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CONCENTRATION OF POLYCYCLIC AROMATIC HYDROCARBONS IN THE SOIL AROUND A UNIVERSITY POWER GENERATING SET

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ABSTRACT

This study determined the concentrations of Polycyclic Aromatic Hydrocarbon (PAHs) in the soil around a University power generating set. Two soil samples A and B were taken at distances 10m and 15m, respectively from a University Power generating set. PAHs were extracted from the soil samples and analysed using the Gas Chromatography Mass - Spectrophotometry (GC-MS) operated in selective ion monitoring mode (SIM). The result showed that the concentration of PAHs obtained in the Soil Sample A ranged from 0 to 33.24 µg/g, while Soil Sample B ranged from 0 to 40 µg/g. The total concentration of PAHs obtained were 92.15 and 151.18 µg/g, for Soil Samples A and B, respectively. Principal Component Analysis (PCA) showed PAHs in the soil around the power generating are heavily supplemented by different sources around the University environment. The result obtained however showed that the total concentration of PAHs was higher than the permissible European limit of 1000 µg/kg for residential and agricultural soil.

1. INTRODUCTION

Epileptic power supply has been a problem in Nigeria, as the country's power generation is far below the amount needed for the population of about 180 million (Arobieke et al., 2012). In view of the importance of electricity to teaching and research, Universities in Nigeria have resorted to the use of power generating set for their daily activity. However environmental pollution from the usage of these sets is inevitable. Pollutants are being emitted into the atmosphere which in turn could be washed down by rain into water bodies and soil (Van Metre et al., 2000).

Emission from the exhaust of the power generating set is one of the sources of atmospheric polycyclic hydrocarbon (PAHs) and these PAHs are deposited into the soil by dry and wet process (El Shahawi et al., 2014). PAHs are compounds consisting of only carbon and hydrogen atoms. Chemically the PAHs are comprised of two or more benzene rings bonded in linear, cluster, or angular arrangements (Arey et al., 2003). There are thousands of PAHs, but most researches have been focused on few individual PAH (Abdel-Shafy and Mansour, 2016). These PAHs have been classified as priority pollutants due to their carcinogenic and mutagenic nature (ATSDR 1995; USEPA 2007; Olu-Owolabi et al., 2015). PAHs are resistant to oxidation and reduction due to their high melting and boiling points, low vapor pressure, and very low aqueous solubility (Abdel-Shafy and Mansour, 2016).

Researches have been focused on investigating PAHs in different environmental samples such as sludge samples (Ju et al., 2009), sediments (Sanctorum et al., 2011; Wang et al., 2012), soils (Man et al., 2013; Wang et al., 2012; Melnyk et al., 2015) and others (Zhang et al., 2012; Soltani et al., 2015). However, none of these works focused on soil around power generating set. More so, there is dearth of literature on PAHs in a sub-Saharan African country such as Nigeria. Hence this present work is focusing on the determination of the concentration of PAHs around a University power generation set. This is with a view of determining the level of contamination of the soil around the set

2. MATERIALS AND METHODS

2.1. Material Collection and Preparation of Samples

Soil samples were collected around a power generating set in Afe-Babalola University, Ekiti State, Nigeria. The generator supplies the students hostel of the University. The generator works on an average of 8 hrs a day. Two soil samples A and B taken at distances 10m and 15m, respectively from a University Power generating set were collected in April 2017 and put into a container covered with foil paper and transferred to the laboratory. The exact positions of the sampling sites were recorded using a portable GPS device. The samples were freeze-dried and after removing the stones, they were homogenized using a mortar and pestle. Samples were maintained at −15 °C prior to analysis (Melnyk et al., 2015).

2.2. PAHs Extraction and Analysis

The PAHs in the soil samples were extracted into dichloromethane using a Sohxlet extractor. Clean-up step was done as described by Hoyos et al. (2008). The extracted PAHs were concentrated to 20 µL using a rotary evaporator under a gentle stream of nitrogen. Analysis of PAHs was carried out using gas chromatography-mass spectrophotometer (GC– MS). The GC (Agilent 7890) with mass detector (Agilent 5975) was operated in selected ion-monitoring mode and using electron impact ionization. The chromatographic column dimension is 30 m × 0.25 mm internal diameter × 0.25 µm film thickness. Injection of 1 µL of each extracted sample was achieved in splitless mode using helium as a carrier gas at a constant flow of 1.2 mL min−1. The temperature program for the analysis was set as follows: the initial temperature (50 °C) was held for 2 min, ramped raised to 120 °C at 30 °C min−1, then ramped again to 280 °C at 6 °Cmin−1 for 15 min. The internal standard method was used for determination of PAHs and the calculation of the recovery (ranged between 70 and 120%) and quantification of the PAHs (Adesina et al., 2017). A procedural blank analysis was performed with every 3 samples to monitor interferences and cross-contamination (Melnyk et al., 2015).

