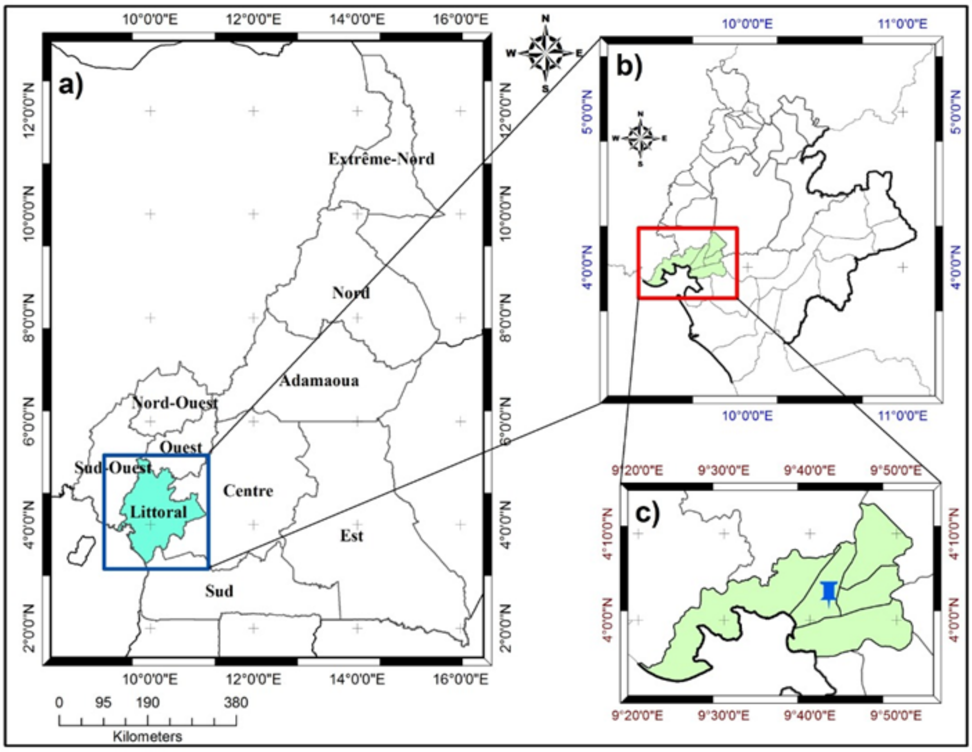


Fig. 1. Map of Cameroon illustrating the Deido roundabout in the city of Douala, Cameroon

Therefore, road traffic at this intersection was considered for estimation of dispersion of fine particles due to road traffic turbulence created by the movement of vehicles in calm wind conditions (wind speed lower than 1 m/s). Real-time air quality monitoring instruments was used in this study, for analysis of air quality in the study area, which is the case more developing countries [20, 21]. PM_{10} and $PM_{2.5}$ ground level concentration (at 1.5 m from the ground) were monitored at the Deido roundabout, a highly circulated square roads in the city (4°3’52’’N and 9°42’25’’E). In order to estimate the level of pollution during this season, a fixed point of data monitoring at the intersection road was suggested all across the dry season, specifically in March 2021, for two consecutive days. Public and private transport both cars and two wheelers, may directly influence the automatic PM measurements using OC-300. The OC-300 Laser dust particle detector is a direct reading and mobile, aerosol monitoring device, which allows simultaneously measurement of four different sizes fine particles concentrations 10µm, 5 µm, 2.5 µm and 1.0 µm, respectively [22]. These types of instruments are also developed to have low cost devices that can measure air quality data with acceptable accuracy. From this point of view, a hybrid measurement kit for Real-time air quality monitoring was constructed in Dakar, Senegal [21]. Concerning PM detectors, it has been found that the laser scattering is the best technique for the precise detection of PMs [23].

Meteorology and traffic flow

Douala is a city on Cameroon's coast that is about 5 meters above sea level and close to the Atlantic ocean. Weather data for the Douala P30 Airport station (WMO station number 64910, latitude 04° 03'16" N, longitude 09° 43'53" E, altitude 5 m above sea level) were received from the Cameroon Meteorological Department. The temperature ranged from 20 to 40 °C, with an average of 29 °C and an 85% relative humidity. Between 06-10 a.m., the calm wind was seen by roughly 29.70 percent, as shown in Fig. 2a (because adequate data was available for the selected period 2004-2009) [18]. The prevailing wind direction was south-west, most likely due to the Atlantic's closeness. In Douala, the plotted wind rose during the month of May, 2020, showing more than 50% quiet wind. Fig. 2b shows a view of the wind direction and speed in the city.

