Monitoring and Assessing (PM10 & PM2.5) Particulate Matters within Federal University Otuoke amidst Seasonal Variation of Relative Humidity

Sakwe Adianimovie, Opololaoluwa Oladimarum Ogunlowo

Abstract: *This study examines the seasonal variation of particulate matter (PM10; PM2.5) concentrations within Federal University Otuoke, Nigeria. The study is premised on monitoring and assessing PM10 and PM2.5 in the environment of the university. Dustmate and Kane 100-1 and 3.5.1 RS-1361C-Humidity/Temperature meter were used in sampling between the hours of 8am to 5pm per day in five day per week for a period of 6month which covers both the rainy and dry season. The sampled concentration of PM10 and PM 2.5 obtained was compared with the guidelines of "The National Ambient Air Quality Standard" established by U.S. Environmental Protection Agency (EPA) for compliance and regulation. Descriptive statistically methods were used in data analysis. The Results revealed that the averages PM10 are 116.71 µg/m3 and 107.25 µg/m3, while PM 2.5 records as 27.52 µg/m3 and 32.21 µg/m3 respectively. Relative humidity was also recorded 55.53 µg/m3 and 73.74 µg/m3. Similarly the results in both seasons shows the total average of PM10 as 100.19 µg/m3 and 110.07 µg/m3, PM 2.5 records 23.88 µg/m3 and 23.37 µg/m3 while relative humidity records 55.78 µg/m3 and 68.18 µg/m3 respectively. These were significantly influenced by the relative humidity of the environment of Federal University Otuoke. The study concludes that the seasonal variation of the relative humidity has an effect on the PM10 and PM2.5 concentrations and consequently the air quality of the university, hence further research into methods that will reduce particulate matter, as well as strategic environmental management policies within the university and beyond is recommended.*

Keywords: *Particulate Matter, Relative humidity, Wet, Dry, Monitoring, Assessing*

I. INTRODUCTION

One of the common environmental threats to public health globally is air pollution, [1] according to UNEP Pollution Action Note of 2021 air pollution accounts for over 7 million premature deaths yearly. Since all living creature survive effectively in the present of humidity in air [2][23].

Manuscript received on 06 March 2024 | Revised Manuscript received on 12 April 2024 | Manuscript Accepted on 15 April 2024 | Manuscript published on 30 April 2024.

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It is expedient that the quality of air needed for daily respiration and survival of body functionality must be without or little particulate matters [3][24][25]. Since humidity is a major component of air that influences breathing, its variation in the environment as relate to air can lead to humans breathing poorly because of heat stress and airborne germs which unknown to many can affects air quality and there by pollution [4], even in ways that worsen its effects on human health, particularly respiratory health. Most importantly, it has been reported that high humidity increases the quantity of dangerous or poisonous substances as well as bacteria and viruses that cause respiratory illnesses in the atmosphere. Similarly, low humidity conditions cause respiratory ailments including bronchitis and asthma [5]. In other words, it is imperative to understand that every individual living homes and indoor spaces has indoor air pollutants which the working and social gathering environment cannot be disputed as well. And the temperature and humidity levels of numerous indoor air pollutants affect their concentrations [3]. Indoor air quality (IAQ) is interpreted largely to mean the interior building environments that could have an impact on people's comfort, health, or productivity [6], and the indoor air quality (IAQ) becomes compromised when humidity levels rise above 50% as reported in 2019 by totalcomfortal.com.

It means that when the air becomes heavy with moisture, living homes becomes a breeding ground for dust mites, allergens and bacterial, [7] to thrive and growth will become inevitable. On the other hand, humidity affects the interior environment and the quality of a home in both direct and indirect ways as it relate to human health [8].

Humidity levels in the home have more complicated indirect impacts. The interactions between humidity and indoor air pollution are the cause of these indirect effects. The discharge of hazardous compounds into the atmosphere is known as air pollution. The simple definition of interior air pollution is the build-up and discharge of hazardous elements within, or the contamination of indoor air. Chemicals are one source of pollutants (typically produced by materials and activities performed by humans). Pollutants can originate from chemical (usually caused by man-made materials and activities) biological (which stem from biological sources which includes: germs, viruses and others) or physical sources. PM 2.5 practically possesses biological materials [9]. But, in adverse contributions, chemicals as ingredients, emits volatile organic compounds (VOCs) commonly known is formaldehyde [10].

