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Assessment of $PM_{2.5}$ in Oluku Dumpsites and Selected Residential Areas, Ovia North East Local Government, Benin City, Edo State, Nigeria

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ABSTRACT: An Assessment of $PM_{2.5}$ at Oluku dumpsite and selected residential buildings was investigated in Ovia North East local government in Benin City, Edo state Nigeria using a portable hand-held digital anemometer (BTMETER 100) and air quality monitor (L529K). Data obtained gives the mean values of PM2.5 range of 36.20-45.50 µg/m^{3}and 58.17–393.82 µg/m^3 for wet and dry season respectively, which shows significant difference in spatial and seasonal distribution of $PM_{2.5}$ ($p< 0.05$) in the study area and control stations. Further findings revealed that concentration $PM_{2.5}$ in both seasons and sampling locations exceeded the WHO and USEPA Limits of 25 µg/m^{3}and 35 µg/m^3 respectively with the exception of the control (GAQC) location during wet season.

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Air pollution has become a growing source of worry and anxiety for our health and environment which is as a result of rapid growths and development such as urbanization, industrialization and automotive emissions (Yan *et al.,* 2020). Particulate matter is regarded as the most significant pollutants in cities around the world because of its negative health impacts, which include cardiovascular illness, respiratory irritation, and pulmonary dysfunction (Yaun yet al., 2012). $PM_{2.5i}$refers to particles with a diameter less than 2.5 or equal to 2.5 and it has been shown to have a greater impact on human health and the environment due to their small diameter and large surface areas,. Their small size and large surface area allows them to be more chemically active and thus are capable of attracting various toxic substances, passing through nose hair filtration, penetrating deeply into the lung, reaching the end of the respiratory tract with airflow and accumulating there by diffusion, damaging other parts of the body through air exchange in the lung (Yu- fei *et al.,* 2018). According to (Ukpebor *et al.,* 2021) premature death is an ultimate impact of air pollution. $PM_{2.5}$ are generally grouped into outdoor sources and indoor source and some of the outdoor sources are; forest fires, waste burning, cars or automobile emissions, coal or natural gas combustion construction sites, soil, natural gas powered plants, fires while some of the indoor sources are; cooking, smoking tobacco, and incense (Esworthy, 2013). Studies have shown that meteorological parameters (temperature, wind speed and humidity) influence the dispersion, transformation and dilution of particulate matter within the environment (Gallagher *et al.,* 2015). The toxicity of PM is determined by their size, composition, and concentration. Studies have shown that smog is generally caused by high concentrations of fine particles (particle size less than or equal to 2.5 um

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referred to as PM$_{2.5}$) or aerosols (Haldane, 2019). It has been found that PMs with an aerodynamic diameter smaller than 2.5 µm have a greater impact on human health (Tunde *et al.*, 2018). A major adverse effect of waste incineration is the release of particulates and other criterion air contaminants (SO_2, NO, CO etc). These contaminants have multiplier effect on environmental components. Because of their minute size, they tend to have a large surface area, therefore allowing more chemical activity combining easily with microbes, PAHs, and toxic metals (Ojeaga and Atufe 2023). Over time they are scavenge and deposited on the earth's surface by mechanisms of either dry or wet deposition. Soil becomes the major recipient of contaminants emitted by incineration. It also has a negative impact on ecosystems, including plants, due to plant uptake, ultimately leading to a disruption in the food chain. Short- or long-term exposures to particulate matters (PM) have negative health impact including responsible for respiratory and cardiovascular illness in children and adults (Zakaria *et al*., 2019). The effect of dirt in the dumpsite on particulate matter and its concentration varies from place to place depending on the nature of activities carried out in the dump. According to global burden of illness estimates, residents in Nigeria have a shorter life expectancy than the regional or global norm because of their exposure to unclean air (Short and Stuable 1967). Over the years, the open dumpsite in the study area Oluku, has witnessed tremendous increase in the volume of waste generated owing to growth in human population occasioned by urbanization and the desire of most Nigerians to own houses. Consequently, managers of the open dumpsite have resorted to incineration or waste burning in order to reduce the waste loadings (volume of the wastes). This is of great concern to public health and environmentalists; as wastes incineration is capable of producing particulate matter that may pose serious threat to the quality of air in the area. Therefore, the objective of this paper is to assess the level of PM$_{2.5}$ in Oluku Dumpsites and Selected Residential Areas, Ovia North East Local Government, Benin City, Edo State, Nigeria.

