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Baseline Assessment Of Road Traffic Characteristics And Its Possible Impact On Human Health And The Environment In Kinshasa (Democratic Republic Of Congo)

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Abstract
Road traffic is often assumed to be a major source contributor to air quality deterioration in many cities in the world. Kinshasa the capital city of the Democratic Republic of Congo does not escape from this reality. Deteriorated air quality has negative impact on human health and the environment. The study focused on road traffic characterization in the city of Kinshasa and in order to evaluate its contribution to air quality deterioration and population health risk. Data from two surveys undertaken in four districts of this city have provided the characteristics of road traffic in Kinshasa in terms of the hourly on road flow rate at peak time (9 am to 12pm and 4 pm to 7pm). The insufficient road networks as well as the aged fleet are the key causes of traffic congestion that leads to the high particulate concentrations that is above the World Health Organisation (WHO) limit value. We suggest the improvement of the road network in this city, the technical control of on road vehicle status as well as the education of traffic officers and road users to abide on road traffic rules to avoid frequent traffic congestions observed at peak hours.

Key words: *Road traffic, congestion, air pollutants, and human heath*

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I. Background

In recent days road traffic seems to be a major source contributor to air quality deterioration in many cities in the world (Claudia Hak *et al*. 2010; Duclaux *et al.,* 2002; European Environment Agency, 2003; Rebolj and Sturm, 1999). Cities are, indeed, concerned by air pollutants such as nano particles, sulphur dioxide, nitrogen dioxide, polycyclic aromatic hydrocarbons (PAHs), etc, from motor vehicles that cause health problems to humans (Zhang, Y., *et al*. 2009) and the environment (Kukkonen, J. *et al.,* 2000). Concentrations of air pollutants from motor vehicle emissions in a city depend on several factors such as the type, the size and the state of the road, the number of in road vehicles, their age, and flow rate per time unit (Personal information).

With regard to human health issues, World Health Organisation (WHO) reports that almost 12.6 million deaths recorded worldwide every year are linked to environmental causes which represent 23% of the total death causes (WHO, 2012). In addition to these findings, recent report published by the same organisation states that air pollution has been classified as the main cause of seven million premature deaths per year worldwide (WHO, 2021). Notwithstanding, UNEP (United Nations Environmental Program) reports that more than 80% people living in urban cities are exposed to poor air quality ranging below WHO standards and limit values which constitute a life threat issue for productivity and economic development (UNEP, 2002). In a study undertaken in the USA, Levy et al, (2010) state that spending time in a traffic congestion cannot be only annoying for the drivers and commuters, but can also lead to real economic costs. This loss can be examined through various parameters including fuel consumption, time wasted (Levy et al. 2010) and pollutants emission and exposure. Emission of CO and CO2 from motor vehicles (Schtz, 1995,). Escourrou, 1996,) is harmful to human health and also to the environment as it causes greenhouse effect. However, this matter does not enter into the discussion of this article.

The focus of this study is to characterized traffic flow in the cities of Kinshasa in order to determine that traffic peak hours; to evaluate the causes of traffic congestion and provide information on potential harmful pollutant emissions which people are exposed to. The methodologies used to achieve these objectives are well

explained below. Air quality data (PM2.5 and PM10) as well as results from two questionnaires undertaken at this end have allowed providing recommendation to decision maker for the improvement of the road traffic in the city of Kinshasa.

Study area

Kinshasa, the capital city of the Democratic Republic of the Congo is a fast-growing population of 12 million inhabitants with a growth rate of 3.4 year. This population is set to double by the year 2030. This population growth will make Kinshasa the most populated capital city in Africa behind Cairo and Lagos (World Bank, 2016). Located along the great river Congo at 4.4419 S latitude and longitude 15.2663 E, Kinshasa is city poorly urbanised with residential areas situated away from Town where millions of people flee every day to either work, sell or try to gain a living (Nzuzi, L.F., 2008).