Major Chemical Pollutants are Carbon Monoxide, Ozone, Tobacco Smoke / Secondhand Smoke, Radon and Pesticides. And hazardous air pollutants (are also referred to as toxic air pollutants which are particulate matter as PM 2.5, PM10 that are toxic or harmful to human life. The PM 2.5 according to Cheng et al, [11] and Dey et al, [12], and PM10 according to Singh and Jamal, (2012) possess the capacity to enter the respiratory system profoundly and, upon inhalation, reach the alveolar region. It is also good to note that particulate matter especially PM2.5 and PM 10 builds up in the lungs and causes inflammation of cells [13], causing mediators to be released and alveolar receptors to be stimulated [14], This results in an imbalance within the neuroendocrine pathway and autonomic nervous system (ANS) [15]. However, relative humidity (RH) ensures internal regulations in our body temperature through perspiration.

As commonly noted according to Kong and Singh [16], a given volume of air at a particular temperature that is present relative to the entire amount of water vapor that can be in that same volume of air at that same temperature is called relative humidity. It helps to regulate the body temperature in ensuring good perspiration, which is sweating excretion [17]. Relative humidity in the environment also helps to absorb moisture during storage [18]. In the same vain it possible that the relative humidity levels that are too high or too low, together with other factors, can have a negative impact on residents' well-being, their dwellings, and their sense of personal comfort. But the standard relative humidity ranges from 20% to 70% all year round; while for temperature is from 26ºC to 28ºC in winter which is found in most regulations in Europe. The United States Environmental Protection Agency (EPA) defines air toxics as air pollutants are either known or suspected of causing cancer, birth abnormalities, or other major health and environmental impacts.

Public buildings like offices, schools, hospitals, daycare centers, shopping malls, airport terminals, train stations, etc. have demonstrated that people spend approximately 80% of their waking hours in these spaces; consequently, the air quality of these environments may have an impact on the health of their occupants. The World Health Organization estimates that indoor air pollutants cause 2 million deaths globally each year, and this situation is ranked as the tenth most preventable risk condition for the general public's health Generally Particulate matter remains suspended in the air, polluting it Yang et [19][20][27] . And PM2.5 and PM10 are the leading 187 under EPA currently regulations of hazardous air pollutants. To this effect, this research monitors the presence of PM10 and PM 2.5 in the auditorium as a major facilities used for indoor learning and other viral functions at the Federal University Otuoke, Bayelsa State.

II. MATERIALS AND METHODS

A. Study Area Description

This study was carried out in one of the major facilities used and occupied by The Federal University, Otuoke, which is a federal government-owned University located in Otuoke, a town in Ogbia local government area of Bayelsa State, Southern Nigeria in the Niger Delta Region see Fig 1 source from [21][26]. It is located about 27 kilometers south of Yenagoa, the Bayelsa State Capital, which itself is 100 kilometers West of Port Harcourt, Rivers State. The facility is the main University Auditorium (Skills) located at the East Campus of the Federal University, Otuoke. It has a capacity of housing a minimum of 750 students during lecture hours 350 and 350 students as specified during Examinations. It is also the major facility whereby the entire University social functions (teaching staffs, nonteaching staffs and students) are officially held (from works Department FUO, 2022). In other words, the University is situated in a humid environment which was reported that, the environmental condition of Niger Delta is harsh with average humidity of about 85 percent (relative), and rainfall of about 2500mm [22].

