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Research Paper

Determination of Organic Pollutants In Water Samples From River Donga, Taraba State, Nigeria

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ABSTRACT
One of the most critical problems of developing countries is improper management of waste generated by anthropogenic activities, more challenging is the usage and disposal of these waste into the ambient environment. Water bodies especially rivers, streams, lakes among others are the most affected. This has often rendered these natural resources unsuitable for both primary and secondary usage. The aim of this research was to determine the organic pollutants present in water samples obtained from river Donga, Taraba State, Nigeria. Water samples of river Donga were collected and analyzed for organic pollutants. The organic parameters were determined using the standard methods of America Public Health Agency (APHA) and was extracted and analyzed using High perfor mance Liquid chromatography (HP-LC). Twelve different organic pollutants were detected in part per billion (ppb) at different percentage values at three sampling points in river Donga and one sampling point from the well as control making four sampling stations designated as River bank1, Middle of the River, River bank2 and well. The detected organic pollutants include; aldrin, dieldrin, endrin, mirex, dioxins, heptachlor, hexachlorobenzene, DDT, furans, PCB, toxaphene, chlordane. The pollutants have been recognized to fall within three classes of organic pollutants, which include Hydrocarbon, Oxygen, nitrogen and phosphorous compounds or organometallic compounds. All the organic parameters determined were lower than limits set by United States Environmental protection Agency (USEPA) and the maximum contaminant level (0.05ppb). The study shows that pesticides were the predominant organic pollutants present in the samples which show clear indication that agricultural activities are prevalent around the river. Therefore, drinking water from River Donga may be associated with certain health effects when consumed in higher amount.

KEYWORDS: *Organic Pollutants; Water Samples; Maximum Contaminant Level; Bioaccumulation; Toxicity.*

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I. INTRODUCTION

The demand for fresh water is always there with the ever increasing population in the world. The oceans and rivers hold about 97% of the earth's total resource of water while the remaining 3% is buried underground to be economically exploited. However, only 0.003% of the total volume of the later fraction is exploitable, though, the hydrological circle replenishes this (Mason, 1996). River constitutes the main inland water body for domestic, industrial and agricultural activities, and often carries large municipal sewage, industrial waste water discharges and seasonal runoff from agricultural fields (Ekevwe, 2014). The River waters are normally contaminated as a result of the discharge of waste waters which contain various types of pollutants such as organic pollutants, nutrients, and domestic effluent and agricultural waste etc (Vittoli *et al.,* 2010; Osidayo *et al.,* 2011). This has often rendered river waters unsuitable for both primary and secondary usage (Osidayo *et al.,* 2011). River water pollution can be linked to the type of waste water produced by urban, industries and agricultural activities that flows into surface and sub-surface water.

Organic pollution is the term used when large quantities of organic compounds which may originate from domestic activities, sewage, urban run-off, industrial effluents and agriculture waste are discharged into drain (Vittoli *et al.,* 2010). These organic compounds include pesticides, fertilizers, hydrocarbons, phenols, plasticizers, biphenyls, detergents, oils, greases, pharmaceuticals, etc (Abah *et al.,* 2021). They often contain carbon, usually in combination with elements such as hydrogen, oxygen, nitrogen and sulphur (Abah *et*

al., 2021). They consist of long bonds, usually made up of carbon and mostly from living origin. During the decomposition process of the organic pollutants, the dissolved oxygen in the receiving water may be consumed at a greater rate than it can be replenished, causing oxygen depletion and having severe consequences on the stream biota (Bhatia, 2006). Waste water with organic pollutants contain large quantities of suspended solids which reduce the light available to photosynthetic organisms, on settling out, alter the characteristics of the river bed, rendering it unsuitable habitat for many invertebrates. The most common toxic organic pollutants are persistent organic pollutants (POPs). POPs are compounds of great concern due to their toxicity, persistence, long-range transport ability, biomagnifications and bioaccumulation in living organisms (Abah *et al.*, 2021). POPs are carbon-based chemical compounds and mixtures that include industrial chemicals such as polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), and some organochlorine pesticides (OCPs) among others (Kronimus *et al.*, 2004). Given their ubiquity and persistence in the environment, there is no safe place for escaping persistent organic pollutants contamination (Adeola, 2004). Typical routes of exposure include workplace (in agriculture and industries), dietary exposure, and direct contact with contaminants in the air, buildings, water, lawns, parks, and soil, including but not limited to accident release (Okoli *et al.*, 2021). Laboratory investigations and environmental impact studies in the wild have implicated POPs in endocrine disruption, reproductive and immune dysfunction, neurobehavioral and disorders and cancer (Pal *et al.*, 2010).

