



Research Article

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Assessment of Polycyclic Aromatic Hydrocarbon Levels in Sediment Samples from Gubi Dam, Bauchi State, Nigeria

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Abstract This study is aimed at determining the levels of sixteen (16) polycyclic aromatic hydrocarbons (PAHS) in sediment samples from Gubi Dam, Bauchi State, Nigeria. Sediment samples were collected at four different sampling points designated S1 to S4. Extraction and clean-up of sediment samples were carried out using GC-MS. The Dam under study was classified as low priority site in terms of pollution control, because the mean effect range medium quotient values in sediment samples were below 0.1, indicating 11% probability of toxicity. Result from diagnostic ratios, showed that pyrogenic sources were found to be responsible for PAHs release to the Gubi Dam sediment because the ratios of BaA/BaA+Chr greater than 0.2, Ant/Ant+Phe greater than 0.1, Fluo/Fluo+Pyr greater than 0.4 and LMW/ HMW less than 1 as proposed by USEPA, 2004. Furthermore, the major environmental concern and the ability of the developing cancer related illness from Gubi Dam is low and not relatively serious. Hence, the relevant agencies should be involved in the management of Gubi Dam with respect to PAHs contamination.

Keywords Polycyclic Aromatic Hydrocarbon, Sediment, Samples, Gubi Dam

1. Introduction

Polycyclic Aromatic Hydrocarbons (PAHs) are part of the list of the 12 Persistent Organic Pollutants (POPs) and benzo(a)pyrene (BaP) is the most toxic of the PAHs. The objective of this convention is to control, reduce or eliminate discharges, emission and losses of POPs into the environment [1]. Owing to the different physicochemical properties of organic contaminants, PAHs tend to interact to different extent with water, soil/sediments and biota. Sediment-pore water interaction is one of the most dominant process controlling the distribution and behavior of PAHs in the river [2]. Dynamics of a river or dam ecosystems are complex with some pollutants adsorbed onto organic matter, while some undergo microbial degradation. Since POPs are capable of undergoing bioconcentration and biomagnifications, comprehensive risk assessment can only be performed by monitoring the presence and levels of these compounds in common freshwater fish. The levels and presence of pollutants in fish therefore have a direct bearing on human health risk. The concentration of pollutants in fish also presents the bioavailable fraction of the pollutants in water bodies. Measurements of the levels of PAHs in water, fish and sediments give almost a complete



picture of the distribution of the chemical in the aquatic ecosystem. However, chemical analysis of PAHs in fish is more complex than in water and sediments.

Environmental pollution caused by oil spills or runoff from landfills that contain transformers, dielectric and coolant fluids in electrical apparatus, carbonless copy paper and in heat transfer fluids are major ecological problems. These contaminants in the environment are primarily evaluated by measuring the chemical concentration of PAHs. The results of chemical analyses are important for estimating water and sediment quality in the risk assessment to the flora and fauna of any contaminated sites. In the world, there are lake ecosystems under permanent chemical stress due to urbanization and the oil industry. PAHs are important environmental pollutants originating from a wide variety of natural and anthropogenic sources. PAHs are generally formed during incomplete combustion of organic matter containing carbon and hydrogen [3]. PAHs constitute a large class of organic compounds containing two or more fused aromatic rings. Hundreds of individual PAHs may be formed during incomplete combustion or pyrolysis of organic matter [4]. These compounds occur as contaminants in different kinds of foodstuffs including dairy products, vegetables, fruits, oils, cereals, and smoked meats [5, 6, 7]. The sources of PAH in food are mainly environmental pollution and food processing (drying, smoking) and cooking (roasting, grilling, and frying) [8]. A number of PAHs have been found to have carcinogenic and mutagenic effects while some of them may act as synergists [9]. One of the major routes of human exposure to PAHs in non-smoking people is food. These compounds can reach the food chain by different ways as PAHs have been found in different food products, such as dairy products, vegetables, fruits, oils, coffee, tea, cereals and smoked meat, therefore the analysis of PAHs in food is a matter of concern [10].