With a poor road network (less the 3000 km) (Shomba K., *et al*. 2015), which is supposed play a crucial role on the connection the rest of the country from fluvial and maritime way, Kinshasa suffers from frequent and quasi permanent road congestions have huge consequences leading to heavy delays in travelling short distances and disruptions in productivity for people working and exposure to harmful emission from motor vehicles.

Poor air quality from road traffic has been reported as one of the causes of several human diseases ranging from pulmonary diseases to lung cancer in China (Zhang, Y., et al. 2009). Several factors play in favour of on road vehicle emissions. As state above, road characteristics determine frequent traffic congestions noted in Kinshasa on daily basis. These factors constitute the focus of this study. Road traffic issues such as addressed above have become an integral part of today's concern by majority of inhabitants in Kinshasa. It forces people to plan additional time whether commuting to work, or traveling for other purposes. However, according to Rousel (2011), evolution of pollution is often pursued as a development index in a given city, besides its effects in the environment. The section below provides aim and objectives of this study.

Aim and objectives of the study

The aim of this study is to provide traffic and road network information and characteristics such as observed in the city of Kinshasa

Three objectives were targeted to achieve the aim of this study. These are stated as follows: to assess the traffic flow rate at many road junctions in the city during peak hours; to assess the cause of traffic congestion noted int the city; and lastly to assess particles (PM 2.5 and PM 10) concentration level in order to assess their potential impact on human. Such information will help decision makers to optimize urban road design for economic and social benefit of the commuters and motorists.

Road network is provided in the map below (Fig.1).

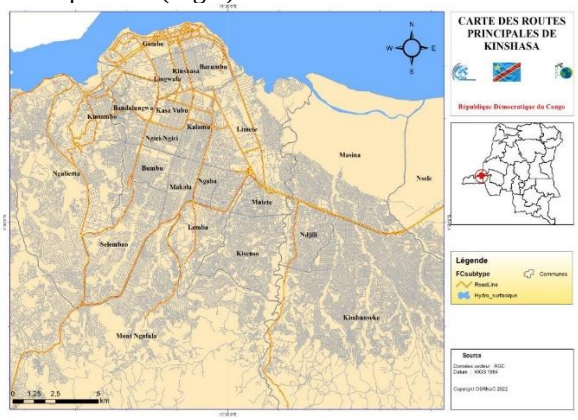

Figure 1. Road network in Kinshasa
Source: ETS/UPN (2022)

II. Data And Method

Data used for this study were provided from two different questionnaires. One of them mattered the causes of traffic jam observed in Kinshasa. The other focused on vehicle flow rate on the road during peak points.

Motor vehicle speed as well as fuel used where not taken into account in this study. This may constitute the future investigation matter for a forthcoming research paper in this field. The first questionnaire

was obtained from google form on internet. It was made of 10 questions of which eight of them were pertained to provide data needed for the aim of this study.

The second questionnaire was compiled through a survey undertaken thanks to WHO procedure (OMS, 2001). The purpose of this survey was to assess traffic flow around some high spot traffic points well identified in Kinshasa. The survey was clustered into two groups. The first group was scheduled from 6 am to 9am; whereas the second group was scheduled from 4pm to 7pm. The survey was made during five working days in twenty sites. Motor vehicles were counted by well-trained five people to perform the counting in each site every day at indicated time during five days a week. Hence, five sites were chosen in each district of Kinshasa; which makes the total of twenty.

Air quality data were collected from Low-cost sensors (LCS) that have the potential to improve air quality data coverage throughout the world, especially in resource-limited areas (Amegah, 2018).

III. Results And Discussion

The first survey made to assess traffic congestion characteristics in Kinshasa have provided the following results as shown in Figure 2 to 4 below.

