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AMBIENT PARTICULATE MATTER (PM) EVALUATION IN GASABO DISTRICT, RWANDA

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ABSTRACT

Industries, and Vehicles emit air pollutants; all among these pollutants Particulate Matter (PM) has the greatest effects on human health like respiratory diseases and effects on environment like global warming and climate change. To find the levels of ambient PM air pollutants in commercial and bus-stations areas of Gasabo-district, one of the three districts of Kigali the capital city Rwanda was the main purpose of this research. The Air Visual Nodes instruments were used to measure values of PM concentration in microgram per cubic-meter (µg/m3). Questionnaire method was used where the total of 125 respondents for all sites was randomly selected to respond some questions before starting sampling activity in July, 2018. Sampling showed that; In both Batsinda and Kinamba commercial areas, level of PM is between (20-60)µg/m3 for PM2.5 and (80-130)µg/m3 for PM10. While in both Kagugu and Gakinjiro (Gisozi) commercial areas level of PM is between (15-45)µg/m3 for PM2.5 and (50-110)µg/m3 for PM10. In Batsinda bus-station level of PM is between (25-60) µg/m3 for PM2.5 and (80-130)µg/m3 for PM10. While in Kakiru bus-station, level of PM is between (15-40)µg/m3 for PM2.5 and (80-120)µg/m3 for PM10. Interview showed vehicle and decomposition of waste materials emissions as source of air pollutants. World Health Organization Guideline indicate that 10µg/m3 for PM2.5 and 20µg/m3 for PM10 are adequate, these above findings are high compared to these guidelines that is why education for all toward good air quality would be the best option in reducing air pollutants in Kigali city.

Contribution/Originality: This study is one of very few studies which have investigated the level of ambient particulate matter (PM) in Kigali. As result, it will help to reduce air pollutants concentration in Kigali for better human health and environmental protection in general.

1. INTRODUCTION

The term air pollution refers to the presence of toxic substances in air, due to different natural phenomena and people activities (Jamal *et al.*, 2004).

Refer to World Health Organization (WHO) reports, the first concern air pollutants due to their effect on human health are Compounds of Carbon, Nitrogen, Volatile organics, Sulfur, Halogen and Particulate Matter (Jamal *et al.*, 2004; Edimansyah *et al.*, 2009). PM refers to a combination of both liquid droplets as well as solid particles in the air. Their size varied from a small number of tens of angstroms to numerous hundred micrometers (µm) where PM2.5 stand for all particles less than 2.5µm or equals to 2.5µm in diameter while PM10 stand for all particles less than 10µm or equals 10µm in diameter (Department for Environment Food and Rural Affaires (DEFRA), 2010; Slezakova *et al.*, 2012; Seinfeld and Pandis, 2016).

In 2014 about 92 percent of world inhabitants was living in regions where WHO Guidelines on air quality standards were not well met where around 88% of the premature deaths were recorded in low middle income countries, mainly in Western Pacific and South East Asia due to air pollution (Egondi *et al.*, 2013; Khan and Kraemer, 2014; Kruza *et al.*, 2017; Yoda *et al.*, 2017). Air pollutants do not have only implications on human health, it also affect environment because of the rising of greenhouse gases emitted into the atmosphere and then pollute the air quality which result to the global warming and climate change (Bhatta *et al.*, 2016; Nahayo, 2019).

Few researches conducted in Rwanda on air quality indicated that human-activities and natural phenomena are major sources of air pollutants, where pollutants levels continue to increase according to the rapid development of the country. Kigali, the capital of Rwanda indicate rapid traffic and industries development which make pollutants to be at high levels (Henninger, 2009; Kumie *et al.*, 2014; Nahayo, 2019) that is why Rwanda Environment Management Authority (REMA) was charged to control, to investigate and to make decision based on future of the air quality in Kigali and in entire country (Authority, 2018).

This study come up with the average of concentration levels of PM in Gasabo district especially in commercial and Bust station areas where we found a large number of populations in their everyday activities.

2. METHODS AND MATERIALS

2.1. Study Ares Description

Gasabo Figure 1 largest district compared to other two districts (Kicukiro and Nyarugenge) of Kigali ($1^0$57'S; $30^0$04'E), the capital city of Rwanda is locates in North East of Kigali City. It is enclosed with Kicukiro district (in South); Nyarugnege district (in West); Rwamagana (in East); Rulindo and Gicumbi districts (in North). About 90% of Gasabo district is rural zones and it is divided into 15 sectors, 73 cells and 501 villages. Gasabo district receive annually a range of rains between (900-1500) mm and 20^0c of temperature (Henninger, 2009; Henninger, 2013; Kumie *et al.*, 2014; Nahayo, 2019).

