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The Level of Polycyclic Aromatic Hydrocarbons in the Ambient Air within and Around Port Harcourt Metropolis

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Abstract Ambient air samples were obtained from three locations namely; Aba road, Woji and Iwofe and analyzed for Polycyclic Aromatic Hydrocarbon (PAHs). PAHs in Suspended Particulate Matter (SPM) trapped on a Tenax GC adsorption fabric were extracted with dichloromethane and eluted in a GC/FID to obtain different peaks that were identified by peaks from PAH standard of known concentration. Samples from Woji gave the highest total monthly PAHs concentration of 0.985 mg/m^3 followed by Iwofe, 0.439 mg/m^3 and finally Aba Road, 0.344 mg/m^3. Figures from Woji exceeded those recommended by USA annual average 0.3-0.7 mg/m^3. This is because of the hub of industrial, commercial and domestic activities that take place in and around Woji. All three locations however have presence of PAHs in the ambient air.

Keywords Woji, Aba Road, Iwofe, PAHs, GC/FID

Introduction

Air is made up of various gases which surround the earth like an envelope to a height of many kilometres. This air envelope is held to the earth by gravitational attraction that is dense at sea level but thins rapidly upwards. Many industrial activities, domestic and agricultural practices have led to the pollution of the atmosphere [1].

Polycyclic Aromatic Hydrocarbons (PAHs) are organic chemical substances that are widely spread in our environment. They are particularly known to be harmful with documented carcinogenic, mutagenic and teratogenic properties [2-3]. PAHs are usually formed during incomplete combustion or thermal decomposition of organic materials [4]. For instance, pyrolysis that takes place during burning of fat in animals and fish generates PAHs which get deposited on the finished products and ultimately ingested by humans. PAHs are also generated from burning of fossil fuels, coal, dump sites and cigarettes through pyrolysis. During pyrolysis, benzene rings fuse together giving rise to differing numbers to produce different members of the PAHs family. In the air, PAHs are adsorbed in soot or particulate matter. On inhalation, they are taken in with soot into the lungs due to their size (2.5µm). This has resulted in pulmonary and cardiovascular diseases [5].

Polycyclic aromatic hydrocarbons contain two or more fused aromatic rings that consist of carbon and hydrogen atom. PAHs have general properties such as low vapour pressure and water solubility, high melting and boiling point which tend to increase with decrease in molecular mass. They are soluble in many organic solvents and lipophilic in nature. They undergo photo-oxidation reactions in the presence of light and oxygen. They are used as intermediate in the production of dyes, pigments, pesticides, PVC's and plasticizers etc. PAHs are released to the atmosphere from incomplete combustion of organic materials during industrial processes such as vehicle emission, tobacco smoke, emission from power plant and residences, crude oil, coal and natural gas manufacturing, burning of refuse and petroleum refining etc [6]. PAHs compounds are ubiquitous, carcinogenic, mutagenic and toxic in the

environment [2]. PAHs subsist in the atmosphere as vapour and particulate substances which are inhalable and ingestible affecting the human respiratory system [7].

The physico-chemical properties of PAHs differ significantly; the semi-volatile property of some PAHs makes them highly movable throughout the environment, deposition and re-volatilization distributing them between air, soil and water bodies. A quantity of PAHs is subject to long range atmospheric transport making them a trans-boundary environmental problem. PAHs are emitted from domestic, mobile, industrial, agricultural and natural source to the environment and these sources are expected to change with time as a result of regulations and economic development. The major source of PAHs in the environment is divided into two, which are natural and anthropogenic. The natural source includes volcanic eruption and forest fire, while anthropogenic relates to both mobile and stationary which relates to transportation and combustion [8].

PAHs remain in the environment when released and react with the soil, sediment, particulate matter, ozone, nitrogen dioxide, sulphuric acids, hydroxyl radical respectively [9]. Fungi and microorganisms in the soil have the ability to degrade PAHs making them metabolized by aquatic and terrestrial organisms [10].

In spite of the global advancement to address important environmental problems, much improvement has not been made in developing countries where the problems are persistent. In many African countries outdoor air pollution continues to be one of the many environmental problems that need attention. It is essential to monitor the exposure levels of toxic air pollutants in the outdoor air environment in order to institute a baseline data for necessary action [11].

