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PARTICULATE AIR POLLUTION AND ITS HEALTH IMPLICATIONS ON PEOPLE IN PUBLIC PLACES ALONG EAST-WEST ROAD, RIVERS STATE NIGERIA.

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Authors' contribution

All authors designed, analyzed, interpreted and prepared the manuscript.

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Consent for publication

All authors are aware of the publication.

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Author Contributions

Authors made the following contributions: 'OOE' designed the study and participated in editing, 'ODS' took part in writing and editing the study, 'EI' outlined the analysis, 'NC' sampled and performed measurements, entered and analyzed the data. All the authors participated in the final drafting and scrutinizing of the entire study.

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ABSTRACT

Background: Globally, air pollution is a public health emergency that affects people of different ages. This study assessed and determined the level of particulate air pollution and its health implications on people in public places along East-West Road in Obio-Akpor LGA, Rivers State. Methods This study was conducted in public places along East-West Road, Rivers State. An analytical cross-sectional study design was used for this study. A potable digital handheld air monitor was used to measure air particulate pollution. A real-time multi-channel particle monitor was used for aerosol profiling (Aerocet 531S Met One High Volume sampler). An interviewer guide was used to assess the health implication of air particulate pollution. We sought and got ethical clearance for the study from the Research and Ethics Committee of the University of Port

Harcourt. Consent was obtained from the participants in the sampled locations where measurements were taken.

Results: Unhealthy concentrations of PM2.5 and PM10 were observed in all study locations. While the concentration of PM10 was significantly higher during the dry season in all study sites, same was observed in only two locations (NK & MK) for PM2.5. There were significant associations between high levels of PM2.5 and reported symptom related to respiratory and dermatological dysfunction.

Conclusion: Study reported unhealthy levels of particulate matter in ambient air in all locations with significant variations between seasons as well as significant association with respiratory and dermatological symptoms. There is a need to create awareness among the population of the potential risk of pollution from particulate matter to instigate focused and coordinated actions that would lead to reduction in the level of particulate matter in ambient air as well as reduce exposure to these pollutants and its associated health issues.

Keywords: air pollution, particulate matter, health implications, Rivers State.

INTRODUCTION

Air pollution is a public health emergency that affects people of different ages in all parts of the world [1]. In 2012, about 6.5 million deaths recorded worldwide were linked to outdoor air pollution [2]. The World Health Organization reported that air pollution forms a major part of the environmental risks leading to over 3 million associated deaths yearly [3]. Ambient air pollution is a rising global health issue estimated to contribute to over 3.1 million all-cause deaths annually [4]. Exposure to air pollution is ranked as the major environmental health risk of modifiable disease risk factors than inactivity, alcohol intake, smoking, drug use and poor dieting [4]. About 90% of the air pollution-associated mortality result from respiratory disease, cardiovascular diseases (CVDs), skin diseases and cancers occur in developing countries particularly Africa [3].

As a major concern, the thresholds for the concentration of environmental air pollutants as contained in the WHO air quality guidelines is meant to protect everybody particularly the most vulnerable [5]. The air is made up of 78% nitrogen, 21% oxygen, and 1% other gases [6]. However, natural events and human activities produce new components that can contaminate the air rendering the air dangerous to both the environment and human health [6]. Air pollution is the introduction of harmful substances into the air with such contaminants to the ambient air being gases, liquid and solid particles in the atmosphere [6]. Solid air contaminants are commonly particulate matters (PM) which are regarded as a combination of substances that can be categorized into five main groups: products of earth's crust and ash, particles of organic carbon, nitrates, elemental carbon and sulphur substances [7]

Air particulate matter

The amount of particulate matter is usually an indicator of the level of air pollution [8]. Air particulate matter (PM) is one of the most complicated forms of air pollution [9]. Air particulate matter (PM) is a combination of different particles, both solid and liquid, that behave in similar ways and are of various sizes [10]. Sun et al., [11] reported that particulate pollutants are minute liquid and solid particles present in the form of a suspension in the air. Particulate matters are inhalable small-sized substances that cause harm to human health [7]. According to the Environmental Protection Agency (EPA), particulate matters are described as solid substances introduced into the atmosphere in one location and can be conveyed to other places [6]. PM is made up of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air [12]. Particulate matters are made up of different compounds, shapes and different sizes [6]. The common sources of particulate matter emission in worldwide including Nigeria are burning of fossil fuels in vehicles, stubble burning, power plants, road dust, power stations, incinerators, industries, automobiles, diesel generators etc [13].

Health implications of particulate air matter

The presence of particulate matters affects more people than any other pollutant with documented short and long-term health impacts on human [8]. About 50% of the people globally reside in cities with exposure to high levels of air particulate pollutants [14]. Particulate matter is a toxic air pollutant, as it can easily penetrate deep into the lungs and bloodstreams of the human body without being filtered [7]. Another study revealed that every 10 μg/m3 rise in PM2.5 level is associated with a 1.04% rise in all-cause mortality [15]. Disease development and deaths from cardiovascular and respiratory ailments are positively related to rises in PM2.5 levels [15].