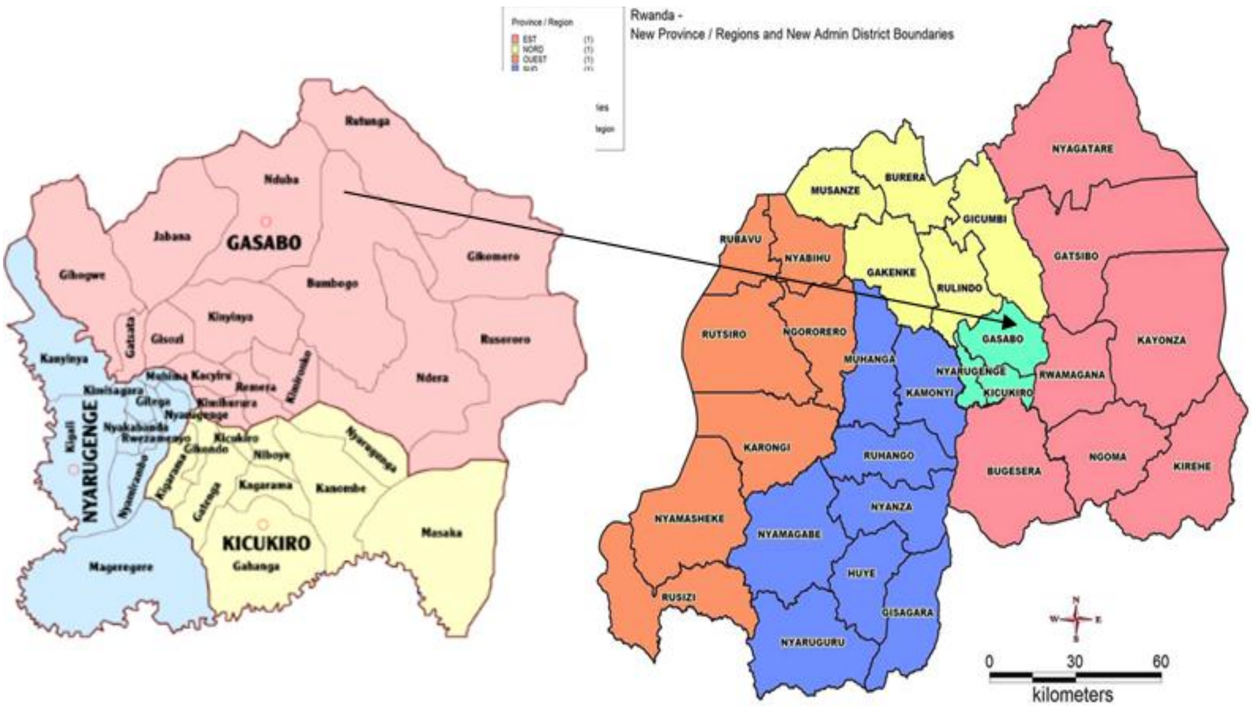

Figure-1. Location of Gasabo district based on the map of Rwanda.

Source: http://scalar.usc.edu/works/cec-journal-issue-2/institutional-causes-of-school-dropout-in-rwanda-perspectives-of-community-education-workers_ and http://www.kigalicity.gov.rw/IMG/bmp/KCC-Cells.bmp

2.2. Data Collection and Analysis

This study was conducted since July to November of 2018, from the mid of July to August was period of questionnaire method, for this later people was invited to respond question papers where all questions was related to know the approximated number of people attend the area per day, probable sources of air pollutants and evidences of poor air quality. Since September to November was the period of sampling during the day time at Morning (8:00-11:00); Noon (11:00-13:00) and at evening (14:00-16:00) by using Air Visual Nodes instruments Figure 2.

Figure-2. Air visual nodes in bus-station and in commercial areas measuring the concentration levels of PM pollutants.
Source: This photo was captured from field sampling activities.

3. RESULTS AND DISCUSSION

In this section, we describe all findings from this study. All commercial areas considered in study are Kinamba, Batsinda, Kagugu and Gakinjiro (Gisozi), these areas are represented in Figure 3 and are the largest sites with highest number of population in Gasabo district. Kinamba commercial center is among the first developed centers in Kigali City. Sampling from this site shows the level of Particulate Matter (PM) concentrations are between (20-60)µg/m3 for PM2.5 and (80-130)µg/m3 for PM10. This center has this concentration level of PM due to different facts; This center has the main roundabout in Kigali City connecting Nyabugogo-Kakiru road, Nyabugogo-Gisozi road, Nyabugogo-Gikonda road and Gisozi-Muhima road due to this, they are some-time traffic jam (which results to high emission of pollutants from pending cars to move); This center has petroleum station where different vehicles and motorcycle stop for fuel; This center has also large number of people during day-time with different activities. These above concentration levels of PM is approximately equal in terms of range to that of Batsinda commercial center where Batsinda commercial center is a still under developing center which is exactly near Batsinda car-park (bus-station) and it present a large number of vehicles passing through the unpaved road which is the main road of center. During Morning time Batsinda represent a large number vehicles and motorcycle and persons due to the biggest food market present at this place.