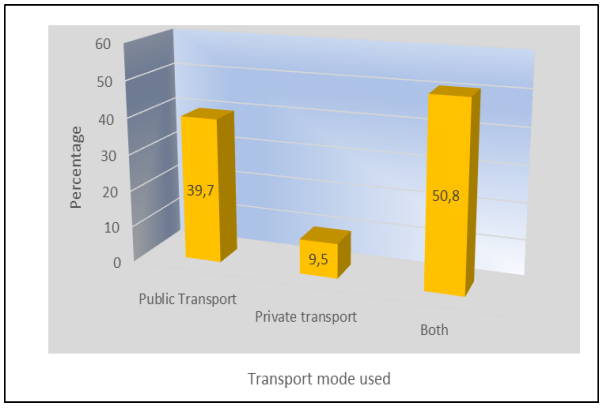

Figure 2. Mode of transport used by commuters in Kinshasa (in percentage)

Results from Figure 2 show that majority inhabitants in Kinshasa (39.7%) use public transport to move from one place to another. Only 9.5% inhabitants use their private vehicles. However, a big portion of the inhabitants (50.7%) use both public and private transports for their displacement. This shows clearly that depends public transport alone is enable to satisfy people needs for their displacement. This is due by the fact that private vehicles can sometime be used as public transport since there is shortage of public transport buses on the road. From the above results, it is worth noting that a small portion (10 %) of people in Kinshasa possess a care, while the rest, almost 90% depend on public transport that seems to be insufficient for the public.

The second question of the survey concerned the quality of public transport in Kinshasa. The figure 3 below shows public appreciation on this topic.

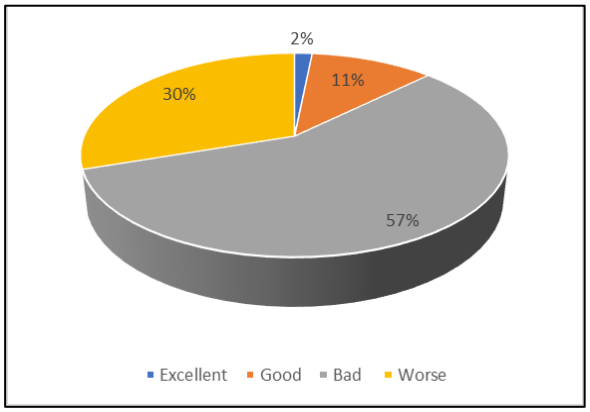

Figure 3. Appreciation of public transport quality in Kinshasa (in percentage)

Figure 2 show that majority fifty seven percent (57%) of people in Kinshasa qualify public transport to be bad. However, thirty percent (30%) of the commuters estimate that public transport is good. A small portion eleven (11%) on contrary qualify it to be bad; while only 2% think it's excellent. These figures explain how

unhappy commuters in Kinshasa are, with regard to public transport. This finding must be considered as a call to government public transport sector improvement.

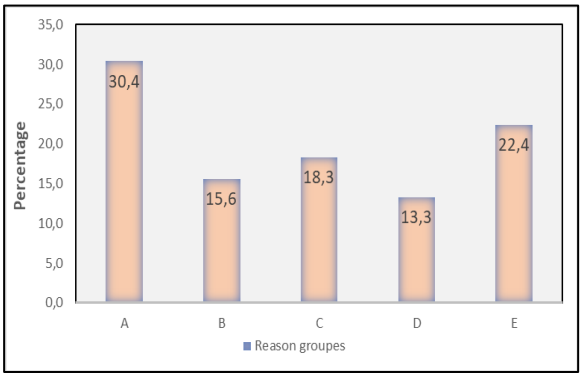

Figure 4. Reasons sustaining the worse traffic road quality in Kinshasa

A: Bad Road network architecture and aged motor vehicle status
B: Bad parking and no respect of traffic rules
C: Traffic police harassments
D: Lack of secondary roads
E: All the above reasons

The third question of the survey related to the causes of worse public transport quality in Kinshasa. At this regard, the following results expressed in Figure 4 provide the opinions of the commuters. Many opinions were evoked in people s' answers. However, for efficient understanding were compiled into main five clusters (A, B, C, D, E) as defined above. These clusters reveal that bad road network architecture and aged motor vehicle status (A) constitutes one of the biggest reasons with 30.4 % for bad traffic quality in Kinshasa. Traffic police harassments (C) stand for 18.3 %. Bad parking and no respect of traffic rules (B) constitutes the second causes with 15.6 % of opinions. Lack of secondary roads (13.3 %) is the cause for public bad quality transport in Kinshasa. Finally, 22.4% of commuters think that transport quality is tarnished by all the above reasons.

