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Levels and Seasonal Variations of Polychlorinated Biphenyls (PCBs) in Sediment of Alariver, Ondo State, Nigeria

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

To assess the level of polychlorinated biphenyl (PCB) contamination in Ala river, surface sediments were collected from ten locations along Ala River, Ondo state, Nigeria and analyzed for the presence of 209 PCB congeners using gas chromatography mass spectroscopy. ∑PCBs levels ranged from< 0.9 - < 3 g/kg dry weight. The levels of ∑PCBs were very low and there were no significant differences in values of ∑PCBs in the wet and dry seasons.

Keywords: Polychlorinated biphenyl; contamination; sediment; Ala River.

1. INTRODUCTION

Polychlorinated biphenyls (PCBs) are a class of organic compounds with 1–10 chlorine atoms attached to a biphenyl molecule [1]. Theoretically, there are 209 PCB isomers and congeners with one to ten chlorine atoms attached to the biphenyl molecule [2].

Polychlorinated biphenyls (PCBs) are industrial products that are mainly of anthropogenic origin and they constitute global environmental health hazard. They are very resistant to decomposition and have an excellent insulating property as well as high heat capacity [2]. Their properties have led to many industrial applications in electrical transformers and capacitors as heat transfer

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fluid, in consumer products [3,4]. Adversely, PCBs is a major environmental pollutant as identified by world health organization [2]. They are hydrophobic and, upon entry into the aquatic environment, they rapidly associate with suspended particulate matters and sediments [3].

PCBs have never been manufactured in Nigeria or in Africa as a whole. They are imported into Africa even into Nigeria, as industrial fluids such as hydraulic and heat transfer fluids in gas turbines; as lubricating oils; and as plasticizers. They can enter the surface river environment from a variety of sources including (i) direct deposition from the atmosphere, (ii) runoff from land, and (iii) directly from industrial and wastewater treatment plant discharges [3,5].

PCBs are of environmental concern because they resist degradation by physical, chemical, or biological pathways, they bioaccumulate through the food web [6], and pose a risk causing adverse effects on human health and the environment [7,8,9].

Studies on humans provide supporting evidence for potential carcinogenic and other health effects of PCBs (neurological, immune, endocrine and reproductive effects). The most serious cases of PCB effects on human health were the accidental leakages of PCBs containing industrial fluids into rice oils that resulted in the exposure of several thousand individuals' in two separate incidents, one in northern Kyushu Island in Japan in 1986 (Yusho) and the other in Tai Chung in central Taiwan in 1979 (Yu-Cheng).

Some recent research has been conducted in order to determine the concentrations of PCBs in soil, sediment, water, fish [2,3,1] (Toan, et al. 2007; Gevao, et al. 2005, Xia, et al. (2012)

2. MATERIALS AND METHODS

Ala River is a major river that transverse across Akure metropolis and serves various purposes ranging from domestic to industrial applications. This river has been the receiving reservoir of various organic waste materials emanating from anthropogenic activities. There are lots of activities around the river like farming, fishing and irrigation, wood treatment and ironworks, vehicles and building paintings. Although, little or no data is available concerning the PCBs contamination in the surface sediment of Ala river. The present study aims to fill this gap by assessing the level and distribution of PCBs in the surface of Ala river.

3. METHODOLOGY

3.1 Sample Collection and Preparation

3.1.1 Sampling

Twenty sediments samples were collected from Ala river in Akure Metropolis. Ten samples were collected during the month of April and another ten samples during the month of December 2014 (Fig. 1). Surface sediments (0-10 cm) were taken from ten different geo- referenced sites from the river bed using stainless steel grab sampler. The samples were allowed to drain before they were separated into labeled polythene bags and aluminum containers for PCBs analysis.

