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Analysis of the PAHs pollution index (PPI) of water from river niger at Onitsha

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Abstract
Testing for the presence of various PAHs was done on water samples taken from the River Niger at Onitsha. Using the GC-FID method, water samples collected from five sampling sites designated (001 - 005) were assessed. The amounts of 14 PAHs in water samples have been measured. The range of the mean concentration (g/l) of each PAH in water was as follows: 0.016±0.02 – 0.124±0.06 (acenaphthylene), 0.000±0.00 – 0.040±0.05 (naphthalene), 0.060±0.08 – 0.729±1.03 (flouranthene), 0.005±0.00 – 0.083±0.11 (phenanthrene), 0.031±0.04– 0.268±0.17 (1,2-benzanthracene), 0.000±0.00–0.075±0.10 (acenaphthene), 0.026±0.03 0.101±0.04 (benzo flouranthene), 0.004±0.00 – 0.142±0.06 (benzo pyrene), 0.000±0.00 – 0.128±0.04 (pyrene), 0.000±0.00 – 0.059±0.06 (perylene), 0.000±0.00 – 0.000±0.00 (dibenzy), 0.000±0.00 – 0.076±0.11 (flourene), 0.000±0.00 – 0.151±0.12 (xylene), 0.000±0.00 – 0.002±0.00 (anthracene). Flouranthene and 1,2-benzanthracene concentrations were the most frequently found PAHs in all samples. These PAHs have four rings (high molecular weight PAHs). This suggests that the river water includes highly strong, non-biodegradable mutagens and carcinogens that are harmful to human health when consumed. The PPI values discovered from the examination of the water samples are in the following order: sample-002 > sample-005 > sample-003 > sample-004 > sample-001.

Keywords: PAHs pollution, index, PPI, Onitsha

Introduction

Water is essential to life and has numerous uses in home, agricultural, and industrial settings. Its importance cannot be overstated. Polycyclic aromatic hydrocarbons (PAHs), for example, are well known for being a significant sink for contaminants in water (Okwesili *et al*., 2022) [10, 11]. Anthropogenic and natural sources such as rock weathering, waste water, industrial effluents, incomplete combustion of organic materials, fossil fuel combustion, petroleum combustion, and ambient air all contribute to the widespread presence of PAHs and the daily leaching of these chemicals into rivers, lakes, and oceans (Okwesili *et al*., 2022) [10, 11]. Cigarette smoke, vehicle exhaust, residential heating, agricultural burning, waste incineration, and emissions from industrial processes are some of the ways that people are exposed to PAH vapor or PAHs that are present in dust and other particulate matter both indoors and outdoors, at home or at work (Okwesili *et al*., 2022) [10, 11]. Ingestion of food, water, or skin contact are other ways by which PAHs might enter the body (Byeong-Kyu, 2010). All tissues in the human body that contain fat are absorbed with PAHs. By receiving frequent and prolonged exposures, they can build up in the fat, liver, and kidneys. The spleen, adrenal glands, and ovaries also hold smaller quantities (Zafer *et al*., 2007) [15]. Plants, birds, and mammals are just a few of the diverse sorts of creatures that are negatively impacted by PAHs. According to several studies (Olubunmi and Edward, 2013) [12], exposure to PAHs from cigarette smoke, roofing tar, and coke oven exhaust is significantly positively correlated with lung cancer mortality in people. Local populations in and around the Onitsha axis of the River Niger rely largely on the water body as a significant supply of portable water, which raises serious concerns given that the river is extensively contaminated as a result of human activities along the coastline line (Okwesili *et al*., 2022) [10, 11]. In order to identify the sources of these pollutants and to enable policymakers to set up efficient waste disposal management programs for individuals living in the study area, it is crucial to measure the amounts of PAHs in the water. To do this, the PAHs pollution index (PPI) must be established.

Materials and Methods

Description of Study Area

The study area is a segment of the River Niger in Onitsha. Between latitudes 5°221 and 6°481 and longitudes 6°321 and 7°201 is Onitsha, a city in the eastern Nigerian state of Anambra. Onitsha, a municipality in the Anambra State, has a size of around 49,000 km^2 and is nestled on the east bank of the River Niger. One of the leading commercial centers in sub-Saharan Africa, it serves as an important transit hub for Nigeria. One million people are claimed to inhabit there, the preponderance of them work as businessmen and manufacturers.