The high toxicity and health issues of particulate matter have been attributed to its composition of numerous compounds such as heavy metals, polycyclic aromatic hydrocarbons (PAHs) etc [6]. Particulate matter enters the body having a wide-ranging deleterious effect on human health [16]. It damages or affects several systems and organs in the body including the cardiovascular system, respiratory system, immune system, and endocrine system [16]. The PM is transported from the upper respiratory tract into the lower respiratory tract. It causes activation or initiation of reactions that cause adverse effects in the system [17]. The airway, which is the primary exposed organ, is considered to have higher adverse effects from PM than other organs [18].

Based on the small size, particles on the order of 10 micrometres or less can penetrate the deepest part of the lungs such as the bronchioles or alveoli [19]. It is reported that its exposure to asthmatics triggers bronchoconstriction [20]. The presence of PM in the respiratory tract is responsible for inflammatory reactions in the lung and stimulation of reactive oxygen species (mROS)-dependent pro-inflammatory on cells of the lung and alveolar macrophages [4]. Exposure to particulate pollution can irritate the nose and throat [21]. It has been associated with tightness in the chest, difficulty in breathing and reduced lung function. Studies revealed that respiratory diseases and deaths are attributed to exposure to air particulate pollution [22].

Long-term exposure to air particulate matter has been linked to decompensating already existing diseases and an upsurge in the number of new cases of COPD, asthma and lung cancer in different settings [22]. Additionally, acute and chronic exposure to PM air pollution is associated with an increased risk of death from cardiovascular diseases ischemic heart disease, heart failure, and ischemic/thrombotic stroke [4]. PM destroys the immune system and reduces the immune capacity of the body [11]. The PM affects the innate immune system (mucosal system, humoral molecules immune cells etc) and the adaptive immune system such as humoral immunity and cell immunity, cytokines which result in an increased risk of diseases [4]. Another study by Zhao et al., [21] reported that long-term exposure to particulate matter damages the homeostasis of the immune system and causes immunosuppression or autoimmune diseases. Also, it has been reported that the effects of particulate matter on various human systems are related to its immune toxicity [23].

Epidemiological studies revealed that PM plays a major in the pathogenesis of diabetes. Additionally, it is reported that there is evidence that PM is linked to dysglycemia, cardiovascular disease and vascular risks such as atherosclerosis [4]. Studies have documented that endocrine disruptors to main diseases drive substantial individual and societal morbidity and mortality [24]. Particulate matter has been reported to be a vital endocrine disrupter, contributing to the development of metabolic diseases such as obesity and diabetes mellitus [4].

Over one decade, the conditions and rate of hospitalizations in health facilities in Obio-Akpor LGA have been increased [25]. This has been linked to an increase in the generation of particulate air pollution in LGA because of its recent developmental undertakings by government and individuals [26]. There has been an upsurge in crude oil exploration and processing companies, artisanal refineries, use of vehicles (automobiles), use of fossil fuels and burring of waste in Obio-Akpor [25]. According to Akinfolarin et al., [25] illegal crude oil processing, bunkering (Kpofire), and burning wastes in communities in Obio-Akpor LGA and neighbouring LGA have contributed to the increase in air particulate matter.

Early this year, particularly during the dry season, the atmosphere of Obio-Akpor LGA and its environs were coated with soot. The particulate air pollution was visible in the outdoor environment and affected the individuals visiting public places in Obio-Akpor LGA [25]. Many persons complained that the particulate matter penetrated the rooms causing acute diseases or worsening their health conditions such as asthma, cough, rhinitis, itching etc [25]. There is evidence that the effort of the government to curtail the generation of particulate air pollution in Obio-Akpor LGA has yielded not much impact. There are no recent studies on the concentration and effect of particulate air pollution in Obio-Akpor LGA. Hence, this study determined the level of particulate air pollution and assessed its health implication in public places along the East-West Road in Obio-Akpor LGA, Rivers State.

MATERIALS AND METHOD

This study was conducted in public places along East-West Road in Obio-Akpor LGA, Rivers State. Rivers State as one of the 36 states in Nigeria has a projected population of 7,303,900, making it the sixth greatly populated state in the country [27]. Rivers state is made up of 23 Local

Government Areas including Obio-Akpor Local Government Area (LGA). The monthly rainfall average in the state varies between 20.7 and 434.0 mm, with a yearly level of greater than 3000 mm. Its temperature variation falls between 25-28°C [25]. About 2.7 million people reside in the main city which is in the Port Harcourt Local Government Area [27]. The urban part of Rivers State is composed of the Port Harcourt LGA itself and some parts of the Obio-Akpor [28].

