*Journal of Scientific Research & Reports*

*20(1): 1-11, 2018; Article no.JSRR.43224*
*ISSN: 2320-0227*

# Evaluation of the Impact of Motorcycles in Urban Transport on Air Pollution: A Case of Douala City in Cameroon

**André Talla[1,2*], Paul Salomon Ngohe-Ekam[1] and Aurel Thibaut Nkeumaleu[2]**

*[1]Energy, Water and Environment Laboratory, National Advanced School of Engineering, University of Yaoundé I, P.O.Box 8390, Yaounde, Cameroon.*
*[2]Research Center, National Advanced School of Public Works, P.O.Box 510, Yaounde, Cameroon.*

***Authors' contributions***

*This work was carried out in collaboration between all authors. Author AT designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed the analyses of the study. Author PSNE managed the literature searches. Author ATN managed the experimental measurements of pollutants on motorcycles. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/JSRR/2018/43224
Editor(s):
(1) Dr. Luigi dell'olio, Professor, School of Civil Engineering, Channels and Ports, University of Cantabria, Cantabria, Spain.
Reviewers:
(1) Chadetrik Rout, Maharishi Markandeshwar (Deemed to be University), India.
(2) Durdana Rais Hashmi, PCSIR Laboratories Complex, Pakistan.
(3) Grzegorz Sierpiński, Silesian University of Technology, Poland.
Complete Peer review History: http://www.sciencedomain.org/review-history/26033

***Original Research Article***

***Received 1st June 2018***
***Accepted 4th August 2018***
***Published 28th August 2018***

## ABSTRACT

**Aims:** This work aimed to evaluate the impact of motorcycle taxis on air pollution for the particular case of Douala city in Cameroon.
**Study Design:** Samples were collected from motorcycle drivers and an exhaust gas analyser was used for better understanding of this area of activity. It was done to obtain the different amounts of pollutants emitted by these motorcycles in different traffic situations.
**Place and Duration of Study:** Douala Urban Community, National Advanced School of Public Works, and Energy, Water and Environment Laboratory of National Advanced School of Engineering (University of Yaounde I) between February 2017 and June 2018.
**Methodology:** The statistical data concerning the motorcycles in circulation, estimated around 233,799, in the transport sector between 2009 and 2013 in Cameroon, were used for the present

**Corresponding author: E-mail: andre_talla@yahoo.fr;*

study. Using these data, the correlation of the evolution of motorcycles in circulation in the transport sector was established. For motorcycles exhausts, atmospheric pollutants namely, carbon dioxide ($CO_2$), carbon monoxide (CO), nitrogen oxide (NOx) and hydrocarbon (HC) were measured.
**Results:** A survey of 500 motorcycle taxis, revealed that 58% of motorcycles were acquired prior to release, 56% was less than 5 years old and 95% consumed gasoline. The survey also revealed that 64% of motorcycles operating in urban transport had a tax power of between 6 and 7 HP. The different amounts of pollutants, emitted on a sample of 45 motorcycle taxis, followed that in slow traffic in urban areas (5 km/h), CO (depending on their aging condition) was emitted between 0.40 and 3.02 g/kg; the Euro 3 standard on motorcycle emissions recommends a limit of 1 g/kg. In the same traffic situation, maximum values for HC and NOx, were 0.62 g/kg and $3.10\times10^{-3}$ g/kg, respectively; values were within the limits set by the same standard, namely 0.8 g/kg and 0.15 g/kg respectively. The statistics available between 2007 and 2011 revealed an almost linear evolution of the "motorcycle" phenomenon in urban centers in Cameroon, making it possible to put 647,000 motorcycles into circulation between 2007 and 2018.
**Conclusion:** Traffic situation, aging of the motorcycles and nature of the fuel revealed their influence on the emissions of pollutants by motorcycle taxis. These results are a useful tool to monitor the air pollution levels caused by motorcycles in urban transport.

*Keywords: Atmospheric pollution; motorcycle taxis; pollutant concentrations; polluting gas emission; urban transport.*

## ABBREVIATIONS

*AF : Adulterated Fuel*
*CV : Commercial vehicle*
*FM : Public work machinery*
*PV : Particular vehicle*
*PWM : Public work machinery*
*RT : Road tractor*
*TL/TT-TL : Trailer/Tractor-trailer*
*TT/MM : Tractors/Mechanical machinery*
*TV : Tourism vehicle*

## 1. INTRODUCTION

Numerous studies have been conducted on air quality, with improvements in cities in developed countries in recent years [1]. In contrast, significant air quality deficiencies were observed in tropical countries [2]. However, the increase in the urban population coupled with the rural exodus in developing countries makes it interesting to accentuate studies related to air pollution in the cities of these countries [3]. Air quality may be better in developed countries than the big tropical cities [4]. Levels of air pollution in developing countries in Asia and Latin America are among the highest in the world [1].