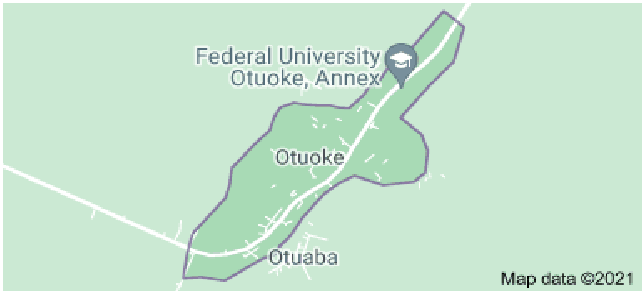

Fig 1: GPS Showing Otuoke and the Federal University Otuoke Geographical Positioning of Sample Sites

B. Sampling Hall

The Auditorium has three main entrance with a central designed of multi-door to ease in and out movements. The hall has a podium of about one meter high and 4 to 6 meters away from seats position. The hall is well ventilated with windows which allow ingress of air inflows. The height of the building is about 6 meters and the top is solidly ceiled with about 30 to 40 ceiling fans powered during usage.

C. Sampling Description and Equipment

The main equipment used for the sampling was Dustmate and KANE 100-1 and 3.5.1 RS- 1361C-Humidity/Temperature Meter. Samplings were carried out for 8 hours per day from 8:00 am to 5:00pm in five days per week (Monday to Friday). The sampling equipment was situated at the center of the podium at a height of one meter from the podium floor and about 4 meters away from the front most seats where particulate (PM10 and PM2.5) and relative humidity were recorded, though Temperature recordings was deliberately neglected throughout the sampling period as well as ventilation was not also taken into consideration. The total sampling period was carried out for a period of 6 months which covers both the rainy and dry season. The sampled concentration of PM10 and PM2.5 obtained was compared to the guidelines of “The National Ambient Air Quality Standard” established by U.S. Environmental Protection Agency (EPA) for PM2.5 which states that “24-hour standard as 35 (µg/m3) and PM10 is 24-hour standard as 150 (µg/m3). That is annual standard for PM2.5 is 12.0 µg/m3.

Retrieval Number: 100.1/ijaent.D440513040424
DOI: 10.35940/ijaent.D4405.11040424
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III. RESULTS AND DISCUSSION

Table 1: Sampled Concentration of PM10, PM 2.5 and Relative Humidity (RH) in Two Season

RCF=

Sampling Season	Dry Season (January)			Rainy/Wet Season (July)		
Parameters	PM10 (µg/m3)	PM2.5 (µg/m)	RH (%)	PM10 (µg/m^3)	PM2.5 (µg/m^3)	RH (%)
Week 1	116.25	32.40	73.30	86.25	28.40	77.33
Week 2	122.47	43.33	86.25	92.40	43.33	82.53
Week 3	119.90	34.34	62.55	121.90	34.31	72.53
Week 4	108.23	42.80	82.56	128.45	22.80	62.58
Total Average	116.71	27.52	55.53	107.25	32.21	73.74
Time (hr.)	24	24	24	24	24	24
Error	RCF	RCF	+3%	RCF	RCF	+3%

reference calibration factor

Table 2: Sampled Concentration of PM10, PM 2.5 and Relative Humidity (RH) in two Season

Sampling Season	Dry Season (February)			Rainy/Wet Season (August)		
Parameters	PM10 (µg/m3)	PM2.5 (µg/m)	RH (%)	PM10 (µg/m^3)	PM2.5 (µg/m^3)	RH (%)
Week 1	116.35	24.45	53.30	76.99	12.60	54.90
Week 2	92.45	13.30	76.75	122.50	23.10	42.70
Week 3	111.70	24.95	42.55	112.50	24.90	82.60
Week 4	83.25	32.80	50.50	128.28	32.88	92.53
Total Average	*100.19*	*23.88*	*55.78*	*110.07*	*23.37*	*68.18*
Time (hr.)	24	24	24	24	24	24
Error	RCF	RCF	+3%	RCF	RCF	+3%

RCF= reference calibration factor

Table 3: Sampled Concentration of PM10, PM2.5 and Relative Humidity (RH) in two Season