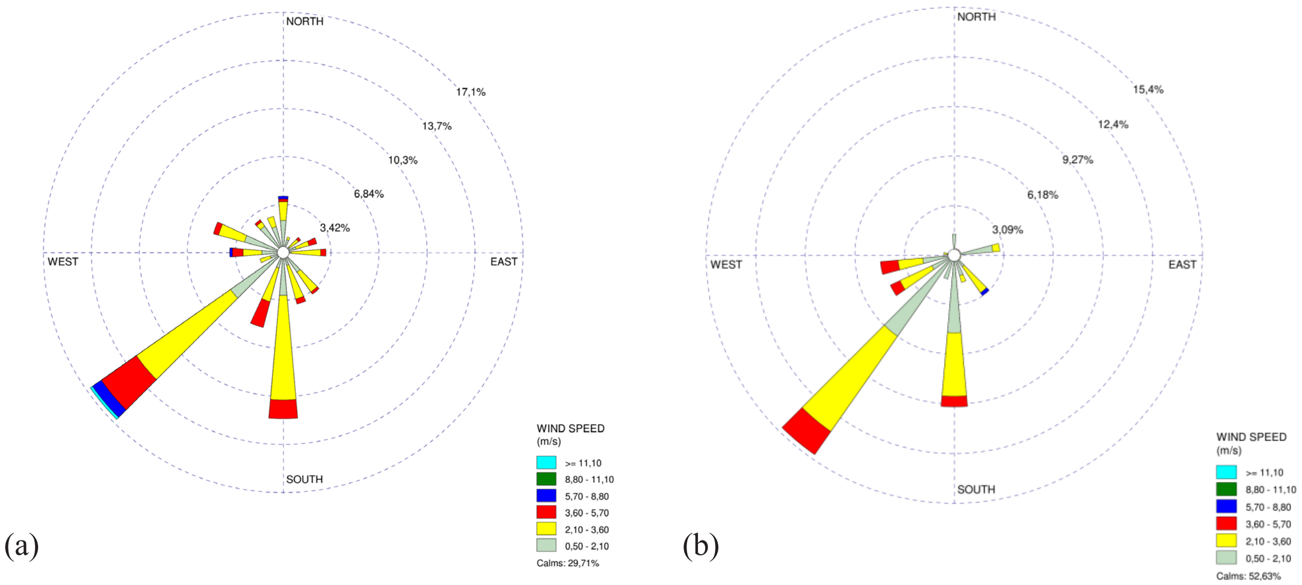
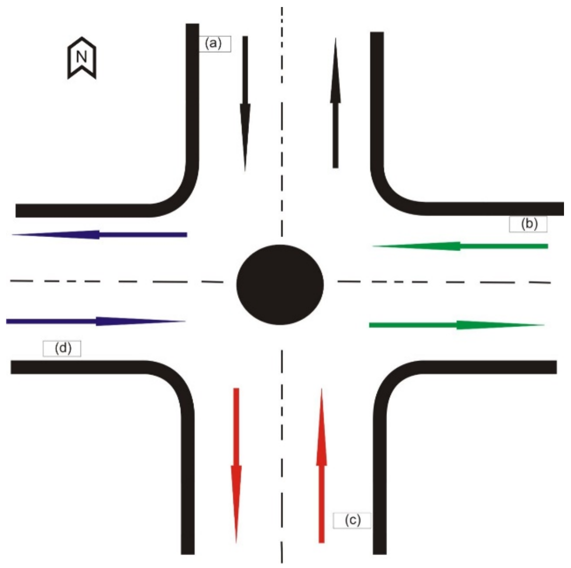


Fig. 2. a) Wind rose at Douala 2004-2009, and b) wind rose at Douala May 2020

The city of Douala's road traffic is diverse, with trucks, tanks, vans, taxis, buses, two- and three-wheel vehicles, and other types of vehicles sharing the road. Vehicles are divided into three categories for our research: Heavy Duty Vehicles (HDV), Light Duty Vehicles (LDV), and Passenger Cars (PC). The volume, form, and weight of vehicles are used to classify them. Vehicles weighing more than 7.5 tons are classified as HDV, 2.5 tons are classified as LDV, and less than 1.4 tons are classified as PC.

The different categories of cars were counted at the Deido roundabout crossroads by taking into account all vehicles crossing the intersection in all directions. The traffic figure is based on a 2008 research of mobility in Douala, which was published in the literature [24]. Fig. 3 shows a diagram of this intersection. The traffic counts were done in both directions for each lane. The traffic count was conducted from 6 to 10 a.m., when the wind is typically calm and traffic density is at its highest.

The traffic flow in Deido roundabout resembling other cities of Douala is heterogeneous in nature, having different type of vehicles present at the same time in the road. Table1 summarizes the traffic flow during four hours: 6-10 AM. Bicycles and other non-engine locomotives are included under "Others". The histogram (Fig. 4) shown that road traffic is dominated by PCs. The higher share of PCs indicating that peak period (6-10 AM) of traffic flow, PCs (taxi, two-wheeled motorcycles) are the main transport mode used by Douala community. The highest traffic count was observed for period of 7-8 AM, which is time of office, school and workers to move for their respective work place (Fig. 5). All vehicle groups taken together, the average daily traffic can be calculated to be roughly 2,422 vehicles. This number falls under the Low-ADT category (Low Average Daily Traffic) [25].



(a) Deido roundabout towards Bessengue / Bessengue towards the Deido

(b) Deido roundabout towards Akwa / Akwa towards Deido roundabout

(c) Deido roundabout towards Bonaberie / Bonaberie to the Deido roundabout

(d) Deido roundabout towards Akwa Nord / Akwa Nord to the Deido roundabout

Fig. 3. Simplified image of the Deido roundabout

Table 1. Summary of the different categories of vehicle counts corresponding to the hours of the day based on CUD data, 2008

	Categories of vehicles			
Time (h)	LDV	PC	HDV	Others
6 - 7 AM	1407	7498	209	80
7- 8 AM	2852	10616	266	90
8 - 9 AM	3034	8611	311	32
9 - 10 AM	2369	7641	358	31

