# Bioaccumulation of Polycyclic Aromatic Hydrocarbons (PAHs) Concentration in Biota from the Niger Delta, South- South, Nigeria

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## ABSTRACT

*One of the most valued biota in the Niger Delta is Penaeusmonodon (shrimp) because of the nutritive and economic benefits to the people. This organism is known to accumulate pollutants like PAHs to a great extent. The determination of PAHs concentration in Penaeusmonodon was carried out first by extraction using soxhlet extractor with dichloromethane while the Gas Chromatography equipped with Flame Ionization Detector was used to determine the concentrations of PAHs in the extract. The bioaccumulation factor was calculated from the ratio of concentration of PAHs in the Penaeusmonodon to that in water which was found to vary from 78.6 to 93.8 on a dry weight basis. Also, the results of the concentration of individual PAHs in the biota ranged between 0.943mg/kg and 2.347mg/kg (dry wt.). From the results of the investigation, it was noticed that Penaeusmonodon bioaccumulated PAHs to high levels and the concentration of individual PAHs in the organism when compared to the national and international recommended limits, was also high, an indication that the consumption of this organism portends health risk. It is therefore the opinion of this research that the consumption of this organism from the environment be stopped forthwith pending when a remediation programme is carried out.*

**Keywords:** Bioaccumulation, Biota, Polycyclic, Aromatic, Hydrocarbon, Niger Delta, Concentration

## INTRODUCTION

Bioaccumulation and subsequent release of PAHs depend on the bioavailability of the toxin and the metabolism of the contaminated organisms. Fish have high metabolic capacity to break down PAHs, so bioaccumulation of the parent PAH compound is short lived (Dunn, 1980), although accumulation of PAH metabolites is more toxic than the parent compound may occur (Stabenau et al., 2006). Although largely insoluble in water, some of them are soluble and dissolve in water and enter groundwater from ash, tar or creosote improperly disposed in landfills. Waste products containing significant amounts of PAHs are indiscriminately dumped into water, on land or buried at sub-surface sites (Christensen and Bzdusek, 2005). Airborne particulates resulting from PAHs activities are transported in the atmosphere and are usually deposited in soils and sediments of aquatic system (Christensen *et al.,* 1997; Christensen and Bzdusek, 2005). In general, PAHs dissolved in pure water are accumulated in sediments (McElroy and Sisson, 1989), and digestion of sediment may play an important role in the uptake of PAHs by some species. Species that metabolize PAHs to little or no extent, like algae, oligochaetes, mollusks, and the more primitive invertebrates (protozoans, porifers, and cnidaria), accumulate high concentrations of PAHs, as would be expected from their $LogK_{ow}$ values, whereas organisms that metabolize PAHs to a great extent, like fish and higher invertebrates such as anthropods, echinoderms, and annelids, accumulate little or no PAHs (James, 1989). Remarkably high bioconcentration factors have been obtained for phenanthrene, anthracene, pyrene, benzo [a] anthracene, and benzo [a] pyrene in the amphipod *pontoporeiahoyi*, which has a 20-50% lipid content by wet weight



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and no capacity to biotransform PAHs (Landrum, 1988). In a study carried out by Nwineewii (2014) on the concentrations of PAHs in surface sediments from Okrika River and Eleme Creeks, it was discovered that the concentrations of PAHs ranged between 1.003mg/kg and 1.650mg/kg. The ratio of the concentration of an individual PAHs in a bottom-dwelling organism and that in the sediment, (the bioaccumulation factor) is usually <1 when expressed as wet weight. In a coastal area, the bioaccumulation factors of 16PAHs in polychaete species varied from 4.9 to 21.8 on a dry-weight basis (Bayona*et al.,* 1991). Results of the study of three sites with different organic carbon contents yielded bioaccumulation factors close to 1 on a wet-weight basis (corrected for the 64mm sieved fraction). The lipid and organic carbon-based bioaccumulation factors in clams (Macomabaltica) for naphthalene and chrysene in sediments were 0.78 and 0.16 respectively (Forster *et al.,* 1987). In a study in which claims were exposed for 28 days to six sediments contaminated with different concentrations of PAHs (and other organic pollutants) and with an organic carbon content of 0.86-7.4%, the bioaccumulation factors (normalized with respect to lipid content and organic carbon content) ranged from 0.15 to 0.85 (Ferraro et al. 1990). Species that can biotransform PAHs have internal concentrations well below the concentrations in the sediment. The average bioaccumulation factors (normalized with respect to lipid content and organic carbon content) for eel, pike and roach at two locations were 0.1 and 0.015. The lowest bioaccumulation factor was found at the site with the highest PAHs concentration (128 mg/kg, organic carbon-based), probably due to the inductive capability of the fish to biotransform PAHs.

