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AN ASSESSMENT OF SEASONAL VARIATION OF GASEOUS AND PARTICULATE MATTER EMISSIONS ACROSS WASTE DUMPSITES IN LAGOS, NIGERIA.

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ABSTRACT

This study evaluated the seasonal differences in the gaseous and particulate matter emitted across the Olusosun, Solous 3 and Abule Egba dumpsites in Lagos. This was with a view to acquire data that would be useful to environmental policy makers and also to create awareness that would minimize the associated public health risks. The study covered a period of one year. Gaseous and particulate emissions taken into consideration were formaldehyde (HCHO), Total Volatile Organic Compounds (TVOCs), hydrogen sulphide, sulphur dioxide, carbon monoxide, particulate matter ($PM_{1.0}$, $PM_{2.5}$, PM_{10}) and Air Quality Index of particulate matter $_{2.5}$. Values for HCHO, TVOCs, particulate matter, AQI of $PM_{2.5}$ were derived using EGVOC-180 multifunctional air quality detector. Aeroqual monitor was used to monitor the levels of H_2S, SO_2 and CO. Three sampling points were randomly sampled across the dumpsites. H_2S, SO_2 and CO recorded zero values across the dumpsites. The independent- samples T test was used to determine significant differences in monthly mean concentrations across dry and wet seasons. The dry season recorded higher concentrations of gaseous and particulate emissions with HCHO (mg/m^3), TVOCs (mg/m^3), $PM_{1.0}$ (µg/m^3), $PM_{2.5}$ (µg/m^3), PM_{10} (µg/m^3) and AQI of $PM_{2.5}$ having mean values of 0.25, 0.57, 52.38, 56.14, 61.38 and 133.98 respectively for the dry season as compared to their mean concentrations of 0.02, 0.07, 32.15, 35.05, 35.12 and 84.14 respectively for the wet season. The study concludes that seasonality significantly influences pollutants emissions across the dumpsites.

Keywords: Pollutants, Seasonal, Gaseous, Particulates, Dumpsites,

INTRODUCTION

A waste dumpsite is a non-engineered area of land or excavation set aside to receive wastes. In Nigeria, Lagos is of special concern for air pollution studies because of its high population density coupled with intense industrial and commercial activities (Oluyemi and Asubiojo, 2001). Lagos takes the lead in the amount of solid wastes generated yearly in the whole of Nigeria (Olorunfemi, 2020). These wastes are generated from various anthropogenic activities. Most waste dumpsites in Lagos are often located in the public domain and surrounded by residential buildings. They generate, emit gases and particulate matter into their ambient environments. As a result, these dumpsites become a public health threat to scavengers, dumpsite workers and vicinity residents (Aderemi and Falade, 2012).

Ailments such as asthma, respiratory problems, cough, nose and eye irritation have been associated with high levels of

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particulate matter (Ndiokwere, 2004; Balogun and Orimoogunje, 2015). Long term exposure to formaldehyde has been associated with nasal and lung cancers.

Seasonality has always been a factor determining the concentration of pollutants in the troposphere and there is therefore a need to establish a relationship between air pollution and seasonality. (Balogun and Orimoogunje, 2015).

Daramola and Makinde, (2024) reported the presence of nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2) and Particulate Matter ($PM_{2.5}$, PM_5 and PM_{10}) in the Olusosun and Solous dumpsites . Sonibare *et al*. (2020) observed that sulphur dioxide (SO_2) was not detected in the Olusosun and Abule Egba dumpsites.

Insufficient data exist on dumpsites' air pollution in Lagos metropolis. Comprehensive studies are also yet to be carried out on these dumpsites.

The present study focuses on the Olusosun , Solous 3 and Abule Egba dumpsites. It provides a baseline levels for formaldehyde, TVOCs, particulate matter ($PM_{1.0}$, $PM_{2.5}$ and PM_{10}), hydrogen sulphide (H_2S), sulphur dioxide (SO_2), carbon monoxide, temperature and relative humidity across these dumpsites.

MATERIALS AND METHODS

Description of the Study Area: The Climate of Lagos.

Lagos lies in the southwestern part of Nigeria within the latitude 6º 23' N and 6 º 41' N and longitudes 2º 42' E and 3º 42' E (Njoku *et al.,* 2016)**.** Lagos as well as the study sites has a tropical climate. There are two seasons in Lagos- the rainy (wet) season and the dry season. The wet season is between March and mid- October while the dry season is between the ending of October to early March (Oyewole *et al.*, 2014). There is also the harmattan period that occurs between late November to March. Being located in coastal area and affected by sea based disturbances, Lagos experiences an average wind speed of 4.3km/h (Komolafe *et al.*, 2014).