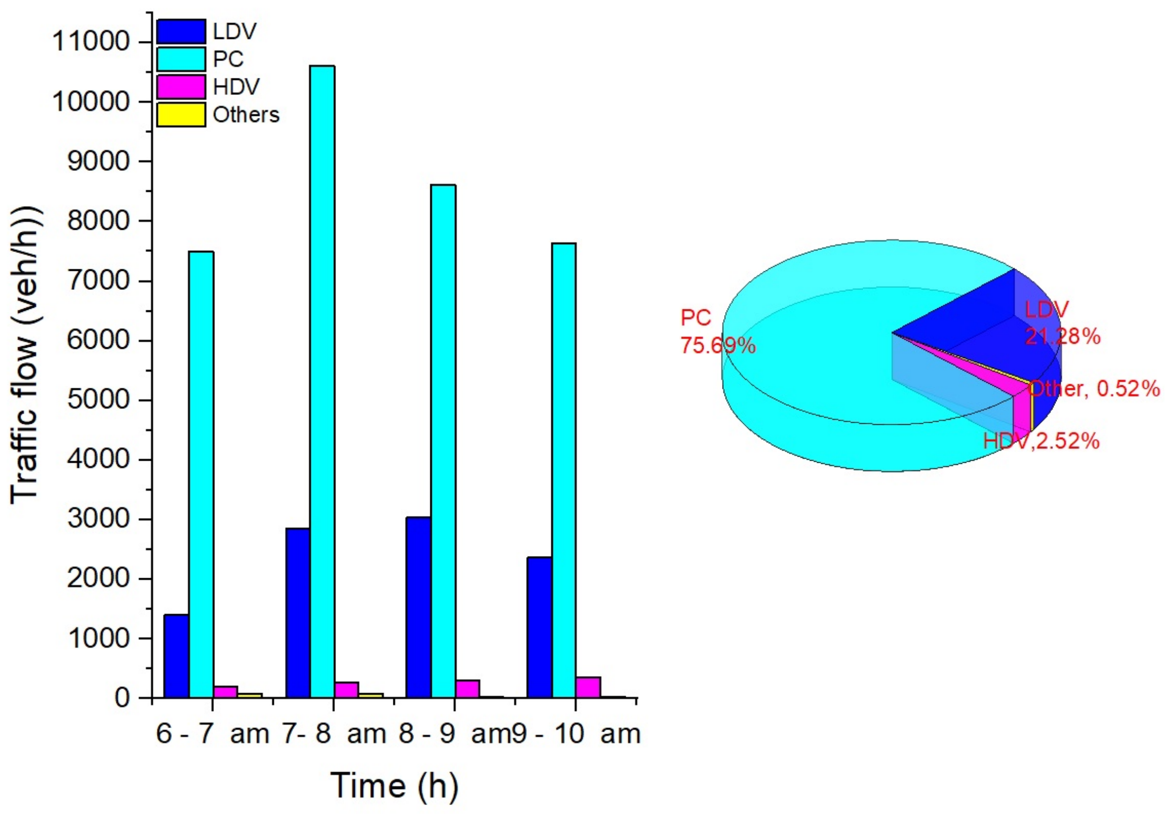


Fig. 4. Traffic flow of the different categories of vehicles at the roundabout Deido between 6-10 AM

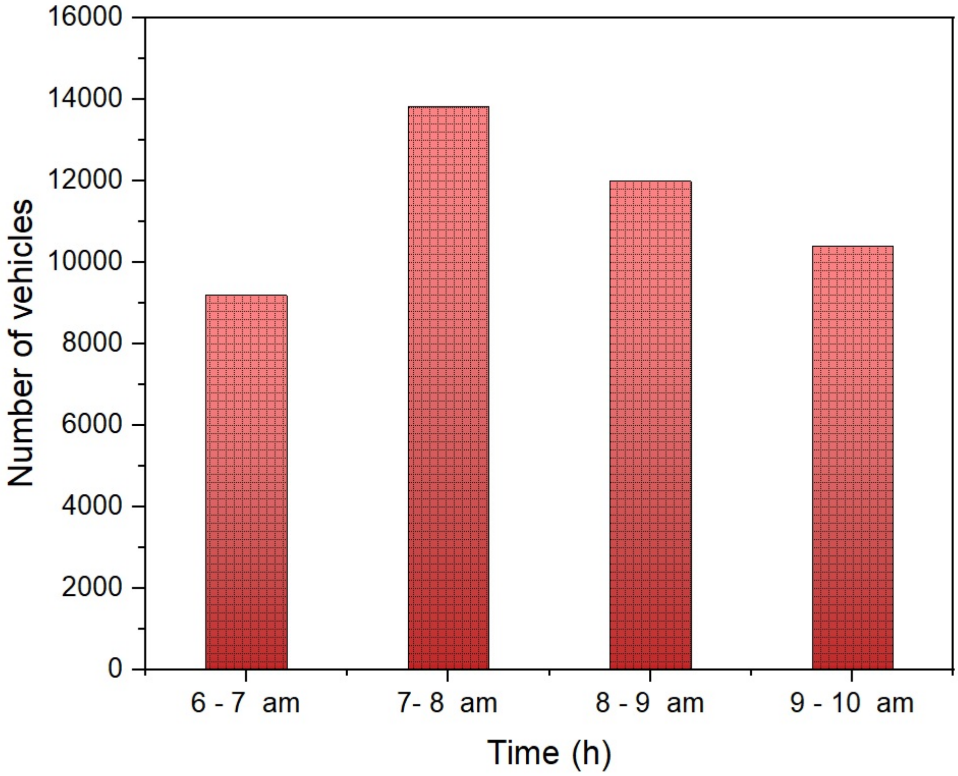


Fig. 5. Vehicle counts at the Deido roundabout between 6–10 AM

Traffic activity and emission

A number of studies, in developed and developing countries, apportioning the sources of air pollution put the transport sector atop, both from direct exhaust and indirect road dust [5, 26–28]. The growing number of vehicles on the road (two and three wheelers, passenger cars, buses, and lorries) increases the amount of pollution produced. Vehicle travels are considered per mode or category in this activity. The histogram in Fig. 5 depicts the activity trends of the various groups of vehicles. A surge of traffic was noted between the hours of 7 and 8 a.m., indicating high road traffic. In general, the higher the traffic density, the more fine particles in suspension, which adversely raises pollution levels [29].

The general methodological principle for calculating emissions is based on the basic Eq. 1.

$$Q = EF \times A \tag{1}$$

Where Q is the emission, generally expressed in mass (g), A is the activity of the transmitters (generally expressed in vehicles.km), EF is the emission factor (g.(veh,km)$^{-1}$). For the estimation of emission factor from the re-suspension of PMs due to road traffic several variables required, vehicle size or category is one of the main parameters that consider in the equation of emission factor (the emission factor is proportional to the category of the vehicle even if it is assumed that the vehicles will have the same travel speed). Several empirical expressions are reported in the literature. For example, researchers of two study applied Eq. 2 and Eq. 3 to estimate emission factor, it consider specific parameters such as vehicle weight and silt loading, respectively.

$$EF_i = k_\alpha \left(sL\right)^{0.91} \left(W_i\right)^{1.02} \tag{2}$$

$$EF_i = k_\alpha \left(sL\right)^{0.91} \left(W_i\right)^{1.02} \left(1 - \frac{P}{4N}\right) \tag{3}$$

Eq. 2 and 3 are almost identical, the only difference is that, Eq. 3 accounts the rainfall, greatly influences the emission load.