The US EPA PAHs are classified into three groups based on their molecular arrangement. Low molecular weight (LMW) PAHs have two or three aromatic rings, intermediate molecular weight (MMW) PAHs have four rings, while high molecular weight (HMW) PAHs have five or six rings. The variability in the physical and chemical properties of these substances results in the difference in structure and size of individual PAHs [12].

Originally PAHs cover hundreds of organic substances. Due to their toxicity, the United States Environmental Agency has conducted an environmental survey on PAHs. They came up with a priority list which included 16 members of the PAHs family, which are known to cause cancer and other health conditions. In the internal cell, PAHs have the capacity to bind to cellular macromolecules, such as DNA after they have undergone metabolic activation to diol epoxides. Once this happens, the cell mutates. Prolonged mutation leads to cell mitosis (reproduction). If the tumour is localized, it is benign but if it spreads, it becomes malignant [13-14].

Materials and Methods

All reagents used were of analytical grade. Glass wares were thoroughly washed, rinsed with distilled and deionised water, dried in the hot air oven at $50\text{-}60^0$Covernight and put in the desiccator containing silica gel till further use. Tenax GC Adsorption fabrics were exposed to the ambient air to trap suspended particulate matter (SPM) for a period of 28 days. 4 weekly samples were collected, labelled and stored at 4^oC. PAHs in the trapped SPM was extracted with dichloromethane. By means of vial, 1µl of the extract was injected into a GC/FID at the injection port whose temperature is high enough to keep the sample vaporized. Elution was effected through the column to emerge as peaks of different components of PAHs in the test sample. These were compared with peaks of PAHs standards of known concentration [15].

Calculation

$$\frac{\text{Instrument Reading x Total Volume of Extract x Dilution Factor}}{\text{Weight of Sample}}$$

Results and Discussions

In this investigation ambient air in Port Harcourt and its environs were analyzed for PAHs, and the results are shown in Tables 1, 3, and 5. Tables 2, 4, and 6 give the total monthly concentration for the three major locations chosen in

this research. The result in the tables revealed that there is a significant difference in the concentration of PAHs among the three locations (Woji, Iwofe and Aba road) $F_{(2,9)}$ =17.09, P=0.00<0.05 level of significance. Consequently, Post-hoc analysis was performed to ascertain precisely where these differences lie among the three locations. The result in the post-hoc table showed significant difference in the concentration of PAHs between Woji location and Iwofe location and also, a significant difference in the concentration of PAHs between Woji location and Aba road.

Table 1: Concentration of PAH (mg/m^3) in ABA Road

PAHs	Week 1	Week 2	Week 3	Week 4
Acenaphthylene	0.03	0.03	0.04	0.02
Acenaphthene	0.06	0.05	0.08	0.05
Anthracene	0.01	0.01	0.02	0.01
Fluoranthene	0.006	0.005	0.008	0.005

Table 2: Total Monthly Concentration in Aba Road

PAHs	mg/m^3
Acenaphthylene	0.03
Acenaphthene	0.24
Anthracene	0.05
Fluoranthene	0.024
TOTAL	**0.344**

The result illustrated above in table 2 showed total monthly concentration in Aba road for acenaphthylene as $0.03mg/m^3$, acenaphthene gave highest total of $0.24mg/m^3$, anthracene $0.05mg/m^3$ and fluoranthene $0.024mg/m^3$.

Table 3: Concentration of PAH (mg/m^3) in IWOFE

PAHs	Week 1	Week 2	Week 3	Week 4
Acenaphthylene	0.02	0.02	0.02	0.02
Acenaphthene	0.03	0.05	0.04	0.03
Anthracene	0.007	0.01	0.009	0.006
Fluoranthene	0.003	0.005	0.004	0.003
Dibenz(a,h)anthracene	0.03	0.01	0.02	0.01
Indeno(1,2,3-cd)pyrene	0.03	0.02	0.02	0.02

Table 4: Total Monthly concentration in IWOFE

PAHs	mg/m^3
Acenaphthylene	0.08
Acenaphthene	0.15
Anthracene	0.032
Fluoranthene	0.015
Dibenz(a,h)anthracene	0.07
Indeno(1,2,3-cd)pyrene	0.09
TOTAL	**0.437**

The result illustrated above in table 4 show total monthly concentration in Iwofe for acenaphthylene as $0.08mg/m^3$, acenaphthene gave highest total of $0.15mg/m^3$, anthracene $0.032mg/m^3$, fluoranthene $0.015mg/m^3$, dibenz(a,h)anthracene $0.07mg/m^3$ and Indeno(1,2,3-cd)pyrene $0.09mg/m^3$.