Sampling Season	Dry Season (March)			Rainy/Wet Season (September)		
Parameters	PM10 (µg/m3)	PM2.5 (µg/m)	RH (%)	PM10 (µg/m^3)	PM2.5 (µg/m^3)	RH (%)
Week 1	126.20	25.80	84.33	116.35	32.80	85.30
Week 2	92.45	33.30	50.20	130.40	38.83	88.80
Week 3	104.60	24.90	82.30	129.30	29.55	87.56
Week 4	78.22	20.60	89.35	127.15	25.70	86.85
Total Average	*100.37*	*26.15*	*76.55*	*125.80*	*31.72*	*87.13*
Time (hr.)	24	24	24	24	24	24
Error	RCF	RCF	+3%	RCF	RCF	+3%

RCF= reference calibration factor

Table 4: Overal Average Concentration of PM10, PM2.5 and Relative Humidity (RH)

Sampling Season	Dry Seasons			Rainy/Wet Seasons		
Parameters	PM10 (µg/m3)	PM2.5 (µg/m)	RH (%)	PM10 (µg/m^3)	PM2.5 (µg/m^3)	RH (%)
Total Average	105.76	25.85	62.62	114.37	29.10	76.35
Time (hr.)	24	24	24	24	24	24
Error	RCF	RCF	+3%	RCF	RCF	+3%

RCF= reference calibration factor

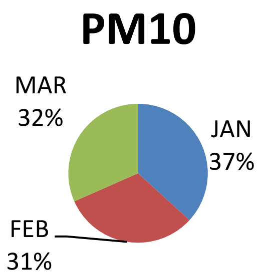

Figure 1: Dry Season PM 10 in Percentage Variation

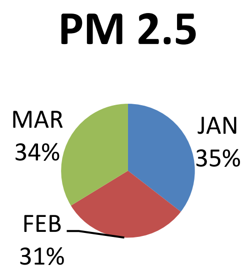

Figure 2: Dry Season PM 2.5 in Percentage Variation

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DOI: 10.35940/ijaent.D4405.11040424
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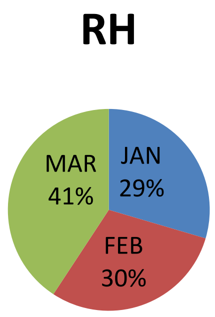

Figure 3: Dry Season RH in Percentage Variation

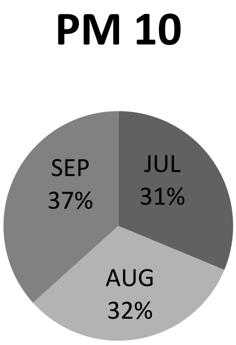

Figure 4: Wet/rainy Season Pm10 in Percentage Variation

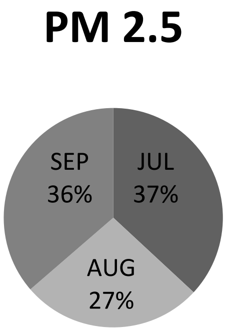

Figure 5: Wet/Rainy Season pm2.5 in Percentage Variation

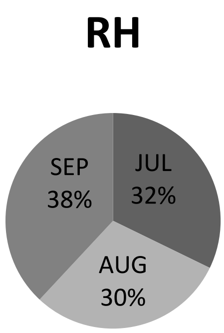

Figure 6: Wet/Rainy Season RH in Percentage Variation

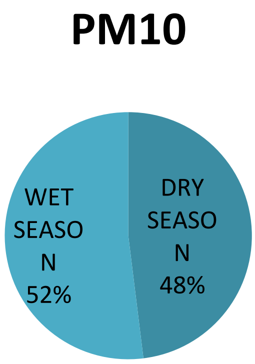

Figure 7: Overall Average Dry and Wet/Rainy Season PM10 in Percentage Variation

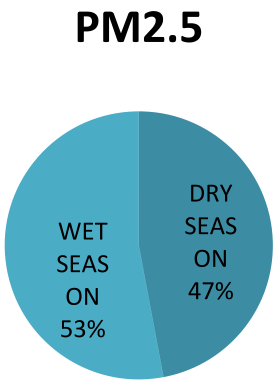

Figure 8: Overall Average Dry and Wet/Rainy Season PM 2.5 in Percentage Variation