The last question for the first survey focused on remedy and suggestions for bettering the traffic road quality in Kinshasa. Figure 5 below reveals some suggestions made by commuters as well as their importance expressed in percentage.

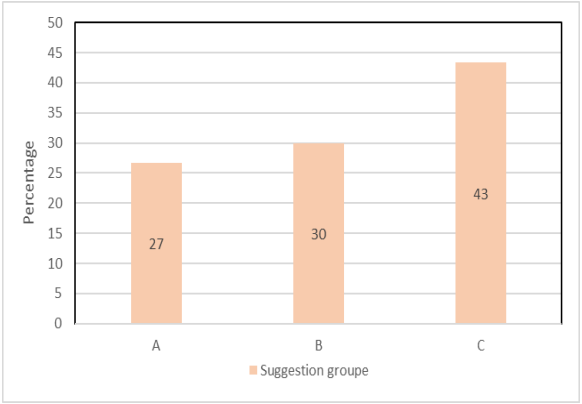

Figure 5. Road traffic improvement suggestions (%)

The second set of survey question related to traffic flow around the four selected key point areas for this study in the city of Kinshasa. As stated above in data and method section, two peak hours have been set up for on road vehicle counting during week days for 20 days or four weeks). The following results were obtained as shown in Figure 6 below.

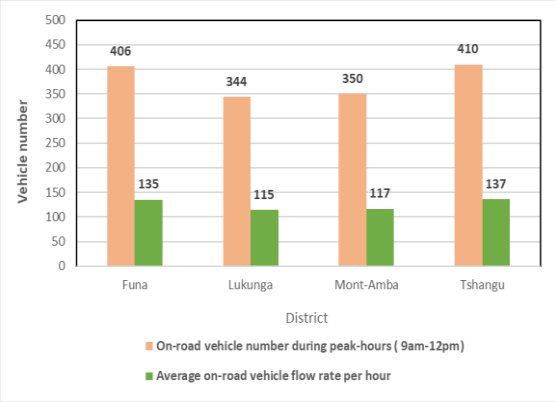

Figure 6. On road vehicles number and hourly flow rate during peak morning time (9 am to 12pm) per district in Kinshasa.

Tshangu district displays the biggest rate of 137 on-road vehicles per hour during morning peak hours in comparison with other districts. Funa comes second with a rate of 135 on-road vehicles per hour. Lukunga and Mont Amba districts display a lowest rate of 115 and 117 on-road vehicles per hour during the same period. The highest on-road vehicle flow rate is noted in Funa and Tshangu districts is due to the existence of Lumumba's boulevard that liaise the city centre to these districts. It is also the main outlet for incoming and outgoing vehicles from and to neighbouring provinces. Moreover, one must note that Tshangu district is the most populated district of the city of Kinshasa that offers a big number of bus and taxi commuters Funa district is mostly both residential and industrial. This shows how congested these roads can be at morning peak hours.

Lukunga and Mont Amba districts display a lower on-road flow rate per hour in comparison with the precedent districts. The reason behind this difference is the size of the road as well as the presence of several secondary roads leading to city centre. It is worth noting also that these two districts are not linked directly to any main highway; rather it is through many outlets that eases on-road vehicle flow in these areas.

With the same question related to on-road vehicle flow rate in Kinshasa during morning time likewise, evening time flow rate was also assessed. Figure 7 shows results obtained.