The Olusosun Dumpsite

The Olusosun dumpsite is located at Ojota in the Kosofe Local Government of Lagos State. The dumpsite is situated between latitudes 2º 42'E and 3º 42' E and Longitudes 6º 23'N and 6º 41'N (Oyebode *et al.*, 2023). The dumpsite has been receiving wastes since 1992. The dumpsite occupies an area of approximately 43 hectares (LAWMA Report, 2024). It is the largest dumpsite in Lagos and receives about 2,100,000 tons of solid wastes annually (Omokaro *et al.*, 2024).

Solous 3 Dumpsite

The Solous 3 dumpsite started receiving wastes in 2008. The landfill is the largest of the three Solous dumpsites. It covers an area of 12 hectares and it's located on N06º 33.897', E003º 15.082' (Aderemi and Falade, 2012). The dumpsite receives different wastes from the entire Lagos metropolis.

Abule Egba Dumpsite

The Abule Egba dumpsite is located in the Northern part of the Lagos metropolis. The site measures about 10.5 ha and receives 250,000 tons of wastes annually (Olorunfemi, 2020).

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Sampling Methodology and Instrumentation

Three sampling points were randomly sampled in all the dumpsites (Olusosun, Solous 3 and Abule Egba). The three sampled points were designated as Point A, B and C. Point A was the Scavengers' gathering point and common area. Point B was where fresh wastes were dumped and point C had relatively older wastes. Analysis of ambient air and air pollutants measurement methods used were those approved by ASTM (2001) for specific parameters. All equipment and air quality detector meters were properly pre-calibrated before each usage for quality assurance (Njoku *et al.*, 2016). Sampling points coordinates were obtained with hand-held automated GPS device. Readings for HCHO, TVOCs, Particulate Matter ($PM_{1.0}$, $PM_{2.5}$, PM_{10}), Air Quality Index of Particulate Matter ($PM_{2.5}$) were derived from the field using EGVOC-180 multifunctional air quality detector. Stable and accurate readings over a period of one hour were taken to be the values at each point. Readings for mean temperature and relative humidity were also derived using EGVOC-180 multifunctional air quality detector. Aeroqual Monitor (S500) was used to determine the levels of H_2S, SO_2 and CO. Readings were taken at a height of approximately two metres from the ground level following the World Meteorological Organization (WMO) standard for ambient weather measurement (WMO, 2008). Sampling frequency was twice monthly (between the hours of 10:00am -18:00pm) for one year. The arithmetic mean was used in compressing a wide variety of data derived from the field.

EGVOC-180 Multifunctional Air Quality Detector

The EGVOC-180 multifunctional air quality detector is a portable gaseous and particulate emission analyzer. It has a photoionization detector (PID). The photoionization devices are not chemical-specific (Adeyemi *et al.*, 2020). The device was calibrated with self-auto calibration for quality assurance/control.

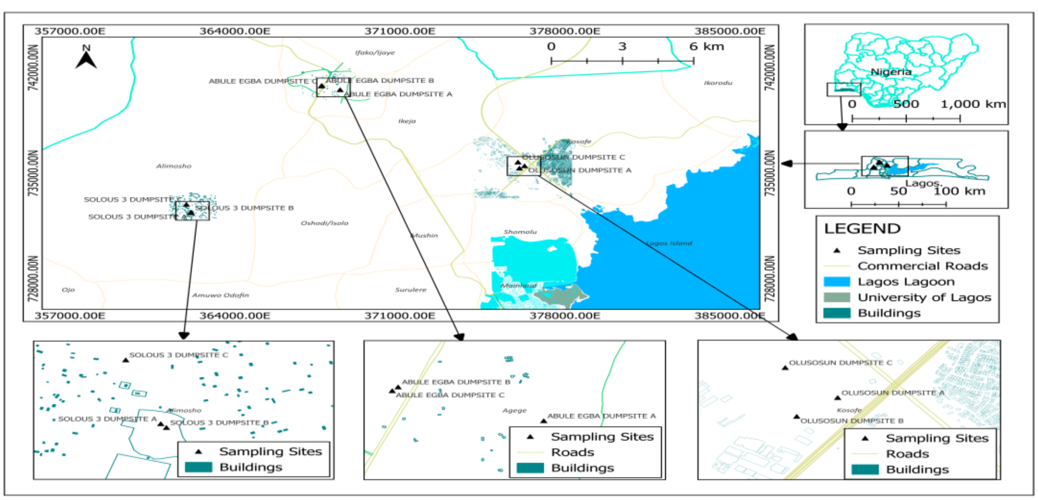

Figure 1: Map of the study areas showing sampling locations

Table 1: Names, coordinates and location of sampling points.