2.3. Statistical Analysis

Statistical analysis was done using principal component analysis (PCA) and Pearson correlation available on the XLSTAT program of Golden Software Surfer 13.0 (USA).

3. RESULTS AND DISCUSSION

Figure 1 shows the compositions of PAHs observed in the soil sample taken in the vicinity of the University power generating set. PAHs observed were Naphthalene, Azulene, Indene, 1 methyl

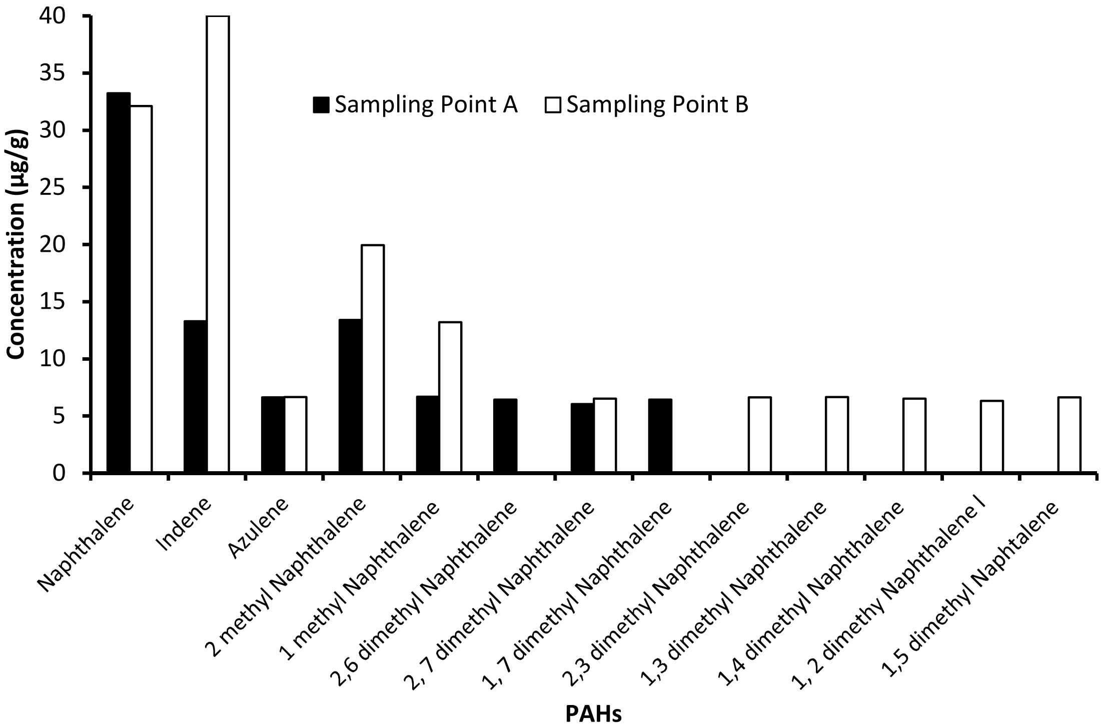

Figure 1: Compositions of PAHs observed in the soil

Naphtalene, 1,2 Dimethyl Naphathlene, 1,3 Dimethyl Naphathlene, 1,4 Dimethyl Naphathlene, 1,5 Dimethyl Naphathlene. Others included 1,7 Dimethyl Naphathlene, 2,3 Dimethyl Naphathlene 2,7 Dimethyl Naphathlene, and 2,6 Dimethyl Naphathlene. Concentration of PAHs obtained in soil Sample A ranged from 0 to 33.24 µg/g, with Naphtalene having the highest concentration (33.24 µg/g). PAH concentration in soil Sample B ranged from 0 to 40 µg/g with Indene having the highest concentration. The total concentration of PAHs obtained were 92.15 and 151.18 µg/g, for soil samples A and B, respectively. This concentration is higher than the total amount PAHs around a municipal landfill (Melnyk et al., 2015) and also higher than the concentration soil samples collected near a railway junction, where the content of PAH compounds was nearly 60 mg/kg (Wiłkomirski et al., 2011). The trend in the Figure 1 showed that the concentrations of virtually of the PAHs in sampling point B were higher than those of sampling point A. This could be as result direction of the wind as the emission from the exhaust from the generator is being dispersed by the wind and then deposited some distance from the generator. The trend could also be as result of potential source of PAHs such as incineration and emission from the university kitchen.

