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CONTRIBUTION OF POWER GENERATING SET TO THE AMBIENT AIR LEVEL CONCENTRATION OF POLYCYCLIC AROMATIC HYDROCARBONS IN A UNIVERSITY ENVIRONMENT

[1,3]Adesina, O.A and [2]*Okewale, A.O.

[1]Department of Chemical Engineering, Landmark University, Omu-Aran, Kwara State, Nigeria
[2]Department of Chemical Engineering, Federal University of Petroleum Resources, Effurun, Delta State, Nigeria
[3]Department of Chemical and Petroleum Engineering, Afe-Babalola University, Ado-Ekiti, Nigeria.
*oketunde2001@yahoo.com; adesinaolusola50@yahoo.com

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ABSTRACT

This study investigated the contribution of power generating sets to the ambient levels of polycyclic aromatic hydrocarbons (PAHs) around a university environment. Five sampling points were selected based on the proximity to the generating set for the study. Ambient level samplings were done using polyurethane foam (PUF) passive samplers for a period of 28 days. The results showed that the concentration of PAHs at various sampling locations for the period under investigation was in the range of 0.22-2.34 ng/ m^3 at point A, 0.14 -7.67 ng/m^3 for point B while points C, D and E had the range of 0.44-3.24 ng/m^3, 0.34-52.13 ng/m^3, 0.11-16.45 ng/m^3, respectively. The observed pollutants concentration were within the tolerance permissible limit set by Organization of Safety and Health Administration (OSHA), that notwithstanding, continuous exposure to these pollutants is worrisome due to chronic effects.

1. INTRODUCTION

The importance of electricity to the economy of any nation cannot be overemphasized. Virtually the day to day activities of man in the modern world depend on electricity. The Nigerian power sector operates well below its estimated capacity with power outage being a frequent occurrence (Arobieke et al., 2012). Due to this epileptic power supply tertiary institutions have resorted to the use of alternate sources of power supply such as electric power generators to meet their daily power needs. However, emission from the exhaust of the generator contributes to the ambient levels of pollutants polycyclic aromatic hydrocarbon (PAHs) and characterization of its concentration in the university environment is important in order to evaluate its risks and predict appropriate management practices (El-Shahawi et al., 2010).

Polycyclic aromatic hydrocarbons PAHs are complex hydrocarbon compounds with a fused ring structure, containing at least two benzene rings (Sexton et al., 2011). PAHs are ubiquitous environmental pollutants generated primarily during the incomplete combustion of organic materials (e.g. coal, oil, petrol and wood) (Abel-Shafy and Mansour, 2016). Human beings can absorb PAHs by various routes e.g. inhalation, dermal contact, and ingestion (Beyer et al., 2010; Dong et al., 2012). PAHs and their effects on human health and the environment is a global issue of concern. The ecotoxic studies of PAHs show that they are potentially genotoxic, carcinogenic, mutagenic to humans. They can also cause reduced immune function, breakdown of blood cells and thus are considered to be among the organic pollutants of public health concern (European Commission, 2002; FAO/WHO, 2005; Nisbet and LaGoy, 1992). In view of this, there is a need for proactive measures in creating awareness of these pollutants in orders to mitigate its adverse effect on the health of humans, animals and plants. This present work is focused on the characterization of ambient levels concentration of PAHs around a university power generating set, this is with a view of determining the contribution of power generating set to the ambient air quality in the university environment.

2. MATERIALS AND METHODS

2.1. Study Area

Table 1 shows the descriptions of the sampling locations .The study area for the research was Landmark University Omu-Aran, Kwara state, Nigeria. The University has five different power generating set located at five different points which are Cafeteria, Senate building of the University, University Library, College building and Health center. These were denoted as sampling points A, B, C, D, and E, respectively.

Table 1: Geographical location of sampling points

Sampling Point	Station	Activity	Geographical Coordinate
A	University Cafeteria	Student relaxation	8°232N 5°041E
B	University Senate Building	Administrative Activities	8°324N 5°122E
C	University Library	Reading Academic Activities	8°139N 5° 088E
D	University College Building	Academic Activities	8° 221N 5°092E
E	University Health Centre	Patients	8°421N 5°127E

2.2. Collection of Samples

Samples were collected using Polyurethane Foam (PUF) passive samplers (Gao et al. 2014). Prior to deployment, PUF disks was pre-cleaned with distilled water and then washed with acetone in Soxhlet extractor for 12 h to remove the contaminant, followed by petroleum ether for another 12h (Pozo et al., 2004). The disks were dried in a dessicator, covered in aluminium foil and transported to the sampling locations. The duration of each sampling was

28 days. At sampling locations, the passive air samplers were hung vertically with the bigger bowl facing downward. They were placed 3.5 m above ground level during sampling at a distance of 3 m from the exhausts of the power generating set.

