Research Article/Review Article

Journal of Computing, Science &Technology. Vol. 3, 2024

Journal of Computing, Science &Technology
https://focjournal.unidel.edu.ng/
editorjcst@unidel.edu.ng

ISSN: 3043-6818 Print

https://focjournal.unidel.edu.ng

Concentration of Polychlorinated Biphenyls in Subterranean Water in Southwest, Nigeria.

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Article Info

Date Received: 09-08-2024
Date Accepted: 15-10-2024

Keywords:
Bioaccumulation, Ekiti state, ground water, polychlorinated biphenyl, sediment

ABSTRACT

Polychlorinated biphenyl compounds (PCBs) are man-made and can be found in any environmental compartment. They are of global concern because of their poisonous, bioaccumulative, persistent, hydrophobic, and long-distance transport characteristics. This study aimed to investigate the effects of certain physicochemical parameters on PCBs and to present data on the distribution of (PCBs) in subterranean water. The concentrations of five (PCBs) in subterranean water were determined at five locations via gas chromatography-electron capture detector (GC-ECD) and the PCB values varied from 0.03 to 3.72 µg/L. No congeners fell below the detection limit. The overall concentration of polychlorinated biphenyls (PCBs) displayed a negative (-0.613) and positive association with pH, a negative (0.203) and poor connection with electrical conductivity, and a negative (-0.499) and poor correlation with total organic carbon. The concentrations measured in this study were significantly lower than the WHO standard of 0.005 ppm at all sites. In conclusion, physicochemical characteristics have no significant effect on the quantity of PCBs in subsurface water, and the water could be adjudged safe for domestic use.

1.0 INTRODUCTION

Water is a life-sustaining resource that is critical to any community's livelihood and socioeconomic growth [1]. Unfortunately, proper provision of safe drinking water remains a major concern worldwide, particularly in developing countries such as Nigeria. Groundwater is part of the natural water cycle that exists within subsurface strata or aquifers. Because of the difficulties associated with technology and finances, groundwater is seen to be the most practical and pure natural supply of water. If contaminated, however, it can give rise to major environmental threats that are hard to reverse [2, 3, & 4]. In other circumstances, full restoration of groundwater quality has proven unachievable. One main issue that may contribute to groundwater contamination is the proximity of groundwater sources to garbage dump sites [5, 6].

For home, agricultural, and industrial purposes, groundwater is a vital source of fresh water for the world's population. For drinking water, almost one-third of the world's population depends on groundwater [7]. In dry and semi-arid regions where precipitation and surface water are in short supply, groundwater is an invaluable resource [2]. One of the main factors influencing a nation's sustainable growth is ensuring a stable and replenishable supply of groundwater for drinking. However, the quality of groundwater is seriously threatened by industrialisation, urbanisation, climate change, and agricultural activities. Human health, ecosystem services, and long-term socioeconomic development are under risk from toxic metals, hydrocarbons, trace organic contaminants, pesticides, nanoparticles, microplastics, and other emerging contaminants [1, 8, & 9]. In groundwater investigations over the past thirty years, chemical pollution has consistently come up. Groundwater contamination presents a serious threat to human populations, but it also offers a great chance for scientists to learn more about the history of our subterranean aquifers and for policymakers to learn how to preserve the quantity and quality of these resources. A vital part of the Critical Zone (CZ), which extends from the top of the vegetative canopy to the aquifer's bottom, are freshwater aquifers [10]. Numerous studies have been carried out to advance our knowledge of groundwater circulation and evolution as part of the global effort to comprehend the roles, structures, and processes inside the CZ. Many pollutants in groundwater are of geological origin, resulting from the breakdown of natural mineral deposits inside the Earth's crust [11, 12 & 13]. However, as the world's population, urbanisation, industry, agricultural output, and economy have grown rapidly, we are now confronted with the dilemma of the detrimental effects of anthropogenic toxins. The countries most affected by these worldwide changes are those experiencing rapid economic development, including many in the Eastern hemisphere [14, 15, & 16]. The objective of this study was to determine the PCBs concentration in ground water in Ekiti, Irele, Odigbo, Ilaje, and Okitipupa southwest, Nigeria.