Food items and products could be contaminated by soils, polluted air and water [11]. Some aquatic food products, such as fish, can be exposed to PAHs present in water and sediments and the PAH content greatly depends on the ability of the aquatic organisms to metabolize them [12]. On the other hand, PAHs are also found in foods as a result of certain industrial food processing methods such as smoke curing, broiling, roasting, and grilling over open fires or charcoal which permits the direct contact between food and combustion products [12]. PAHs have solubility in water but are readily soluble in organic solvent or organic acids. Thus environments, PAHs are generally found adsorbed on particulates and on humic matter, or dissolved in any oily contamination that may be present in water, sediment soil. The solubility of PAHs in water is inversely proportional to the number of rings the PAHs molecule contains [13].

A comprehensive study was carried out by Johnson *et al.* (2002) [14] to determine the Effects of Polycyclic Aromatic Hydrocarbons in Fish from Puget Sound, Washington. This study reveals the various effects of PAH on the environment and the living things that depend on Puget Sound (an semi-enclosed part of the Pacific Ocean near the coast west of Seattle). Sediment mass balance studies for Puget Sound show that the Sound is an efficient sediment trap [15]. Puget Sound receives sediment particles from the river systems that drain the Cascade Mountains, and, to a lesser extent, from shoreline erosion. Much of the sediment accumulates as fine-grained sediment in the central Basin [16]. About 30% of Puget Sound is depositional, and sedimentation rates are estimated to be in range of 0.05 to 1.2 g/cm² per year. The prevalence of fine-grained, depositional sediments in Puget Sound acts to encourage the accumulation and retention of sediment-sorbed organic contaminants such as PAHs [17].

Aliphatic, aromatic, sulfur, and nitrogen-containing hydrocarbons have all been identified in sediments of Puget Sound. The majority of PAHs associated with sediments in Puget Sound as well as at other coastal urban sites originate from petroleum and combustion products [17, 18]. The geographic distribution of combustion PAHs in Puget Sound suggests that major sources are municipalities and industries that generate large quantities of PAHs, such as aluminum smelting, creosote, and oil refining. Atmospheric emissions from incineration and automobile emissions are other major sources of PAHs. PAHs are also introduced into marine systems through accidental spills of fuel oil, crude oil, and other petroleum products. The suite of PAHs detected in aquatic systems can generally be divided into two broad classes: the lower molecular weight compounds with one to three fused benzene rings (LAHs), which are mainly petrogenic or oil derived, and the higher molecular weight compounds with four to six rings (HAHs), which are mainly pyrogenic or combustion derived [18]. Both classes tend to adsorb to organic or inorganic matter and become immobilized in sediments; however, relative to the LAHs, the HAHs are more



hydrophobic and tend to remain more tightly sorbed to sediment, so they are more likely to be trapped in sediments and accumulate in depositional areas of the Sound. Studies of Puget Sound sediment cores [17, 18] show that at most sites, maximum PAH concentrations (e.g., ~8 to 12 mg/kg dry wt.) occurred between 1945 and 1960, probably as a result of domestic coal burning, which increased until about 1950 [15]. Levels reported in sediment cores by Mac-Donald and Crecelius (1994) [15] were about 4 to 5 mg/kg dry weight; however, this trend is countered by increasing fossil fuel use as a result of the increasing population, as well as increasing urbanization with its associated increased PAH-laden street and storm water runoff.

Consequently, PAH levels in sediment at a number of Puget Sound sites remain well above background concentrations. Recent surveys (Long *et al.*, 2003) report sediment PAH levels above Washington State sediment quality standard at a number of sites in Puget Sound. The majority of these sites were located in urban embayments, including Bellingham Bay, Sinclair Inlet, Everett Harbor, Elliott Bay, and Commencement Bay. At some sites in Puget Sound, sediment PAH levels appear to be increasing. A recent study by Washington State Department of Ecology comparing surface sediment collected in 2000 to results from 1989 through 1996 at 10 long-term Puget Sound sites showed that PAH levels were significantly higher in samples collected in 2000 than they were historically at 5 of the 10 sampling stations. Total HAH levels were, on the average, 1.5 times higher than they were historically, while total LAH levels were 2.5 times higher [19, 20].

The proportion of the total contaminant concentration that is available for uptake by organisms defines the bioavailable fraction. For neutral hydrophobic organic compounds such as PAHs, organic carbon is the main variable controlling bioavailability. Hydrophobicity, or the tendency to be water insoluble, is the primary determinant for partitioning behavior between water, sediment, and tissue. As the hydrophobicity of PAHs increases, the ratio of water to sediment concentrations of a PAH will decline due to the tendency of the compound to avoid water and seek a nonpolar environment. The affinity for tissue also increases with hydrophobicity because of lipid in the organism. The octanol–water partition coefficient (K_{ow}) is one physical parameter that can be used to predict the partitioning behavior exhibited by PAHs in the environment [21].