This increase of air pollution in large urban centers of developing countries is attributed to the steady increase in urban traffic, industrial and economic activities and the general burning practice by the common people on regular basis [2]. Transport is the main source of pollutant emission because, in addition to the rapid growth in the number of vehicles and motorcycles, there is a large number of poorly maintained engines and poor quality fuel [5]. Other factors explain the significant emissions of pollutants by the transportation sector such as pavement maintenance, its condition (dry or wet) and traffic jams [6]. In Africa, for example, with the growth of cities, transport (especially private transport) is growing rapidly, to make up for the inadequacy of public transport. These private transports hardly respect the rules of environmental protection, with the consequence of a rather localized impact on the quality of the air.

In Brazil, in 2004, the concentrations of airborne particles, due to vehicle emissions in tunnels, were higher than those measured in other cities of the world [7]. In addition, in 2006, 75% of the NOx present in the air in Mexico City and Santiago, were due to transport [8]. This significant air pollution had adverse effects on the human health, the environment and biodiversity, as well as climate change [9,10]. Air pollution affects many people and may be fatal in cases. In cities, the quality of air is an important issue that affects people's living conditions. Several studies have been conducted in tropical countries in relation with pollution. Work has been done to gain knowledge about the sources of air pollution in order to limit their effects on human health [11].

In addition, several studies have been made on global warming linked to air pollution on a global scale with important economic consequences [12,13,14,15]. Many researchers and international institutions have given particular

attention to the issue of transport in the major cities of sub-Saharan Africa. The previous works showed the importance given to this problem. They have developed reflections on the forms of transport, including the integration of the popular sector into urban transport systems [16,17,18]. Some studies focused on the various complementary or competitive modes that are adapted to the nature of the traffic and meet the users' requirements [19].

Accelerated urbanisation on the periphery has become a kind of engine for the transport system, as long travelling distances within the city increase the need for motorized travel. In the current context of urban transport in Sub-Saharan African cities in general, and the cities of Cameroon in particular, is dominated by accelerated urbanization. Due to significant lack of road infrastructure, motorcycle taxis generally provide access to any point of the town, because of their great flexibility, whereas public transport plays their full role only in a radius close to stopping points.

It is, however, difficult today to calculate a figure on the number of motorcycle taxis operating in Cameroon. Between 2007 and 2011, 269,625 motorcycles were registered in Cameroon and put into circulation [20]. Estimates ranged from 40,000 to 50,000 motorcycle taxis, according to the official figure, in Douala city of Cameroon [21]. Previous reports have amply demonstrated the problem of urban air quality, linked inter alia to transport. However, studies have not been carried out to our knowledge on the quantification of pollutants of motorcycle origin in the cities of Sub-Saharan Africa. This work focused on the contribution to the quantification of pollutants of motorcycles on air pollution for the case of Douala city.

## 2. MATERIALS AND METHODS

### 2.1 Materials

The equipment used in this work consists of a Tronic Test G750/A type exhaust gas analyser. It measures carbon monoxide (CO), carbon dioxide ($CO_2$), hydrocarbon residue (HC), oxygen ($O_2$) and nitrogen oxides (NOx) present in the exhaust gases and deduce the factor λ which characterizes the quality of carburation. The response time is 6 s with automatic reset. Fig. 1 shows the device used for the measurements of the various characteristic quantities of the exhaust gases from motorcycles in Douala city.

### 2.2 Methods

The five most important exhaust components, namely carbon monoxide, carbon dioxide, hydrocarbons, oxygen and nitrogen oxides, were found in the emissions of each gasoline engine. The relationship of these gases to each other is largely dictated by the state of the engine and the quality of the combustion, which itself depends on the preparation of the mixture, the ignition, the mechanical condition of the engine and its condition to work instantly. In order to get closer to the real conditions of driving motorcycles in Cameroon, the motorcycles sample chosen for this study was subjected to very specific criteria.


**Fig. 1. Device used for measurement of exhaust gases from motorcycles**

### 2.2.1 Sample of motorcycles

Three parameters were taken into account, in the present work, for the choice of the representative sample to be analysed:

- The type of fuel used;
- The distance traveled since the first use (mileage);
- The number of years of use of the motorcycle.

### 2.2.2 Experimental protocol

Once the motorcycle started, we waited for about 15 minutes to allow the engine to reach its equilibrium regime (minimum oil temperature 60°C). The tip of the measurement probe was then inserted at least 30 cm into the end of the exhaust pipe in accordance with the instructions in the exhaust gas analyser's operating instructions. We then proceeded to select the type of fuel that resulted in the lighting of a red indicator at the fuel selection on the analyser's operating interface.

The present experiments on the measurement of gaseous pollutants have taken into account the conditions of motorcycle circulation by varying the speed from 0 km/h in a plugged state or congestion (Fig. 2) to 70 km/h in traffic on the urban motorway.