1.1 Materials and Methods

1.1.1 Study Area

The 2006 census placed the population of Ado-Ekiti, the capital of Ekiti State in southwest Nigeria, at about 2,737,186. The state of Ekiti is situated in the rainforest belt of southwest Nigeria, between latitudes 7 251 8 21 N and longitudes 5 001 6 001 E17-19. The state is bordered to the east and south by Ondo State and lies south of Kwara and Kogi states, east of Osun state. The sampling sites are mapped out in Figure 1. Ekiti State has a land area of approximately 6,353 km² of land area. The State is primarily a highland zone that is more than 250 metres above sea level. It is in an area characterised by steep hills and metamorphic rock formations. With two distinct seasons—wet (April–October) and dry (November–March)—Ekiti State has a tropical environment. The Ikale language is spoken in Okitipupa, a Local Government Area in Ondo State, Nigeria. The Okitipupa local government has 316,100 residents, based on a 2016 estimate. Farmers make up the majority of the town's population. The principal crops grown are cassava, rubber, and oil palm. In addition, yams, beans, okra, pepper, melon, and vegetables are also widely cultivated. The town is home to a few businesses, such as Oluwa Glass Factory and Okitipupa Oil Palm Plc. The southern part of Ondo's economy and social life centre is Okitipupa. For nearly a decade, the community has been plagued by power outages. Diesel and premium motor spirit are still major sources of energy for a large number of homes and companies today. PCBs are now mostly found in exhaust emissions from generators and cars.

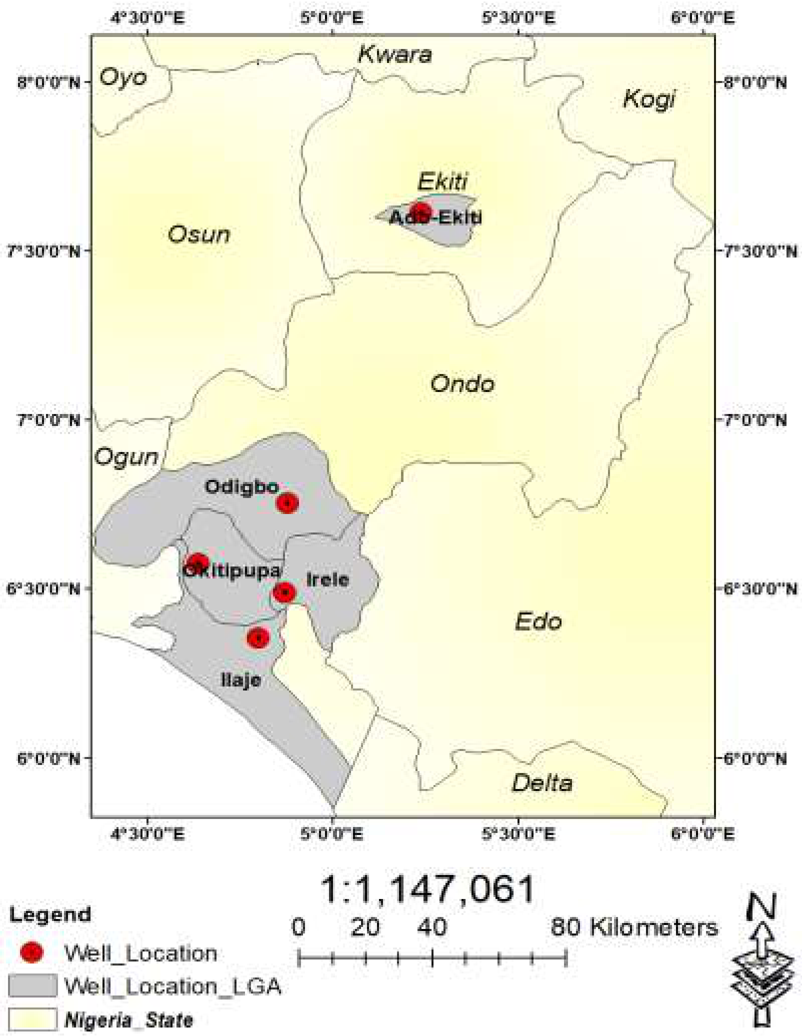

Figure 1: Map of Study Areas

1.2 Sample Collection

Fifteen water samples were obtained in Ekiti City and Ondo State. Samples were collected from several locations, including many urban areas namely Ekiti, Irele, Odigbo, Ilaje, and Okitipupa. Water was collected in pre-cleaned amber glass bottles and delivered to the laboratory immediately after sampling. The samples were kept in the refrigerator at 4°C until analysis [17].