2.3. Extraction and Sample Analysis

The PAHs trapped in PUF disks were extracted into dichromethane using a Sohxlet extractor. Clean-up step was carried as described by Hoyos et al. (2008). The extracted PAHs were concentrated to 20 µL using rotatory evaporator under a gentle stream of Nitrogen. Analysis of PAHs in the samples was carried out using Agilent Gas Choromatography – Mass Spectrophotometry operated under selective ion monitoring mode (SIM) (Gao et al., 2014). Analysis of Laboratory blanks, field blanks, method blanks and spiked blanks was done to ensure good quality of the samples.

2.4. Statistical Analysis

Statistical analysis was done using Principal Component Analysis (PCA) and Pearson correlation available on the XLSTAT program. In this statistical procedure, a new set of variables (principal components) were derived from a linear combination of the original variables or observations through an orthogonal transformation (Pozo et al., 2015).

3. RESULTS AND DISCUSSION

The compositions of various polycyclic aromatic hydrocarbon in the ambient air around university generating sets are shown in Figure 1. PAHs observed were Naphthalene, Azulene, Indene, Perylene, 1 methyl Naphtalene, 1,2 Dimethyl Naphathlene, 1 ethyl Naphthalene. At the sampling point A, the concentration of the various PAHs ranged from 0.22 - 2.34 ng/m^3 with Naphtalene having the highest concentration and Indene with the lowest concentration. The same trend was observed at the sampling point B which had the range of 0.14-7.67 ng/m^3 with highest and lowest concentrations were Naphthalene and indene, respectively. At sampling point C, PAHs concentration ranged from 0.44 - 3.24 ng/m^3, the highest and lowest concentration were Naphthalene and 1 methyl Naphthalene, respectively. The highest and lowest concentrations at the sampling point D were Naphthalene and 1 methyl naphthalene, respectively while the highest and lowest concentration at the sampling point E were Naphthalene and Azulene, respectively. Generally the abundance of Naphthalene in the air samples could be attributed to its easy formation during the cyclization process occurring in which aliphatic hydrocarbon reacts to form cyclic compounds (Mastral et al., 2000). Other PAHs found in the air samples is believed to have formed by subsequent aromatization to Naphthalene (Thome-Kozmiensky, 1994).

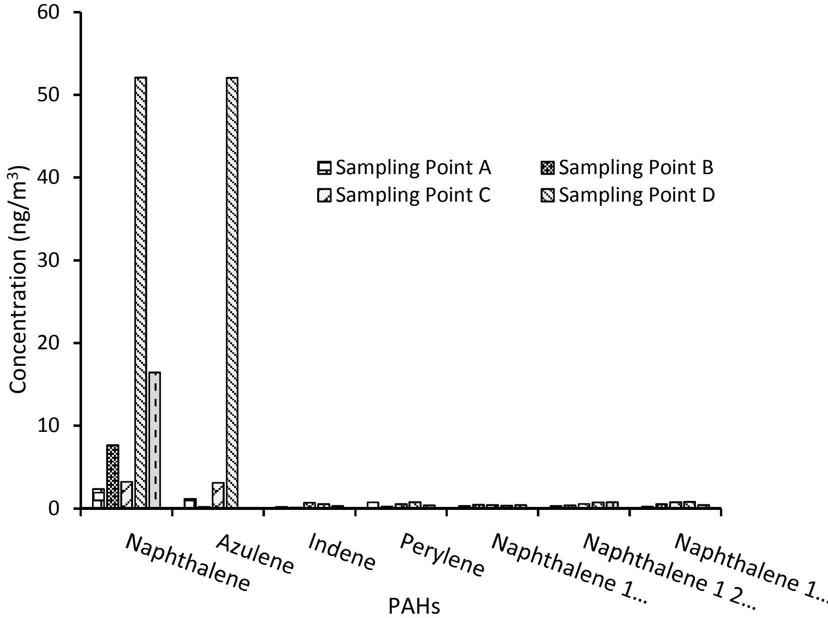

Figure 1: Concentrations of the alkyl naphthalene from the various sampling points