### 2.2.3 Quantification of pollutants

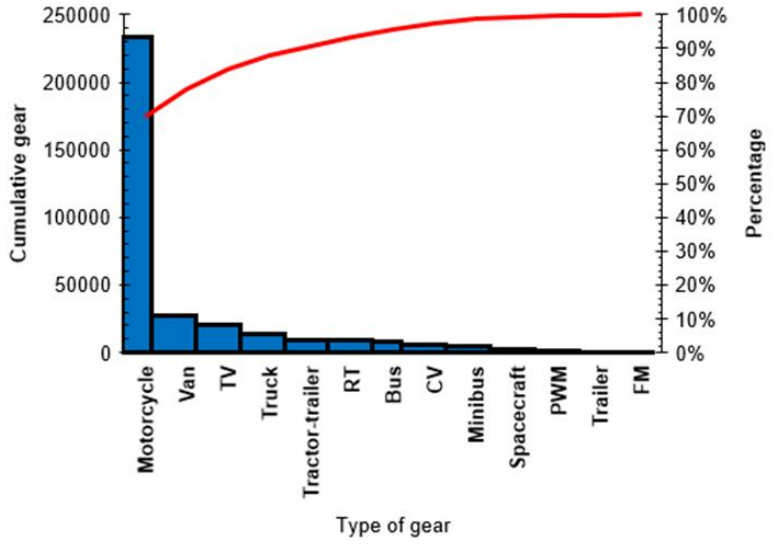
The quantities of gaseous pollutants were measured according to the experimental protocol described previously. Values of carbon monoxide, hydrocarbons, nitrogen oxides and carbon dioxide were provided by the exhaust gas analyser in PPM (parts per million) and g/kg. The selected final value was an average obtained after 3 tests, lasting 60 s each, for each selected sample motorcycle, displacement speed and each type of gas.

### 2.2.4 Data source

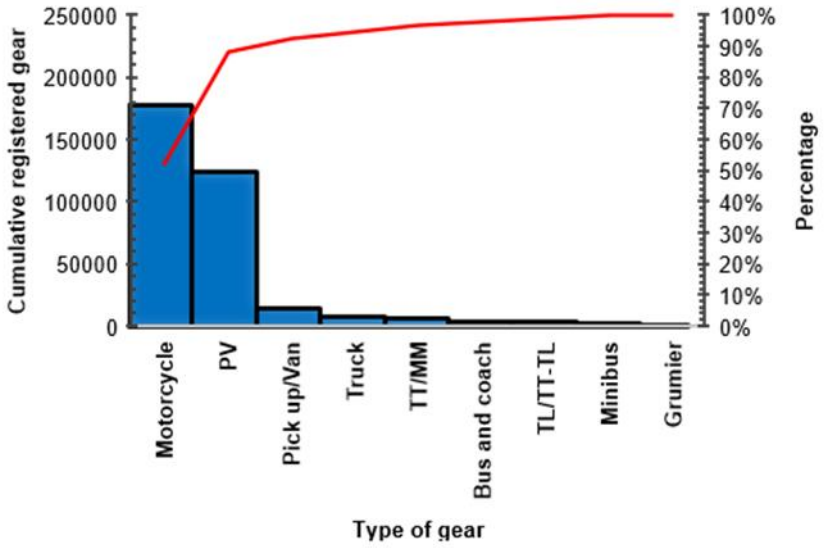
The concentration of the gaseous pollutants was estimated using the data obtained with the "Tronic Test G750/A" exhaust gas analyser. In total, 500 motorcycle taxis operators accepted an interview about their trade. But only 45 of them, precisely 40 motorcycles using gasoline and 5 using adulterated fuel, had agreed to use their engines for the experimental support of this work. The condition imposed was compensation for loss of earnings of up to FCFA 3,000 per motorcycle engaged in the operation.

The distribution of the total number of vehicles in circulation in the transport sector in Cameroon between 2009 and 2013 shows that 70% represents motorcycles [20] (Fig. 3a). According to the same source, the distribution of the cumulative number of gears registered in the transport sector in Cameroon between 2007 and 2011 shows 52% for motorcycles (Fig. 3 (b)). It should be noted that many motorcycles went into hiding and went into service without registration. This shows to a sufficient extent the importance of the phenomenon "motorcycles" in the transport sector in this country thus justifying the interest to bear on its impact related to air pollution.

**Fig. 2. Congestion phenomenon at the Ndokoti tunnel – Douala city**




**(a) Distribution of cumulative number of gear in circulation in Cameroon between 2009 and 2013**




**(b) Distribution of cumulative registered gear in circulation in Cameroon between 2007 and 2011**

**Fig. 3. Distribution of gear in the transport sector in Cameroon**

## 3. RESULTS AND DISCUSSION

### 3.1 Results

#### 3.1.1 Evolution of motorcycles in circulation in Cameroon

According to data from the National Institute of Statistics [20], the evolution of motorcycles, registered between 2007 and 2011, circulating in the transport sector in Cameroon has been illustrated in Fig. 4. The same figure shows that these data can be estimated from a linear model with a correlation coefficient $R^2 = 0.96$. Assuming that this curve keeps the same trend until 2018 and beyond, this model can be used to estimate the evolution of motorcycles in circulation over years. This hypothesis was justified by the fact that no political initiative was undertaken to

fundamentally address the problems of public traffic in cities and the state of urban roads. With this model it was estimated that about 646,600 motorcycles were put in circulation in Cameroon between 2007 to 2018. However, the extent of the phenomenon "motorcycle" like "motorcycle taxi" in the urban centers of Cameroon dates from 1990 because of the popular demonstration where taxis were not allowed to circulate on working days, the economic crisis had led to the dumping of many workers in the street seeking conversion to another easily accessible activity and finally the urban transport in common company collapsed. That is to say the number of motorcycles in circulation in Cameroon is so far well above the estimation made between the periods of 2007 to 2018.