Sediments are the final environmental sink for PAHs Vandermeulen (1989) [22] where they persist and transform very slowly. Biodegradation half-lives of sediment-bound PAHs range from 0.3 to 129 days for naphthalene and from 0.3 to 58 years for B[a]P [23]. Polycyclic aromatic hydrocarbons in sediments are relatively stationary. Near Seattle, Washington, 63% of particle-bound PAHs were found at the bottom of Puget Sound less than 100 metres away from their point of entry [24]. Nonetheless, sediments may be partially resuspended and are then subject to transport processes [25, 26]. PAHs are removed from soils principally by volatilization and microbial activity, the extent of which varies, depending on several factors such as temperature, soil type, presence of other contaminants, and previous contamination [27]. Low molecular weight PAHs volatilize more rapidly than high molecular weight PAHs [28]. Biodegradation half-lives in soil have been estimated for various PAHs, including anthracene 170 days by Herbes and Schwall (1978) [23] to 8 years by Wild *et al.* (1991) [27]; phenanthrene from 2.5 to 210 days by Sims and Overcash (1983) [29] to 5.7 years by Wild *et al.* (1991) [27]; and B[a]P 8.2 years by Wild *et al.* (1991) [27] and 0.3 to 58 years by Herbes and Schwall (1978) [23]. In farming operations in which refinery wastes and sewage sludge are applied to the soil, low molecular weight PAHs (two and three rings) are expected to volatilize or biodegrade within three to four month; higher molecular weight PAHs (more than three rings) can be substantially biodegraded in a four-month period, but repeated applications of oily sludges containing PAHs may result in accumulation of these compounds in soil [30].

Gubi Dam is located 12km northeast of Bauchi City, in the Northeastern part of Nigeria. The source of water in Gubi Dam comes mainly from three tributaries, namely Gubi River, Tagway river links with Shadawanka and Ran River. A Temporary Dam close to the site was constructed across one of the streams to provide water needed for the construction of the permanent Dam. The embankment of the Dam which has length of 3.86km and bottom earth-fill of 2,315, 000m³ with a reservoir area of 590 hectares. The catchments area is 17,900 hectares with total storage capacity of 38.4 x 106m³, the expected yield from the reservoir is 90,000m³/d (BSWB, 1981). Initially, the main function of the Gubi Dam was to supply the Bauchi State Capital and its environs with potable water; however,



provision was made for agricultural activities to take place around the Dam. Over time, as the quantity of fish increased in the Dam, fishermen moved from other fishing areas around Bauchi to Gubi Dam [31].

Gubi Dam is greatly affected by the commercial, environment and industrial activities that take place within and around the city. The city is also a hub for long-haul and passenger vehicles that convey cargo and people to the northeast region of Nigeria. This population growth comes with a proportionate increase in wastes, oil-related spills, and increase in use of electricity and electrical components that are normal for a fast growing modern city. The pollutants, untreated sewage, industrial and domestic landfill waste and by-products of slash and burn activities from the city end up in Gubi Dam. Thus, the contamination of fish and the aquatic environment by pollutants such as PAHs is viewed with serious concern.

The objectives of the study are to determine the level of polycyclic aromatic hydrocarbons (PAHs) which include Naphthalene, 2-Methylnaphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenz(a,h)anthracene, Benzo(g,h,i)perylene, and indinol (1,2,3-cd)pyrene in sediment samples from Gubi Dam, Bauchi State, Nigeria and conduct risk assessment of PAHs in the water, sediment and fish samples.

2. Materials and Methods

Collection of Sediment Samples

Sediment samples were collected from four (4) sampling point designated S₁- S₄. Point S₁ was the point of flow of water into Gubi Dam. Point S₂ to S₄ was 0.5km away from each other, making a total of 3.5 km for the study. The sediment samples were collected using plastic hand trowel by scooping 0-5 cm of the top layer of the sediment and placed in an amber glass bottle and stored in an ice-block cooler as described by Boyd and Tucker (1992). The samples were transported to the Department of Chemistry laboratory, University of Maiduguri and stored in a refrigerator pending extraction and analysis.

