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Assessment of Particulate Matter and Associated Pollution Index in Oil Producing Communities in the Niger Delta of Nigeria

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ABSTRACT: The particulate matter concentration in the study area showed that the PM 2.5, of Rivers state ranged between 58.3 - 87.9 µg/m3 while PM 10.0 ranged between 28.5 - 34.3 µg/m^3. For the air sampling conducted n Delta state, the values ranged between 45.7 - 56.9 and 20.9 - 24.1(µg/m^3) respectively for PM 2.5 and PM 10.0. The particulate matter sampled in Akwa Ibom state revealed that it ranged between 38.4 - 44.5 and 20.9 - 24.1 (µg/m^3) for PM 2.5 and PM 10 respectively. The values of PM 2.5 obtained from Bayelsa were 45.7, 44.5 and 38.4 (µg/m^3) for stations 1-3 while the values of PM 10.0 obtained from same location were 18.3, 22.5 and 25.3 (µg/m^3) respectively. The concentration of PM 2.5 and 10.0 were relatively lower with a record of 24.6, 23.6, 29.5(µg/m3) and 17.9, 18.5 and 23 (µg/m3) respectively for PM 2.5 and PM 10.0 respectively. The mean values of the PM 2.5 and PM 10 were; 71.9±8.6 and 30.9±1.7 (µg/m3) for Rivers, 52.8±3.5 (µg/m3) and 22.4±0.9 (µg/m3) for Delta, 42.8±2.2 (µg/m3) and 22.0±2.0 (µg/m3) for Akwa Ibom, 56.5±6.3 for 31.5±1.7 (µg/m3) for Bayelsa and 25.9±1.8 - 19.8±1.6 9 (µg/m3) for Enugu respectively. These findings indicate significantly elevated particulate matters are reported in Nigerian cities with significant oil exploration activities such as the Niger delta states. The elevated levels of particulate matter in these oil producing communities correlated with a high pollution index in comparison to non-oil producing communities.

KEYWORDS: PM2.5, PM10, Air pollution, Niger Delta

I. INTRODUCTION

Air pollution is one of the major environmental problems confronting the Niger Delta Area (NDA) yet information regarding this is very scanty. Aside from data collected by a few individuals and corporate organizations at scattered locations, there is no comprehensive and empirical database on the magnitude of the hazard and its deleterious effects on the ecosystems and people in the region(Nwachukwu et al., 2012; Ubong et al., 2015). The existing network of meteorological stations is too coarse to provide data covering the whole of the region. A key air pollutant in the Niger Delta is the Particulate Matter (PM). The World Health Organization estimates that particulate matter (PM) air pollution contributes to approximately 800,000 premature deaths each year, ranking it the 13th leading cause of mortality worldwide (WHO, 2020). PM is a portion of air pollution that is made up of extremely small particles and liquid droplets containing acids, organic chemicals, metals, and soil or dust particles. PM is categorized by size and continues to be the fraction of air pollution that is most reliably associated with human disease(Nriagu et al., 2016; Yakubu, 2017). PM is thought to contribute to cardiovascular and cerebrovascular disease by the mechanisms of systemic inflammation, direct and indirect coagulation activation, and direct translocation into systemic circulation(Kalagbor et al., 2019; Nwachukwu et al., 2012; Ubong et al., 2015).

Several studies have not only emphasized the poor air quality in the Niger Delta, including Port Harcourt, but also the above national and international regulatory-recommended levels of ambient air pollutants(Chidumeje et al., 2015; Ubong et al., 2015; Weli & Efe, 2015). In recent years, studies carried out to assess the levels of criteria air pollutants in cities of Rivers State, including Port Harcourt, and their probable association with air borne diseases, provide evidence of correlation the petroleum industry constitutes a major source of air pollution in the Niger Delta(Nriagu et al., 2016; Ubong et al., 2015). Within this industry, production operations, such as oil and condensate spills, gas flaring and

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venting, as well as transportation, constitute main sources of pollutants(Okhumode & Yakubu, 2018; Otu & Oloidi, 2018). Other sources include power plants, heavy industry equipment, including boilers, burners, coolants, and separators. Industries such as foundries, chemical and solvent, automobile, construction, and agriculture also contribute to air quality impairment in the Niger Delta (Manisalidis et al., 2020; Tuccella et al., 2017).