## SAMPLE COLLECTION

Penaeusmonodon (shrimp) samples were collected from the following communities vizAgbonchia, Aleto, Abam, Ogan and Okrika River in the South Eastern part of Rivers State of the Niger Delta, Nigeria. The specific sampling points were location I(Agbonchia1), location2(Agbonchia2), location 3 (petrochemicals), location 4 (Dredging), location 5 (slaughter), location 6 (Railway), location7 (NNPC QTRS), location8(Abam), location9(Ogan), location10(Okrika River). Sampling was carried out monthly for a period of eight months for the determination of polycyclic aromatic hydrocarbons PAHs in shrimp.

## ANALYSIS OF SAMPLE

Polycyclic aromatic hydrocarbons were extracted from Shrimp by Soxhlet extraction with dichloromethane. Extracts were further purified to reduce interferences. The empirical purification entailed the use of alumina (neutral activity 1) as an adsorbent. This was introduced in a slurry form with hexane into 1-cm glass columns to a depth of about 10cm. Concentrated extracts were dissolved in hexane and subsequently introduced to the wet adsorbent and eluted with this solvent (hexane) to remove aliphatic hydrocarbons. The second eluant was benzene, which removed the aromatic materials with sufficient purity for capillary GC analysis. The purified aromatics were analyzed by capillary GC using an HP 6890 Series GC system equipped with FID. The column used was a HP-5, 30 m X 0.25 mm X 0.25µm (HP Part No. 19091S-433). Hydrogen (10.2psi) was used as carrier gas at 1.5ml/min. The column was kept at 80$^{o}$C (1 min), 20$^{o}$C/min 280$^{o}$C, 2.5$^{o}$C/min, 300$^{o}$C (4 min). Temperature of the FID $T_{ij}$ was kept at 325$^{o}$C.

## RESULTS AND DISCUSSION

Penaeusmonodon (shrimp) from the Niger Delta (Okrika River and Eleme Creeks) has been known to accumulate PAHs to a great extent up to 78.9 and 83.9 from the result of the investigation. This Bioaccumulation factor is very high and portrays high risk to consumers of this organism.



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Table 1. Means concentrations (mg/kg, dry wt.) of polycyclic aromatic hydrocarbons in biota (shrimp) from Eleme creeks