Extraction of PAHs in Sediment Samples

Analysis for PAH in sediment samples was carried out in accordance with USEPA (2000) 8270 analytical method. 10g of the sample was dried using anhydrous sodium sulphate and 1ml of 60 µg/mls o-Terphenyl surrogate standard added and mixed thoroughly with the sample. 30 mls of methylene chloride was added and the sample extracted. The sample extracted was subsequently filtered through glass wool containing anhydrous sodium sulphate in a glass funnel. 2 g of silica gel was added and allowed to stand for a while. The extract was then decanted and allowed to concentrate at room temperature to 1 ml volume.

Instrumental Analysis of PAHs Using GSMS for Sediment

The extract was thereafter analyzed using Agilent 7890A GC/MS previously calibrated with PAHs standards. The equipment turned out the concentration of the PAHs as the sample details was supplied for sediment and fish samples.

3. Results and Discussion

Mean Concentrations of Some Polycyclic Aromatic Hydrocarbon (PAHs) in Sediment Samples

Table 1: Mean Concentrations of Some Polycyclic Aromatic Hydrocarbon (PAHs) in Sediment Samples from Gubi Dam, Bauchi State, Nigeria

PAHs	No. of Rings	MACs	Concentrations (mg/kg)			
			S1	S2	S3	S4
Naphthalene	2	1	1.38E-04	9.13E-04	1.81E-04	1.48E-04
2-methylnaphthalene	2	1	5.57E-04	4.54E-05	5.70E-04	2.34E-05
Acenaphthylene	3	3	8.50E-05	6.32E-06	4.39E-05	4.34E-03
Acenaphthene	3	3	6.34E-05	2.17E-04	1.39E-03	2.34E-04
Fluorene	3	3	6.94E-04	2.43E-04	1.63E-04	1.43E-05
Phenanthrene	3	3	8.22E-05	1.09E-03	1.31E-03	3.41E-04



Anthracene	3	3	2.28E-04	2.07E-04	8.31E-04	5.32E-05
Fluoranthene	4	3	1.35E-02	4.93E-03	4.18E-03	2.54E-04
Pyrene	4	3	9.50E-03	8.71E-03	3.03E-03	1.47E-04
Benzo(a)anthracene	4	0.15	3.86E-02	9.50E-04	3.64E-04	1.28E-03
Chrysene	4	-	8.68E-06	8.46E-05	2.32E-04	1.04E-04
Benzo(b)fluoranthene	5	0.3	3.19E-03	1.29E-03	4.04E-03	7.99E-04
Benzo(k)fluoranthene	5	-	3.13E-04	3.17E-04	4.04E-04	1.62E-04
Benzo(a)pyrene	5	0.3	3.38E-04	3.54E-04	8.60E-04	5.65E-04
Dibenz(a,h)anthracene	5	0.3	2.35E-03	1.06E-03	9.07E-04	1.12E-03
Indinol(1,2,3-cd)pyrene	6	-	7.85E-04	1.21E-03	4.44E-03	3.14E-03
Total			7.05E-02	2.16E-02	2.29E-02	1.27E-02

MACs= Maximum Allowable Concentrations (ATSDR, 2006)

Table 1 show the mean concentrations of some polycyclic aromatic hydrocarbon in sediment samples for point S₁-S₄ from Gubi Dam, Bauchi State, Nigeria. The concentration of naphthalene ranged from 1.38E-04 to 9.13E-04 mg/kg; 2.34E-05 to 5.70E-04 mg/kg 2-methylnaphthalene; 6.32E-06 to 4.34E03 mg/kg acenaphthylene; 6.43E-05 to 1.39E-03 mg/kg acenaphthene; 1.43E-05 to 6.94E-04 mg/kg fluorene; 8.22E-05 to 1.31E-03 mg/kg phenanthrene; 5.32E-05 to 8.31E-04 mg/kg anthracene; 2.54E-04 to 1.35E-02 mg/kg fluoranthene; 1.47E-04 to 9.55E-03 mg/kg pyrene; 3.64E-04 to 3.86E-02 mg/kg benzo(a)anthracene; 8.68E-06 to 2.32E-04 mg/kg chrysene; 7.99E-04 to 4.04E-03 mg/kg benzo(b)fluoranthene; 1.62E-04 to 4.04E-04 mg/kg benzo(k)fluoranthene; 3.54E-04 to 8.60E-04 mg/kg benz(a)pyrene; 9.09E-04 to 2.35E-03 mg/kg dibenzo(a,h)anthracene and 7.85E-04 to 4.44E-03 mg/kg indinol(1,2,3-cd)pyrene. The highest total concentration of 2.29E-02 mg/kg was observed at point S₃, while the lowest total concentration of 2.44E-05 mg/kg was recorded at sampling point S₁.