Obio-Akpor Local Government Area (LGA) is in the Port Harcourt metropolis. It is one of the main hubs for economic activities in Rivers State and Niger Delta. The LGA extends over 260 km2, 100 sq mi, with a projected population of 464,789 as of the 2006 Census. Its postal code or ZIP code is 500102 [29]. Obio-Akpor has a boundary with Oyigbo to the east, Ikwerre to the north, Port Harcourt LGA to the south and Emohua to the western pole. Obio-Akpor LGA is situated within latitudes 4°45’N: 4°60'N and longitudes 6°50’E: 8°00'E. Generally, Obio-Akpor is a lowland area with an average elevation lower than 30 metres above sea level [29].The headquarters of Obio-Akpor LGA is Rumuodomaya. There are many communities that make up of Obio-Akpor LGA which include Nkpolu, Rumosi, Alakahia and Choba where the study was conducted.

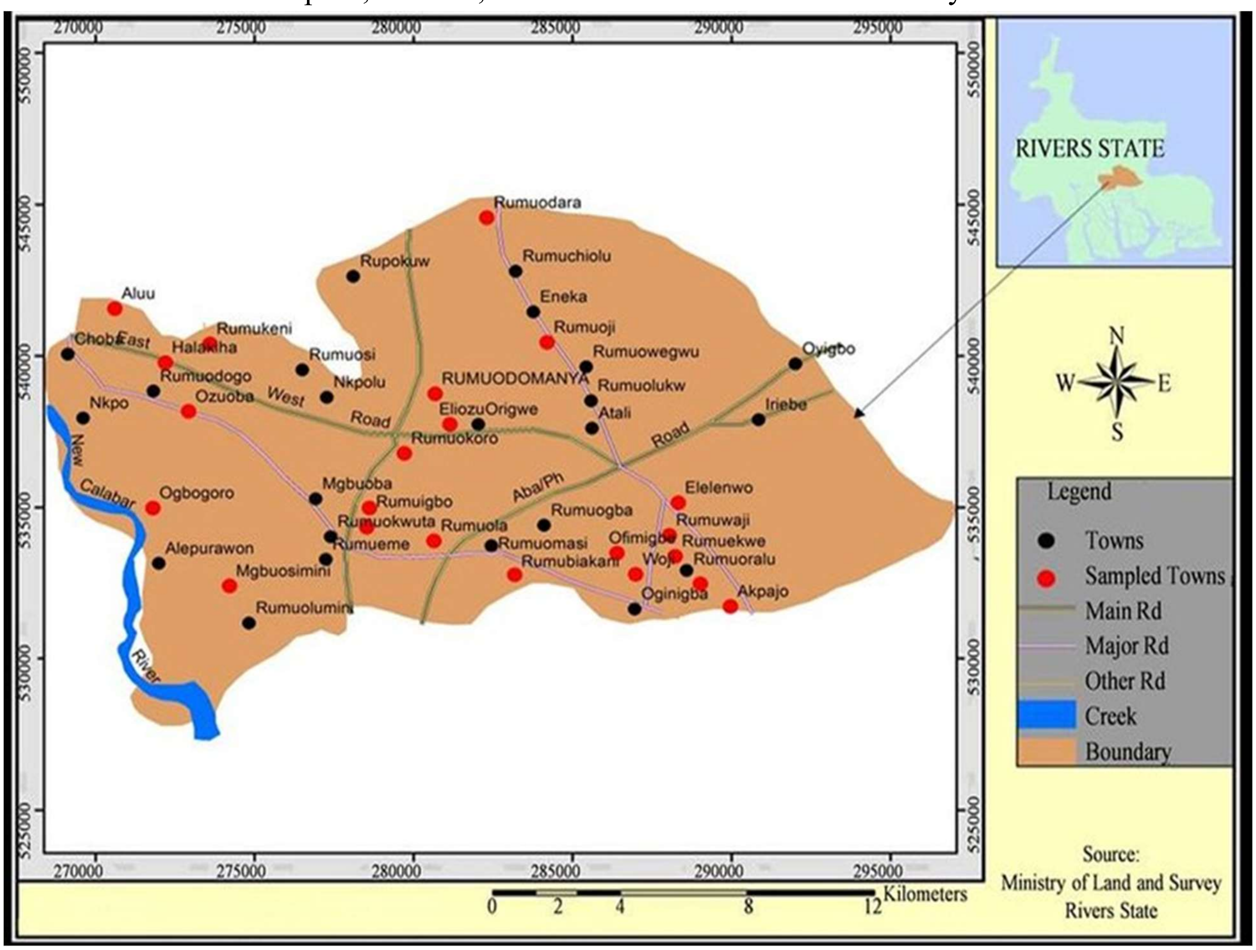

Figure 1: Map of the Obio-Akpor indicating sampled locations [30]

An analytical cross-sectional study design was used for this study. A purposive sampling and random sampling were used to select the major junctions/public places along the East-West Road and participants respectively. The junctions/public places included Nkpolu Junction (NK), MercyLand Junction (ML), Rumosi Junction (RM), Alakahia Junction (AL) and Choba Junction (CH). (Figure 1). A total of 15 participants, 3 from each of the 5 sampled locations were randomly selected from the shops around the junctions and interviewed with an interviewer guide and their responses were properly recorded. This was conducted to assess and ascertain the health implications of the air particulate pollution.