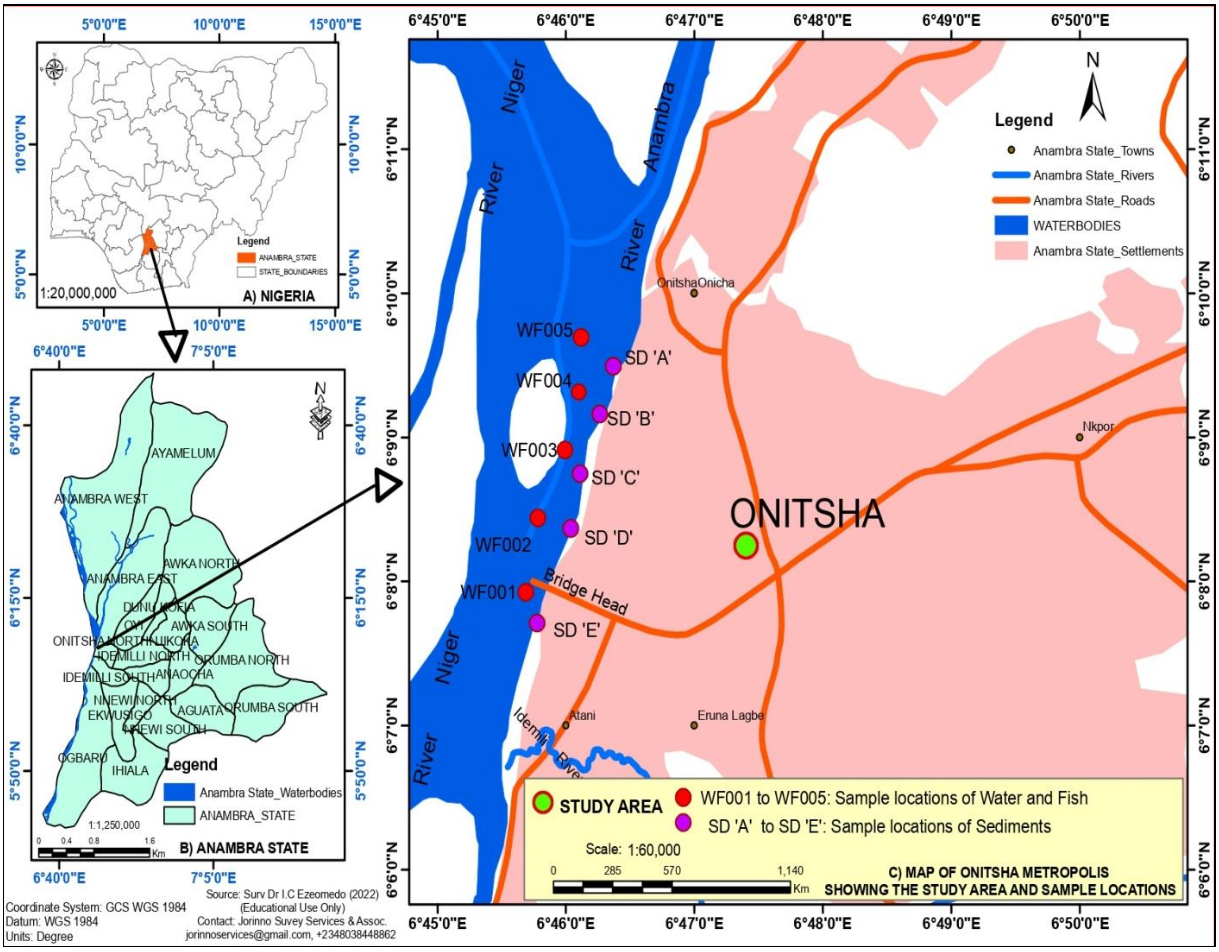

Fig 1: *The sample locations in the River Niger at Onitsha on the map of Anambra State.*

Sample collection

In this investigation, water samples from the River Niger at Onitsha were randomly taken at two-kilometer intervals. Five composite samples, denoted [001], [002], [003], [004], and [005], were generated having twenty sample points.