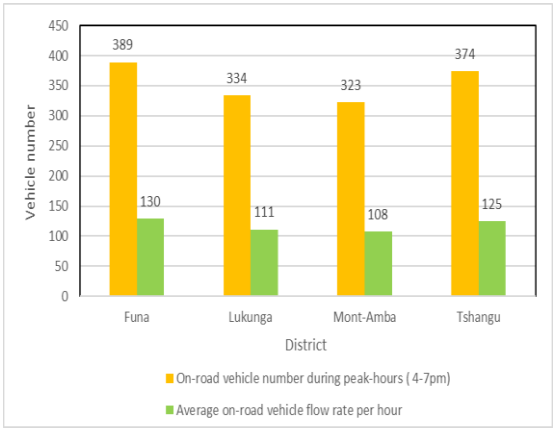

Figure 7. On road vehicle number and hourly flow rate during peak afternoon time (4 pm to 7pm) per district in Kinshasa.

Funa district displays the biggest rate of 130 on-road vehicles per hour during morning peak hours in comparison with other districts. This rate is lower than the morning rate. This may be due to its geographical position along the main high way in the city. Many vehicles leaving city centre pass over this road to reach residential areas linked to the Lumumba' Boulevard. Tshangu comes second with a rate of 125 on-road vehicles per hour for the same reason and that evoked for morning on road vehicle flow rate. Lukunga and Mont Amba districts display a lower on-road flow rate per hour in comparison with the precedent districts with 115 and 117 respectively. The reason behind this difference is the same as those evoked for the morning survey.

These results are almost similar to those recorded during morning survey. However, one must note that evening congestion is heavier than morning's one for the reasons evoked above.

Beside on road vehicle flow in the main streets in the four Kinshasa districts, an additional parameter was assessed to fulfil the purpose of this study. Total on-road vehicles at peak time as well as the average on

road vehicle flow rate per hour computation have allowed us to determine one critical characteristic of road traffic in Kinshasa. These parameters confirm well the bad quality of road network in Kinshasa such expressed by 30% of commuters in Figure 4.

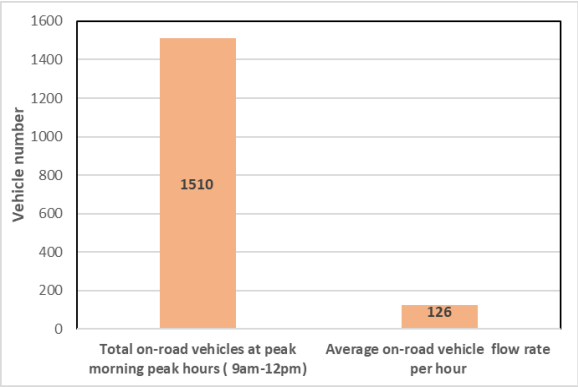

Figure 8. Morning peak hours on vehicle number and average on road vehicle flow rate per hour in Kinshasa

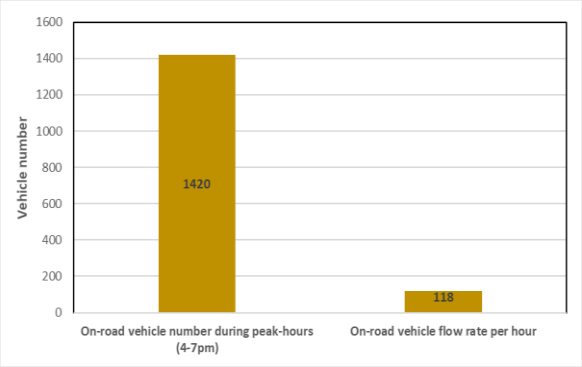

Figure 9. Evening peak hours on vehicle number and average on road vehicle flow rate per hour in Kinshasa

At this end, Figure 8 and 9 reveal that total on -road vehicle during morning peak time (9am to 12pm) are more abundant than on road vehicle evening peak (4-7pm). Morning peak reveals an average of 126 on road vehicle in comparison with 118 on road vehicle in the evening peak time.