Gakinjiro (Gisozi) and Kagugu centers are also developed commercial centers in Gasabo district where main contribution to air pollution are vehicles emissions. Especially in Gakinjiro (Gisozi) center, at time of sampling presented a burning of waste materials from the presence of large workshop of wood materials, and the presence of small inclined roundabout. The results show that both in Kagugu and in Gakinjiro (Gisozi) commercial centers the level of Particulate Matter (PM) concentrations are between (15-45)µg/m3 for PM2.5 and (50-110)µg/m3 for PM10.

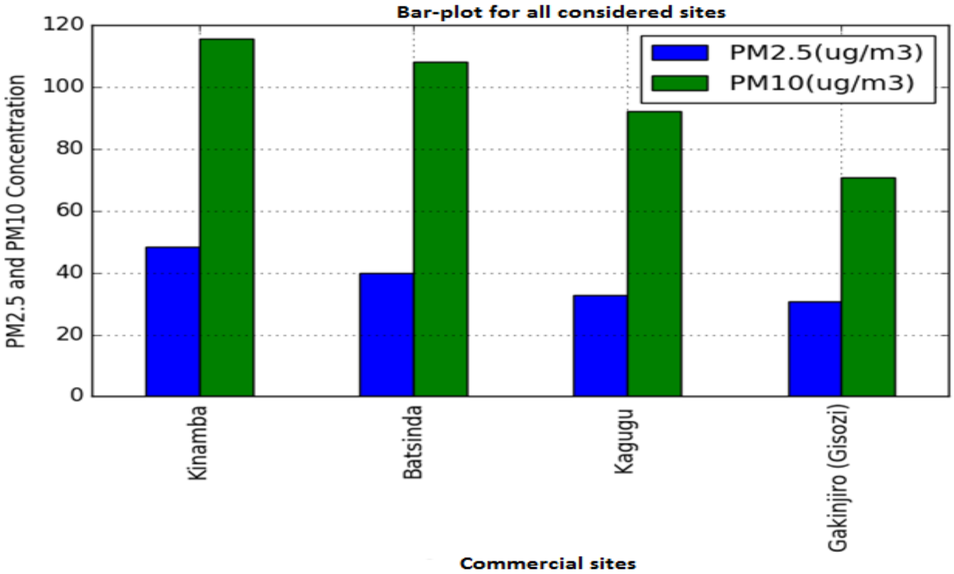

Figure-3. Levels of Particulate Matter in all commercial areas considered (Kinamba, Batsinda,Kagugu and Gakinjiro (Gisozi)) where Kinamba and Batsinda have highest levels of PM compared to that of Kagugu and Gakinjiro (Gisozi) Areas.

Source: Average values plot of PM concentration in all commercial areas.

Bas-stations considered in Gasabo district are Batsinda and Kakiru Figure 4, the selection of these two stations was based on their large number of passengers present during day time, this resulting to the presence of many cars. In Batsinda bus-station findings show that the level of Particulate Matter (PM) concentrations are between (25-60) µg/m3 for PM2.5 and (80-130) µg/m3 for PM10, this level is due to the presence of unpaved bus-station and road, many numbers of cars and the presence of large food market Batsinda bus-station is near Batsinda commercial center. Kakiru bus-station, the paved bas-station presents large number of cars and many passengers during day-time. Findings show that in Kakiru bus-station the level of Particulate Matter (PM) concentrations are between (15-40) µg/m3 for PM2.5 and (80-120) µg/m3 for PM10.

