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Research Article

Effects of Seasons in the Distribution of Volatile Organic Compounds across Dump Sites in Some Selected Niger Delta States, Nigeria

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Abstract

This study assessed the effects of seasons in the distribution of volatile organic compounds across Dump sites in some selected Niger Delta states, Nigeria. The volatile organic compounds were assessed at 3 distances (3.05 m, 7.62 m and 15.24 m) from four states in the two predominant seasons (wet and dry). Measurements were carried out using portable multiprobe AEROQUAL meter. Three factorial was used to show significant variations across locations, months, distances and interactions. The health risk index was calculated. The concentration of volatile organic compounds ranged from 11.88 – 15.11ppm. There were no significant interactions at $p>0.05$across months, locations, and the interaction of distances and locations, and months, distance and locations, but significant variations exist at $p<0.05$in the various distances, and across months and distances. Seasonality was a determinant on the concentration gradient, with higher values in the dry season compared to the wet except for Abia state with near equal emission rate. The health risk showed slight pollution ($50<HRA\leq100$) to moderate pollution ($100<HRA\leq150$), an indication that only sensitive group (infants, children, elderly individuals with immune-compromised system) is at risk if exposed for long. The risk to sensitive individuals and aesthetics must be considered in the citing and management of dumpsites.

Keywords: Public Health; Season; Risk Assessment; Volatile Organic Compounds waste Dumpsite

Introduction

Many individuals have found themselves earning a living from certain activities including scavenging on waste dumps, processing cassava tuber into *gari*, buying and selling in market places along express ways and using biomass to cook. Some individuals also build their houses close to locations where such activities are carried out, thus exposing themselves to health risk [1]. Several studies have been carried out in the Niger Delta Region with regard to air quality but mostly focused on the activities of the oil sector. Most recently there is increased focus on air quality assessment of waste dumpsites by environmentalists and public health practitioners [2,3,4].

Volatile organic compounds are mainly organic substances that have increased vapor pressure at ambient temperature. Basically at elevated vapor pressure many substances tend to change from solid to gas through sublimation and enter the atmosphere. Volatile organic compounds are so many and some are caused by anthropogenic activities. Some volatile organic compounds are beneficial to biodiversity in their ecosystem. Some microbes could also produce volatile organic compounds which in turn are useful in controlling plant pathogens. Volatile organic compounds produced by plants are known to serve as chemosensory/signaling tool to animals in the forest, while several others are harmful to the environment and its biota.

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Other sources of Voc include solvents and some chemicals used in industries such as tetrachloroethene, benzene, Methylene chloride, Perchloroethylene and combustion of gasoline. Anthropogenic sources of Vocs are regulated in most developed countries. However in developing nations like Nigeria, regulatory measures are directed at the oil/gas sector and few other industrial sectors only. Human activities such as oil palm production [5], wastes dumpsite, *gari* processing facilities among others generate huge volumes of volatile gases.

Concentration gradient of volatile organic compounds in the atmosphere is relatively low and as such poses health risk only after prolonged exposure [1]. Like other air pollutants such as particulates, temperature and sunlight are essential for the volatility and biosynthesis of Vocs in the environment [6,7].

Apart from health effects, volatile organic compounds could also cause an alteration in the ecosystem which in turn lead to environmental degradation and affect its resources including biodiversity with respect to reproduction, growth and survival.

Most importantly, the use of atmospheric pollution in the assessment of health index as practiced in some countries of the world including India, Mexico, Singapore, Scotland, China etc is rudimentary in Nigeria. Hence, this study investigates the release of volatile organic compounds from dumpsite activities using air quality index to assess the associated health risk to individuals residing close to such locale in the Niger Delta region of Nigeria.

Materials and Methods

Study Area

The Niger Delta region lies between latitudes 4.15°N and 7.17°N, and longitudes 5.05°E and 8.68°E. Its ecosystem has one of the highest concentrations of biodiversity in the world, in addition to supporting the abundant flora and fauna, it consist of arable land that can sustain a wide variety of crops, economic trees, and more species of freshwater fishes [8, 9, 10]. The Niger Delta is blessed with several water resources including surface (i.e. estuarine, freshwater and brackish water), ground water and rainwater. These aquatic ecosystems harbor several numbers of biodiversity including planktons (phytoplankton, zooplanktons and algae), fishes, aquatic mammals, sea birds etc [11]. The Niger Delta consists of nine states but this study was carried out in four states including Delta (AgbharaOtor), Bayelsa (government approved central dumpsite along Amassoma-Yenagoa road), Rivers (Elele) and Abia (Aba). The temperature (28 ±8 °C) and relative humidity (50 - 95%) is within the range reported all year round in other Niger delta states [8]. Two predominant seasons occur in the area including five months of dry season (November to March of the preceding year) and seven months of wet season (April to October).