The levels recorded in the present study are similar to the levels detected in the sediment of Jakarta Bay, Indonesia [32] Jiulong River Estuary and Western Xiamen Sea, China [33] and Tokyo Bay, Japan. The most dominant PAH compounds found in the sediment samples include fluoranthene (2.29E-02 mg/kg); pyrene (2.14E-02 mg/kg) and benzo(a)anthracene (4.12E-02 mg/kg) belonging to four-ring PAHs family, with a content percentage of 31% of the total PAHs in all sampling points. The levels of PAHs in the sediment samples were observed to be lower than maximum allowable concentrations as proposed by ATSDR (2006), naphthalene was present across all the sampling points [34]. This finding corresponds with the findings of Tam *et al.* (2001) [35], who found a high level of naphthalene in the sediment of mangrove swamps in Hong Kong. Moreover, the abundance of chrysene is due to their very low solubility in water and high resistance to degradation. Wang *et al.* (1995) [36] arrived at the same conclusion when the level of chrysene in the sediment was not degraded even 12 years after discharged. This compound also has the highest mean concentration for individual PAH (9.32E-03 mg/kg), which is lower than the value indicated in the SQGs-ERL (85 ng g⁻¹). The most probable source of BbF is the burning of fossil fuels (e.g., gasoline and diesel engine) and vehicle engines. A study by Omar *et al.* (2007) [37] also supported the emission of BgP from engines which is similar to the study area. The study mentioned that the highest abundance of BgP was recorded in the urban aerosols of Kuala Lumpur, Malaysia. The source of these aerosols was the incomplete fuel combustion. Benzo[a]pyrene (BaP) is considered as the most hazardous of the seven carcinogenic PAHs [38]. An effective marker of pollution by PAHs was detected in all sediment samples from the jetties and fish farms, where the concentrations ranged from 18 to 55 ng g⁻¹ (mean of 36.4 ng g⁻¹), which are lower than the ERL and ERM SQGs of 430 ng g⁻¹ and 1600 ng g⁻¹, respectively. Result of (BaP) from the above study were higher than the results from the present findings.

The composition pattern of PAHs by ring size in the sediment samples around Gubi Dam is as shown in Table 1. On average, the high molecular weight PAHs with four rings (Flu, Pyr, BaA, and Chr) with a total load of 1.08E-03 mg/kg, five rings (BbF, BkF, BaP, and DBA) with a total load of 2.06E-03 mg/kg, and six rings (InP) with a total load of 3.14E-03 mg/kg account for 31%, 20%, and 16% of the total PAH concentrations, respectively. However, the lower molecular weight PAHs with two rings (2MNap, and Nap) with a total load of 3.06E-03 mg/kg and three rings (Acy, Ace, Fl, Phe Ant) with a total load of 1.02E-02 mg/kg comprised 10% and 13% of the total PAH



concentrations in the sediment, respectively. Sediment samples from Gubi Dam were dominated by HMW-PAH (4 to 6 rings) (Table 1). The results further indicate that the high content of HMW fractions may be due to lower water solubility, less volatility, and higher persistence of the HMW compared with the LMW in an aquatic environment [39]. The major source of HMW-PAHs in this area is also probably anthropogenic activities this findings are in line with the finding of Dickhut *et al.*, (2006) [40], such as the incomplete combustion of organic materials and vehicle engines as well as the unscrupulous disposal of engine oil from trucks [41]. However, the presence of LMW-PAHs in Gubi dam suggests relatively recent local PAH discharged from other sources that entered the surface water which is in agreement with the study conducted by Law *et al.* (1997) [42].