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SAMPLING POINTS	COORDINATES	DUMPSITES
A	6º 33’ 54” N, 3º 15’ 11” E	SOLOUS 3 DUMPSITE
B	6º 33’ 53”N, 3º 15’ 12” E	
C	6º 34’ 11”N, 3º 15’ 5” E	
A	6º 35’ 33” N, 3º 22’ 49” E	OLUSOSUN DUMPSITE
B	6º 35’ 28” N, 3º 22’ 42” E	
C	6 º 35’ 41” N, 3º 22’ 40” E	
A	6º 38’ 15” N, 3º 18’ 36” E	ABULE EGBA DUMPSITE
B	6º 38’ 24”N, 3º 18’ 11” E	
C	6º 38’ 23” N, 3º 18’ 10” E	

Note: Point A = Scavengers’ gathering point and common areas
Point B = Fresh wastes point.
Point C = Old wastes spot.

Statistical Analysis

Descriptive statistics, group statistics and independent samples T test were performed. Duncan multiple post Hoc test was also performed at $P < 0.05$ in ONE way-ANOVA (Analysis of Variance). Correlation relationships between the parameters for all the dumpsites were also analyzed. Statistical analysis was conducted using SPSS (Version 27) and Microsoft Excel 2013.

RESULTS AND DISCUSSION

Table 2 shows the differences in mean values of air quality parameters across the dry and wet seasons (ranging from 0.02-133.98). The result of the independent-samples T tests reveal significant differences in seasonal variations for all categories of gaseous and particulate emissions; where $P = 0.001 < 0.05$

Table 2: Group statistics showing differences in mean values of air quality parameters across the dry and wet seasons.

Group Statistics					
	Season	N	Mean	Std. Deviation	Std. Error Mean
HCHO (mg/m^3)	Wet	54	0.02	0.026	0.003
	Dry	54	0.25	0.17	0.023
TVOCs (mg/m^3)	Wet	54	0.07	0.09	0.013
	Dry	54	0.57	0.21	0.028

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$PM_{1.0}$ (µg/m^3)	Wet	54	32.15	25.40	3.45
	Dry	54	52.38	20.92	2.84
$PM_{2.5}$ (µg/m^3)	Wet	54	35.05	26.55	3.61
	Dry	54	56.14	22.64	3.08
PM_{10} (µg/m^3)	Wet	54	35.12	30.57	4.16
	Dry	54	61.38	27.02	3.67
TEMP (^{0}C)	Wet	54	29.38	1.17	0.15
	Dry	54	31.92	0.49	0.06
HUMIDITY (%)	Wet	54	80.09	6.52	0.88
	Dry	54	52.17	9.81	1.33
AQI OF $PM_{2.5}$	Wet	54	84.14	49.25	6.70
	Dry	54	133.98	39.44	5.36

Gaseous and particulate matter emissions across the dumpsites were significantly higher in the dry season as compared to the wet (rainy) season. Meteorological factors such as temperature, relative humidity and wind speed play important roles in the concentration, dilution and dispersion of air pollutants. Higher temperature, low humidity and low wind speed reduce the rate of dispersion of air pollutants thus increasing the ground level concentration of these contaminants and vice versa (Balogun and Orimoogunje, 2015). If the temperature of a gaseous pollutant is higher than the surrounding ambient air, the gas will tend to rise. Conversely, if temperature of a gaseous pollutant is lower than the surrounding ambient air, the gaseous contaminant becomes concentrated at the ground level (Jacobson, 2005; Balogun and Orimoogunje, 2015). Lagos generally experiences average wind speed of 4.3km/h (Komolafe *et al*., 2014). In Lagos, the wet season is characterized by higher relative humidity and lower atmospheric temperature (Oyewole *et al*., 2014). Higher humidity, lower temperature causes dilution and a reduced tendency of gases to rise and also a decreased tendency of particulate matter to rise (Balogun and Orimoogunje, 2015). This explains why lower concentrations and readings were recorded during the wet season months of the year when compared to the dry season months of the year. In addition, there is a higher frequency of open solid waste burning during the dry season. Burning released gaseous and particulate emissions. This also contributes to the seasonal variations in the dumpsites' emissions.