Where: α represents the different types of particles according to their aerodynamic radius (PM_{10}, $PM_{2.5}$ $etc....$).

EF_i represents the emission factor of the particle, k_α represents the default size of the particle α. Generally, the size of particles was $k_{PM_{10}} = 0.62\mu g.(veh.km)^{-1}$ and $k_{PM_{2.5}} = 0.15$ $\mu g.(veh.km)^{-1}$ [30], sL: is the silt loading and according to the report by the US EPA (United States Environmental Protection Agency, 2011,Chap.5), this term refers to the mass of sedimentary material of size equal to or less than 75 micrometers of physical diameter per unit area of a route considered. The total amount of the dust on the road surface is made up of different loose materials which can be collected through a sweep and vacuum system. W represents the weight of each vehicle category, P is the number of days during which the precipitation was greater than 0.254 mm over a given period (months, days, hours), N is the number of days in the period considered (year, season, month),$\boldsymbol{i}$ represents vehicle category (HDV,LDV and PC).

Air quality modeling

Air quality modeling is a complex phenomenon which involves studying any parameters that can influence the dispersion of fine particles (wind speed, precipitation, and the temperature inversion phenomenon). In this study a Gaussian model adapted for the calm wind conditions. Several studies have already been carried out as part of the dispersion of particles in low wind conditions [31, 32]. Assuming that the average wind speed is less than a certain threshold (0.1 m/s), the horizontal spread of the plume covers 360°; thus proposed empirical Eq. 4. It takes into account the contribution of the vertical and horizontal component of the plume of the linear source [33].

$$C_{lw}(x,y,z) = \sqrt{\frac{2}{\pi}}\frac{Q\times F(z)\times\theta_s}{2\pi u\sigma_z} \tag{4}$$

Where: $F(z) = \exp\left(-\frac{(h_s - z)}{2\sigma_z^2}\right) + \exp\left(-\frac{(h_s + z)}{2\sigma_z^2}\right)$]and $\theta_s = \tan^{-1}\left(\frac{y_2 - y_1}{x}\right) + \tan^{-1}\left(\frac{y - y_1}{x}\right)$.

Where C_{lw} (x,y,z) is the concentration of pollutants at the location of the receptor (x, y, z) in μg/m^3, x is the distance from the source along the wind direction in m, y and z are the wind distances along of the transversal with respect to the midline of the plume in m, Q is the amount of emission of fine particles in (g or μg), θ_s is the angle which connects the linear source from the receiver in degree, u is the wind speed in m/s, σ_z is the standard deviation representing the dispersion of pollutants in the wind direction in urban area. The present study considers only the standard deviations that belong to the interval corresponding to calm winds (class A or A-B), it is calculated here with the setting of Briggs with the mathematical expression [34]:

$$\sigma_z(z) = \alpha x(1+\beta x)^\gamma = 0.24x\sqrt{1+0.001x} \tag{5}$$

Where α, β and γare constants which depend on the Pasquill stability class.

Results and discussion

Emission factor

Using Eq. 3, which is an adapted equation proposed by someresearchers used to estimate the emission factors of particles as a function of the different vehicle categories and also according to the season in our case study. The $PM_{2.5}$ and PM_{10} emission factors for each vehicle type are calculated using Eq. 3 and reported in Table 2. The analysis shows that the emission factor is proportional to the vehicle's weight, hence the emission factor is higher when the particle size is larger.

Table 2. The emission factors by vehicle category and by particle size µg/veh.km

Vehicle categories	PM_{10}	$PM_{2.5}$
PC	0.038	0.009
LDV	0.046	0.015
HDV	0.19	0.049

Table 3. Emission load of PM_{10} and $PM_{2.5}$ as a function of the particle size (μg)

Vehicle categories	PM_{10}	$PM_{2.5}$
PC	1305.56	309.21
LDV	618.36	144.93
HDV	217.36	56.05

Estimation of fine particulate matters emission load

By combining the Eqs. 1 and 3, Eq. 6 was obtained.

$$Q_i = A_i \times k_\alpha \left(sL\right)^{0.91} \left(W_i\right)^{1.02} \left(1 - \frac{P}{4N}\right) \quad (6)$$

Where, i represent the different categories of vehicles. More explicitly according to the vehicle category emission load was estimated by applying Eqs. 7, 8 and 9.

$$Q_{HDV} = A_{HDV} \times k_\alpha \left(sL\right)^{0.91} \left(W_{HDV}\right)^{1.02} \left(1 - \frac{P}{4N}\right) \quad (7)$$

$$Q_{LDV} = A_{LDV} \times k_\alpha \left(sL\right)^{0.91} \left(W_{LDV}\right)^{1.02} \left(1 - \frac{P}{4N}\right) \quad (8)$$

$$Q_{PC} = A_{PC} \times k_\alpha \left(sL\right)^{0.91} \left(W_{PC}\right)^{1.02} \left(1 - \frac{P}{4N}\right) \quad (9)$$

The parameter α, depend on the size of the particle that is considered (PM_{10} or $PM_{2.5}$).

For the purposes of this study, a period of 6 months, or 181 days, will be taken into account, which corresponds to the dry season from January 2008 to June 2008. This is based on information provided by the Douala P30 Airport station (WMO station number 64910, latitude 04° 03'16" N, longitude 09° 43'53" E, altitude 5m above sea level). We notice that during the period of the six months, there are approximately 32 days with precipitation totaling more than 0.254 mm: P=32 days and N=181 days. One of the key variables used to compute dust re-suspension is the silt load (sL). The default setting for the parameter sL corresponds to a daily traffic density of roughly 0.40 g/m^2 . From Eqs. 8, 9, 10 emission load was estimated for $PM_{2.5}$ and PM_{10}, reported in the Table 3.