The prevalence of Naphthalene at sampling points D maybe due to work load on the generator as it supplies all the engineering workshops, laboratories and classrooms in the University. Also there could be other potential source of Naphthalene at the sampling point apart from the power generating set. This is the same reason could be explained for the high concentration of Azulene at the point. Workload on the generating set, frequent use and other potential source at the sampling point E could also be the reason for the high concentration of the Naphthalene at this sampling location. Relatively lower workload and low usage of the generating set could be attributed for the low concentration of all the pollutants observed at the sampling point A-C. The occupational safety and health administration (OSHA) stipulates that the PAH level in air at the workplace for an 8–hour time-weighted average (TWA) permissible exposure limit (PEL) at 0.2 mg/m^3. The National institute for occupational safety and health (NIOSH) also recommended that the workplace exposure limit for PAHs be set at the lowest detectable concentration of 0.1 mg/m^3. In comparing the observed pollutants levels observed in this study with these stipulated permissible limit, it was observed none of the individual PAH violated the exposure limits. This implied that the concentrations of PAHs at the sampling points were lower than the estimated minimal risk level (MRL) of 0.1 mg/m^3 for chronic inhalation exposure. Notwithstanding, continuous exposure to these pollutants is worrisome due to chronic effects. Hence, regular monitoring of the ambient PAHs level around these powers generating set is highly recommended.

3.1. Principal Component Analysis

Multivariate receptor model analysis (Principal Component Analysis– PCA) was used in this study for the source identification and contributions to ambient air receptors. In the score plot of the PCA, variables with similar pattern will be located close to each other, while those with divergent patterns will be located far apart (Jambu, 1991; Lee et al., 2004a; Lee et al., 2004b). Figure 2 shows the score plot of PCA for this study in which factor 1 which is the principal component in the direction of highest variance, explained 84.54 % of the total variance while factor 2 is the principal component in the direction of the second highest variance, explained 14.41 % of the total variance and both accounted for 98.95 % of the total variance. The Figure showed the clustering of most of the PAHs detected in the ambient air indicating correlation between the emission from the exhaust of the generator and observed concentration in the ambient air. However, compounds such as azulene and naphthalene showed in the Figure 2 which are far from the cluster indicating other possible sources such as vehicular emission and bush burning that occurs few times during the sampling period could also contribute to ambient levels concentration of naphthalene and Azulene (Gao et al. 2014).

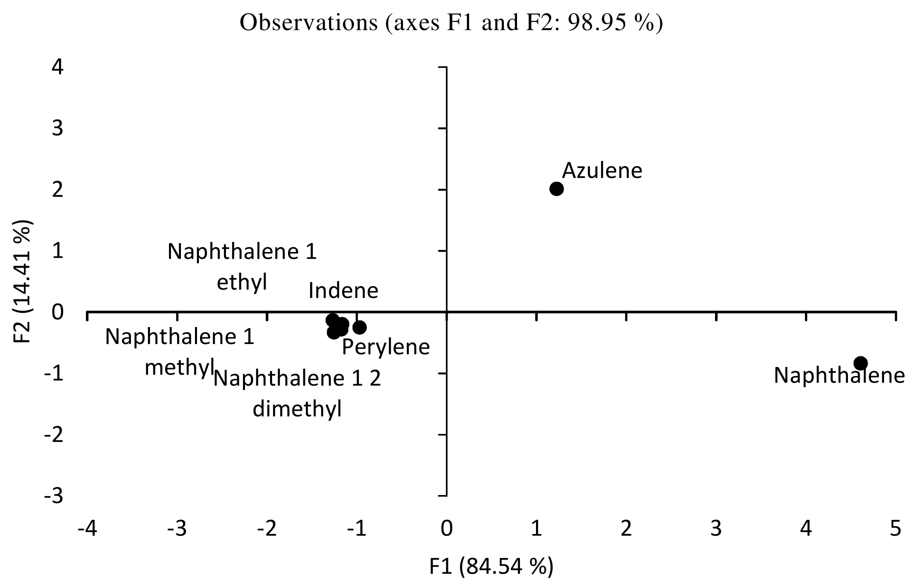

Figure 2: PCA score plot for PAH emission.

4. CONCLUSION

The study determined the contribution of power generating set to the ambient air level of polycyclic aromatic hydrocarbon in a University environment by sampling ambient air around generator for 28days. The results showed that the concentration of PAHs at various sampling locations for the period under investigation had the range of 0.22-2.34 ng/ m^3 at point A, 0.14 -7.67 ng/m^3 for point B while points C, D and E had the range of 0.44 - 3.24 ng/m^3, 0.34-52.13 ng/m^3, 0.11-16.45 ng/m^3, respectively. Multivariate receptor model analysis using principal component analysis (PCA) suggested high correlations between the emission from the power generating set and the ambient concentration of PAHs at the various sampling points.

However, Naphthalene and Azulene might have been significantly supplemented at the sampling points D and E by other emission sources such as such as vehicular emission and bush burning that occurs few times during the sampling period. The observed PAHs concentrations at the sampling points were lower than the estimated Minimal Risk Level (MRL) for chronic inhalation exposure to PAHs – 0.1 mg/m^3. However, continuous exposure to these pollutants is worrisome due to their chronic effects.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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