Study tool and Validation

A potable digital handheld air monitor was used to measure air particulate pollution. The machine is a real-time multi-channel particle monitor used for aerosol profiling (Aerocet 531S Met One High Volume sampler). Particulate Matter (PM) 2.5 in µg/m3 (PM) 10 in µg/m3 was recorded. The Automated GPS for sampling locations coordinates were recorded. The working condition of the equipment was verified to be good and calibrated to zero before using it to take records of the air particulate pollution. The measurement of the air particulate matter was performed during the dry and rainy seasons in 2022. The interviewer guide was formulated from open questions in the semi-structured questionnaire pretested and validated for this study. The pretest was performed in Etche LGA with 3 persons and validation was done through reliability testing using Cronbach's alpha which gave a score of 0.72. Residents of the study locations who were 18 years and above at time of the study, have resided in those locations for at 6months were selected and granted interview.

Data analysis and interpretation

We compared the level of all the air particulate matter recorded with the (EPA) and (DPR) acceptable limits. The concentrations of the air particulate matter recorded were entered into an excel spreadsheet version 13 to generate a graphical representation. The Statistical Package for Social Sciences (SPSS) software version 25 for analysis was used to carry out a t-test analysis while considering $p \leq 0.05$ as statistically significant. According to the Environmental Protection Agency (EPA) and DPR national air quality guidelines for maximum exposure for a period of 1-Hour Mean(µg/m3) are as follows; PM2.5 (35-65 µg/m3) and PM10 (150 µg/m3).

Ethical Considerations

We sought and got the ethical clearance for the study from the Research and Ethics Committee of the University of Port Harcourt. Consent was obtained from the participants in the sampled locations where measurements were taken. The participants were ensured that their responses would be used only for academic purposes and stored in a confidential place.

Results

The information for the GPS coordinates of Nkpolu Junction (NK), Mercy Land Junction (ML), Rumosi Junction (RM), Alakahia Junction (AL), Choba Junction (CH) and their respective concentrations of particulate matter (PM2.5) and (PM10) are provided in Table (1).

Table 1: Comparison of the air particulate matter in junctions/public places along East-West Road and EPA/DPR acceptable limit

Sample codes	AQ 1- AQ5	

Locations	NK				
Coordinates	**N4.870436, E6.982165 °**			**EPA/DPR Acceptable Limit**	**Description**
	D.S	**R.S**	**Average**		
PM 2.5 μg/m³	83.20	61.20	72.20	35-65 μg/m³	Unhealthy
PM 10 μg/m³	241.10	157.60	199.35	150 μg/m³	Unhealthy
Locations	ML				
Coordinates	**N4.871670 °, E6.981090 °**				
	D.S	**R.S**	**Average**		
PM 2.5 μg/m³	74.20	58.20	66.20	35-65 μg/m³	Unhealthy
PM 10 μg/m³	185.10	149.50	167.30	150 μg/m³	Unhealthy
Locations	RM				
Coordinates	**N4.883067 °, E6.940338 °**				
	D.S	**R.S**	**Average**		
PM 2.5 μg/m³	78.10	62.80	70.45	35-65 μg/m³	Unhealthy
PM 10 μg/m³	229.80	161.20	195.50	150 μg/m³	Unhealthy
Locations	AL				
Coordinates	**N4.870999 °, E6.968138 °**				
	D.S	**R.S**	**Average**		
PM 2.5 μg/m³	76.40	54.50	65.45	35-65 μg/m³	Unhealthy
PM 10 μg/m³	175.10	141.80	158.45	150 μg/m³	Unhealthy
Locations	CH				
Coordinates	**N4.898989 °, E6.906039 °**				
	D.S	**R.S**	**Average**		
PM 2.5 μg/m³	84.10	68.10	76.10	35-65 μg/m³	Unhealthy
PM 10 μg/m³	244.20	158.00	201.10	150 μg/m³	Unhealthy

Table 1 shows that the PM2.5 had an average value of 83.20 μg/m3 for the dry season above the EPA/DPR acceptable limit and 61.20 μg/m3 for raining season within the EPA/DPR acceptable limit. The PM10 had an average value of 241.10 μg/m3 for the dry season and 157.60 μg/m3 for the rainy season were both above the EPA/DPR acceptable limit. PM2.5 had an average value of 74.20 μg/m3 for the dry season above the EPA/DPR acceptable limit and 58.20 μg/m3 for raining season within the EPA/DPR acceptable limit. The PM10 had an average value of 185.10 µg/m3 for the dry season above the EPA/DPR acceptable limit and 149.50 µg/m3 for raining season within the EPA/DPR acceptable limit.