### 3.1.2 Characteristics of motorcycles in circulation in Douala

This work focused on a sample of 500 motorcycles. Fig. 5 presents some of the most relevant results obtained from the interviews of the motorcycle taxis drivers. It can be observed from Fig. 5(a) that the acquisition of motorcycles leaving the factory was dominated by 8% on used motorcycles. This trend is largely due to imports of motorcycles of Chinese origin at very affordable costs. It is in the same vein that motorcycles in operation, less than 5 years ago, remained the majority (Fig. 5 (b)), Fig. 5(c) shows that 95% of motorcycles in circulation consumed gasoline and 5% used a fuel known as "adulterated" fuel (a mixture of super fuel with kerosene to reduce the cost) officially banned by the Cameroonian legislation. Regarding the tax power of these motorcycles, it was spread over a wide range with predominance between 6 and 7 HP (Fig. 5 d). The age of the motorcycles, their states and the nature of the fuel used necessarily had an influence on their effect of pollution of the ambient air. In addition, surveys conducted on this sample of 500 motorcycles taxis drivers revealed that each driver travelled an average of 50 km per day.

### 3.1.3 Pollutant measurements related to motorcycles in circulation in Douala

The different experimental values of carbon monoxide (CO), hydrocarbon (HC), oxides of nitrogen (NOx) and carbon dioxide ($CO_2$) were obtained at speeds of 0 km/h, 5 km/h, 25 km/h, 40 km/h and 70 km/h on a sample of 45 motorcycles taxis. Figs. 6 to 9 shows the emissions of CO, HC, NOx and $CO_2$ respectively in the atmospheric air depending on the mileage. The mileage (distance already travelled by the motorcycle) reflects the aging of the motorcycle and consequently the decline in engine efficiency. These results also took into account the influence of the fuel type.