| | | **Location** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PAHs | Abbr | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total | Mean |
| Acenaphthene | Ace | 1.013 | 1.100 | NS | NS | 1.981 | 2.667 | 2 | 1.568 | 1.680 | 1.783 | 13.876 | 1.684 |
| Acenaphthylene | Any | 1.335 | 0.779 | NS | NS | 2.023 | 1.318 | 0.637 | 0.955 | 1.692 | 1.200 | 9.938 | 1.242 |
| Anthracene | Ant | 0.733 | 0.898 | NS | NS | BDL | 0.406 | 2.215 | 1.394 | BDL | 0.610 | 6.255 | 1.042 |
| Benzo (a)anthracene | B(a)A | 0.910 | 1.542 | NS | NS | BDL | 1.714 | 1.414 | 1.861 | 1.443 | 2.411 | 11.294 | 1.663 |
| Benzo (a) pyrene | Bap | 1.222 | 0.324 | NS | NS | BDL | 1.013 | 1.017 | 0.065 | 1.012 | 1.532 | 6.185 | 0.943 |
| Benzo (b) fluoranthene | B(b)F | 2.387 | BDL | NS | NS | BDL | 1.607 | 0.922 | BDL | 2.042 | 0.112 | 7.070 | 1.413 |
| Benzo (g,h,i) perylene | BghiP | 0.603 | 0.280 | NS | NS | BDL | 1.170 | BDL | 2.026 | 1.992 | 2.145 | 8.216 | 2.347 |
| Benzo (k) flouranthene | B(k)F | 1.213 | 1.041 | NS | NS | 1.418 | 1.017 | 2.340 | 0.119 | BDL | 0.527 | 7.675 | 1.096 |
| Chrysene | Chr | 2.472 | 0.174 | NS | NS | 1.534 | 0.868 | 0.514 | BDL | 1.010 | 1.867 | 8.438 | 1.205 |
| Dibenzo (a,h) anthracene | DahA | 1.340 | 2.268 | NS | NS | BDL | 2.220 | 1.242 | 2.053 | 1.673 | 0.809 | 11.604 | 1.657 |
| Flouranthene | Flu | 1.533 | 1.566 | NS | NS | BDL | 0.951 | 0.312 | 1.428 | BDL | 0.897 | 6.687 | 1.186 |
| Flourene | Fln | 1.225 | 1.301 | NS | NS | 0.652 | 1.531 | 1.764 | 1.340 | 0.489 | BDL | 8.302 | 1.186 |
| Indenzo (1,2,3 -cd) pyrene | Ideno | 1.082 | 1.455 | NS | NS | BDL | 2.866 | 2.274 | BDL | 1.379 | BDL | 9.056 | 1.811 |
| Naphthalene | Nap | 0.273 | 1.447 | NS | NS | 0.932 | 0.784 | 2.341 | 2.157 | 1.506 | 2.161 | 11.600 | 1.449 |
| Phananthrene | Phe | BDL | 0.855 | NS | NS | 1.228 | 2.584 | 1.106 | 2.015 | 1.673 | 1.800 | 11.262 | 1.608 |
| Pyrene | Py | 0.904 | BDL | NS | NS | 1.077 | 2.664 | 2.400 | 2.324 | 0.185 | BDL | 9.552 | 1.592 |



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The concentrations of individual PAHs from the various locations were also high ranging between 0.943Mg/kg and 2.347Mg/kg. The biota (Shrimp) was not seen in some locations (ie locations 3 and 4), those locations around the Petrochemicals company probably due to the high concentration of the pollutant in these locations. It was noticed that the concentrations of PAHs were also below detection limit (BDL) at some locations as shown in Table 1.

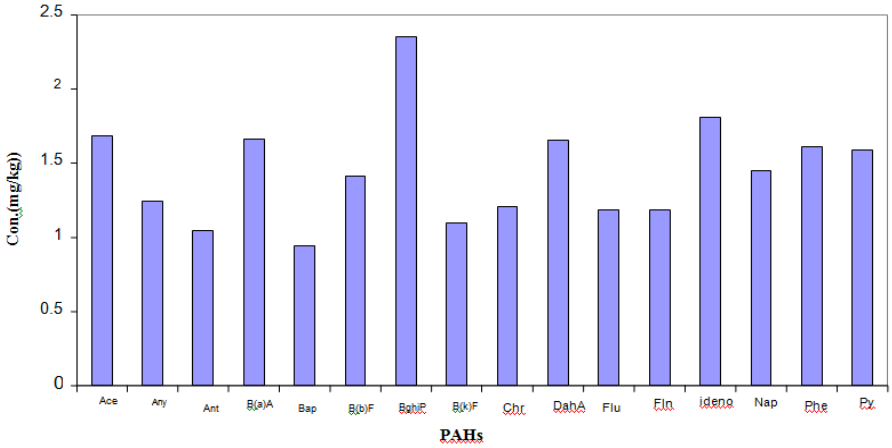


Figure 1. Bar chart showing the concentrations of polycyclic aromatic hydrocarbons in shrimp