PM2.5 had an average value of 78.10 µg/m3 for the dry season above the EPA/DPR acceptable limit and 62.80 µg/m3 for raining season within the EPA/DPR acceptable limit. The PM10 had an average value of 229 µg/m3 for the dry season and 161.20 µg/m3 for the rainy season were both above the EPA/DPR acceptable limit. PM2.5 had an average value of 78.10 µg/m3 for the dry season above the EPA/DPR acceptable limit and 54.80 µg/m3 for raining season within the EPA/DPR acceptable limit. The PM10 had an average value of 189.80 µg/m3 for the dry season above the EPA/DPR acceptable limit and 139.20 µg/m3 for raining season within the EPA/DPR acceptable limit. PM2.5 had an average value of 84.10 µg/m3 for the dry season and 68.10 µg/m3 for the rainy season both above the EPA/DPR acceptable limit. The PM10 had an average value of 244.20 µg/m3 for the dry season acceptable limit and 158.00 µg/m3 for the rainy season were both above the EPA/DPR acceptable limit.

Table 2: ANOVA comparison of the PM2.5 concentration air particulate matter during the dry season and rainy season

Location/Seasons		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	F	P-value
NK	Dry	2	84.1000	1.27279	.90000	72.6644	95.5356	30.740	0.031*
	Raining	2	64.6000	4.80833	3.40000	21.3989	107.8011		
ML	Dry	2	73.1000	1.55563	1.10000	59.1232	87.0768	22.418	0.042*
	Raining	2	60.6000	3.39411	2.40000	30.1051	91.0949		
RM	Dry	2	75.5500	3.60624	2.55000	43.1492	107.9508	10.394	0.084
	Raining	2	64.9000	2.96985	2.10000	38.2170	91.5830		
AL	Dry	2	74.2000	3.11127	2.20000	46.2463	102.1537	6.444	0.126
	Raining	2	59.7500	7.42462	5.25000	-6.9576	126.4576		
CH	Dry	2	74.0500	14.21285	10.05000	-53.6474	201.7474	0.672	0.498
	Raining	2	65.5500	3.60624	2.55000	33.1492	97.9508		

$P \leq 0.05$ *(statistically significant)

Table 2 shows a statistically significant higher concentrations of PM2.5 in NK [F = 30.740, p = 0.031] and ML [F = 22.418, p = 0.042] locations during the dry season.

Table 3: ANOVA comparison of the PM10 concentration of air particulate matter during the dry season and rainy season

Location/Season		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	F	P-value
NK	DRY	2	231.0500	14.21285	10.05000	103.3526	358.7474	54.359	0.018*
	Raining	2	155.9000	2.40416	1.70000	134.2995	177.5005		
ML	DRY	2	185.6000	.70711	0.50000	179.2469	191.9531	544.837	0.002*
	Raining	2	150.9000	1.97990	1.40000	133.1113	168.6887		
RM	DRY	2	224.5000	7.49533	5.30000	157.1571	291.8429	125.352	0.008*
	Raining	2	158.6500	3.60624	2.55000	126.2492	191.0508		
AL	DRY	2	183.1500	11.38442	8.05000	80.8651	285.4349	19.395	0.048*
	Raining	2	145.0000	4.52548	3.20000	104.3401	185.6599		
CH	DRY	2	235.1500	12.79863	9.05000	120.1588	350.1412	63.216	0.015*
	Raining	2	160.5000	3.53553	2.50000	128.7345	192.2655		

$P \leq 0.05$* (statistically significant)

Table 3 shows that there was a statistically significant difference between the concentrations of PM10 in (NK) during the dry season and raining season [F = 54.359, p=0.018]. Also, a statistically significant difference was observed between the concentrations of PM10 in (ML) during the dry season and raining season [F=544.837, p=0.002]. A statistically significant difference was observed between the concentrations of PM10 in (RM) during the dry season and raining season [F=125.352, p=0.008]. Also, a statistically significant difference was observed between the concentrations of PM10 in (AL) during the dry season and raining season [F=19.395, p=0.048]. p=0.048) during the dry season and raining season at ($P \geq 0.05$). The CH location indicated statistically significant difference during the dry season and raining season [F=63.216, p=0.015].

Table 4: Association between PM 2.5 and self-reported symptoms

Variables	PM 2.5					Odds ratio(OR)
	High – Freq (%)	**Low – Freq (%)**	**Total**	**df**	**p-value**	**95% (CI)**
Fever						
Yes	13(92.9)	1(7.1)	14(100.0)	1	0.008*	14.08R
No	0(0.0)	1(100.0)	1(100.0)			(0.011-0.472)
Total	**13(86.7)**	**2(13.3)**	**15 (100%)**			
Sneezing						
Yes	10(90.9)	1(9.1)	11(100.0)	1	0. 423	3.333
No	3(75.0)	1(25.0)	4(100.0)			(0.157-70.906)
Total	**13(86.7)**	**2(13.3)**	**15 (100%)**			
Shortness of breath						
Yes	13(92.9)	1(7.1)	14(100.0)	1	0.008*	14.08R