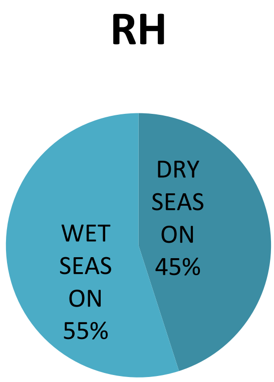

Figure 9: Overall Average Dry and Wet/Rainy Season RH in Percentage Variation

Table 1 is the summary of sampled concentration results of PM10, PM2.5 and Relative Humidity (RH) in the months of January and July as part of the two seasons under investigation. The results in both seasons show the total average of PM10 as 116.71 µg/m^3 and 107.25 µg/m^3, PM2.5 records 27.52 µg/m^3 and 32.21 µg/m^3 while relative humidity records 55.53 µg/m^3 and 73.74 µg/m^3 respectively.

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Table 2: also is the summary of sampled concentration results of PM10, PM2.5 and Relative Humidity (RH) in the months of February and August as part of the two seasons under investigation. The results in both seasons shows the total average of PM10 as 100.19 µg/m^3 and 110.07 µg/m^3, PM2.5 records 23.88 µg/m^3 and 23.37 µg/m^3 while relative humidity records 55.78 µg/m^3 and 68.18 µg/m^3 respectively. Table 3: is the summary of Sampled Concentration results of PM10, PM2.5 and Relative Humidity (RH) in the months of March and September as part of the two seasons under investigation. The results in both seasons show the total average of PM10 as 100.37 µg/m^3 and 125.80 µg/m^3, PM2.5 records 26.15 µg/m^3 and 31.72 µg/m^3 while relative humidity records 76.55 µg/m^3 and 87.13 µg/m^3 respectively. However, Table 4: is the summary Sampled Concentration results of the six (6) months under investigation in both seasons. The results shows that the total average of PM10 was 105.76 µg/m^3 and 114.37 µg/m^3, PM2.5 records 25.85 µg/m^3 and 29.10 µg/m^3 while relative humidity records 62.62 µg/m^3 in the dry season and 76.35 µg/m^3 respectively. Comparatively, in Table 1, the results indicate that PM10 was higher in concentration in the month of January (dry season) than July (wet/rainy season), but PM2.5 and Relative Humidity (RH) indicates higher concentration in the month of July (wet/rainy sea) than January (dry season). For the months of February and August (Table 2), PM10 and Relative humidity was higher in concentration in the month of August (wet/rainy season) than February (dry season), but PM2.5 was slightly higher in the month of August (wet/rainy sea) than the month of February (dry season).And for the months of March and September (Table 3), the results shows that PM10, PM2.5 and Relative Humidity (RH) records higher concentrations in September (wet/rainy season) than March (dry season). Also, Table 4 shows that the wet/rainy season has higher concentration in the wet/rainy season over the dry season in all the three parameters (PM10, PM2.5 and Relative Humidity) used in the investigation in the research. However, relative humidity does not correlate with [22] who reported that, the environmental condition of Niger Delta is harsh with average humidity of about 85 percent relatively. Furthermore Figure 1 is the percentage summary of PM10 during the dry season (January, February and March). The result shows that the month of January records the highest percentage concentration level as 37% followed by March with 32% and February had been the least as 31%. Figure 2 is the percentage summary of PM2.5 during the dry season (January, February and March). The results show that the month of January records the highest percentage concentration level as 35% followed by March with 34% and February had been the least as 31%. Figure 3 is the percentage summary Relative Humidity during the dry season (January, February and March). The results show that the month of March records the highest percentage concentration level as 41% followed by February with 40% and January had been the least as 29%. Figure 4 is the percentage summary of PM10 during the wet/rainy season (July, August and September). The results show that the month of September records the highest percentage concentration level as 37% followed by August with 32% and July had been the least as 31%. Figure 4 is the percentage summary of PM10 during the wet/rainy season (July, August and September). The results show that the month of July records the highest percentage concentration level as 37% followed by September with 36%, August with 32% and July had been the least as 27%. Figure 5 is the percentage summary of PM2.5 during the wet/rainy season (July, August and September). The results show that the month of July records the highest percentage concentration level as 37% followed by September with 32% and August had been the least as 27%. Figure 6 is the percentage summary of Relative Humidity (RH) during the wet/rainy season (July, August and September). The results show that the month of September records the highest percentage concentration level as 38% followed by August with 32% and July had been the least as 31%. Figure 7 is the percentage summary of PM10 between dry and wet/rainy season. The results show that the wet/rainy season months (July, August and September) records the highest percentage concentration level as 52% over the dry season months (January, February and March) which records 48%. Figure 8 is the percentage summary of PM10 between dry and wet/rainy season. The results show that the wet/rainy season months (July, August and September) records the highest percentage concentration level as 53% over the dry season months (January, February and March) which records 47%. Figure 7 is the percentage summary of PM10 between dry and wet/rainy season. The results show that the wet/rainy season months (July, August and September) records the highest percentage concentration level as 55% over the dry season months (January, February and March) which records 45%. Comparatively, the results shows the wet/rainy season (July, August and September) records higher concentration level in percentage measurement over the dry season (January, February and March) of all the three parameters (PM10, PM2.5 and Relative Humidity (RH) under investigation. This a clear indication that the wet/rainy season is more humid than the dry season which could have possibly influenced the wet/rainy season (July, August and September) having higher results than the dry season (January, February and March). In other words, in comparing the summary results of the three parameters (PM10, PM2.5 and Relative Humidity (RH) under investigation with "The National Ambient Air Quality Standard" established by U.S. Environmental Protection Agency (EPA) for PM2.5 which states that "24-hour standard as 35 (µg/m^3) and PM10 is 24-hour standard as 150 (µg/m^3), and that annual standard for PM2.5 is 12.0 µg/m^3. Table 4: had been the summary Sampled Concentration results of the six (6) months under investigation in both dry season (January, February and March) and wet/rainy season (July, August and September). The result shows that the total average concentration of PM10 and PM2.5 was 105.76 µg/m^3 and 25.85 µg/m^{3}in dry season (January, February and March) respectively, while PM10 and PM2.5 records 114.37 µg/m^3 and 29.10 µg/m^3 in wet/rainy wet/rainy season (July, August and September) respectively. This indicates that, the auditorium of the Federal University Otuoke, used for the investigation is below the allowable limits of National Ambient Air Quality Standard" established by U.S.