MATERIALS AND METHODS

The Study Area: The study area Oluku and environs is an emerging commercial hub in Benin City and it also serves as residential areas for thousands of people in the locality. It lies between latitude and longitude and a major gateway into Benin City, Edo State from Lagos and Ondo States respectively. The research was conducted at Oluku dumpsite and some residential areas in Ovia North East local government in Benin City, Edo state Nigeria. The dumpsite is of great concern due to its proximity to residential areas.

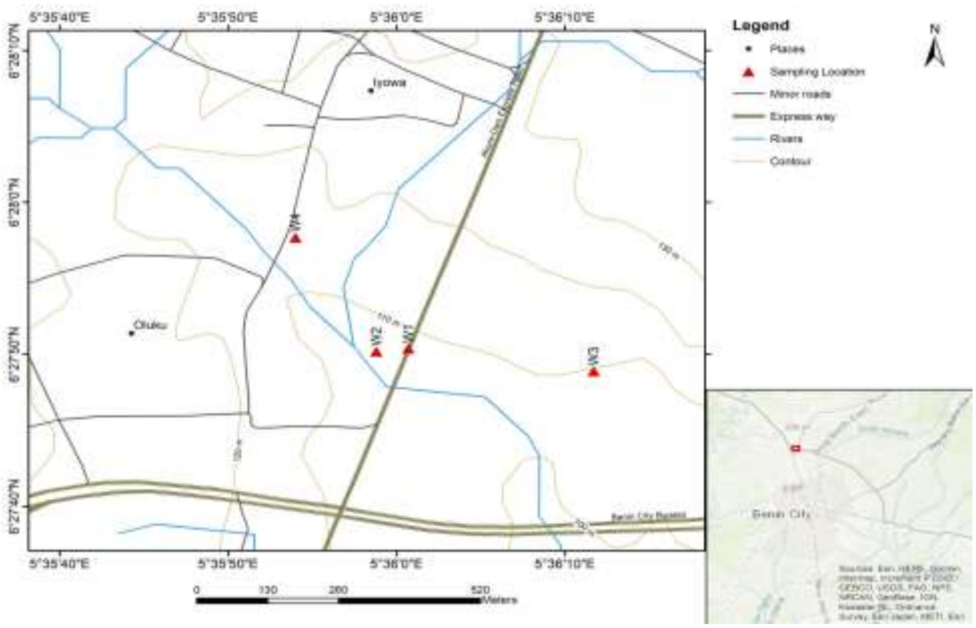

Fig. 1. Sampling location map within Oluku open dumpsites

The Geology of The Study Area: The study area and environs is underlain by the Benin Formation which is part of the Niger Delta basin. The geology is generally marked by top reddish earth, composed of ferruginized or lateralized clay sand. Parkinson in 1907, first used the term Benin sand to describe the reddish earth underlain by sands, sandy clays and ferruginized sandstone that marked the paleo-coastal environment of the Paleocene- Pleistocene age. These sediment spread across the southern fringes of the Anambra basin and mark the Upper facies off-flaps of the Niger Delta. The formation is characterized by top reddish to reddish brown lateritic massive, fairly indurated clays and sands. This is often marked with reticulate mud cracks. This caps the underlying more friable pinkish-yellowish to white, often gravelly-pebble sands, clayey soils, sands and clays. The sedimentary sequences are poorly bedded with discontinuous clay horizons at various depths (Ojeaga and Atufe 2023)