Measurement of Volatile Organic Compounds

Volatile organic compounds were measured using aportable multiprobe AEROQUAL meter (Aeroqual Limited Auckland-New Zealand-Series 300) to monitor the concentration gradient. The head probe was attached to the AEROQUAL meter and switched on. The range of detection is between 0 -25 ppm. Measurement was done across four states, Bayelsa, Rivers, Delta and Abia at 3 distances (3.05 m i.e 10feet, 7.62 m i.e. 25 feet and 15.24 m i.e 50ft) for wet season (May, July and September) and dry season (November, January and March).

Statistical analysis

SPSS software version 20 was used to carry out the statistical analysis. Three-way analysis of variance was carried out at $\alpha = 0.05$ and Duncan multiple range test statistics was used to compare the means and charts plotted with Microsoft excel.

Health Risk Assessment

Background values used for assessing health risk of volatile organic compounds in this study were geometric and median means. This has been widely applied in assessing environmental risk [12,13,14] with slight modification. Modification was carried out by replacing the National Regulatory Limit with the background means

$$\text{Air Quality Index} = \frac{\text{Volume of individual air emission(V)}}{\text{Refernece Background value(RBV)}} x100$$

The criteria used were based on the index previously applied by [15] and that of other countries such as China, India, South Korea and Singapore. The health risk index for classification is; HRA≤50 (no pollution), 50<HRA≤100 (Slight pollution), 100<HRA≤150 (moderate pollution), 150<HRA≤200 (Significant/Dense pollution), 200<HRA≤250 (Hazardous), HRA>250 (Very Hazardous).

Results and Discussion

The distribution of volatile organic compounds across waste dumpsites in the Niger Delta region of Nigeria is presented in Figure 1- 4. Concentration of volatile organic compounds in the various months studied ranged from 9.46 – 12.48, being not significant at p>0.05 (Figure 1). The spatial-temporal distribution of Volatile organic compounds do not also differ significantly at p>0.05 and the concentration ranged from 8.99 - 12.09 ppm (Figure 2). The concentration gradient based on distances ranged from 6.28 – 4.21

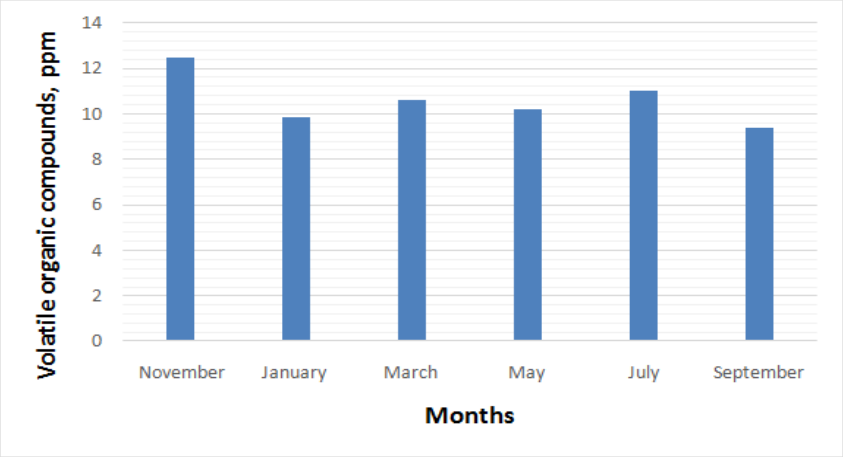

Figure 1: Bimonthly distribution of Volatile organic compounds from waste dumpsite in the Niger Delta region of Nigeria