Table 1. Monitoring sites and their co – ordinates

Site No	Location	Latitude	Longitude	Site descriptions
1	Aule	07º16.45'N	005º09.99E	Mechanic workshops, petrol stations
2	Ayedun	07º15.82'N	005º11.48E	refuses
3	Araromi	07º15.67'N	005º11.67E	Car wash, saw mill,refuses
4	Oke-Ijebu (Cocola deport)	07º15.75'N	005º12.31E	Car wash, refuses
5	Oke- Ijebu (3- Ages Hotel)	07º16.44'N	005º12.44E	Refuses
6	Fiwasaye	07º15.33'N	005º13.23E	refuses
7	Alagbaka	07º15.43'N	005º12.67E	refuses
8	Odudu	07º19.16'N	005º14.31E	refuses
9	Kojola- Ilado	07º11.60'N	005º17.58E	Agriculture
10	Ehin- Ala	07º11.51'N		Agriculture

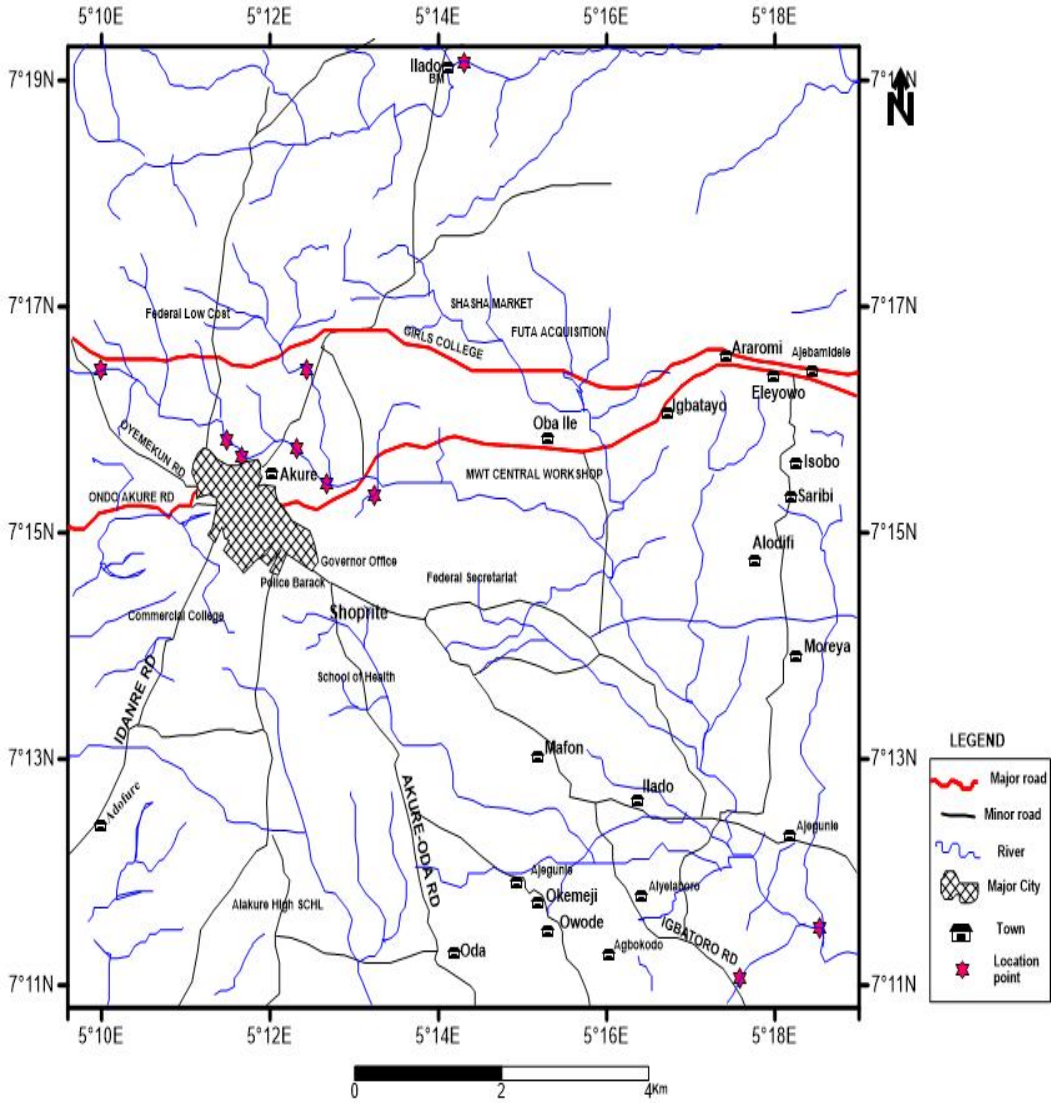

Fig. 1. Map showing the sampling locations
Source: Google map

3.2 Sample Preservation

The sediment samples were air-dried for two weeks in the laboratory. The air-dried sediments were sieved using a 2.0 mm sieve to remove the debris [11] and then lightly ground in an agate mortal for homogenization before PCBs analysis were carried out.

3.3 Determination of PCBs in Sediment Samples

The extraction of PCBs was carried out by solvent extraction [3]. 2 g of the air-dried sediment was homogenized with an anhydrous sodium sulphate. A mixture (30 cm^3) of hexane was added as extracting solvents in a conical flask. The conical flask was covered and placed in a sonicating machine for 1 h in two cycles. The extracts were filtered with Whatman No 42 filter paper and concentrated using rotary evaporator.

3.4 Clean up

The clean-up for PCBs was to remove impurities such as aliphatic hydrocarbons, biogenic materials and other contaminants that may serve as interference during analysis with GC-MS.

Table 2. PCB concentrations (µg g^{-1}dry weight) in the surface sediment of Ala river (wet season)

Locations	PCB 008	PCB 020	PCB 028	PCB 035	PCB 052	PCB 077	PCB 101	PCB 105	PCB 118	PCB 126	PCB 128	PCB 138	PCB 149	PCB 153	PCB 156	PCB 169	PCB 170	PCB 180	∑PCB
ADS1	<2	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<0.9	<1	<0.9- <2