No	0(0.0)	1(100.0)	1(100.0)			(0.011-0.472)
Total	**13(86.7)**	**2(13.3)**	**15 (100%)**			
Wheezing						
Yes	13(92.9)	1(7.1)	14(100.0)	1	0.008*	14.08R
No	0(0.0)	1(100.0)	1(100.0)			(0.011-0.472)
Total	**13(86.7)**	**2(13.3)**	**15 (100%)**			
Tightness of Chest						
Yes	9(100.0)	0(0.0)	9(100.0)	1	0.063	1.500
No	4(66.7)	2(33.3)	6(100.0)			(0.852-2.641)
Total	**13(86.7)**	**2(13.3)**	**15 (100%)**			
Chronic Cough						
Yes	13(92.9)	1(7.1)	14(100.0)	1	0.008*	14.08R
No	0(0.0)	1(100.0)	1(100.0)			(0.011-0.472)
Total	**13(86.7)**	**2(13.3)**	**15 (100%)**			
Weight Loss						
Yes	12(100.0)	0(0.0)	12(100.0)	1	0.002*	3.000
No	1(33.3)	2(66.7)	3(100.0)			(0.606-14.864)
Total	**13(86.7)**	**2(13.3)**	**15 (100%)**			
Skin reaction						
Yes	12(92.3)	1(7.7)	13(100.0)	1	0.409	12.000
No	2(50.0)	2(50.0)	4(100.0)			(0.384-374.837)
Total	**13(86.7)**	**2(13.3)**	**15 (100%)**			
Chest Pain						
Yes	10(90.9)	1(9.1)	11(100.0)	1	0.423	3.333
No	3(75.0)	1(25.0)	4(100.0)			(0.157-70.906)
Total	**13(86.7)**	**2(13.3)**	**15 (100%)**			
Skin eruption						
Yes	10(100.0)	0(0.00)	10(100.0)	1	0.032*	1.667
No	3(60.0)	2(40.0)	5(100.0)			(0.815-3.409)
Total	**13(86.7)**	**2(13.3)**	**15 (100%)**			

$P \leq 0.05$ (statistically significant), Fischer's exact (0.0%), R= (inverse of Odd Ratio > 1)

Table 4 revealed that a statistically significant relationship exists between fever (p=0.008), shortness of breath (p=0.008), wheezing (p=0.008), chronic cough (p=0.008), weight loss (p=0.002), skin eruption (p=0.032) and PM2.5. The result showed that respondents who had fever, shortness of breath, wheezing, chronic cough are 14.08 times more likely to have been exposed to high level of PM2.5 (OR: 14.08R; CI = 0.011-0.472). Participants who experienced weight loss and skin eruption 3.000 and 1.667 times more likely to have been exposed to high amount of PM2.5 (OR: 3.000; CI = 0.606-14.864) and (OR: 1.667; CI = 0.815-3.409) respectively.

Table 5: Association between PM 10 and self-reported symptoms

Variables	**PM 10**					**Odds ratio (OR)**
	High (n(%)	**Low (n (%)**	**Total**	**df**	**p-value**	**95% (CI)**
Fever						

Yes	14(100.0)	0(0.00)	14(100.0)	1	0.0001*	-
No	3(75.0)	1(25.0)	4(100.0)			
Total	**14(93.3)**	**1(6.7)**	**15 (100%)**			
Sneezing						
Yes	11(100.0)	0(0.00)	10(100.0)	1	0.086	1.333 (0.757-2.348)
No	3(75.0)	1(25.0)	4(100.0)			
Total	**14(93.3)**	**1(6.7)**	**15 (100%)**			
Shortness of breath						
Yes	14(100.0)	0(0.00)	14(100.0)	1	0.0001*	-
No	0(0.00)	1(100.0)	1(100.0)			
Total	**14(93.3)**	**1(6.7)**	**15 (100%)**			
Wheezing						
Yes	14(100.0)	0(0.00)	14(100.0)	1	0.0001*	-
No	0(0.00)	1(100.0)	1(100.0)			
Total	**14(93.3)**	**1(6.7)**	**15 (100%)**			
Tightness of Chest						
Yes	9(100.0)	0(0.00)	9(100.0)	1	0.205	1.200 (0.839-1.716)
No	5(83.3)	1(16.7)	6(100.0)			
Total	**14(93.3)**	**1(6.7)**	**15 (100%)**			
Chronic Cough						
Yes	14(100.0)	0(0.00)	14(100.0)	1	0.0001*	-
No	0(0.00)	1(100.0)	1(100.0)			
Total	**14(93.3)**	**1(6.7)**	**15 (100%)**			
Weight Loss						
Yes	12(100.0)	0(0.00)	12(100.0)	1	0.038*	1.500 (0.674-3.339)
No	2(66.7)	1(33.3)	3(100.0)			
Total	**14(93.3)**	**1(6.7)**	**15 (100%)**			
Skin reaction						
Yes	13(100.0)	0(0.00)	13(100.0)	1	0.008*	2.000 (0.500-7.997)
No	1(50.0)	1(50.0)	2(100.0)			
Total	**14(93.3)**	**1(6.7)**	**15 (100%)**			
Chest Pain						
Yes	11(100.0)	0(0.00)	11(100.0)	1	0.086	1.333 (0.757-2.348)
No	3(75.0)	1(25.0)	4(100.0)			
Total	**14(93.3)**	**1(6.7)**	**15 (100%)**			
Skin eruption						
Yes	10(100.0)	0(0.00)	10(100.0)	1	0.143	1.250 (0.806-1.938)
No	4(80.0)	1(20.0)	5(100.0)			
Total	**14(93.3)**	**1(6.7)**	**15 (100%)**			