Gas flaring constitutes a major environmental public health issue in Port Harcourt and other Niger Delta states. The human health consequences are diverse and include various morbidities and mortalities(Manisalidis et al., 2020; Nwachukwu et al., 2012). Health conditions associated with pollutants discharged in flares include asthma, cancer of the lungs, difficulties in breathing, miscarriages among pregnant women, and premature deaths(Okhumode & Yakubu, 2018; Otu & Oloidi, 2018; Tuccella et al., 2017). Some gases released from gas flares and other petroleum production-related activities, and their health consequences are well documented(Manisalidis et al., 2020; Nwachukwu et al., 2012; Tuccella et al., 2017). The study assessed the particulate matter concentrations (PM2.5 and PM 10) found in oil producing areas of the Niger Delta region in Nigeria.

II. METHODS

Study Area

This study was conducted in selected oil producing communities in the Niger Delta. The Niger Delta is the fan-shaped area of about 70,000 square kilometers in the southern part of Nigeria, through which river Niger and river Benue empty into the Atlantic Ocean. It is basically a huge floodplain, formed primarily by centuries of silt washed down by the rivers Niger and Benue and crisscrossed by a web of creeks that link together the main rivers of Benin, Bonny, Brass, Cross, Forcados, Kwa-Ibo, Nun and other rivulets and streams.

Sample Collection

Daily atmospheric particulate matter samples (PM10 fraction) were collected from 1 January to 31 December, 2015 (total of 350 samples) at three stations each in oil producing states of Rivers, Bayelsa, Delta, Akwa Ibom and a non-oil producing state (Enugu).

Assessment of Particulate Matter

Concentrations of PM2.5 and PM10 were measured by a monitoring device, environmental dust model Haz-Dust EPAM 5000. The Haz-Dust EPAM 5000 is a highly sensitive real-time particulate monitor designed for ambient environmental and indoor air quality applications. This unit combines traditional filter techniques with real-time monitoring methods. These combined techniques can overcome the limitations of all other aerosol monitoring products. The Haz-Dust EPAM-5000 uses the principle of near-forward light scattering of an infrared radiation to immediately and continuously measure the concentration of airborne dust particles in mg/m3.

III. RESULTS

The particulate matter concentration in the study area showed that the PM 2.5, of Rivers state ranged between 58.3 - 87.9 µg/m3 while PM 10.0 ranged between 28.5 - 34.3 µg/m^3. For the air sampling conducted n Delta state, the values ranged between 45.7 - 56.9 and 20.9 - 24.1(µg/m^3) respectively for PM 2.5 and PM 10.0. The particulate matter sampled in Akwa Ibom state revealed that it ranged between 38.4 - 44.5 and 20.9 - 24.1 (µg/m^3) for PM 2.5 and PM 10 respectively. The values of PM 2.5 obtained from Bayelsa were 45.7, 44.5 and 38.4 (µg/m^3) for stations 1-3 while the values of PM 10.0 obtained from same location were 18.3, 22.5 and 25.3 (µg/m^3) respectively. The concentration of PM 2.5 and 10.0 were relatively lower with a record of 24.6, 23.6, 29.5(µg/m3) and 17.9, 18.5 and 23 (µg/m3) respectively for PM 2.5 and PM 10.0 respectively. The mean values of the PM 2.5 and PM 10 were; 71.9±8.6 and 30.9±1.7 (µg/m3) for Rivers, 52.8±3.5 (µg/m3) and 22.4±0.9 (µg/m3) for Delta, 42.8±2.2 (µg/m3) and 22.0±2.0 (µg/m3) for Akwa Ibom, 56.5±6.3 for 31.5±1.7 (µg/m3) for Bayelsa and 25.9±1.8 - 19.8±1.6 9 (µg/m3) for Enugu respectively.