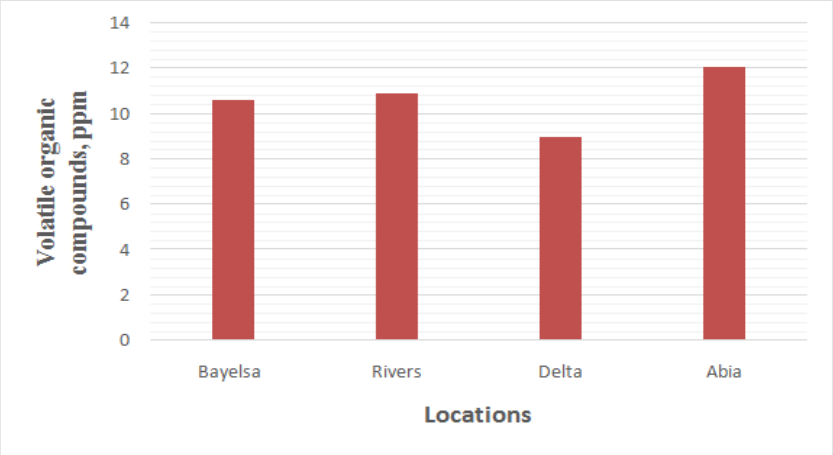

Figure 2: Spatial distribution of volatile organic compounds from waste dumpsite in the Niger Delta region of Nigeria

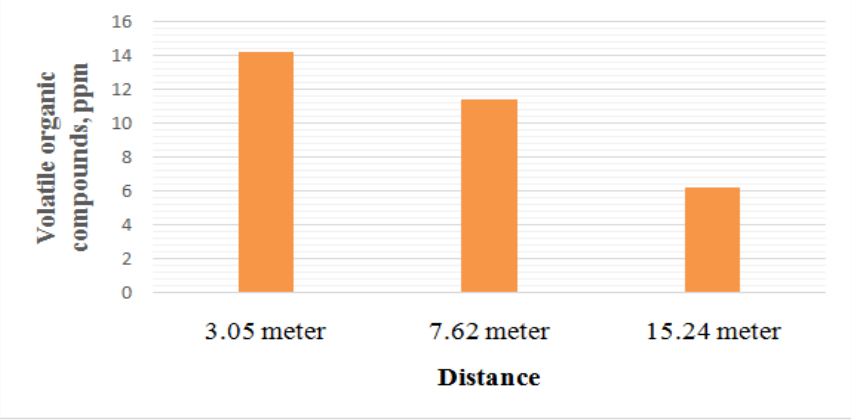

Figure 3: Distance distribution of volatile organic compound from waste dumpsite in the Niger Delta region of Nigeria

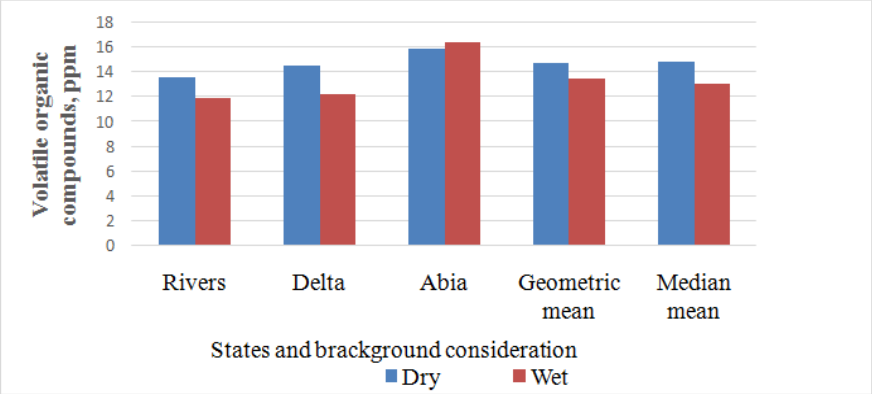

Figure 4: Overall of seasonal influence volatile organic compoundsin the waste dumpsite in the Niger Delta region of Nigeria