$P \leq 0.05$ (statistically significant), Fischer's exact (0.0%)

Table 5 shows a statistically significant association between fever (p=0.0001), shortness of breath (p=0.0001), wheezing (p=0.0001) chronic cough (p=0.0001), weight loss (p=0.038), sneezing (p=0.008), and PM10. The result revealed that respondents who had fever, shortness of breath, wheezing, chronic cough were more exposed to high level of PM10. Participants who experienced weight loss and skin eruption 1.500 and 2.000 times more likely to have been exposed to high amount of PM10 (OR: 1.500; CI = 0.674-3.339) and (OR: 2.000; CI =0.500-7.997) respectively.

Discussion

Studies have shown a substantial relationship between exposure to particle pollution and health risks, including premature death [31]. The health issues may include cardiac arrhythmias, heart failure, heart attacks, and respiratory effects such as asthma attacks and bronchitis [32]. Exposure to particle pollution has led to an increase in hospitalization by worsening health conditions, particularly for those with underlying heart diseases, lung disease, and the extremely young and old [31]. PM stays in the atmosphere and is absorbed into the body through the skin, eyes, and the part of the respiratory tract exposed to the outside [33]. PM can act as an irritant or allergen at the primary contact site and causes local adverse effects. In addition, PM causes abnormal inflammation and anticoagulation in the body [34]. Even in healthy people, exposure to PM can lead to abnormal inflammatory responses in the airways.

Our study found that the mean concentrations of PM2.5 and PM10 recorded during the dry and rainy seasons in most of the sampled locations were high and exceeded the EPA/DPR acceptable limit (Table 1). The dry season had higher concentrations of PM2.5 and PM10 compared to that of raining season. This has been linked to the level of human activities that generate air particulate pollution and increased random movement of particulate matter. Similarly, a study conducted by [35] reported a statistically significant difference in the mean concentrations of PM2.5 and PM10, and the amounts of PM2.5 were reduced than that of PM10 concentrations by precipitation. The findings in this study are consistent with the findings by Were et al., [36], who reported that high amounts of PM2.5 and PM10 exceeded the World Health Organization (WHO) recommended levels. There is a similarity between the finding in this study and that of Moran-Zuloaga et al., [37], who reported the yearly mean PM concentrates were higher in high-traffic–commercial and industrial sites, 55 µg m–3 and 52 µg m–3 for PM10 and 37 µg m-3 and 36 µg m–3 for PM2 5, respectively. This study is in line with findings by Shaibu, & Weli, [38] reported that all the state capitals had annual mean concentrations of PM2.5 that exceeded the WHO recommended level. They reported that PM2.5 concentration will continue to increase as the year goes by due to an increase in illegal refining activities, and gas flaring activities in the Niger Delta region of Nigeria [38].

There is uniformity between this study and the study by Asghara et al., [15] who found that the mean level of PM10 was 228.33µg/m3 with a range of 228-230µg/m3. This is similar to findings by Akinfolarin et al., [25] who indicated that the amounts of PM10 for the dry season were high (236.00-1926.30 µg/m3, 940.25-1399.80 µg/m3, 960.20-1154.45 µg/m3and 177.85-855.60 µg/m3) in the study area (Rumuolumeni, Oginigba, Eleme and Omuanwa, respectively). The

PM10 concentrations recorded by Ifezue et al., [39] in Delta State, Nigeria was as high as those recorded in the sample locations in Port Harcourt, Rivers State Nigeria. This is also in line with findings by Olalekam et al., [40] who found the reasonably poor air quality in Ogbomoso with the mean PM10 (175.5μg/m³). ANOVA comparison indicated a statistically significant difference between the concentrations of PM2.5 in the sample location (NK) at ($p=0.031$), and (ML) at ($p=0.042$), while no statistically significant difference was observed between the concentrations of PM2.5 in (RM, AL, CH) respectively during the dry season and raining season at ($P \geq 0.05$).