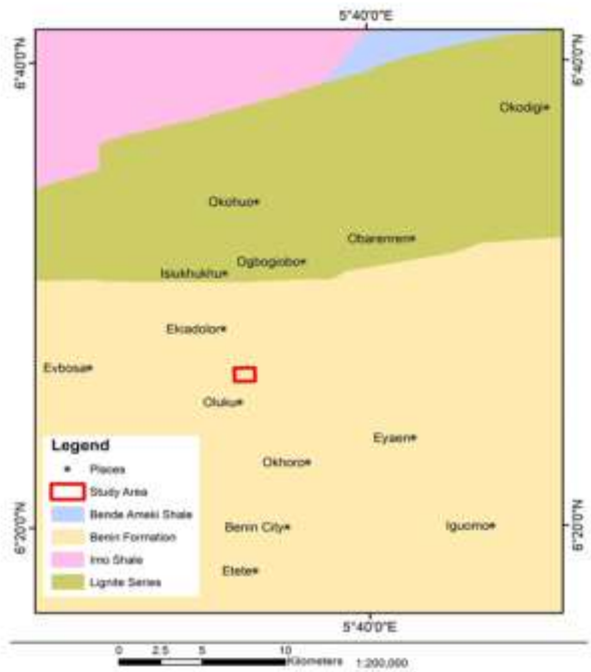

Fig 2: Geological map of the Study area.

Sampling Locations: A total of five (5) sampling locations were sampled for PM$_{2.5}$ within Oluku axis, Ovia North East local government area, Edo State. One (1) open dumpsite, three (3) residential areas and one (1) control location.

The locations were geo-referenced by the application of global positioning system (GPS). A total of 126 PM2.5 data were measured from (January 2022 to March 2022) and (September to November 2022) for a six month period with a 6-days interval to examine seasonal variations.

Particulate Matter (PM$_{2.5}$) Sampling: Portable hand-held air quality monitor (L529K) is a seven (7) in one active sampling device that is calibrated to detect In-situ values for PM$_{2.5.}$ The sampler uses light scattering method in determining the PM$_{2.5}$ concentration. It has a display screen which gives the active values for PM$_{2.5}$ measure at each location.

Table 1. Showing the details of sampling locations across Seasons

Location Code	Coordinates	Traffic	Seasons
GAQ-L1	N 060° 27' 50.4'' E 0050° 36' 00.7''	Moderate	Dry
GAQ-L2	N 060° 27' 50.2'' E 0050° 35' 58.8''	Moderate	Dry
GAQ-L3	N 060° 27' 50.4'' E 0050° 36' 00.7''	Moderate	Dry
GAQ-L4	N 060° 27' 57.7'' E 0050° 35' 54''	Low	Dry
GAQC	N 060° 27' 57.7'' E 0050° 35' 54''	Low	Dry
GAQ-L1	N 060° 27' 50.4'' E 0050° 36' 00.7''	Moderate	Wet
GAQ-L2	N 060° 27' 50.2'' E 0050° 35' 58.8''	Moderate	Wet
GAQ-L3	N 060° 27' 50.4'' E 0050° 36' 00.7''	Moderate	Wet
GAQ-L4	N 060° 27' 57.7'' E 0050° 35' 54''	Moderate	Wet
GAQc	N 060° 27' 57.7'' E 0050° 35' 54''	Moderate	Wet

Meteorological Parameters: The meteorological information were collected using a Portable hand-held air quality monitor (L529K) a seven (7) in one multifunctional meter equipped with a hygrometer for determination of the relative humidity and a thermometer for temperature determination. The wind speed was measured using a portable hand held anemometer BTMETER (BT-100). Air temperatures and humidity were measured simultaneously during the survey at an operating conditions of 0 to 50 °C, the thermometer measures within a range of -10°C to 130°C with a sensitivity of 0.1°C and an accuracy of ± 1%; the hygrometer records relative humidity within a range of 10 to 95% with a sensitivity of 0.1% and an accuracy of ± 4%; while the anemometer measures in a range of 0.3 to 30.0 ms-1, a sensitivity of 0.10ms-1 and an accuracy of ± 1%.

Statistical Analysis: Statistical analysis of the obtained data was performed using descriptive statistics with the help of Microsoft Office Excel 2013 software the association between different parameters were done using correlation and regression statistical model. Finally, the level of data significances was done by determining the p-value by two-ways analysis of variance (ANOVA) using Microsoft Excel 2013 statistical package software.

RESULT AND DISCUSSION

Table 1 and 2 represents mean values of PM$_{2.5}$ and climatogical parameters obtained from the open dumpsite and other sampling locations, Oluku and environs, Ovia North East local government.

Table 1: Mean values of both meteorological parameters and $PM_{2.5}$ concentration obtained during the wet season.