1.2.1 Clean Up

This is a crucial step in the analysis of PCBs in groundwater as it serves to remove interfering compounds, improve separation, and enhance detection sensibility. PCBs were analysed via a previously developed method [18]. Aliquots of 50mL/5 g of sample (water) was crushed into a dry homogenate using 5 g of anhydrous sodium sulphate. Potassium hydroxide in an ethanolic solution was used to saponify the biota samples [19]. PCBs were removed from the samples using ultrasonic extraction in 50 mL of hexane/acetone (1:1 v/v) after an internal standard was applied. Using a rotary evaporator, the extract was concentrated to around 3 mL. The sample combination was agitated in a test tube containing concentrated H_2SO_4 for cleanup; the acid layer was then removed by centrifugation. Until the hexane layer was dried with anhydrous sodium sulphate and concentrated to roughly 1 mL for column chromatography clean-up, this process was repeated multiple times. Using an Agilent 7820A GC-ECD, the concentrations of five PCB congeners were measured. Certain PCB congeners have recovery rates ranging from 87% to 100%.

1.2.3 Quality Assurance and Statistical Analysis

SPSS 16.0 (SPSS Inc., Chicago, IL, USA) and Microsoft Excel (Microsoft Inc., USA) were used for all statistical calculations. The target PCB congeners' extraction efficiency was evaluated using the surrogate standard of $^{13}C_{12}$-labelled PCBs. Prior to extraction, the surrogate PCBs were added, and the standards' average recoveries from the different ambient matrices varied from 89.7 to 98%. Standard solutions including a mixture of PCBs at six concentrations were injected to carry out the calibration. R2 values were given for the PCB congener calibration lines. The blanks did not contain any PCB that was the subject of the study.

Parameters at various wells

2.0 RESULTS AND DISCUSSION

Spatial Variation of Physiochemical Parameters

Table 1: Spatial variation of Physiochemical

	Ekiti Well	Odigbo	Irele well	Ilaje well	Okitipupa/ Igbotako well	P
P^H	6.55±0.06	6.56±0.03	7.34±0.02	6.58±0.01	6.56±0.01	0.000
EC	32.67±15.01	117.67±15.14	240.67±2.52	162.00±3.61	100.67±3.21	0.000
TOC	0.55±0.04	0.56±0.03	0.20±0.03	0.67±0.03	0.68±0.02	0.000

Table 1 indicated significant geographical variance ($p < 0.05$) in the physicochemical parameters. The pH values of the water samples ranged from 6.55 to 7.34, which was within the WHO limit. The total amount of dissolved salts in water was indicated by electrical conductivity, a measurement of the water's capacity to conduct electricity. The micromhos/cm range for the EC values was 32.67±15.01 to 240.67±2.52µScm^{-1}. Electrical Conductivity (EC) is the highest in all drilled wells, followed by pH and Total Organic Carbon (TOC) which are the lowest. The ECs in Irele was the highest, with Ekiti having the lowest. The pH of the groundwater samples in this study (see Table 2) are in the range 6.5 – 8.5, the level recommended by the World Health Organization [20] for drinking water. The electrical conductivity (EC) of this study varied from 32.67 ± 15.01 to 240.67 ± 2.52 µScm^{-1} which fell within WHO recommended EC value for drinking water (250 µScm-1).

The TOC levels in this study ranged from 0.20 ± 0.03 to 0.68 ± 0.03. Eighty-one percent of the groundwater samples taken from this study were considered safe for drinking.

2.1 Concentration of Polychlorinated Biphenyls Congeners

Table 2: Concentration of different polychlorinated biphenyls congeners (PCBs) in wells from the five locations (ug/L).