Maintaining a supply of pure water for ever increasing population is already a daunting challenge all over the world while the organic contaminants are aggravating the challenges further (Otitoju *et al.*, 2022). Hence, there is need for clear understanding of the classes of organic compounds, which find their way into the fresh water system, their sources, and their transformation through physicochemical and biological processes in the fresh water system in order to control their entry and undesired transformation coupled with the numerous health effects they pose to humans and aquatic life. The primary aim of this study is to investigate the organic pollutants present in water samples obtained from River Donga, Taraba State, Nigeria.

II. MATERIAL AND METHODS

Study Area

The study was carried out in Donga Local Government Area, Taraba state of Nigeria. Its headquarters is in Donga town close to River Donga between longitudes $7^{o}43'00"$N and latitudes $10^{o}03'00"$E. It has an area of 31,121km^2 and a population of 134,111 at 2006 census. Donga River is a river in Nigeria and Cameroon. The River arises from the Mambila Plateau in the southern Nigeria, forms part of the international bodies between Nigeria and Cameroon, and flows northwest to eventually merge with Benue River in Nigeria. Donga watershed is 20,000 square kilometer (7,700sq mi) in area. At its peak, close to Benue State, the River delivers 1,800 cubic meters (64,000cu ft.) of water per second. The River cuts across domestic and agricultural areas which make it carry pollutants due to the activities prevalent in areas it passes through.

Sample Collection

With the aid of a boat, eight (8) water samples were collected at various points along River Donga in the morning and two (2) samples were collected the same day in the evening in well water in Wukari as control, making a total of 10 samples which were composited to a total of 1liter. 100cm^3 of water samples was collected at each designated point which was 20meters to the next point. Two (2) samples were collected at the first phase of the River bank, four (4) at the middle of the river and two (2) at the other end of the bank. Water samples were collected by lowering pre-cleaned plastics bottles in the bottom of the water body, 30cm deep, and allowed to overflow before withdrawing. Samples were collected in the month of May, 2016 indicating wet season. The samples were labeled and taken to the laboratory for analysis.

Storage and Preservation

Since changes occur frequently in water samples and analysis could not be performed immediately due to the far distance of the place of analysis. Samples were stored at 4^{o}c in the refrigerator in biochemistry laboratory Federal University Wukari, Wukari, according to the method of APHA 1985. The samples were packed properly in a thermo flask and conveyed the next morning to IITA Ibadan for analysis.

Procedure

50cm^3 of each composite water sample was measured and added into a cleaned 250cm^3 separatory funnel. 50cm^3 each of diethyl ether and trichloromethane were measured and added into the separatory funnel. The resultant mixture was vigorously shaken. The mixture was allowed to stand on Retort stand for 5 minutes and the organic layer was collected in cleaned glass sample bottle, labeled and kept for further HPLC analysis. This procedure was repeated for all the composite samples (APHA, 1985).

Statistical Analysis

Statistical analysis of the results was done using the SPSS statistical software version 21. The results were analyzed using analysis of variance (ANOVA). The post HOC test was carried out using a significance level of ($P < 0.05$).

III. RESULTS AND DISCUSSION

Table 1: The table below shows the organic pollutants detected in River Donga water samples and well water in Wukari with their various mean concentrations (µg/L). The pesticides detected are, aldrin, dieldrin, DDT, toxaphene, chlordane, mirex, heptachlor, hexachlorobenzene and eldrin.