Diagnostic Ratio of Some Polycyclic Aromatic Hydrocarbon (PAHs) in Sediment Samples from Different Sampling Points

Table 2: Diagnostic Ratio of Polycyclic Aromatic Hydrocarbons (PAHs) in Sediment Samples from Gubi Dam, Bauchi State, Nigeria

Sediment	BaA/BaA+Chr	Ant/Ant+Phe	Fluo/Fluo+Pry	LMW/HMW
S1	9.97E-01	7.35E-01	2.34E-04	6.00E-02
S2	9.22E-01	1.60E-01	1.26E-01	1.40E-01
S3	6.10E-01	8.81E-01	2.43E-01	2.20E-01
S4	9.25E-01	1.35E-01	6.81E-01	6.80E-01
MR	3.45E+00	1.91E+00	1.05E+00	1.10E+00

BaA = Benzo(a)anthracene, Chr = Chrysene, Ant = Anthracene, Phe = Phenanthrene, Fluo = Fluoranthene, Pry = Pyrene

The diagnostic ratio of some polycyclic aromatic hydrocarbon in sediment samples for points S₁ to S₄ from Gubi Dam, Bauchi State, Nigeria are presented in Table 2. The ratio of BaA/ BaA+Chr ranged from 6.10E-01 to 9.97E-01; 1.35E-01 to 8.81E-01 for Ant/Ant+Phe; 2.34E-04 to 6.81E-01 for Fluo/Fluo+Pry and 6.00E+00 to 6.80E+00 for LMW/HMW. The highest mean ratio of 3.45E+00 was for Fluo/Fluo+Pry, while the lowest mean ratio of 1.00E+00 was observed for LMW/HMW.

Diagnostic ratios is used to explain the details regarding the sources of PAHs in sediment samples [43, 44, 45]. Diagnostic ratios are used to distinguish the sources, (petrogenic and pyrogenic), of PAH in different environment media depending on their physical and mical properties and stability against photolysis (Yunker *et al.*, 2002). Several PAH diagnostic ratios have been selected as indicators that have the most potential to distinguish between petrogenic and pyrogenic sources and are the most consistently quantifiable compounds in the majority of these samples. This includes the ratios of BaA/BaA+Chr, Ant/Ant+Phe, Fluo/Fluo+Pry and LMW-PAH to HMW-PAH [46, 47, 48]. Table 2 shows the diagnostic ratios of several PAH compounds and their possible sources. The ratio of Ant/Ant+Phe of >0.1 indicates a dominance of heavy fuel combustion, whereas a ratio of <0.1 suggests petroleum sources [48]. In this study, the values of the Ant/Ant+Phe ratio were between 0.13 and 0.88, which suggests that the PAHs are from a combustion source. A possible contribution source of PAH in the study Dam might be from combustion of trucks and vehicle engines within Bauchi Metropolis which ends up in the Dam through waste discharged and rainwater run up. Results from the present study is inline with that of Lim *et al.* (2007) [49]. In addition, a BaA/BaA+Chr ratio of <0.2 usually implies a petrogenic origin, 0.2 to 0.35 indicates a mixed petrogenic and pyrogenic origin, and >0.35 indicates pyrogenic origin Yunker *et al.* (2002) [45]. Result from the present study ranged from 8.68E-06 to 3.86E-02 mg/kg (Table 2) which indicate a strong pyrogenic origin. The LMW/HMW ratio was relatively low, ≤1, suggesting a pyrogenic origin of PAHs within the Dam 0.31–1.53. However, these ratios generally suggest that PAHs can be largely attributed to the fuel combustion of petrogenic origin. Distinguishing the sources of PAH depends on the chosen diagnostic ratios, which can reveal pyrogenic material inputs. Moreover, the decrease in HMW-PAHs compared to the LMW-PAHs in the dam also reflect a lesser contribution by petrogenic sources. Similar results were reported in sediments from Komadugu river basin by Akan *et al.* (2017) [50].

Ecological Risk Assessment of Some Polycyclic Aromatic Hydrocarbon in Sediment Samples



Table 3: Ecological Risk Assessment of Some Polycyclic Aromatic Hydrocarbon (PAHs) in Sediment Samples from Gubi Dam, Bauchi State, Nigeria