Location	Temperature (C)	Humidity (%)	Wind speed (m/s)	$PM_{2.5}$ (µg/m³)
GAQ-L₁	31.05 ± 1.05	64.80 ± 6.18	0.78 ± 0.26	40.40 ± 4.16
GAQ-L₂	31.50 ± 0.57	62.00 ± 5.87	2.28 ± 0.26	45.50 ± 1.87
GAQ-L₃	31.60 ± 0.10	64.20 ± 3.11	0.30 ± 0.08	37.17 ± 1.17
GAQ-L₄	32.57 ± 1.20	68.20 ± 6.91	0.67 ± 0.17	36.20 ± 0.84
GAQ$_C$	31.85 ± 1.14	68.00 ± 6.04	1.34 ± 0.45	22.19 ± 0.36
WHO 2005				25 µg/m³
USEPA 2009				35 µg/m³

Table 2 Mean values of both meteorological parameters and $PM_{2.5}$ concentration obtained during the dry season

Location	Temperature (C)	Humidity (%)	Wind speed (m/s)	$PM_{2.5}$ (µg/m³)
GAQ-L₁	34.60 ± 2.94	55.60 ± 4.04	1.67 ± 0.98	393.82 ± 17.11
GAQ-L₂	32.05 ± 2.97	51.60 ± 5.32	0.89 ± 0.37	108.83 ± 5.79
GAQ-L₃	31.85 ± 1.35	50.00 ± 6.32	1.88 ± 0.23	63.83 ± 16.50
GAQ-L₄	33.48 ± 2.30	51.20 ± 7.53	0.93 ± 0.23	58.17 ± 8.65
GAQ$_C$	32.92 ± 1.12	51.20 ± 6.98	1.01 ± 0.19	37.30 ± 1.44
WHO 2005				25 µg/m³
USEPA 2009				35 µg/m³

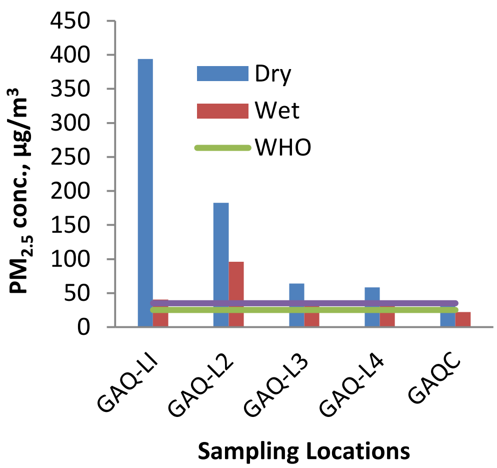

Fig.3. Average seasonal $PM_{2.5}$ concentration comparison along with standards

Particulate Matter ($PM_{2.5}$): The mean value of $PM_{2.5}$ varied from 36.20 – 45.50 µg/m³ and 58.17 – 393.82 µg/m³ during the wet and dry season respectively as depicted in Table 1 and Table 2. The highest mean concentration of 393.82 µg/m³ was obtained at GAQ-L_1 in the dry season and the lowest mean concentration of 36.20 µg/m³ was obtained at GAQ-L_4 during the wet season respectively. The high mean concentration of $PM_{2.5}$ recorded in the dry season could be attributed to the particles generated during incineration at the dump and the prevailing harmattan wind which might be responsible for their resuspension in the air (Ojeaga and Atufe 2023). Further findings indicate that the value of $PM_{2.5}$ exceeded the (WHO, 2021) and (USEPA 2009) 24 hour regulatory limits of 25 µg/m³ and 35 µg/m³ across the sampling locations and in all seasons (wet and dry) with the exception of Control location GAQ$_C$ as depicted in Fig.1

Temperature and Relative Humidity: The seasonal and spatial variations of temperature at the sampling locations during the sampling period are presented in Table 1 and Table 2. The wet season mean temperature varied from 31.05 – 32.57°C while the mean temperature in dry season varied from 31.85 – 34.60°C in all sampling locations. The lowest mean temperature (31.05°C) was observed at location GAQ-L_1 during the wet season and the highest mean temperature was recorded (34.60°C) at the same location during the dry season sampling period as indicated in Fig 4.