As shown in Table 3, the emission load is directly proportional to the vehicle activity. Because the activity of HDV is very low compared to PC, the emission load is inversely related to the vehicle weight. As a result, the emission load falls even though the overall emission is proportionate to the vehicle category (Fig. 4). HDV traffic is lower between 6 and 10 a.m. (morning hours), whereas PC (taxis, motorbikes with two wheels) traffic is highest between 6 and 10 a.m., because it is the most convenient mode of transportation in Douala. This justifies the fact that PC has a much higher emission load than other categories. Other categories such as: LDV (large bus, minibus); HDV (two-axle trucks, trucks with more than two axles, semi-trailer) are less in count during this period, which justifies the various results in Table 3. Fig. 6 shows the particle emission load of PM_{10} and $PM_{2.5}$ depending on the vehicular activity in study area.

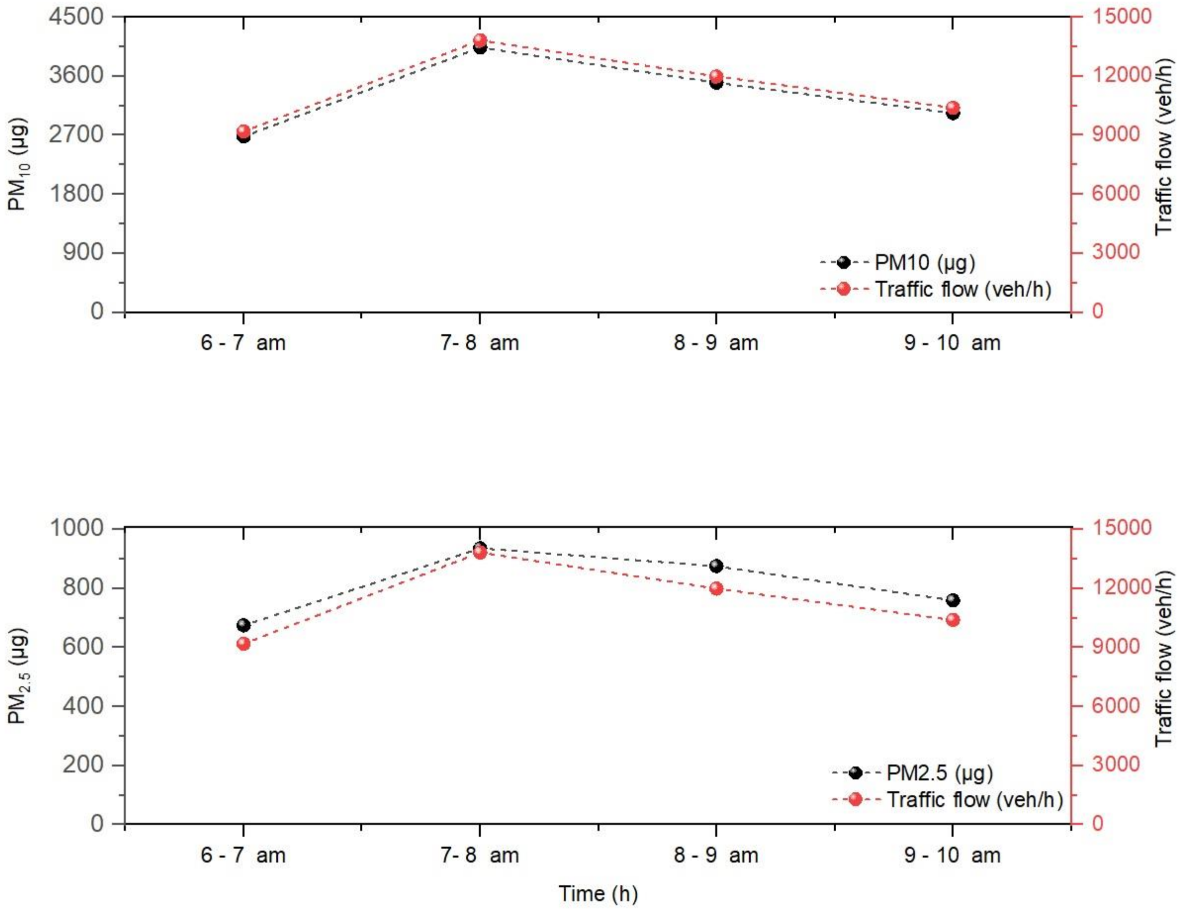


Fig. 6. Traffic flow and emission load of $PM_{2.5}$ and PM_{10} at the Deido roundabout during 6–10 AM

Computation of fine particulate matter concentration

The PM concentration was estimated in the study using the Gaussian plume model under calm wind conditions (Eq. 5) and considered traffic flow as the principal source contributing to the emission burden. Fig. 7 shows the $PM_{2.5}$ concentration trend from 6 to 10 a.m. under a calm wind situation. High $PM_{2.5}$ concentrations are displayed in orange coloration in Fig. 7 (a-d), with a threshold of 257.20 $\mu g/m^3$. It was observed that a minor dispersion of $PM_{2.5}$ exceeding the radius of the roadway set at 10 m.