Table 5: Concentration of PAH (mg/m^3) in WOJI

PAHs	Week 1	Week 2	Week 3	Week 4
Acenaphthylene	0.04	0.06	0.06	0.04
Acenaphthene	0.07	0.16	0.12	0.09
Anthracene	0.02	0.04	0.03	0.02
Fluoranthene	0.009	0.02	0.01	0.01
Benz(a)anthracene	-	-	-	0.006
Benzo(a)pyrene	-	-	-	0.07
Indeno(1,2,3-cd)pyrene	0.03	0.02	0.03	0.03

Table 6: Total Monthly concentration in WOJI

PAHs	mg/m^3
Acenaphthylene	0.2
Acenaphthene	0.44
Anthracene	0.11
Fluoranthene	0.049
Benz(a)anthracene	0.006
Benzo(a)pyrene	0.07
Indeno(1,2,3-cd)pyrene	0.11
TOTAL	**0.985**

The result illustrated above in Table 6 showed total monthly concentration in Woji for acenaphthylene as 0.20mg/m^3, acenaphthene gave highest total of 0.44mg/m^3, anthracene 0.11mg/m^3, fluoranthene 0.049mg/m^3, benz(a)anthracene 0.006mg/m^3, benzo(a)pyrene 0.07mg/m^3 and Indeno(1,2,3-cd)pyrene 0.11mg/m^3. Acenaphthene with 0.44mg/m^3 is higher than PAHs recommended limit of 0.2mg/m^3 by OSHA (Occupational Safety and Health Administration) but fall within USA annual average of 0.3-0.7mg/m^3 while Acenaphthylene with 0.20mg/m^3 is higher than recommended limit of 0.1mg/m^3 by NIOSH (National Institute for Occupational Safety and Health). Comparing this work with Kori and Upadhyay (2007), benz(a)anthracene is higher with a value of 0.2mg/m^3 and benzo(a)pyrene is slightly higher than the result from this work with a value of 0.1mg/m^3.The significant difference in the concentration of PAHs in the locations could be related to activities carried out in the environments. From the tables above, Woji has the highest total concentration of PAHs in the atmosphere followed by Iwofe and Aba road. Woji is a highly populated residential area and its high total concentration of PAHs could be attributed to the numerous manufacturing, oil and gas and mining industries in and around the town with different commercial and domestic activities. Woji town is basically a place where shipping companies are based like the B and T Marine & Construction Limited where they construct and maintain Barges and Tug Boats. Woji Town is surrounded by companies and industries whose operations can affect and contaminate the environment. Companies like Shell (Oil and Gas) and Air Liquid Nigeria Plc situated at Trans Amadi; Petrochemicals Company situated at Eleme and many more. Iwofe is a community with a Fabrication/construction Company and Bunkering (illegal refining of crude), with movement of automobiles, commercial and domestic activities. Aba road is a highway where vehicles, motor cycles, trucks etc move on daily basis for over 24hours releasing fumes coupled with large number of commercial activities such as buying and selling of roasted meat, corn, fish, yam and other domestic activities. All these organizations and businesses contribute to the pollution of the ambient air of the environment.`

Conclusion

The result obtained in the course of this study reveal the presence of PAHs in Woji town with a total of 0.985mg/m^3, Iwofe 0.437mg/m^3 and Aba road 0.344mg/m^3. Considering how populated these areas can be, the continual emissions from industries, vehicles, commercial and domestic activities, burning of crude etc make PAHs widespread in the environment. The consequent result is high rate of illnesses and death in this region. Cases of cancer and teratogenicity are evidenced in our hospitals and health centres. With Port Harcourt being the centre of industrial and commercial activities in the oil rich area of the Niger Delta, it's expedient to have pollution in the environment. However, pollution could be controlled at all levels. Industrial exhaust emissions could be checked on regular basis. Vehicles too should be monitored by the authorities in charge because vehicular emissions could also contribute to the pollution load. Advocacy could be a better tool in fighting pollution problems. The general public should be made to understand the dangers associated with a polluted environment and fight to protect the environment we live in. Finally, illegal refining (bunkering) of crude petroleum should be met with stiff action such as confiscation and prosecution.

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