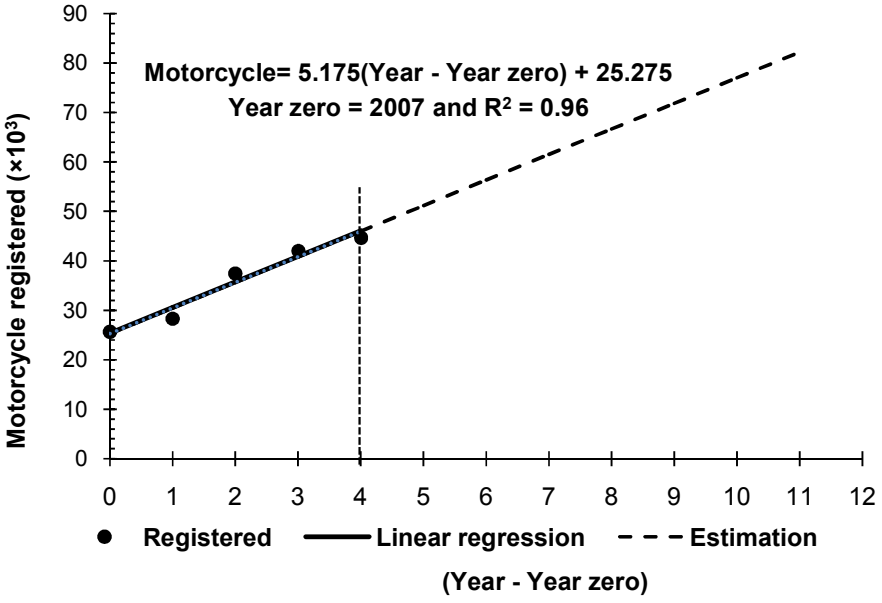



**Fig. 4. Evolution of motorcycles in circulation in the transport sector in Cameroon**

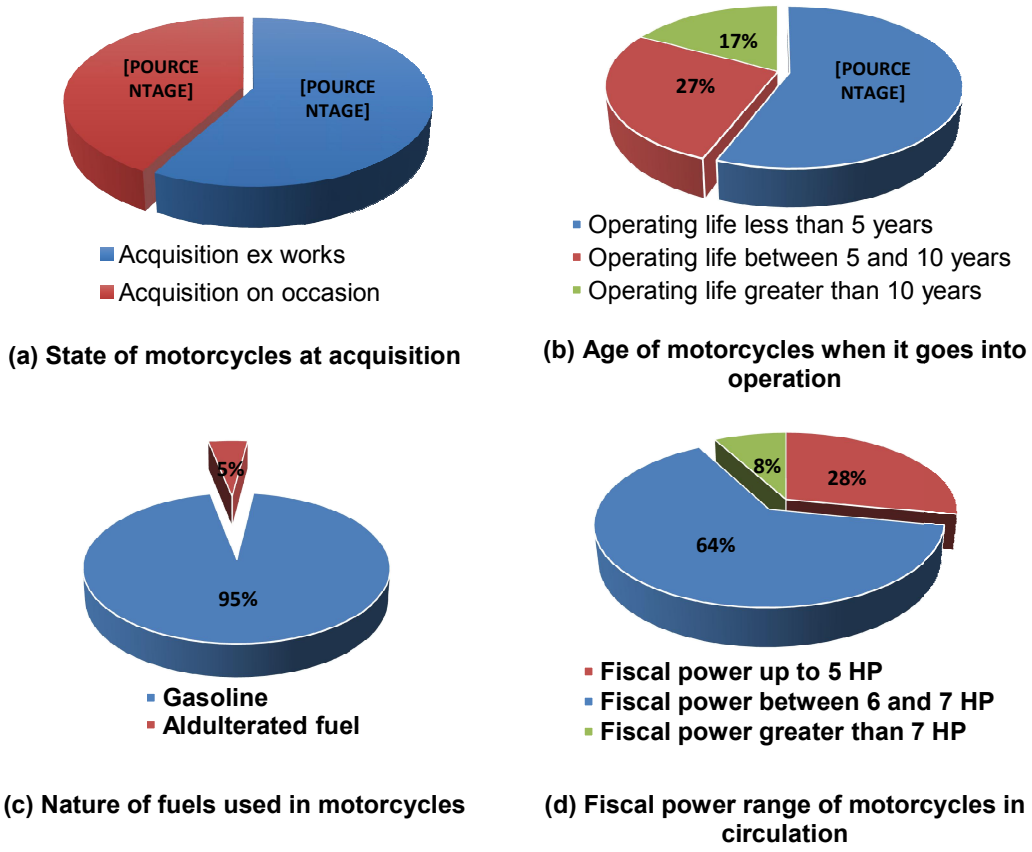



**Fig. 5. Some characteristics of motorcycles in circulation in Douala city**

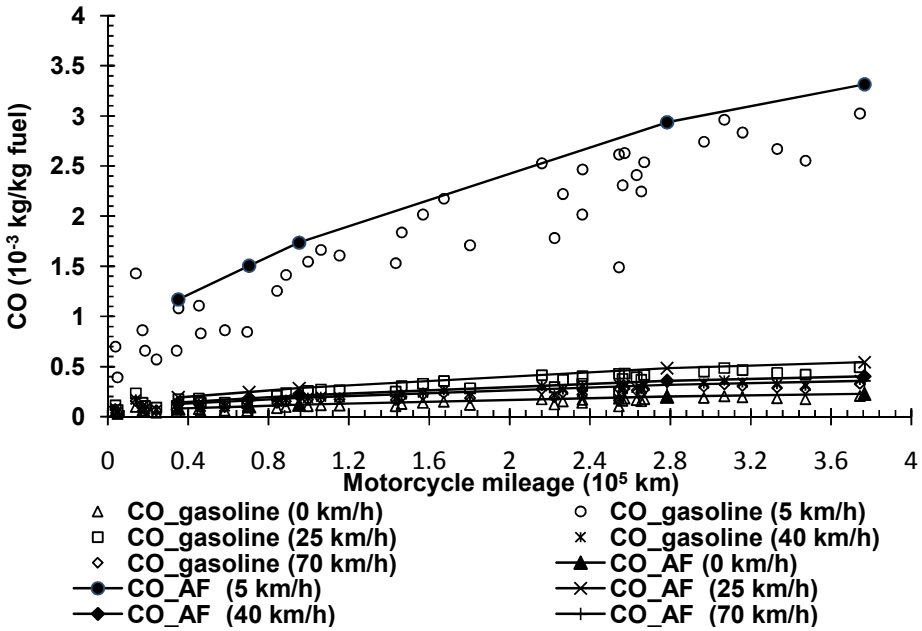



**Fig. 6. Influence of the circulation rate on the emission of carbon monoxide**

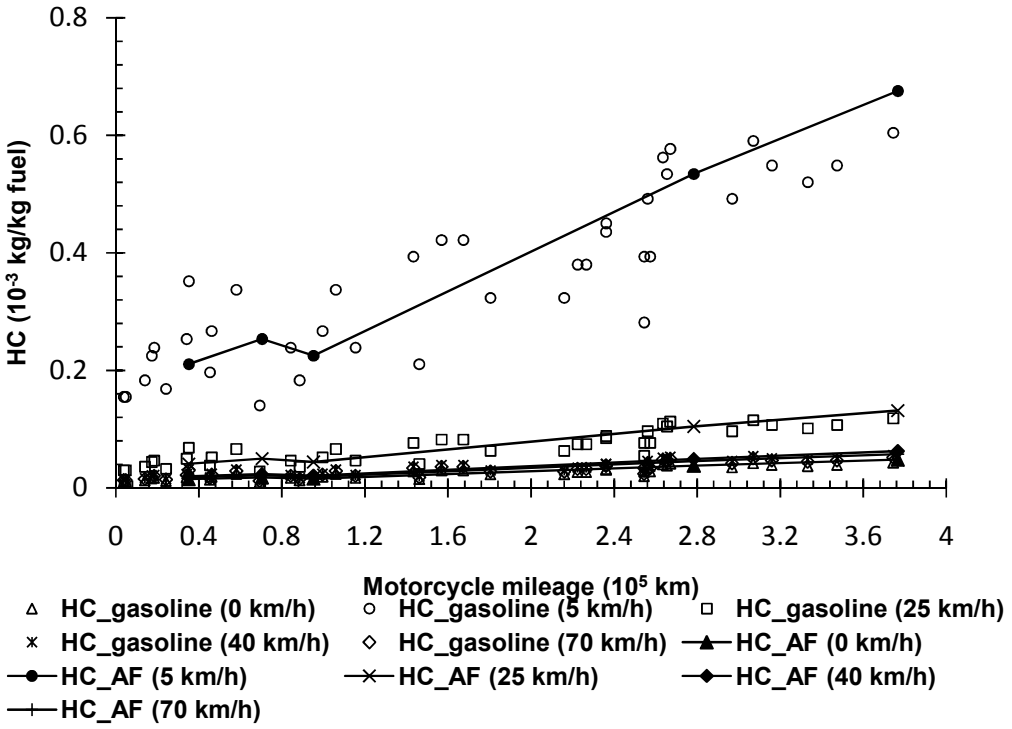



**Fig. 7. Influence of the circulation rate on the hydrocarbon emission**

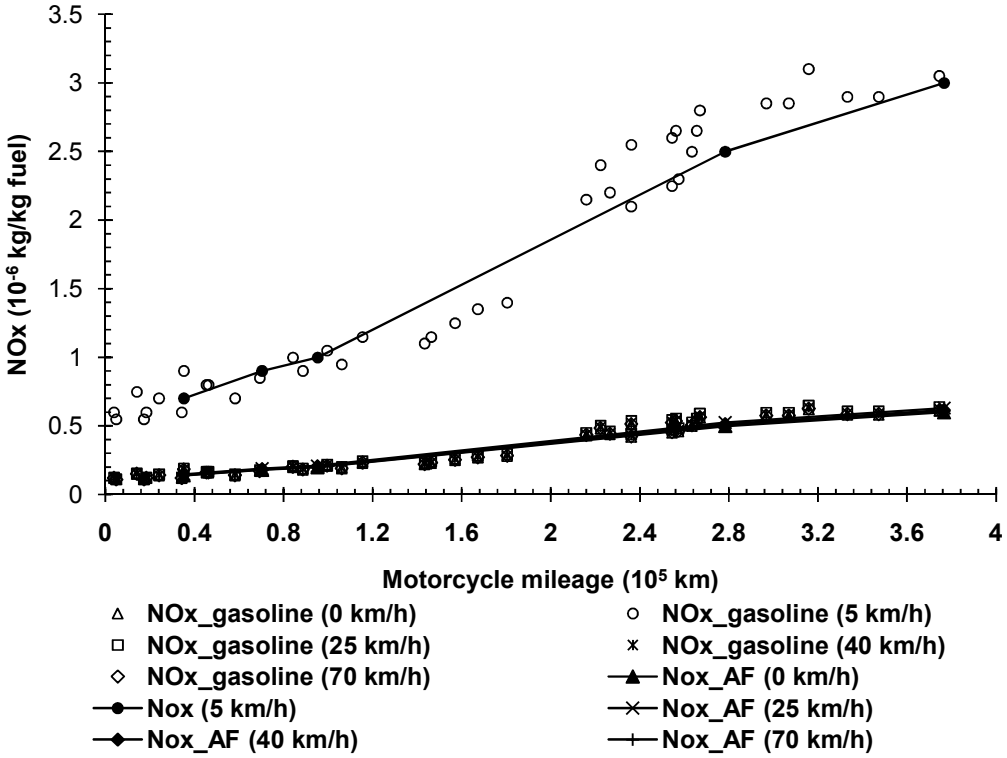



**Fig. 8. Influence of the circulation rate on the emission of nitrogen oxides**

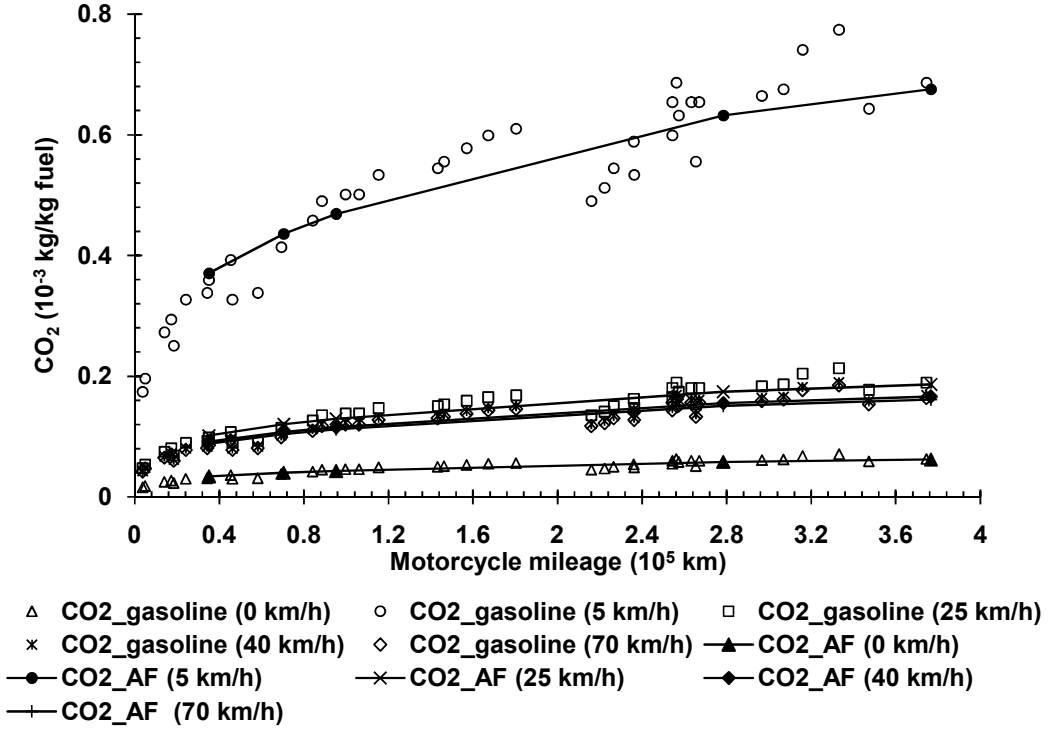



**Fig. 9. Influence of the circulation rate on the emission of carbon dioxide**

## 3.2 Discussion

### 3.2.1 Influence of the speed of circulation on the emission of gaseous pollutants

Figs. 6 to 9 show that the emissions of gaseous pollutants by the motorcycles, in the same state of aging, depend on the speed of circulation. Particularly high emissions were noted at the traffic speed of 5 km/h, reflecting the situation of recurrent congestion in metropolitan areas in Sub-Saharan Africa in general and in Douala city in particular. This can be explained by a solicitation of the motorcycle motor at its highest speed (speed