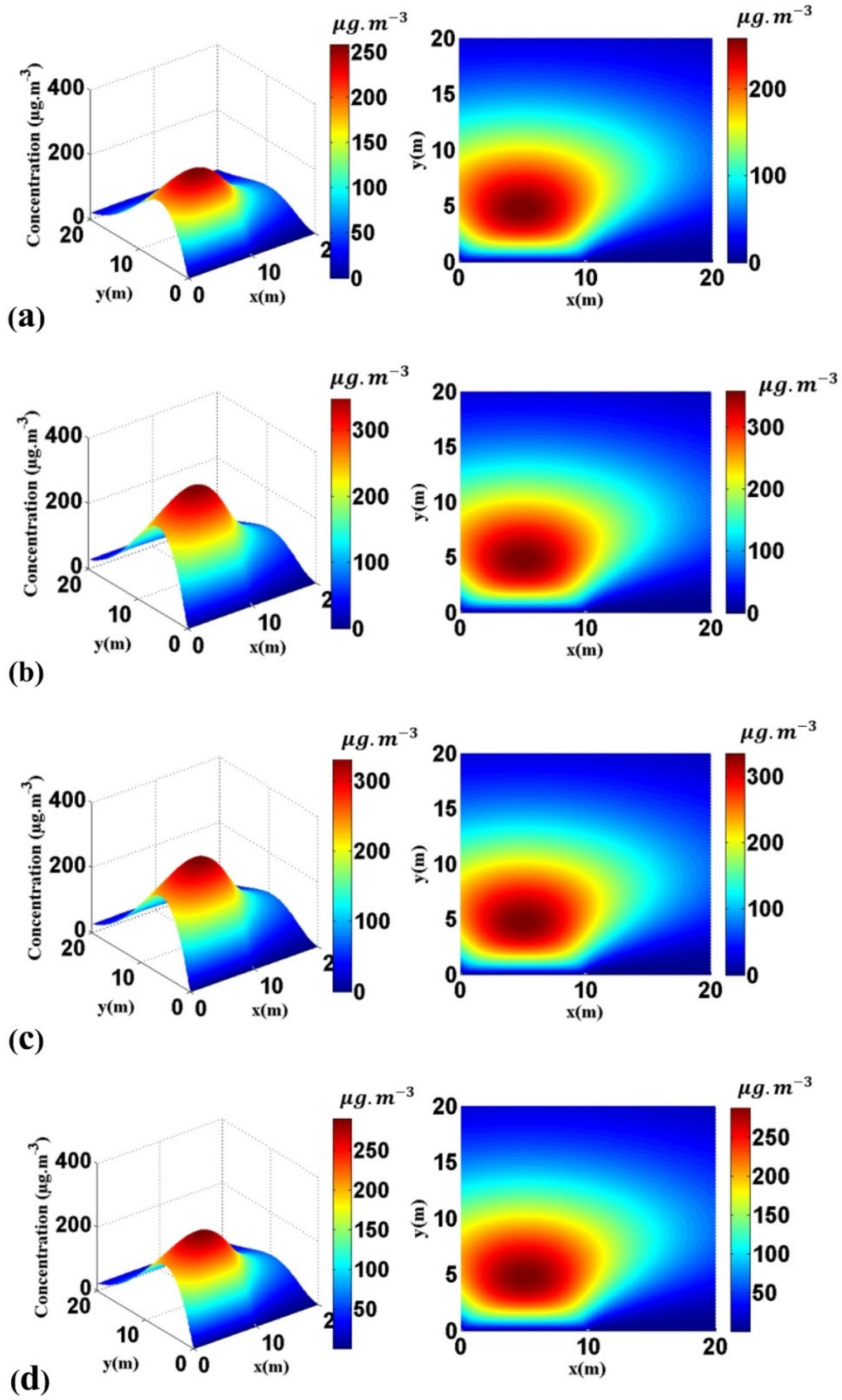


Fig. 7. Dispersion of $PM_{2.5}$ between 6-10 AM (a-d) at the Deido roundabout

During 7-8 AM $PM_{2.5}$ threshold was found around 358.10 $\mu g/m^3$ (Fig. 7b). The sharp increase in concentration during this period is due to the increase in vehicle activity, more specifically passenger's cars (taxi, motorbikes two or three wheels), which is the most commonly used mode of travel at this time. During 8-9 AM $PM_{2.5}$ threshold was found 332.60 $\mu g/m^3$ (Fig. 7c). It is observed that a considerable decrease in concentration at this time is due to decrease in vehicular activity, especially among PCs, because at this time most of the users reached to their respective work place. The pollution threshold during 9-10 AM is estimated 290.10 $\mu g/m^3$ (Fig. 7d). Alike to $PM_{2.5}$, PM_{10} depicting similar dispersion trend in calm wind condition during 6-10 AM at roundabout, the only difference in magnitude is observed (Fig. 8 a-d). Such as during 6-7 AM, 7-8 AM,8-9 AM and 9-10 AM PM_{10} emission threshold value was 513.00 $\mu g/m^3$, 771.50 $\mu g/m^3$, 668.90 $\mu g/m^3$, and 572.30 $\mu g/m^3$, respectively (Fig. 8a, b, c and d, respectively).

As a summary on the modeling of PMs at the Deido roundabout the average concentrations of the PMs (PM_{10}, $PM_{2.5}$) was around CM_PM_{10} 631.42 $\mu g/m^3$ and $CM\_PM_{2.5}$ 310.00 $\mu g/m^3$, respectively which is much higher from the values set by the World Health Organization (WHO) which are 60 $\mu g/m^3$ for PM_{10} and 20 $\mu g/m^3$ for $PM_{2.5}$.

Table 4. Summary of traffic flow, PM concentrations (PM_{10}, $PM_{2.5}$) during 6-10 AM

Time (h)	Traffic flow (veh/h)	Concentration ($\mu g/m^3$)	
		PM_{10}	$PM_{2.5}$
6-7 AM	9.185	513.00	257.20
7-8 AM	13.811	771.50	358.10
8-9 AM	11.988	668.90	332.60
9-10 AM	10.399	527.30	290.10

It can be concluded from the Table 4, summarizes the results of study that concentration of fine particles increases with the traffic flow. The concentration levels of PMs are higher with higher traffic activity (Fig. 9). The highest PM concentrations is observed between 7-9 AM, similar findings are reported by other researchers. The exposure of the population to air pollution on the roads is more intense during 6-10 AM, since the level of particles concentration is higher for highest traffic flow as compared to the lower traffic flow condition.