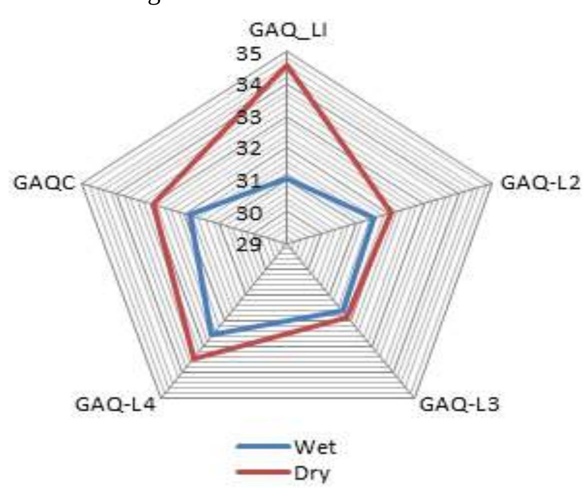

Fig.4. Average temperature at sampling locations during wet and dry seasons

The relatively high temperature recorded in location GAQ-L_1 could be responsible for the fairly low humidity observed at the same location GAQ-L_1. Mean values for relative humidity varied of 62.00 – 68.20% and 50.00 – 55.60% for both wet and dry season as shown in Fig5. The lowest mean relative humidity (50.00%) and were obtained at GAQ-L_3 during dry season sampling and the highest mean relative humidity (68.20%) was found during the wet season at GAQ-L_4.

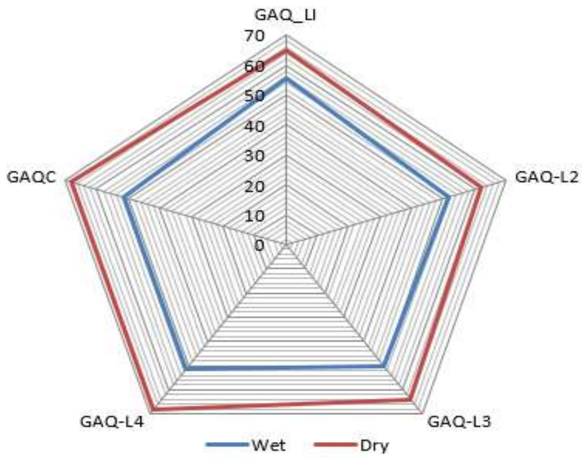

Fig.5. Average relative humidity for sampling locations in both wet and dry season

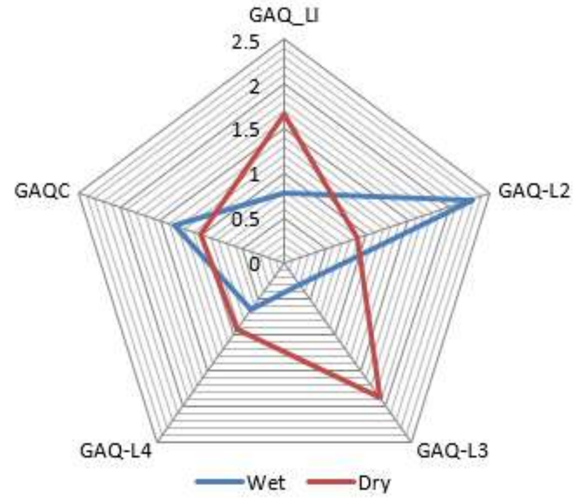

Fig.6. Average wind speed at the sampling locations during wet and dry seasons

Table 3. Seasonal relationship in the obtained $PM_{2.5}$ data

Sources of Variations	Seasonal Mean of $PM_{2.5}$	*P-value*
Wet Season	54.68 ± 12.43	0.463655
Dry Season	170.65 ± 34.74	
Spatial	112.67 ± 18.65	0.212621

Wind Speed: Wind speed is responsible for the mechanism that influences the resuspension and diffusion of particulate emissions in the atmosphere (Tunde *et al.*, 2018). The mean values of wind speed recorded at the various sampling locations in both wet and dry seasons are presented in Table 1 and 2 respectively. Mean values of wind speed in the wet season ranged from 0.3m/s-2.28m/s and ranged from 0.89m/s -1.67m/s in the dry season. The high value of wind speed recorded in location $GAQL_2$ might be responsible for the slight increase in the concentration of $PM_{2.5}$ at the same location during the dry season Fig 5. The seasonal relation table for the obtained $PM_{2.5}$ parameter and other meteorological details is presented in Table 3. The table above reveals a significant difference in the spatial and seasonal distribution of $PM_{2.5}$ concentration obtained. Comparing the concentration of $PM_{2.5}$ obtained around Dumpsite.