These figures show that morning peak road traffic is lighter than evening peak. The reason behind these findings may be attributed to the fact that many people in the evening rush to reach their home on time; while morning peak reveals that road traffic is not that much heavy in comparison with the evening traffic flow rate. This may be to economics and social reasons to be investigated in future studies.

After the assessment of traffic road characteristics in Kinshasa, a corollary consequence was drawn from the quantity of pollutants emitted in the atmosphere during slow vehicle motion on the road. As mentioned above in this paper, motor vehicle emissions have negative impact on human health. They are made of chemical pollutants such as CO, CO_2, NOx, SO_2, etc and particulate matters. By lack of data for chemical pollutants, and although emission trends are not monitored in Kinshasa (McFarlane et al. 2021) only particulates from low-cost sensor installed at ETS/UPN (latitude 4.4039 S and longitude 15.2572 E), laboratory were used for illustration According to this study highest PM2.5 values (50-55 µg /m^3) of the day where recorded. These concentration peak in the evening (at about 18:00 - 20:00) coinciding with evening vehicle traffic and cooking. After 20:00, PM2.5 values start to drop quickly overnight. This reveals the role played by traffic congestion on the roads of Kinshasa.

The highest daily mean extreme value (nearly 180 µg/m^3) was observed at the Kinshasa Embassy located in city centre where heavy traffic for the whole day. These concentrations are well above WHO limit value of 10 (µg/m^3) (Fig 10).

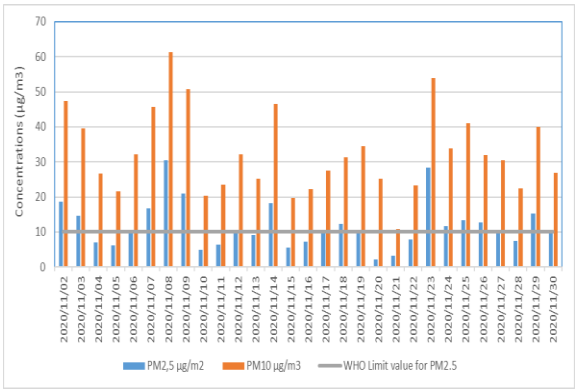

Figure 10: PM.2.5 and PM10 concentration at Belle vue cité in Kinshasa in November 2020

IV. Conclusion Et Suggestions

The purpose of this study was to assess the characteristics of road traffic quality in Kinshasa in order to warn about possible health effects on its population. From two surveys undertaken through google form questionnaire as well as in four district key points during peak hours on the day viz 9am to 12 pm and 4pm to 7 pm, data have allowed to get road traffic characteristics in Kinshasa. A biggest percentage (57%) of commuters qualified road traffic in Kinshasa to be bad while 30% state that its worse. The ultimate cause (30%) behind these qualifications was evoked in terms of bad road network architecture.

It is worth noting that 50 % of the population in Kinshasa use public transport; whilst 40 % depend on either public or private transport. Only 10 % of inhabitants in Kinshasa won a vehicle. Through a second survey related to determining on road vehicle flow in four districts of Kinshasa it was been noted that evening traffic was heavier than daily traffic congestion with a one road vehicle rate of 115 and 117 vehicles per hour in Lukunga et Mont-Amba respectively. The lowest total on-road vehicle rate observed in the four districts was 118 on-road vehicles. This confirms regular traffic jam observed in the road of Kinshasa.

With regard to impact of these traffic jam observed in the road of Kinshasa, one can conclude that the concentration of pollutants from such as particulates PM 2.5 and PM10 may cause health effects to exposed population. Such allegation confirms the findings made those particulate matter concentrations are those higher than WHO limit values. We suggest further ambient air quality studies be undertaken using more performant equipment for best data results.

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