The Olusosun dumpsite recorded the highest gaseous and particulate emissions. It is also the biggest of the three dumpsites and has more wastes deposited. The quantity of wastes in a dumpsite is directly proportional to the quantity of gaseous and particulate matter generated and emitted by the dumpsite (Daramola and Makinde, 2024).

Formaldehyde recorded a mean concentration of 0.02 mg/m^3 and 0.25 mg/m^3 for wet and dry seasons respectively. Total volatile organic compounds recorded a mean value of 0.07 mg/m^3 and 0.57 mg/m^3 for wet and dry seasons respectively. Sulphur dioxide (SO_2), H_2S and CO were not

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detected in all the dumpsites. This agrees with the findings of Sonibare *et al*. (2020).

$PM_{1.0}$ recorded a mean concentration of 32.15µg/m^3 and 52.38 µg/m^3 for wet and dry seasons respectively. $PM_{2.5}$ recorded a mean value of 35.05µg/m^3 and 56.14µg/m^3 for wet and dry seasons respectively.

PM_{10} recorded a mean concentration of 35.12 and 61.38µg/m^3 for wet and dry seasons respectively.

The Nigeria's Federal Ministry of Environment ambient air quality standard for non- methane hydrocarbon is 160 µg/m^3 (0.16 mg/m^3) of daily average of 3 hourly values (FEPA, 1991).

The World Health Organization (WHO) emphasizes keeping formaldehyde levels low with a recommendation of 0.1mg/m^3 for 30 minutes intervals. The National emissions inventory showed that TVOC ground level concentration below 0.3 or 0.5 mg/m^3 is not detrimental to human health (USEPA, 2016; Adeyemi *et al*., 2020).

The WHO recommended annual average concentration for PM_{10} is 15 µg/m^3 and 45 µg/m^3 for 24- hour averaging time. The WHO recommended annual average concentration for $PM_{2.5}$ is 5 µg/m^3 and 15 µg/m^3 for 24 – hour average time. The annual average is the main guideline for long term exposure. The results of this study showed that the dry season values of TVOCs exceeded the Nigerian Ambient Air Quality Standards. The results also showed that the dry season value for HCHO exceeded the WHO recommended guidelines (WHO, 2010). The result of this study also revealed that the WHO recommended annual average guidelines were exceeded for the dry season particulate matter concentrations.

Air Quality Index (AQI) is a rating scale for outdoor air based on pollution levels for the air pollutant (Njoku *et al.*, 2016). It is a standard index that translates a pollutant or pollutants concentration level into numerical values that describes the associated level of health concerns or effects. It is a numerical scale ranging from 0 to 500. AQI values of 50 or below indicate good air quality. AQI values above 300 are considered hazardous. The result of this study revealed a mean dry season value of 133.98 for AQI of $PM_{2.5}$. This is unhealthy.

The current air quality guidelines and recommendations are based on the concept of an 'effect threshold'. However, no such threshold is guarantee. Therefore, even if the standards are not exceeded, adverse health impacts may still occur (Balogun and Orimoogunje, 2015).

It is important to understand that even if the current air quality guidelines for some gaseous and particulate emissions are not exceeded in these dumpsites such as we have it in the wet season, adverse health impacts may still occur in sensitive and vulnerable people such as children, elderly and those with underlying health conditions in these dumpsites' vicinities and in Lagos generally.

CONCLUSION

This study evaluated the seasonal differences in the gaseous and particulate matter emitted across the Olusosun, Solous 3 and Abule Egba dumpsites in Lagos. Gaseous and particulate emissions taken into consideration were HCHO, TVOCs, H_2S, SO_2, CO, particulate matter ($PM_{1.0}$, $PM_{2.5}$, PM_{10}) and Air Quality Index of $PM_{2.5}$. The findings revealed that seasonality

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significantly influences air pollutants concentration across these dumpsites.

In order to minimize the public health risks and adverse environmental consequences associated with these gaseous and particulate emissions, there is a need for Lagos State Government and Environmental Managers to adopt global best practices in the management of these dumpsites, prioritize and adopt the operation of properly planned modern landfills, create awareness campaigns for dumpsites' scavengers, dumpsite workers and nearby residents. There is also a need for policy makers to encourage periodic air quality and risk assessments of these dumpsites and surrounding vicinities.

CONFLICT OF INTEREST

The Authors hereby declare that there is no conflict of interest regarding this publication.

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