GC-FID Analysis

The presence of 16 PAH in the water samples was determined using gas chromatography with a fame ionization detector (Trace 1310, Thermo Scientific, Milan, Italy), outfitted with an automatic sampler (Tri Plus RSH), split/splitless injection system, and split/splitless injection system. An OV-5 capillary column with a fused silica core and an internal coating of dimethylpolysiloxane stationary phase containing 5 % phenyl (produced by Ohio Valley Specialty Company, Marietta, Ohio, USA) was used for chromatographic separation. Its dimensions were 30 m 0.25 mm i.d. 0.25 m flm thickness. As a carrier gas, 2.0 mL per minute of 99.99 % pure helium from Linde, Pará, Brazil, was utilized. The sample extraction process was carried out using a vacuum SPE machine (VisiprepTM, Supelco, Bellefonte, PA, USA) that can hold 12 C-18 cartridges.

Statistical Quality Control

Each PAH was tested in triplicates, with the evidence that points as mean standard deviation, to assess the instrument precision, which refers to the degree of similarity of results of replicate samples or an indicator of the reproducibility of results of replicate samples was measured under the same condition (David, 2000) [3]. The mean values from the triplicate findings, the standard deviation, the analysis of variance (ANOVA) at a value less than 0.05 ($P<0.05$), and the principal component analyses (PCA) based on the Pearson Correlation matrix analysis were all estimated using the SPSS version 20 software program.

PAHs pollution index (PPI)

PAHs Pollution Index (PPI) estimations were made to compare the overall amount of PAHs present at the various sampling sites (Mohd *et al*., 2015) [8] PPI are vital tools for evaluating PAH pollution; PPI values above 1 indicate that the samples have been polluted, whereas PPI values below 1 indicates that no pollution has occurred.

PAHs Pollution Index (PPI) = $(Ch_1 \times Ch_2 \times Ch_k)^{1/k}$

Where, Ch_1 = concentration value of the first
Ch_2 = concentration value of the second PAH.
Ch_k = concentration value of the kth PAH.

Results

The results of the evaluation of fourteen PAHs' mean concentrations in the water samples 001–005 are shown in table 1 below.

Table 1: Results of PAHs in Water Samples

Parameters (µg/l)	Sample-001	Sample-002	Sample-003	Sample-004	Sample-005	Control
	Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D	Sample
Acenaphthylene	0.016±0.02	0.021±0.00	0.124±0.06	0.097±0.01	0.041±0.04	0.00
Naphthalene	0.009±0.00	0.000±0.00	0.029±0.04	0.040±0.05	0.038±0.05	0.00
Flouranthene	0.060±0.08	0.671±0.22	0.119±0.17	0.135±0.10	0.729±1.03	0.00
Phenanthrene	0.080±0.11	0.006±0.00	0.083±0.11	0.083±0.11	0.005±0.00	0.00
1,2- Benzanthracene	0.073±0.07	0.187±0.01	0.031±0.04	0.122±0.02	0.268±0.17	0.00
Acenaphthene	0.000±0.00	0.000±0.00	0.000±0.00	0.001±0.00	0.075±0.10	0.00
Benzo Flouranthene	0.022±0.03	0.101±0.04	0.042±0.00	0.026±0.03	0.084±0.12	0.00
Benzo Pyrene	0.045±0.00	0.211±0.00	0.004±0.00	0.079±0.09	0.142±0.06	0.00
Pyrene	0.000±0.00	0.128±0.04	0.008±0.01	0.013±0.02	0.003±0.00	0.00
Perylene	0.059±0.06	0.000±0.00	0.000±0.00	0.000±0.00	0.000±0.00	0.00
Dibenzy	0.000±0.00	0.000±0.00	0.000±0.00	0.000±0.00	0.000±0.00	0.00
Flourene	0.076±0.11	0.000±0.00	0.000±0.00	0.000±0.00	0.000±0.00	0.00
Xylene	0.151±0.12	0.000±0.00	0.063±0.00	0.032±0.05	0.000±0.00	0.00
Anthracene	0.002±0.00	0.000±0.00	0.000±0.00	0.000±0.00	0.000±0.00	0.00