Retrieval Number: 100.1/ijaent.D440513040424
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Environmental Protection Agency (EPA) for PM10 in 24-hour standard as 150 (µg/m^3) and PM2.5 which states that 24-hour standard as 35 (µg/m^3), though on the annual 'bases, PM2.5 having shown 105.76 µg/m^3 and 25.85 µg/m^3 in dry and wet/rainy season is above The National Ambient Air Quality Standard" established by U.S. Environmental Protection Agency (EPA) for PM2.5 annual standard as 12.0 µg/m^3.However. This may not be detrimental to occupants since the period of occurrence is not total, yet, safety precaution and advice in demanded.

IV. CONCLUSIONS

The study revealed that there are higher concentrations of PM10 and PM2.5 in the wet season than the dry season, meaning that the difference in the concentration is consequent upon the high relative humidity of the environment of Federal University Otuoke in the wet/rainy season months. So, the seasonal variation of the relative humidity effects on the PM10 and PM 2.5 concentrations and consequently the air quality of the university. This study recommends further research into methods that will reduce particulate matter, as well as strategic environmental management policies within the university and beyond

DECLARATION STATEMENT

Funding	No, did not receive fund from any resources.
Conflicts of Interest	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material	Not required.
Authors Contributions	Sakwe Adianimovie wrote part of introduction, the methodology and discussion while Opololaoluwa Oladimarum Ogunlowo wrote abstract, part of introduction, conclusion, referencing and general editing.

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