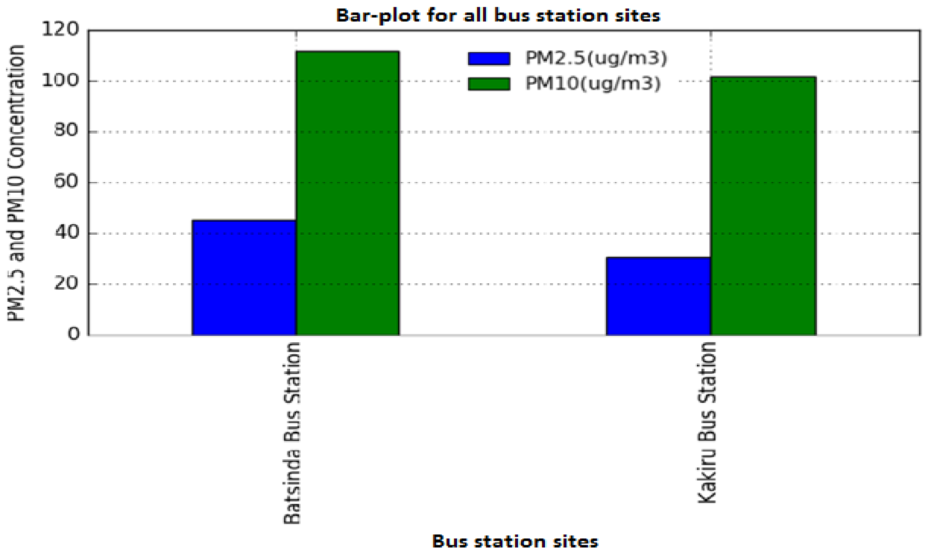

Figure-4. Levels of particulate matter for two bus-station areas considered (Batsinda and Kakiru) where Batsinda Bus station has high level of PM compared to that of Kakiru Bus stations.

Source: Average values plot of PM concentration in all bus stations.

By considering all sites Figure 5, Measurements show that levels of Particulate Matter in Kinamba and Batsinda commercial centers, Kakiru and Batsinda Bus-station have the highest concentration levels while Kagugu and Gakinjiro (Gisozi) commercial centers have low levels compared to other sites.

Results from questionnaire method where the total of 125 respondents for all sites was randomly selected to respond questionnaires designed in order to get the primary information (presence of smell, behaviors of persons in each site, the estimated sources) related to air quality of the sites. In general for all sites considered respondents said that the primary air pollution sources are automobile emissions, followed by decomposition of waste materials emissions which make them to be uncomfortable when they breathe these above emissions.

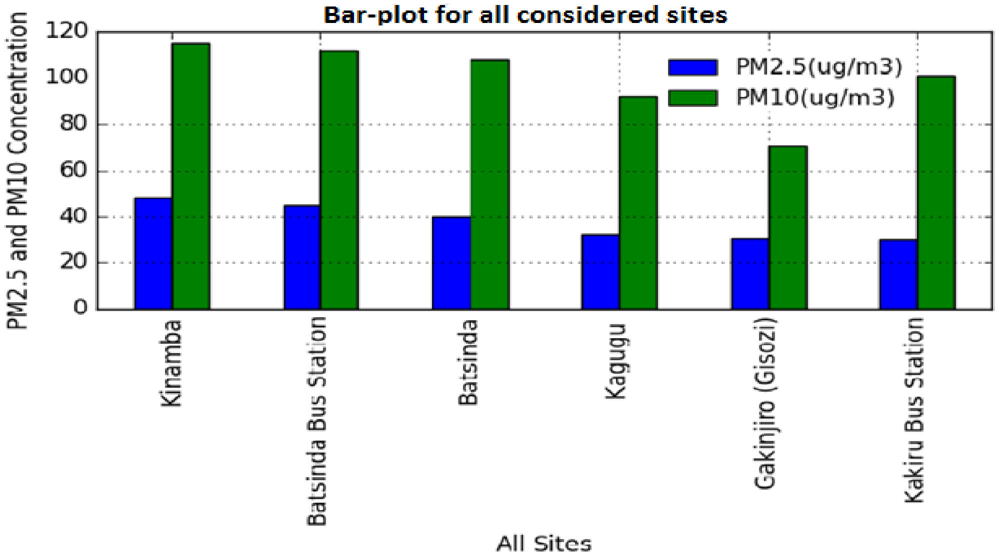

Figure-5. Concentration levels of $PM_{2.5}$ and PM_{10} for all sites by considering commercial and bus stations areas.
Source: Average values plot of PM concentration in all considered areas.

4. CONCLUSION

Findings from sampling show that; In both Batsinda and Kinamba commercial areas, the level of Particulate Matter (PM) concentrations are between (20-60)µg/m3 for PM2.5 and (80-130)µg/m3 for PM10. While in both Kagugu and Gakinjiro (Gisozi) commercial areas the level of Particulate Matter (PM) concentrations are between (15-45)µg/m3 for PM2.5 and (50-110)µg/m3 for PM10. In Batsinda bus-station the level of Particulate Matter (PM) concentrations are between (25-60) µg/m3 for PM2.5 and (80-130)µg/m3 for PM10. While in Kakiru bus-station, the level of Particulate Matter (PM) concentrations are between (15-40)µg/m3 for PM2.5 and (80-120)µg/m3 for PM10. Findings from interviews indicated the primary air pollutants sources are vehicle emissions followed by decomposition of waste materials emissions.

World Health Organization (WHO) Guideline indicate that 10µg/m3 for PM2.5 and 20µg/m3 for PM10 are adequate, these above findings are high compared to the above guidelines that is why more efforts toward good air quality through traffic jam reduction policies, creation of paved road and car-parks, emission control of cars, education from primary to graduate level, local meetings, trainings and appropriate information sharing via media and social media would be the best option in reducing the air pollutants in Kigali city for both better human-health and environment in general.

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