Discussion

In the water samples, fourteen of the sixteen pollutants identified by the USEPA as priority pollutants were found. The mean concentration (µg/l) of individual PAHs in water ranged from 0.016±0.02 – 0.124±0.06 (acenaphthylene), 0.000±0.00 – 0.040±0.05 (naphthalene), 0.060±0.08 – 0.729±1.03 (flouranthene), 0.005±0.00 – 0.083±0.11 (phenanthrene), 0.031±0.04 – 0.268±0.17 (1,2- benzanthracene), 0.000±0.00 – 0.075±0.10 (acenaphthene), 0.026±0.03 – 0.101±0.04 (benzo flouranthene), 0.004±0.00 – 0.142±0.06 (benzo pyrene), 0.000±0.00 – 0.128±0.04 (pyrene), 0.000±0.00 – 0.059±0.06 (perylene), 0.000±0.00 – 0.000±0.00 (dibenzy), 0.000±0.00 – 0.076±0.11 (flourene), 0.000±0.00 – 0.151±0.12 (xylene), 0.000±0.00 – 0.002±0.00 (anthracene). The most frequently found PAHs in the water samples were flouranthene and 1, 2-benzanthracene. The four-ring PAHs clearly predominated in terms of PAH composition by ring type (high molecular weight PAH). This suggests that the water in the River includes very intense, non-biodegradable mutagens and carcinogens that are dangerous to human health when consumed; as a result, their removal from the aquatic ecosystem is crucial. HMW PAHs, such as phenanthrene, fluoranthene, and pyrene, were found in higher concentrations in the current study than LMW PAHs, such as acenaphthene and fluorene, indicating that PAHs in water samples were mainly of anthropogenic origin rather than of naturally derived (petrogenic and biogenic). Adeniji *et al*. (2019) [1], who assessed the concentration of PAHs in surface water and its sediments, obtained a finding that was identical to this one. Duke (2008) [4] also found the presence of high molecular weight PAHs in surface water from a creek in the Niger Delta. However, other investigations have revealed that two-ring or three-ring PAHs predominate in surface water (Nasr *et al*., 2010; Kafilzadeh *et al*., 2011; Tongo *et al*., 2017) [9, 7, 13]. According to the WHO standards for PAHs in drinking water, individual PAH concentrations were often greater than the acceptable range of 0.05 g/l, particularly in the high molecular weight PAHs detected in this investigation (WHO 1993) [14]. Given that this water body provides drinking water to the towns residing along the river, there should be major pollution concerns.

Table 2: Pearson's correlation coefficient for PAHs in water

	Sample-001	Sample-002	Sample-003	Sample-004	Sample-005
Sample-001	1				
Sample-002	0.099146	1			
Sample-003	0.297541	0.44644	1		
Sample-004	0.283941	0.670367	0.73684	1	
Sample-005	0.127093	0.962275	0.490509	0.709145	1

The findings of the examination of correlation of PAHs in river water samples (Table 2) showed a strong and positive correlation between sample-002/sample-004 ($r=0.670367$ at $p > 0.05$), sample-003/ sample-004 (r=0.73684 at p > 0.05), sample-002/ sample-005 (r=0.962275 at p > 0.05), sample-004/ sample-005 (r=0.709145 at p > 0.05).

Table 3: Polycyclic Aromatic Hydrocarbon Pollution Index (PPI) of Water Samples

	Sample-001	**Sample-002**	**Sample-003**	**Sample-004**	**Sample-005**
PPI Values	0.070	0.298	0.117	0.095	0.154

The PPI values in the analyzed water samples are listed in this order: sample-002 > sample-005 > sample-003 > sample-004 > sample-001. The sampling sites were liable for the trend. The amount of pollutants sample-002 received from home and industrial activities inside the sampling location can be shown to indicate that it was the most contaminated. Additionally, there is greater room for these toxins to settle into the sediments at the sampling site due to the slower water flow. Other elements might result from fishing operations or from decreased water-sediment friction caused by slower water velocity (Ji *et al*., 2015; Ekere *et al*., 2017) [6, 5]. Similar pollution studies on the river have linked its high concentration of PAHs and marine debris to other pollutants such microplastics like polyester and polystyrene. According to correlation analyses, the majority of the microplastics in fish and water samples originated from sources that were generally of similar origin, typically PAHs (Okwesili *et al*., 2022) [10, 11].

Conclusion

This study investigated the quantities of polycyclic aromatic hydrocarbons in water samples as well as the relationships between the various PAHs, and the findings have been published. The distribution showed that 1,2-benzanthracene and flouranthene concentrations were the most often found PAHs in the water samples. The four-ring PAHs clearly predominated in terms of PAH composition by ring type (high molecular weight PAH). This suggests that the water in the River includes very potent, non-biodegradable mutagens and carcinogens that are harmful to human health when consumed; as a result, their removal from the aquatic environment is crucial. Meanwhile, the outcomes of the estimation of the PPI values in the investigated water samples are as follows: sample-002 > sample-005 > sample-003 > sample-004 > sample-001. The results of this study indicate that statistical methods can be an effective tool for estimating PAH concentrations in assessments of water contamination.