Conclusion: This research has shown that incineration or waste burning is a major contributor of particulate matter in Oluku and environs especially during dry season. Therefore it can be concluded that the practice of reducing the volume of the waste by burning or incineration should be abolished as it pose significant threat to residents and environmental components. The use of air purifiers should be encouraged in every home and offices to remove particulate pollutants that may be present in air.

REFERENCES

Erin, E; Randall, V. M; Joseph, V; Richard, B; Steven, J. S; Patrick, O; Melanie, S; Aaron, V; Liam, B; Viral, S; Lyatt, J; Gan, L; Fangqun, Y; Jamiu, A. A; Jintai, L; Micheal, B. (2021). Source Sector and Fuel Contributions to ambient $PM_{2.5}$ and attributable mortality across Multiple Spatial Scales. *Nature Communications.* 12: 3594.

Esworthy, R. (2013). Air Quality: EPA's 2013 Changes to particulate matter (PM) Standard *Congressive Reserve Service.* 6: 157-208.

Gallagher, M; Turner, E. C; Kamber, B. (2015) In situ trace metal analysis of Neoarchaean – Ordovician shallow-marine microbial-carbonate-hosted pyrites. *Geobiology*, 13: 316–339.

Haldane; K. (2019). What is $PM_{2.5}$ and how can you Reduce Your Exposure? *Molecule Science.* 30: 21-53.

Ojeaga, K; Atufe, A. (2023) Assessment of $PM_{2.5}$ around rock quarrying site and residential communities of Iyuku and Ikpeshi, Estako west, Akoko Edo, Edo state. *J. Sci. Technol. Res.* 5(2): pp. 9-20.

Short, K.O; Stauble, A.J. (1967). Outline of the geology of Niger Delta. *Bulletin American Association Petroleum Geologist* 51:761 – 779.

Tunde, O. E; Ayotunde, T. E; Gregory, O. A; Ajay, P; Saravana, D. S; Kannan, K; Narendra, KA. (2018). The gains in life Expectancy by Ambient $PM_{2.5}$ Pollution reductions in localities in Nigeria. *Environ. Pollution.* 236: 146-157.

Ukpebor, JE; Omagamre, WE; Abayode, B., Unuigbe, CA; Dibie, EN; Ukpebor, EE (2021). Baseline Concentrations of Fine and Coarse Particulate Matter in a Tropical City with Introduced Traffic Control Measures. *Inter. J. Environ. Pollution and Environ. Modeling*. 4(1): 28-48.

United States Environmental Protection Agency (2009). Integrated Science Assessment for particulate matter. Washington DC.

World Health Organization (WHO). (2021). Air Quality Guidelines: Global update 2005. Availablefrom:https://www.c40knowledgehub.org/s/article/WHO-Air-Quality-Guidelines?language=en_US

Yan, G; Yu, Z; Wu, iiY.,Liu, J; Wang, Y; Zhai, J; Cong, L; Zhang, Z (2020). Understanding $PM_{2.5}$ Concentration and removal efficiency variation in urban forest park-Observation at human breathing height. *Peer-Reviewed Sci. J.* 8: 1-3.

Yuan, Y., Liu, S., Castro, R. Pan, X. (2012). $PM_{2.5}$ Monitoring and Mitigation in the Cities of China. *Environ. Sci. Technol.* 46(7): 3627-3628.

Yu-Fei X; Yue-Hua, X; Min-Hua, S., Yi-Xin. L. (2018). The impact of $PM_{2.5}$ on the human respiratory system. *J. Thoracic Disease.* (1): 69-74.

Zakaria, N. N; Othman, M; Sokkalingam, R; Daud, iiH., Abdullah, L; Abdul Kadir, E. (2019). Markov chain model development for forecasting air pollution index of Miri, Sarawak. *Sustainability*, 11(19): ii5190.