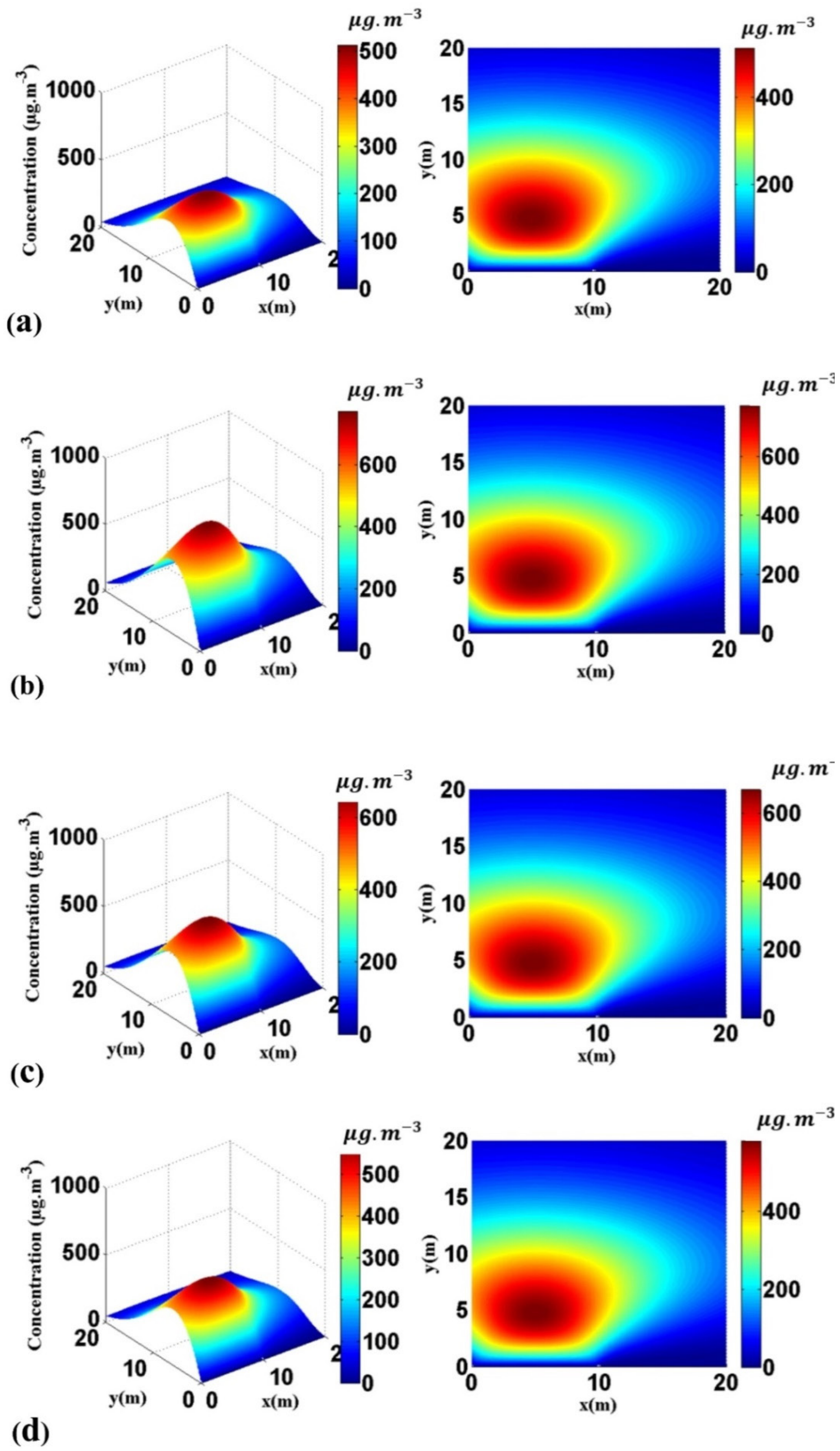


Fig. 8. Dispersion of PM_{10} during 6–10 AM (a-d) at the Deido roundabout

Evolution and prediction

It is well known that most of the developing countries having the higher traffic flow rate and consequently higher traffic activity, roadway transportation is the 24 h mobile and most dynamic sector, particularly in large cities. Furthermore, the quantity of vehicles (passenger cars, light commercial vehicles, heavy goods vehicles) increases by 10% each year [18]. By considering the fact of 10% annual growth of all categories of vehicles, the present study extrapolated the data of average concentrations, which is used to estimate the possible thresholds pollution up to 2021 (Fig. 10).

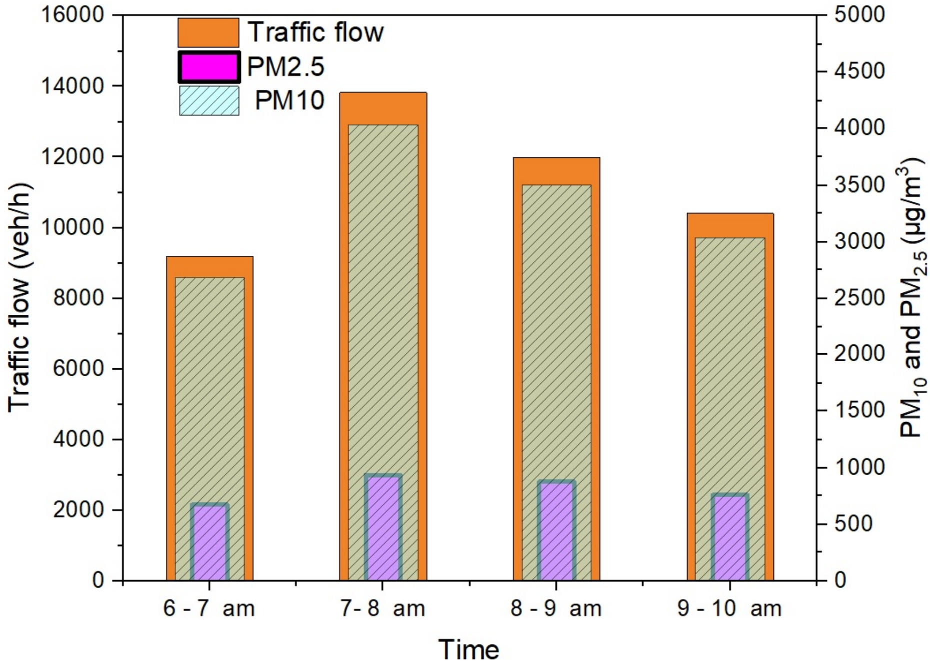


Fig. 9. Hourly variations of $PM_{2.5}$ and PM_{10} concentrations according to Traffic flow