In the whole, a total of 16 EPA priority listed PAHs were quantified in shrimp as shown in Table 1. The lowest total individual concentration of 6.255mg/kg (mean of 1.042mg/kg) was obtained for anthracene. The lowest concentration of anthracene of 0.400mg/kg was obtained at location 6 (QRTS) and the highest concentration of 2.215mg/kg was obtained at location 8 (ABM). The highest total individual concentration of 13.876mg/kg was obtained for acenaphthene. The lowest concentration of acenaphthene of 1.013mg/kg was obtained at location 1 (AGA I) and the highest concentration of 2.667mg/kg was obtained at location 6 (QTRS). No Shrimp samples were found at locations 3 and 4. This may be attributed to high levels of PAHs around these locations which may have probably made it difficult for them to survive. After acenaphthene the highest individual concentration of polycyclic aromatic hydrocarbons was benzo (a) anthracene (13.310mg/kg) with mean concentration of 1.604mg/kg, dibenzo(a,h) anthracene (11.604mg/kg) with mean of 1.657mg/kg, naphthalene (11.600mg/Kg) with mean concentration of 1.449mg/kg, phenanthrene (11.262mg/kg) with mean concentration of 1.608mg/kg, acenaphthylene (9.938mg/kg) with mean concentration of 1.242mg/kg, pyrene (9.552mg/kg) with mean concentration of 1.1592mg/kg, ideno (1,2,3,-d) pyrene (9.056mg/kg) with mean concentration of 1.811mg/kg, chrysene (8.438mg/kg) with mean concentration of 1.205mg/kg, fluorine (8.302mg/kg) with mean concentration of 1.186mg/kg, benzo (g,h,i) perylene (8.216mg/kg) with mean concentration of 1.369mg/kg, benzo(k) fluoranthene (7.675mg/kg) with mean of concentration of 1.096mg/kg, benzo (a) pyrene (7.548mg/kg) with mean concentration of 0.943mg/kg, benzo (b) fluoranthene(7.070mg/kg) with mean concentration of 1.413mg/kg and fluoranthene (6.687mg/kg) with mean concentration of 1.186mg/kg. The distribution of polycyclic aromatic hydrocarbons (PAHs) in shrimp with location is shown in Figure 1. Opuene (2004) while investigating the levels of PAHs in biota (Bagrusbayad) from Taylor creek, Baylesa State found that the mean levels of PAHs ranged from 173µg/kg to 1457.9µg/kg which are similar to the results from this study. Adie (2010) in a study to investigate the levels of persistent organic pollutants in biota from Calabar River found that the TPAHs in biota varied from a minimum concentration of 16,382.8ng/g to a maximum of 96,331.3ng/g. These levels were low compared to those obtained from this study. However, the results from this

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study were still high. It has been noted that the bioaccumulation factors of 16PAHs in polychaete species varied from 4.9 to 21.8ng on a dry-weight basis. It has been discovered from this study that the concentrations of PAHs in surface water were lower than those in biota.

## CONCLUSION

The bioaccumulation of PAHs and other pollutants by *Penaeusmonodon* (shrimp) has been of great interest to researchers because of the dangers inherent in consuming such organism. *Penaeusmonodon* has been shown to accumulate PAHs to a great extent from the results of the investigation. The bioaccumulation factor of this organism ranged between 78.6 and 93.8 and the concentrations of individual PAHs obtained also surpassed the background limits of national and international standards. PAHs are known to be toxic and with the levels recorded in this study, it is advisable to curtail the consumption of this organism from the River and Creeks pending when a remediation programme is carried out on this environment.



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