	Ekiti Well	Odigbo well	Irele well	Ilaje well	Okitipupa/ Igbotako well	P
PCB 18	3.72±0.01	3.48±0.03	3.32±0.16	0.16±0.00	0.16±0.02	0.000
PCB28	0.57±0.00	0.41±0.01	0.03±0.00	0.50±0.00	0.14±0.00	0.000
PCB 44	0.57±0.00	0.48±0.00	0.54±0.00	0.40±0.00	0.36±0.00	0.000
PCB156	2.15±0.00	1.95±0.00	1.84±0.05	0.39±0.03	0.29±0.04	0.000
PCB170	1.23±0.02	1.27±0.01	0.73±0.01	1.00±0.03	0.88±0.02	0.000
Total PCBs	**8.24±0.06**	**7.56±0.02**	**6.34±0.08**	**2.43±0.01**	**1.81±0.02**	**0.000**

PCBs are a class of chemical compounds having one to ten chlorine atoms attached to biphenyl. [21]**.** A variety of factors influence the composition of PCBs in shallow groundwater, including the chemical and physical properties of PCB congeners, aquifer features, and the impact of human activities. In Ekiti well, PCB-18 (3.72 µg/L) was the most prevalent indicator PCB, while PCB-28 and PCB-44 had the lowest concentrations (0.05 µg/L). In Ondo State, PCB congeners were found at the maximum level of 7.56 µg/L in the Odigbo well and the lowest level of 1.81 µg/L in the Okitipupa/Igbotako well. Groundwater in the investigated location had greater PCB levels than the China's Nanshan surface water [22]. The Houston Ship Channel was found to have PCBs with mean total concentrations ranging from 1.18 to 8.24 µg/L [23] but were lower than those found in the Tonghui surface water, Beijing [24], and the Hudson River [25]. Five PCBs (18, 28, 44, 156, and 170) were identified in all sampling regions.

Table 3.: Relationship between the Mean PCB concentration and the Physiochemical Parameters

	pH	EC	TOC	Total PAHs	Total PCBs
pH	1	-0.075	.741**	0.130	-.613*
EC	-0.075	1	-.616*	-0.008	-0.203
TOC	.741**	-.616*	1	0.291	-0.499
Total PCBs	-.613*	-0.203	-0.499	-0.112	1

*The significance of the correlation is established at the 0.01 (2-tailed) level for ** and the 0.05 (2-tailed) level for *.*

The correlation of the total PCBs in groundwater with pH was good and negative (-.613) but has poor correlation with electrical conductivity (-0.203) and total organic carbon (-0.499).

Table 4. Correlation of various congeners

	Tri	**Tetra**	**Hexa**	**Hepta**
Tri	1	.936**	.997**	0.481
Tetra	.936**	1	.945**	0.262
Hexa	.997**	.945**	1	0.419
Hepta	0.481	0.262	0.419	1

**. *At the 0.01 level (2-tailed), the correlation is significant.*

Table 4 indicated a substantial positive connection between tri-PCB and tetra-PCB. This implies that lower/higher tri-PCB values will result in correspondingly greater or lower tetra-PCB values. Among the other homologs, the tri-PCB had a correlation coefficient of (0.481) with hepta-PCB that was positive.

There is a 0. 995 association between tri- and hexa-PCBs.

. The correlation between tri-PCB and tetra-PCB is 0.934. Also, the correlation between tetra-PCB and hepta-PCB is (0.262). The correlation between tetra-PCB and hexa-PCB is 0.943. According to the table above, the correlation between hexa-PCB and hepta-PCB is 0. 419. Globally, tri-, tetra-, and penta chlorinated biphenyls accounted for 70% of PCBS production, with tri chlorinated biphenyls being the most common homologue **[26].**

3.0 CONCLUSION

The amounts of PCBs in groundwater samples from five distinct wells Southwest, Nigeria, were determined. The Ekiti well had the greatest concentration levels due to pollution from home, wastewater and wood for domestic use, whereas the Okitipupa/ Igbokota well water had the lowest PCB levels due to its localization. The data obtained for the five total PCB concentrations in this study were compared with those acquired from earlier investigations, and it was noted that PCBs concentrations in the subterranean water were lower than those reported in other studies.

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