Source identification of the various sources of PAHs in the soil samples was carried out using Multivariate receptor model analysis (Principal Component Analysis– PCA). Figure 2 shows the score plot PCA. Variables with similar pattern will be located close to each other, while those with divergent patterns will be sparse (Jambu, 1991; Lee et al., 2004a; Lee et al., 2004b). Figure 2 shows that factor 1 which is the principal component in the direction of highest variance and explained 86.28 % of the total variance while factor 2 is the principal component in the direction of the second highest variance and explained 13.72 % of the total variance and both accounted for 100.00 % of the total variance, in view of this variability in the PAH concentrations observed in the soil could be explained. Two clusters of PAHs were observed in the plot while other compounds are far from the clusters, this is an indication of multiple sources of PAHs in the soil apart from the power generating set. This could also be reason for high concentration of Naphthalene and indene observed in both soil samples.

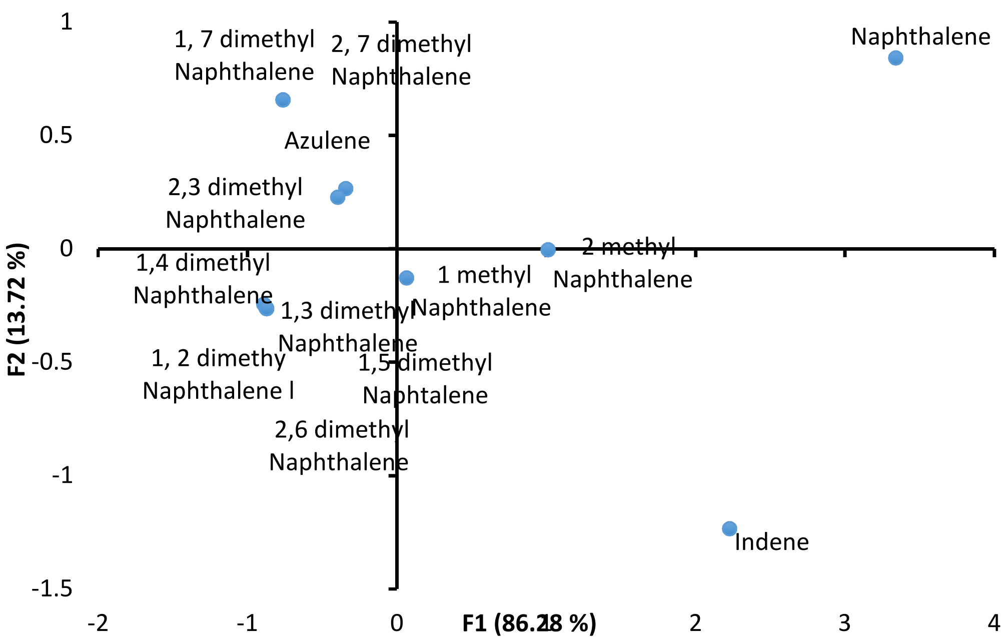

Figure 2: The PCA score plot

4. CONCLUSION

The study determined the concentration of PAHs in the soil around a university power generating set, two soil sample were and analysed. The result showed the summation of PAHs around the power generating set were 92.15 and 151.18 µg/g, for soil samples A and B respectively. The total concentration of PAHs obtained is however higher than the permissible European limit of 1000 µg/kg for residential and agricultural soil (Ortiz et al., 2012). Multivariate receptor model analysis of Principal Component Analysis (PCA) showed PAHs in the soil around the power generating set are only from the set but also heavily supplemented by different sources around the University environment.

5. ACKNOWLEDGMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

Abdel-Shafy, H. I. and Mansour, M. S. (2016). A review on polycyclic aromatic hydrocarbons: Source, environmental impact, effect on human health and remediation. *Egyptian Journal of Petroleum*, 25, pp. 107-123.

Adesina, O. A. Sonibare, J. A. Diagboya, P. N., Adejuwon, A., Famubode, T. and Bello, J. O. (2017). Periodic characterization of alkyl-naphthalenes in stack gas and ambient air around a medical waste incinerator. *Environmental Science Pollution Resource*, 24, pp. 21770-21777

Arey, J. and Atkinson, R. (2003). Photochemical reactions of PAH in the atmosphere, In: P.E.T. Douben (Ed.). PAHs: an ecotoxicological perspective, *John Wiley and Sons Ltd, New York*, pp. 47–63.

Arobieke, O., Osafehinti S., Oluwajobi F. and Oni O. (2012). Electrical Power Outage in Nigeria: History, Causes and Possible Solutions. *Journal of Energy Technologies and Policy*, 2(2), pp. 18-23.

ATSDR, (1995). Toxicological profile for polycyclic aromatic hydrocarbons (PAHs). *http://www.atsdr.cdc.gov/toxprofiles/tp69.pdf.*

El-Shahawi, M. S., Hamza, A., Bashammakh, A. S. and Al-Saggaf, W. T. (2010). An overview on the accumulation, distribution, transformations, toxicity and analytical methods for the monitoring of persistent organic pollutants. *Atalanta*, 80, pp. 1587-1597.