first). Differences in pollutant emissions remained relatively moderate at normal circulation rates for carbon monoxide, hydrocarbon and carbon dioxide. On the other hand, emissions of nitrogen oxides varied little at these speeds. In addition, this polluting gas has the lowest emission rates out of the four gases measured. Finally, the lowest emissions were recorded at zero speed; which was predictable from the moment the motorcycle motor runs at its lowest speed with low fuel consumption. In the regime under congestion conditions (5 km/h), the maximum carbon monoxide emission was 3.02 g/kg approximately 3 times the limit value (1 g/kg) recommended by the Euro 3 standard for motorcycle emission [22]. This result illustrates the discomfort experienced by the countries of Sub-Saharan Africa, particularly with regard to the standards for importing transport equipment. The majority of these machines were from second hand, sometimes dating back more than 20 years. The maximum hydrocarbon emission, in the same regime, was 0.62 g/kg, which was less than the limit value (0.8 g/kg) recommended by the same standard. For nitrogen oxides, the maximum emission in this regime was $3.10\times10^{-3}$ g/kg 0.15 g/kg less than the recommended value by the Euro 3 emission standard for motorcycles.

### 3.2.2 Influence of mileage on the emission of gaseous pollutants

Figs. 6 to 9 show that the emissions of gaseous pollutants by motorcycles increased with the mileage index, reflecting their state of aging. These results were predictable as engine efficiency decreases with operational year and maintenance quality. In Cameroon, preventive maintenance is not in the habits of the users of transport vehicles in general and particularly in the sector of motorcycles which escapes

completely to a relevant regulation of the administration. The maintenance is essentially curative. To this, the poor state of the road infrastructure which contributed significantly to the wear of these machines must be added.

#### 3.2.3 Influence of the nature of fuel on the emission of gaseous pollutants

Motorcycles operating in the public transport sector in Douala consume mainly gasoline. A small fraction (5%) however uses an adulterated fuel. Fig. 6 shows that in a congestion situation (5 km/h), the carbon monoxide emissions of motorcycles consuming adulterated fuel were greater than those of motorcycles consuming gasoline. The precise composition of this fuel is not known to allow interpretation. For hydrocarbon emissions, nitrogen oxides and carbon dioxide, values fluctuated around the same averages for both types of fuel.