ADS2	<2	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<0.9	<1	<0.9 - < 2
ADS3	<2	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<0.9	<1	< 0.9 - <2
ADS4	<2	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<0.9	<1	< 0.9 - <2
ADS5	<2	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<0.9	<1	<0.9- < 2
ADS6	<2	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<0.9	<1	< 0.9 - <2
ADS7	<3	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<0.9	<1	< 0.9- < 3
ADS8	<3	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<0.9	<1	< 0.9- < 3
ADS9	<3	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<0.9	<1	<0.9 - <3
ADS10	<3	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<0.9	<1	< 0.9- <3

ADS = April sediment sites

Table 3. PCB concentrations (µg g^{-1}dry weight) in the surface sediment of Ala river (dry season)

Locations	PCB 008	PCB 020	PCB 028	PCB 035	PCB 052	PCB 077	PCB 101	PCB 105	PCB 118	PCB 126	PCB 128	PCB 138	PCB 149	PCB 153	PCB 156	PCB 169	PCB 170	PCB 180	∑PCB
DDS1	<2	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<2	<1	<0.9- <2
DDS2	<3	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<2	<1	<0.9- < 3
DDS3	<2	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<2	<1	< 0.9- <2
DDS4	<2	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<2	<1	< 0.9- <2
DDS5	<2	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<2	<1	<0.9 - < 2
DDS6	<2	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<2	<1	< 0.9- <3
DDS7	<3	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<2	<1	< 0.9- < 2
DDS8	<3	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<2	<1	< 0.9- < 2
DDS9	<3	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<2	<1	<0.9 - <3
DDS10	<2	<2	<2	<2	<1	<2	<2	<1	<1	<1	<1	<1	<1	<1	<0.9	<0.9	<2	<1	< 0.9- <2

DDS = December sediment sites

Table 4. Comparison of PCB concentration (µg Kg⁻dw) in surface sediments from coastal area in the world (modified from Hong et al. [14])