Hoyos, A., Cobo, M., Aristizabal, B., Cordoba, F., de Correa, C.M. (2008). Total suspended particulate (TSP), polychlorinated dibenzodioxin (PCDD) and polychlorinated dibenzofuran (PCDF) emissions from medical waste incinerators in Antioquia, Colombia. *Chemosphere*, 73, pp. 137–142.

Jambu, M. (1991). Exploratory and Multivariate Data Analysis. *Academic Press, Boston.*

Ju, J.H., Lee, I.S., Sim, W.J., Eun, H., Oh, J.E., (2009). Analysis and evaluation of chlorinated persistent organic compounds and PAHs in sludge in Korea. *Chemosphere* 74. pp. 441–447.

Lee, W. S., Chang-Chien, G. P., Wang, L. C., Lee, W. J., Tsai, P. J., Wu, K. Y. and Lin, C. (2004a). Source Identification of PCDD/Fs for Various Atmospheric Environments in a Highly Industrialized City. *Environmental Science Technology*, 38, pp. 4937-4944.

Lee, W. S., Yuan, C. S., Wang, L. C., Chen, C. K., Lin, C. and Chang-Chien, G. P. (2004b). Evaluating the Influence of PCDD/F Emission from Municipal Solid Waste Incinerators on Ambient Air by PCDD/F Concentration Isopleths and Principal Component Analysis. *Journal of the Chinese Institute of Environmental Engineering*, 14, pp. 1-10.

Man, Y.B., Chow, K.L., Kang, Y., Wong, M.H. (2013). Mutagenicity and genotoxicity of Hong Kong soils contaminated by polycyclic aromatic hydrocarbons and dioxins/furans. *Mutation Resource*, 752, pp. 47–56.

Melnyk, A. Dettlaff, A. Kuklińska, K. Namieśnik, J. Wolska, L. Kuklińska, K. Namieśnik, J. and Wolska, L. (2015). Concentration and sources of polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) in surface soil near a municipal solid waste (MSW) landfill. *Science of the Total Environment*, 530-531, pp. 18-27

Ortiz R., Vegas S., Gutierrez R, Gibson R., Schettino B, Ramirez M. L. (2012). Presence of Polycyclic Aromatic hydrocarbon (PAHs) in top soils from rural terrains in Mexico City. *Bulleting Environmental Contamination Toxicology,* 88(3) pp. 428-432

Olu-Owolabi, B. I. Diagboya, P. N. and Adebowale, K. O. (2015). Sorption and desorption of fluorene on five tropical soils from different climes. Geoderma, 239-240, pp. 179–185.

Sanctorum, H., Elskens, M., Leermakers, M., Gao, Y., Charriau, A., Billon, G., Goscinny, S., De Cooman, W., Baeyens, W., (2011). Sources of PCDD/Fs, non-ortho PCBs and PAHs in sediments of high and low impacted transboundary rivers (Belgium–France). *Chemosphere* 85, pp. 203–209.

Soltani, N., Keshavarzi, B., Moore, F., Tavakol, T., Lahijanzadeh, A.R., Jaafarzadeh, N., Kermani, M. (2015). Ecological and human health hazards of heavymetals and polycyclic aromatic hydrocarbons (PAHs) in road dust of Isfahan metropolis, Iran. *Science of Total Environment*, 505, pp. 712–723.

United State Environmental Protection Agency (USEPA). (2007). Treatment technologies for site clean-up: *annual status report (ASR).* Twelfth Edition. (EPA 542-R- 07-012).

Van Metre, P.C., B.J. Mahler and E.T. Furlong, (2000). Urban sprawl leaves its PAH signature. *Environmental. Science. Technology*, 34, pp. 4064-4070.

Wang, Z., Liu, Z., Yang, Y., Li, T. and Liu, M. (2012). Distribution of PAHs in tissues of wetland plants and the surrounding sediments in the Chongming wetland, Shanghai, China. *Chemosphere* 89, 221–227.

Wiłkomirski, B., Sudnik-Wójcikowska, B., Galera, H., Wierzbicka, M. and Malawska, M. (2011). Railway transportation as a serious source of organic and inorganic pollution. *Water, Air, & Soil Pollution*, 218, pp. 333–345.

Zhang, W., Wei, C., Chai, X., He, J., Cai, Y., Ren, M., Yan, B., Peng, P., Fu, J. (2012). The behaviors and fate of polycyclic aromatic hydrocarbons (PAHs) in a coking wastewater treatment plant. *Chemosphere,* 88, pp. 174–182.