PAHs	ERM SSG	S1	S2	S3	S4
Naphthalene	2100	6.57E-08	4.35E-07	8.62E-08	7.05E-08
2-methylnaphthalene	670	8.31E-07	6.78E-09	8.51E-07	3.49E-08
Acenaphthylene	640	1.34E-07	9.86E-09	6.86E-08	6.78E-06
Acenaphthene	500	1.27E-07	4.34E-07	2.78E-06	4.68E-07
Fluorene	540	1.29E-06	4.50E-07	3.02E-07	2.65E-08
Phenanthrene	1500	5.48E-08	7.27E-07	8.73E-07	2.27E-08
Anthracene	1100	2.07E-09	1.88E-09	7.5E-09	4.84E-08
Fluoranthene	5100	2.65E-06	9.67E-07	8.10E-07	4.99E-08
Pyrene	2600	3.67E-06	3.35E-06	1.17E-06	5.65E-08
Benzo(a)anthracene	1600	2.41E-05	5.94E-07	2.28E-07	8.00E-07
Chrysene	2800	3.10E-09	3.02E-08	8.29E-08	3.71E-08
Benzo(b)fluoranthene	-	3.19E-03	1.29E-03	4.04E-03	7.99E-04
Benzo(k)fluoranthene	-	3.13E-04	3.17E-04	4.04E-04	1.62E-04
Benzo(a)pyrene	1600	5.24E-07	2.21E-07	5.38E-07	3.53E-07
Dibenz(a,h)anthracene	260	9.04E-06	4.08E-06	9.07E-04	4.31E-06
Indinol(1,2,3-cd)pyrene	950	8.26E-07	1.27E-06	4.67E-06	3.31E-06
M-ERM-Q		3.5E-03	1.62E-03	5.36E-03	9.77E-04

Table 3 presents the ecological risk assessment of some polycyclic aromatic hydrocarbon in sediment samples from Gubi Dam, Bauchi State, Nigeria. The Ecological risk assessment of naphthalene ranged from 6.57E-08 to 4.35E-07 mg/kg; 8.31E-07 to 8.51E-07 mg/kg 2-methylnaphthalene; 9.86E-09 to 6.78E-06 mg/kg acenaphthylene, 1.27E-07 to 2.78E-06 mg/kg acenaphthene; 2.65E-06 to 1.29E-06 mg/kg fluorene, 2.27E-08 to 8.73E-07 mg/kg phenanthrene; 1.88E-09 to 4.84E-08 mg/kg anthracene; 4.99E-08 to 2.65E-06 mg/kg fluoranthene; 5.65E-08 to 3.67E-06 mg/kg pyrene, 2.28E-07 to 2.41E-05 mg/kg benzo(a)anthracene; 3.01E-09 to 8.29E-08 mg/kg chrysene; 7.99E-04 to 4.04E-03 mg/kg benzo(b)fluoranthene; 1.62E-04 to 4.04E-03 mg/kg benz(k)fluoranthene; 2.21E-07 to 5.38E-07 mg/kg benzo(a)pyrene; 4.08E-06 to 9.07E-04 mg/kg dibenz(a,h)anthracene and 8.26E-07 to 4.67E-06 mg/kg indinol(1,2,3-cd)pyrene. The highest total mean effect range medium quotient (MERMQ) of 6.44E-06 mg/kg was observed at sampling point S₂, while the lowest total MERMQ of 1.17E-07 mg/kg was recorded at sampling point S₃. Calculated Benzo(a)pyrene Equivalent Concentrations of Some Polycyclic Aromatic Hydrocarbon in Sediment Samples

Table 4: Calculated Benzo(A)pyrene Equivalent Concentrations of Polycyclic Aromatic Hydrocarbon (PAHs) in Sediment Samples from Gubi Dam.

PAHs	IJSFPATFF	S1	S2	S3	S4
Naphthalene	0.001	1.38E-07	9.13E-07	1.83E-07	1.48E-07
2-methyl Naphthalene	0.001	5.57E-07	4.54E-08	5.70E-07	2.34E-08
Acenaphthylene	0.001	8.50E-08	6.32E+09	4.39E-08	4.34E-06
Acenaphthene	0.001	6.34E-08	2.17E-07	1.39E-06	2.34E-07
Fluorene	0.001	6.94E-07	2.43E-07	1.63E-07	1.43E-08
Phenanthrene	0.001	8.22E-08	1.09E-06	1.31E-06	3.41E-07
Anthracene	0.01	2.28E-06	2.07E-06	8.31E-06	5.321E-07
Fluoranthene	0.001	1.35E-05	4.93E-06	4.18E-06	2.54E-07
Pyrene	0.001	9.50E-06	8.71E-06	3.03E-06	1.47E-07
Benzo(a)anthracene	0.1	3.86E-03	9.50E-05	3.64E-05	1.2813E-04
Chrysene	0.001	8.68E-09	8.46E-08	2.32E-07	1.04E-07
Benzo(b)fluoranthene	0.1	3.19E-04	1.29E-03	4.04E-04	7.9912E-05
Benzo(k)fluoranthene	0.1	3.13E-05	3.17E-05	4.00E-05	1.62E-05
Benzo(a)pyrene	1	8.38E-04	3.54E-04	8.60E-04	5.65E-04
Dibenz(a,h)anthracene	1	2.35E-04	1.06E-03	9.07E-04	1.12E-03
Indinol(1,2,3-cd)pyrene	0.01	7.85E-06	1.21E-05	4.44E-05	3.14E-05
£BaPTEQ		5.32E-	6.32E+09	2.31E-03	1.95E-03