Table 1 Concentration of Particulate matter (PM 2.5 and PM 10.0)

State	Station	PM 2.5 (µg/m^3)	PM 10.0 (µg/m^3)
Rivers	Station 1	69.5	28.5
	Station 2	58.3	34.3
	Station 3	87.9	29.9
Mean and SEM		**71.9±8.6**	**30.9±1.7**

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Delta	Station 1	55.9	22.3
	Station 2	45.7	24.1
	Station 3	56.9	20.9
Mean and SEM		**52.8±3.5**	**22.4±0.9**
Akwa Ibom	Station 1	45.7	18.3
	Station 2	44.5	22.5
	Station 3	38.4	25.3
Mean and SEM		**42.8±2.2**	**22.0±2.0**
Bayelsa	Station 1	67.8	30.3
	Station 2	55.9	29.4
	Station 3	45.8	34.9
Mean and SEM		**56.5±6.3**	**31.5±1.7**
Enugu (Control)	Station 1	24.6	17.9
	Station 2	23.6	18.5
	Station 3	29.5	23
Mean and SEM		**25.9±1.8**	**19.8±1.6**

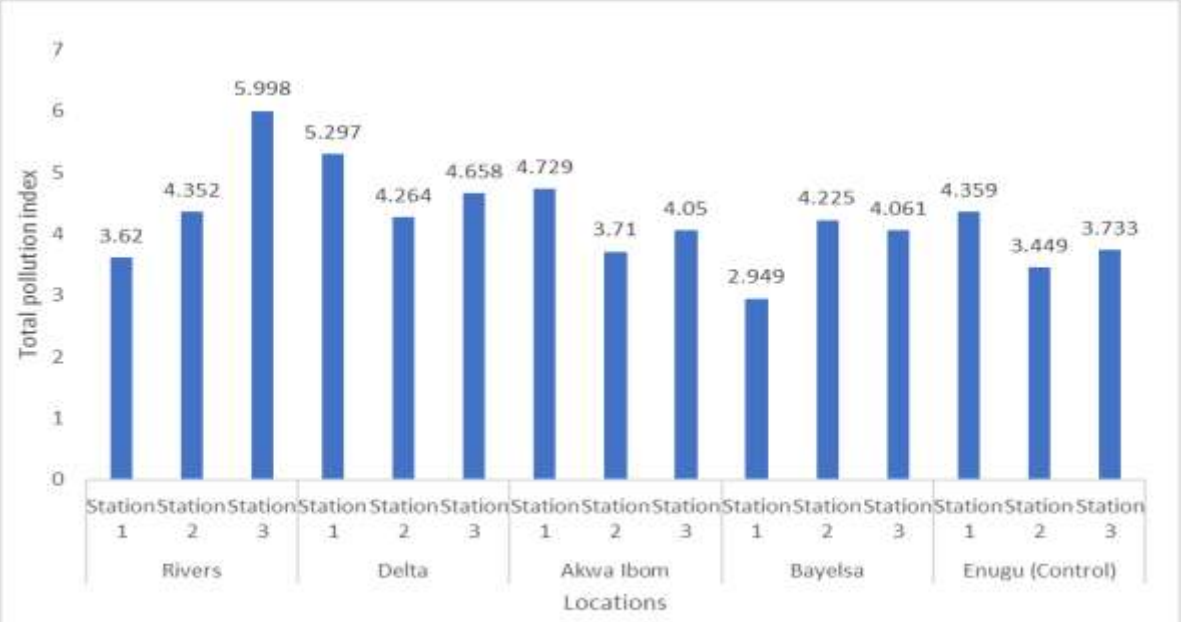

Figure 2: Total pollution index

IV. DISCUSSION

It has been stated by that over 6000 tons of PM2.5 was emitted via gas flaring in the region on annual basis(Wodu et al., 2020). Also, 2590 tons/yr of PM2.5 were reported to be released in Rivers State of Nigeria due to flaring activities in the state alone(Nwachukwu et al., 2012). These values are far less than the annual quantity (1.29 × 104 tons) of PM2.5 estimated in this study as the studies appear to underestimate the particulate. As no previous work has reported or estimated the emission of OC from FG, no comparison could be made of the quantity of the particles emitted into the region. In selected locations in the South West (Ile-Ife) and South South (Port-Harcourt) zones, studies have shown an emerging trend depicting weak correlation between meteorological parameters and particulate matter concentrations. In particular, while increasing temperatures lead to increased aerosol loadings and hence increased particulate concentrations, increasing precipitation, relative humidity and wind speeds tend to lower

levels of aerosol loadings. Relevant studies on cities in Nigeria showing this seasonal trend in particulate matter loads for PM2.5 and PM10 are depicted.

The findings of the current study are consistent with the reports of (Giwa et al., 2017)which indicated that range of the values of PM 2.5 and PM 10 reported in the current study are unhealthy. PM2.5 contained in polluted ambient air has been strongly linked with human health problems and life expectancy (Dziubanek et al., 2017). The estimated PM2.5 in this work was is consistent with the findings of Effiong et al., (2012)which showed that exposure to Particulate matter (2.5/10) correlated with reduced life expectancy in the Niger-Delta region. Available $PM_{2.5}/PM_{10}$ ratios in published air pollution-related studies in Nigeria by Offor et al., (2016) ranged from 0.05 to 0.68, with most of the most of the ratio falling below the 0.5 mark, implying that particulate matter in Nigeria is dominated by coarse particles (PM_{10}).