Location	Year	∑PCB (µg Kg⁻dw)	Reference
Agbabu river (Nigeria)	2010	bdl	Fagbote and Olanipeku [15]
Costal river, Kuwait	2005	0.4− 84	Grevao et al. [3]
Baltic Sea (North Coast	1991	9−9.3	Fernandez et al. [16]
Vietnam (North coast)	1997	1.1−66.4	Nhan et al. [17]
Sri Lanka (West coast)	1996	0.45−4.4	Guruge and Tanabe [10]
Osaka Bay, Japan	1989	63−240	Iwata et al. [18]
Masam Bay, China	1997	0.27−75	Hong et al. [14]
Daya Bay, China	1999	2−110	Zhou et al. [19]
Xiamen Harbor	1994	0.05−7.24	Hong et al. [12]
Victoria Harbor, Hong Kong	1994	3.2−16	Hong et al. [12]
Pear River Estuary, China	1996	0.2−1.8	Hong et al. [13]
Ala river, Nigeria	2014	<0.9− <3	This study

The Silica Bond Elute cartridges were pre-conditioned with hexane before passing the extracts through it for clean-up. The extract was eluted with a mixture of hexane and DCM (1:1 v/v) after discarding the initial 20 cm^3 eluting off the column. Concentration was done under nitrogen to 2 cm^3 of extracts.

3.5 GC-MS Instrumentation and Conditions

An Agilent 7890A GC (Agilent Technologies, Santa Clara, CA, USA) equipped with an Injector (Agilent 7683A) having a 30 m, 0.25 mm i.d. HP-5MS capillary column coated with 5% phenyl-methylsiloxane (film thickness 0.25 µm). A mass selective detector (MSD), (Agilent 5975C) was used to separate and quantify the PCBs compounds. The samples were injected in the splitless mode at an injection temperature of 300°C. The transfer line and ion source temperatures were 280°C and 200°C respectively. The column temperature was initially held at 40°C for 1 min, raised to 120°C at the rate of 25°C/min, then to 160°C at the rate of 10°C/min, and finally to 300°C at the rate of 5°C/min, held at final temperature for 15 min. Detector temperature was kept at 280°C. Helium was used as a carrier gas at a constant flow rate of 1 mL/min. Identification and quantification was carried out against five calibration standards of known concentration.

A peak was positively identified if it was within ±0.05 min of the retention time in the calibration standard and quantified only if the S/N = 3, and the ratio of the ion to its qualifier ion was within ±20% of the standard value.

3.6 Identification and Quantification

An analytical blank was processed for every five samples with the same weight of sodium sulfate used to dry the sediments. The PCBs present in the appropriate blank were subtracted from those in the sample extracts. Sample peaks are reported only if the signal exceeded three times the baseline noise.

4. RESULTS AND DISCUSSION

The concentration data for PCBs in sediments arising from this study are presented in Tables 2 and 3. The available data for PCBs in sediments from other regions in other area in Nigeria are relatively sparse and generally suggest low levels of PCBs contamination relative to other river in the world. The concentrations encountered in this study were in agreement with those reported for coastal marine sediments in the world Table 4 [10,13].

There weren't much data on PCBs value in sediment of Nigeria river. Fagbote and Olanipekun that determined PCBs level on bitumen impacted area of Agbabu discovered that there were no PCBs in that area [15]. The use of pesticides containing chlorine and heat such as production of chlorinated solvents, paints, printing inks, agricultural chemicals, plastics and detergent bars, fluid from electrical transformer, discharge of industrial waste into the rivers and incineration might be the principal sources of PCBs.

5. CONCLUSION

The figures and results of analysis obtained from this research suggest that: The ∑PCBs values

from Ala river ranged from <0.9 to <3 μg Kg^{-1}dw. The ∑PCBs values in both wet and dry season were the same. There were polluting agents that may cause spatial increase in the PCBs level in both seasons. The ∑PCBs in this river were very low compared to other rivers in the world though the value agreed with some researcher. The river should adequately monitor so that the level of PCBs would not increase to avoid potential harm to human and organism living in the river.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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