USEPA TEF = United State Environmental Protection Agency, Toxic Equivalent Factor, BaPTEQ = Benzo(a)Pyrene Toxic Equivalent and S1=First Sampling Point, S2= Second Sampling Point, S3= Third Sampling Point and S4= Fourth Sampling Point



Table 4 presents the Calculated BaP equivalent concentration of some polycyclic aromatic hydrocarbon in sediment samples from different sampling points S_1 to S_4 in Gubi Dam, Bauchi State. The concentration of naphthalene ranged from $1.38E-07$ to $9.13E-07$ mg/kg; $2.34E-08$ to $5.57E-07$ mg/kg 2-methylnaphthylene; $6.32E-09$ to $4.34E-06$ mg/kg acenaphthylene; $6.34E-08$ to $1.39E-06$ mg/kg acenaphthene; $1.43E-08$ to $6.94E-07$ mg/kg fluorene; $8.22E-08$ to $1.31E-06$ mg/kg anthracene; $5.32E-07$ to $8.31E-06$ mg/kg fluoranthene; $2.54E-07$ to $1.35E-05$ mg/kg benzo(a)pyrene; $3.03E-06$ to $9.55E-06$ mg/kg pyrene; $3.65E-05$ to $3.86E-03$ mg/kg benzo(a)anthracene; $0.08E-09$ to $2.32E-07$ mg/kg chrysene; $7.99E-05$ to $1.29E-03$ mg/kg benzo(b)fluoranthene; $1.62E-05$ to $4.00E-05$ mg/kg benzo(k)pyrene; $2.35E-04$ to $1.12E-03$ mg/kg dibenz(a,h)anthracene and $7.85E-06$ to $4.44E-5$ mg/kg indinol(1,2,3-cd)pyrene. The highest (BaP) equivalent concentration of $5.32E-03$ mg/kg was observed at sampling point S_1 , while the lowest (BaP) equivalent of $6.32E-09$ mg/kg was observed at sampling point S_2 .

Carcinogenic risk assessment was performed using total toxic BaP equivalent of PAHs. Toxic equivalency factor and total carcinogenic toxic equivalency factors for all the sediment studied as presented in Tables 4.9. Total carcinogenic toxic equivalency factors ranged from $1.95E-03$ to $6.32E+09$ mg/kg-Bapeq dry weight. The results revealed that Flu, Pyr, B(a)A, and Chr were the most contributors to total carcinogenic potency of the sediment samples with values ranging from $3.88E-08$ to $3.88E-08$ mg/kg for Flu, $3.10E-08$ to $3.10E-08$ mg/kg for Pyr, $5.99E-07$ to $5.99E-07$ mg/kg for B(a)A, and $6.98E-06$ to $6.98E-06$ mg/kg for Chr. These PAHs are highly carcinogenic [51]. The high carcinogenic potency of PAHs is an indication of high degree of carcinogenic risk in the above areas when compared to the present studies. This study revealed that the sediment from Gubi Dam is partially polluted with some levels of PAHs, but are within the safe limit of 10^6 as proposed by USEPA (1999) [52].

4. Conclusion

Polycyclic Aromatic Hydrocarbon residues were analysed in the sediment samples from Gubi Dam, Bauchi State. The mean concentration of 16 polycyclic Aromatic Hydrocarbons in sediment samples was higher at point S_3 , while point S_1 shows the lowest concentration. Result from diagnostic ratio shows that the source of PAHs are from both pyrogenic and petrogenic. Based on the findings of this study, The Government should setup a committee for timely monitoring the levels of PAHs in the Dam.

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