Globally, gas flaring is recognized as a colossal waste of natural resource of which around 150 billion cubic metres are flared annually(Dziubanek et al., 2017; Effiong et al., 2012; Wodu et al., 2020). Flared gas (FG) is a major contributor to global warming and climate change. This infamous act is a foremost source of greenhouse gases, precursor gases, volatile organic chemicals (VOCs), polycyclic aromatic hydrocarbon (PAH), particulate matter (PM) and black carbon that pollutes the air, soil and water(Ede & Edokpa, 2015; Otu & Oloidi, 2018; Wodu et al., 2020). Over 250 toxins such as hydrogen sulfide, toluene, benzene, sulphur dioxide, benzapryene, nitrogen dioxides, xylene etc. have been identified with the flaring of gas(Benson et al., 2013, 2016). These pollutants especially PM and precursor gases emitted have been reported to have adverse effects on both the environment and human health(Giwa et al., 2014).

A previous study showing the spatial distribution of particulate air pollution in Nigerian cities and reported that 70% of Nigerian urban cities are sites with a high rate of daily mean/annual mean ambient PM10 of over 120µg/m^3, while < 30% of Nigerian urban centres had mean annual ambient PM10 value of 119.2µg/m^3(Otu & Oloidi, 2018). It has been reported that industrial area and high-density residential areas has the higher value of PM10 compared to the transportation sector. The author further suggested that risk of respiratory related diseases is expected to be higher among high density residential and industrial areas(Weli & Efe, 2015). Ede & Edokpa, (2015) studied ambient air particulate matter levels in selected urban centres of Niger Delta region and reported that the particulate matter levels in Uyo and Port Harcourt were relatively higher than those of the other three cities monitored.

V. CONCLUSION

These findings indicate significantly elevated particulate matters are reported in Nigerian cities with significant oil exploration activities such as the Niger delta states. The elevated levels of particulate matter in these oil producing communities correlated with a high pollution index in comparison to non-oil producing communities.

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