## 4. CONCLUSION

Given the inadequacy of public transport and poor road conditions, public transport by motorcycle both inside and around the major metropolitan areas of Sub-Saharan Africa in general was an alternative must. The occupation of space by motorcycle taxis in the immediate environment of users in Douala city - Cameroon, should be analysed in terms of utility and ease of travel. This work has measured the rate of gaseous emissions, including carbon monoxide, hydrocarbon, nitrogen oxides and carbon dioxide, from the activities of motorcycles taxis in this city. The evaluations of these polluting gases have been made experimentally in the various traffic situations for motorcycles. It follows that the traffic constraints (congestion situation in particular), the aging (mileage) and the nature of the fuel are the main pollution factors. At the end of this study, the significant contribution of motorcycles to atmospheric pollution in the urban transport sector has been shown. It can be suggested that, to preserve air quality, one must rethink and better organise urban transportation by acting on all the factors of the system: traffic, condition of vehicles, road conditions, fuel quality. Well thought out legislation should be considered for effective management with the dual aim of satisfying urban mobility thereby reducing the pollution rate associated with this mobility.

## ACKNOWLEDGEMENT

The authors express their sincere thanks to the National Advanced School of Public Works for his collaboration.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Krzyzanowski M, Cohen A. Update of WHO air quality guidelines. Air Qual Atmos Health. 2008;1:7-13.
2. Arku RE, Vallarino J, Dionisio KL, Willis R, Choi H, Wilson JG, Hemphill C, Agyei-Mensah S, Splengler JD, Ezzati M. Characterizing air pollution in two low-income neighborhoods in Accra, Ghana. Sci Total Environ. 2008;402(2-3):217-31.
3. Fourn L, Fayomi EB. Pollution atmosphérique en milieu urbain à Cotonou et à Lokossa, Bénin. Bulletin de la Société Pathologique Exotique. 2006;99(4): 264-268.
4. Vahlsing C, Smith KR. Global review of national ambient air quality standards for PM10 and SO2. Air Qual Atmos Health; 2011.
   DOI: 10.107/s11869-010-0132-2
5. Assamoi EM, Liousse C. A new inventory for two-wheel vehicule emissions in West Africa for 2002. Atmos. Environ. 2010;44: 3985-96.
6. Begum RA, Satari SK, Peirera JJ. Waste generation and recycling: Comparison of conventional and industrialized building systems. American Journal of Environmental Sciences. 2010;6(4): 383-388.
7. Sanchez-Ccoyllo OR, Ynoue RY, Martins LD, Astolfo R, Miranda RM, Freitas ED, et al. Vehicular particulate matter emissions in road tunnels in Sao Paulo, Brazil. Environmental Monitoring and Assessment. 2009;149(1-4):241-249.
8. Bell ML, Ebisu K, Belanger K. Ambient air pollution and low birth weight in connecticut and massachusetts. Environ Health Perspect. 2007;115:1118-1124.
9. Elichegaray C, Bouallala S, Maitre A, Ba M. État et évolution atmosphérique. Revue des Maladies Respitoires. 2009;26(2): 191-206.

10. Besancenot JP. Notre santé à l'épreuve du changement climatique. Ed. Synthèse de l'ouvrage: Delachaux et Niestlé, Paris; 2007.
11. Cisneros R, Brown P, Cameron L, Gaab E, Gonsalez M, Ramondt S, et al. Understanding public views about air quality and air pollution sources in the San Joaquin valley. California. Journal of Environmental and Public Health; 2017.
ID 4535142.
12. N'gotta C. Évaluation économique de la qualité de l'air à Abidjan: Une approche de par la méthode de l'évaluation contingente. Mémoire Master NPTCI, Université de Cocody; 2009.
13. Sportise B. Pollution atmosphérique : Des processus à la modélisation. Ed. Springer Science & Business Media; 2008.
14. Bertrand F, Larrue C. Gestion territoriale du changement climatique: Une analyse à partir des politiques régionales. Programme GICC, UMR Citeres 6173; 2007.
15. Nordhaus WD, Boyer J. Warning the world: Economic models of global warning. Ed. MIT Press, Cambridge Mass, ISBN 0 262 14071 3; 2000.
16. Godard X. Transport artisanale, esquisse de bilan pour la mobilité durable. Proceedings de la Conférence CODATU XIII, Ho Chi Minh City, Vietnam; 2008.
17. Kassi-Djodjo I. Rôle des transports populaires dans le processus d'urbanisation à Abidjan. Cahiers d'Outre-Mer: Aspects de la Côte-d'Ivoire. 2010;251:391-402.
18. Audard F, Perez J, Wester L, Grondeau A. Système de transport en commun et auto-organisation: Le cas de Brazzaville. Proceedings de la Conférence CODATU XV, Addis Abeba, Ethiopie; 2012.
19. Bamas SMM. Deux roues et transports collectifs à Ouagadougou: A la recherche d'une articulation. Thèse de Doctorat en Géographie, Bordeaux 3; 1995.
20. National Institute of Statistics. Transport, annuaire statistique du Cameroun, Yaoundé, Cameroun; 2015.
21. Nyobia A. Cameroun – Transport par moto-taxi: Douala fait ménage. Cameroun Tribune; 2016.
(Accessed 3 March 2017)
Available: www.actucameroun.com
22. ADEME. Deux-roues motorisés Euro 3: Progrès environnementaux et comparaison à l'automobile, rapport mai; 2007.



*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*http://www.sciencedomain.org/review-history/26033*