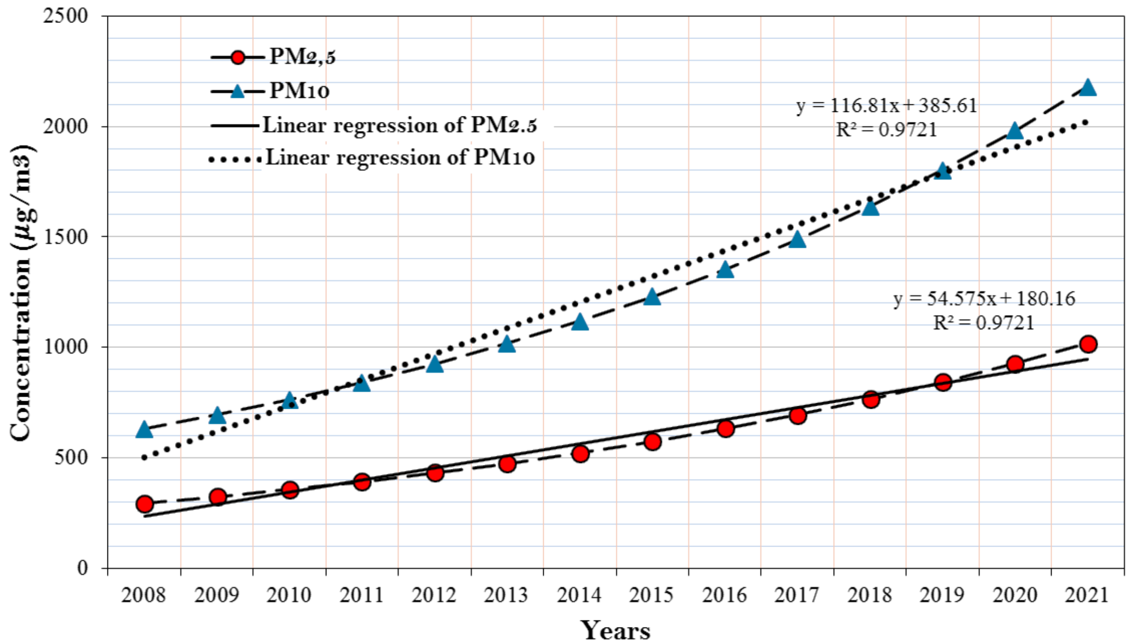


Fig. 10. Evaluation and prediction of PMs based on an annual increase of 10% in the number of vehicles

Discussion

In practically every country on the planet, road transportation contributes significantly to rising levels of air pollution. This study modelled the dispersion of PMs from the re-suspension of particles from vehicle movement or the re-suspension of PMs previously deposited on the roadway and re-suspension by vehicle movement in calm wind conditions to understand the current time contribution of PMs in Douala, Central Africa. Further, proposed equation used to estimate the amount of specific emission to each category of vehicles (HDV, LDV, and PC) and by particles size (PM_{10} and $PM_{2.5}$) with the known input of the traffic flow. The present study only account emission load by re-suspension, and assumes that presence of background pollution, and modeling the dispersion of PMs concentration during calm wind conditions. Thus, results will be suggestive about the risks in-linked to PM exposure, to the society. Using Dust track real time analyzer, the daily average concentration of PM_{10} and $PM_{2.5}$ is obtained 391.81 $\mu g/m^3$ and 183 $\mu g/m^3$ in dry season, respectively [35].

This study performed a numerical simulation in calm wind conditions using traffic data of year 2008. It is found that simulated concentrations are twice of the measured value. The measurement PMs concentration using the OC 300 Laser dust particle detector in 2021 during 6-10 AM for calm wind condition, was found around 650±150 $\mu g/m^3$ and 300±150 $\mu g/m^3$ for PM_{10}, $PM_{2.5}$ respectively (Table 5). The prediction for the city of Douala up to 2021 is based on 2008 traffic flow statistics, with a 10% annual increase in vehicle fleet. The expected results are higher than those obtained during the measuring campaign, according to the study (Fig. 10). The study also emphasizes the significance of weather variables on PM dispersion. It is obvious that when a strong wind blows, particles disperse over a vast area, lowering the pollutant concentration threshold in the area under consideration. In contrast, in calm wind conditions, particles disperse less and are very dense on a small area, magnifying the concentration of fine particulate pollutants, while higher traffic flow periods amplify the concentration of fine particulate pollutants. The conclusion drawn from the results is consistent with study in Libya, which shows that emissions, especially those produced at low and moderate wind speeds, cause a dispersion with high concentration levels in the vicinity of the emission source [36]. The findings also demonstrate that the confidence interval widens as air pollution concentration increases; the observation error significantly affects the confidence interval [37].

Table 5. The average concentrations of measured and simulated PMs at the Deido roundabout in dry weather conditions

Average concentration	Daily measurement 2018	Calm wind period measurement 2021	simulated	Relative error
CM_PM_{10}	391.81 $\mu g/m^3$	650 ± 150$\mu g/m^3$	631.42 $\mu g/m^3$	2.94 %
CM_$PM_{2.5}$	183.43 $\mu g/m^3$	300 ± 150$\mu g/m^3$	310.0 $\mu g/m^3$	3.23%

Conclusion

In metropolitan areas, particles re-suspended by autos account for half of the pollution limitations. The study's average concentrations were discovered to be higher above the WHO's threshold limits. The increased pollutant concentrations calculated by numerical simulation are also due to the calm wind conditions, as particles scatter less in a calm wind, resulting in higher pollutant concentrations. The particles matters seen in an isotropic medium with no preferential dispersion direction plainly justify a higher particle concentration in one region (demonstrated with strong orange color). This research shows how wind speeds affect fine particle dispersion in the atmosphere. Particles matters, molecules, and other chemicals are transported more easily by the wind, which might change pollutant concentration thresholds.

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Competing interests

The authors declared no conflicts of interest with respect to concerning the authorship and/or publication of this article.

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Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely observed by the authors.

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