Furthermore, ANOVA comparison revealed a statistically significant difference between the concentrations of PM10 in all areas during the dry season and raining season Similarly, Enotoriuwa et al., [41], found that the highest levels of PM were all obtained during the dry season, and an ANOVA analysis showed a significant difference between PM in the season's PM values ($p<0.05$). This is similar to the findings by Nwaichi et al., [42] who reported that an increase in the concentrations of PM2.5 and PM10 when those for 6 am-8 am (1138.00±120.25) was compared with 9 am-11 am (90.66±9.06), 12 pm-2 pm (85.33±5.04) and 3 pm-5 pm (97.00±12.85). The PM10 and PM2.5 (8684.66±337.25, 2440.00±270.61 and 1477.33±128.55) and (75.00±1.73, 93.00±8.08 and 37.00±4.58) were considerably ($p<0.05$) high. This present study revealed that a statistically significant difference was observed between the concentrations of PM2.5 and PM10 in the same sample location during the dry season and rainy season at ($p \leq 0.05$).

This study indicated high levels of PM2.5 and PM10 in the sample area during the dry season and as compared with the concentrations during the rainy season. This is similar to the reports of the findings by Gobo et al., [43]. The increased levels of PM2.5 and PM10 are unhealthy and linked to increased health issues and hospitalizations. There is a strong relationship between fever, shortness of breath, wheezing, chronic cough, weight loss, skin eruptions, sneezing and PM 2.5 and PM10. Our findings revealed that respondents who had fever, shortness of breath, wheezing, chronic cough weight loss and skin eruption were more exposed to high levels of PM2 and PM10 [Table 4 and 5]. Additionally, Gobo et al., [43] reported a high level of PM during the dry season due to the haphazard movement of air particulate matter. Akinfolarin et al., [25] reported a high level of PM2.5 µm particulate matter during the dry season ranging from 181.35-245.65 µg/m3, 148.85-300.35 µg/m3, and 149.90-182.30 µg/m3 and 143.80-156.75 µg/m3 for Rumuolumeni, Oginigba, Eleme and Omuanwa, respectively. The geographical location and human activities can be linked to the similarity of findings in both studies. The PM2.5 concentrations (440 ug/m3) recorded by Ifezue et al., [39] were very high when compared to EPA/DPR regulatory limit. There is evidence of lower amounts of PM2.5 and PM10 during the rainy season because the rainfall dissolves most of the particulate matter [39].

On the contrary, Moran-Zuloaga et al., [37] reported that PM10 and PM2.5 concentrations in most of the sampling sites were lower during the dry season and increased gradually in the rainy season due to wind patterns. The values of PM2.5 and PM10 recorded in this present study are higher than those reported by Olalekan et al., [40] in Ilorin Metropolis, Kwara State, Nigeria. This is not in keeping with the finding of this study. The PM10 and PM2.5 levels were lower in the rainy season but increased during the dry season due to random movement of the air and increased human activities such as industrialization, crude oil exploration and processing, illegal artisanal refineries, or oil bunkering, (Kpofire), indiscriminate dumping and burring of wastes in the study areas [40]. Also, the findings in this study are inconsistent with findings by Gupta et al., [44] from satellite remote sensing of cities in India, who found very low amounts of PM2.5 µm at 16.25 ± 6.91 µg/m3, 26.17 ± 8.08 µg/m3, 22.75 ± 10.50 µg/m3and 5.52 ± 2.49 µg/m3. Our finding is not keeping with findings by Asghara et al.[15], who reported low mean levels of PM2.5 (with a range of 55-58µg/m3).

Implications from the findings of this study

The increased concentrations of PM2.5 and PM10 are unhealthy and correlated to symptoms of health issues [Table 4 and 5]. The symptoms identified to be associated with high level of PM2.5 and PM10 includes fever, shortness of breath, wheezing, chronic cough, weight loss, skin eruption, sneezing, tightness of chest, allergic disease, and chest pain. We deduced that more exposure to high amounts of PM2.5 and PM10 in the public places in along East-west Road, Obio-Akpor exacerbate health conditions. It is advisable that people who go about their daily business in those areas wear protective materials and reduce the duration spent outdoors.

Limitations

There were several disruptions in the sampling and measurements air quality of by rainfalls in some of the days. In such days, measurements were postponed which led to extension of period of air quality measurements. Also, this study is limited to the interviewer guide, some of the participants find it difficult to communicate properly the health issues experienced. In this regard, case definition of diseases was used to describe diseases and obtain the right information.

Conclusion

There are unhealthy concentrations of PM2.5 and PM10 in all the sample stations during the dry and rainy seasons which exceeded international and local acceptable limits. The level PM2.5 and PM10 concentrations recorded were higher in the dry season than to the rainy season. The high amounts of PM2.5 and PM10 suggestive of poor air quality showed association with higher reported incidence of fever, shortness of breath, wheezing, chronic cough and skin eruptions. There is the need to create awareness among the population of the potential risk of pollution from particulate matter to instigate focused and coordinated actions that would lead to reduction in the level of particulate matter in ambient air as well as reduce exposure to these pollutants and its associated health issues.

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