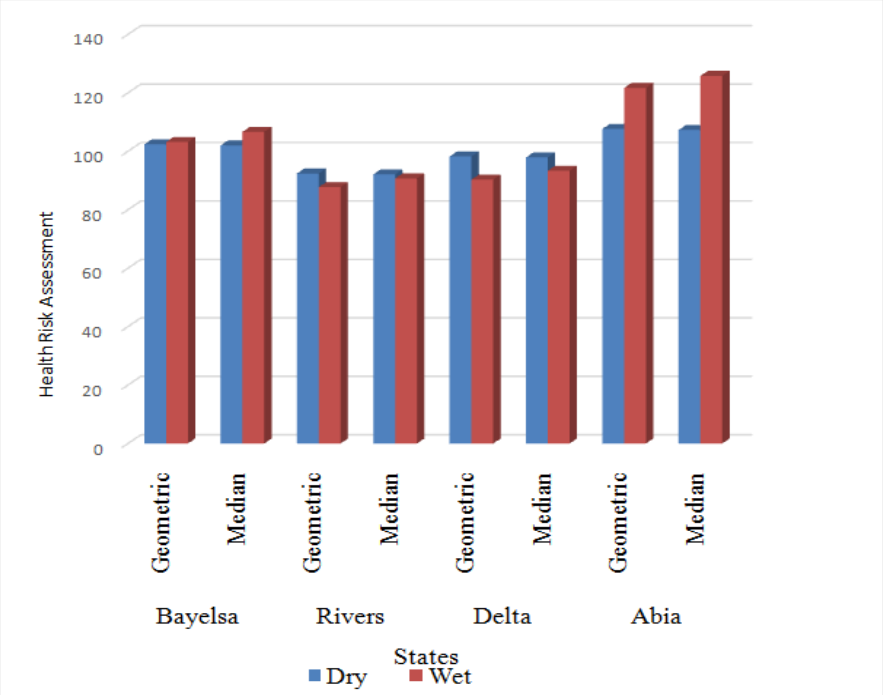

Figure 5: Air quality index of volatile organic compounds from waste dumpsite in some Niger Delta states
Note: HRA≤50 (No pollution); 50<HRA≤100 (Slight pollution); 100<HRA≤150 (Moderate pollution); 150<HRA≤200 (Significant/Dense pollution); 200<HRA≤250 (Hazardous); HRA>250 (Very Hazardous)

ppm and decreased significantly at $p<0.05$ as distance from the emission source increased (Figure 3). Interactions at $p>0.05$ between months and distance, distance and location, and months, distance and locations was not significant, but significant interaction at $p<0.05$ exist between months and location. The concentration of volatile organic compounds in dry and wet season ranged from 13.64 – 15.89 ppm and 11.88 – 16.43 ppm respectively being generally higher during the dry season but overlapped occasionally with the wet season (Figure 4). Variations in the spatial-temporal distribution for volatile organic compounds suggest the influence of distance, season and location across the study area. The concentration reported in this study is comparable to the range 0.53 – 13.93 ppmat 3.05 meter (10 feet) distance, 1.033 – 13.133 ppm at 7.62 meter (25 feet) distance and 0.500 – 9.467 ppm at 15.24 meter (50 feet) distance in the wind ward direction, and 0.300 – 3.200 ppm at 3.05 meter (10 feet) distance, 0.133 – 6.733 ppm at 7.62 meter (25 feet) distance and 0.100 – 4.773 ppm at 15.24 meter (50 feet) distance in the lee ward direction from small scale palm oil processing mill in Rivers state [5]. Typically, the

authors reported that low molecular weight organic fractions are highly volatile, with short atmospheric life-time.

Air quality index of volatile organic compounds in some activities releasing emission across some Niger Delta states is presented in Figure 5. The health risk assessment of volatile organic compounds showed slight pollution (50<HRA≤100) to moderate pollution (100<HRA≤150). This suggests that only sensitive group could be affected. Typically, the severity of toxicity depends on type of compound, level and duration of exposure, temperature and sunlight [4,5]

Based on the air quality index, sensitive people may suffer more from high volatile organic compound in the study area. High concentration of volatile organic compounds could lead to irritation of the sensory organs such as eyes, nose and throat [16,3]. Prolong exposure could also put the individuals at risk of liver and kidney diseases. Due to the physical and chemical nature of volatile organic compound, it could be cancerous.

Conclusion

This study investigated the effect of season on the Volatile organic compounds around waste dumpsites in the Niger Delta region of Nigeria. The values obtained were within slight pollution to moderate pollution under both background considerations. This is an indication that only sensitive groups (infants, children, elderly and the immuno-compromized) are susceptible over prolonged period. The above underscores the need to improve on the waste management strategies in the study area.

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