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References

1. Adeniji AO, Okoh OO, Okoh AI. Levels of Polycyclic Aromatic Hydrocarbons in the Water and Sediment of Buffalo River Estuary, South Africa and Their Health Risk Assessment, Archives of Environmental Contamination and Toxicology,2019:76:657-669 https://doi.org/10.1007/s00244-019-00617-w.
2. Byeong-Kyu Lee. Sources, Distribution and Toxicity of Polyaromatic Hydrocarbons (PAHs) in Particulate Matter, Air Pollution, Vanda Villanyi (Ed.), 2010. ISBN: 978- 953-307-143-5, In Tech, Available from: http://www.intechopen.com/books/air-pollution/sources-distribution-and-toxicity-of-polyaromatic-hydrocarbonspahs-in- particulate-matter.
3. David Harvey. Modern Analytical Chemistry. McGraw-Hill Higher Education, USA, 2000, 710.
4. Duke O. Source determination of polynuclear aromatic hydrocarbons in water and sediment of a creek in the Niger Delta region. African Journal of Biotechnology,2008:7:282-285.
5. Ekere N, Yakubu N, Ihedioha J. Ecological risk assessment of heavy metals and polycyclic aromatic hydrocarbons in sediments of rivers Niger and Benue confluence, Lokoja, Central Nigeria, Environ Sci Pollut Res, 2017. DOI 10.1007/s11356-017-9511-6.
6. Ji Li, Guobing Luo, Jufen Gao, Song Yuan, Juan Du, Zhaohui Wang. Quantitative evaluation of potential ecological risk of heavy metals in sewage sludge from three wastewater treatment plants in the main urban area of Wuxi, China. Chemistry and Ecology,2015:31:3:235-251.
7. Kafilzadeh F, Shiva A, Malekpour R. Determination of polycyclic aromatic hydrocarbons (PAHs) in water and sediments of the Kor River, Iran. Middle-East Journal of Scientific Research,2011:10:01-07.
8. Mohd Zahari Abdullah, Veronica Cyrila Louis, Mohd Tahir Abas. Metal Pollution and Ecological Risk Assessment of Balok River Sediment, Pahang Malaysia. American Journal of Environmental Engineering,2015:5(3A):1-7.
9. Nasr I, Arief M, Abdel-Aleem A, Malhat F. Polycyclic aromatic hydrocarbons (PAHs) in aquatic environment at El Menofiya Governorate, Egypt. Journal of Applied Sciences Research,2010:6:13-21.
10. Okwesili Lotanna Chidera, Nsude Okechukwu Paul, Onyishi Chukwuebuka Kenechukwu. Correlation analysis of levels of microplastics in fish from river Niger at Onitsha. International Journal of Environmental and Ecology Research,2022:4:(3):38-41.

11. Okwesili Lotanna Chidera, Udeozo Prisca Ifeoma, Eze Emachi Ephraim. Assessment of microplastic contamination in water from River Niger at Onitsha. International Journal of Chemical Science,2022:6:(2):40-42.
12. Olubunmi E. Fagbote, Edward O, Olanipekun. Polycyclic Aromatic Hydrocarbons (PAHs) and Polychlorinated Biphenyls (PCBs) in soils of Agbabu, Nigeria. 1st Annual Intern. interdisciplinary conference, AIIC, proceedings *Azones Protugal.,* 2013, 849-856.
13. Tongo I, Ezemonye L, Akpeh K. Distribution, characterization, and human health risk assessment of polycyclic aromatic hydrocarbons (PAHs) in Ovia River, Southern Nigeria, *Environ Monit Assess*,2017:189:247. DOI 10.1007/s10661–017-5931-5.
14. World Health Organization (WHO) WHO guidelines for drinking water quantity (2nd ed.p. 1993). Geneva: World Health Organization, 1993.
15. Zafer Ayas, Guler Ekmekci, Sedat Vahdet yeili, Murat Ozmen. Heavy metal accumulation in water sediments and fishes of Nallihan Bird Paradise, Turkey. J. Environ. Biology,2007:28(2):545-549.