S/N	**ORGANIC POLLUTANTS**	**WATER SOURCE**			
		RIVER BANK1 (µg/L)	**MIDDLE** (µg/L)	**RIVER BANK2** (µg/L)	**WELL** (µg/L)
1	Ppb aldrin	0.0046^{a}±0.0003	0.0052^{a}±0.0018	0.0074^{d}±0.0022	0.0058^{a} ±0.0016
2	Ppb Dieldrin	0.0015^{a}±0.0003	0.0016^{a}±0.0002	0.0025^{d}±0.0004	0.0019^{a}±0.0003
3	Ppb chlordane	0.0172^{a}±0.0005	0.0172a±0.0021	0.0191^{a}±0.0001	0.0177^{a}±0.0025
4	Ppb DDT	0.0154^{a}±0.0003	0.0135^{a}±0.0006	0.0123^{a}±0.0005	0.0135^{a}±0.0006
5	Ppb endrin	0.0052^{a}±0.0000	0.0055^{a}±0.0009	0.0055^{a}±0.0001	0.0041^{b}±0.0008
6	Ppb mirex	0.0115^{a}±0.0000	0.0250^{d}±0.0044	0.0137^{a}±0.0000	0.0124^{a}±0.0002
7	Ppb heptachlor	0.0261^{a}±0.0002	0.0255^{a}±0.0009	0.0269^{a}±0.0012	0.0271^{a}±0.0028
8	Ppb hexachlorobenzene	0.0103^{a}±0.0001	0.0099^{a}±0.0006	0.0108^{a}±0.0007	0.0109^{a}±0.0012
9	Ppb PCB	0.0031^{a}±0.0000	0.0024^{a}±0.0008	0.0010^{c}±0.0000.	0.0064^{d}±0.0028,
10	PPB Toxaphene	0.0083^{a}±0.0004	0.0085^{a}±0.0022	0.0084^{a}±0.0030	0.0080^{a}±0.0023
11	Ppb dioxin	0.0088^{a}±0.0003	0.0088^{a}±0.0009	0.0086^{a}±0.0000	0.0081a±0.0011
12	Ppb furans	0.0124a±0.0002	0.0097^{b}±0.0047	0.0053^{c}±0.0002	0.0368^{d}±0.009

Mean ± SE variations of organic pollutants in River Donga and well water in Wukari.

NB: The means with the same superscript letter within the same row are not significantly different at ($p<0.05$).

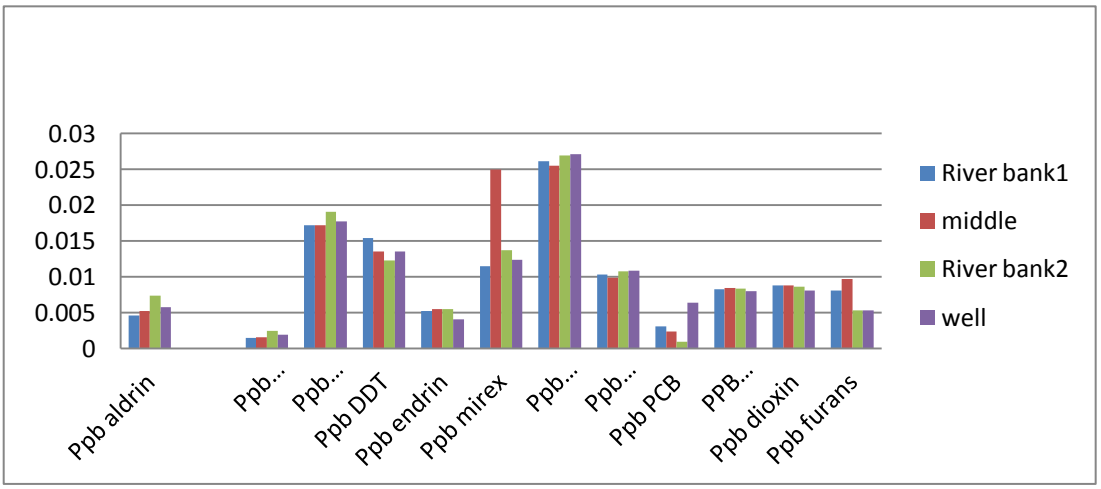

Figure 1: A chart representation of organic pollutants detected with their level of concentration (µg/L) in various sampling points.

Every day, the flow of organic contaminants into the fresh water system is increasing with increase in industrial activities and intensification of agricultural practices alongside the expansion of big municipalities all over the world. Human activities are capable of altering and affecting each part of the hydrologic cycle chemically, physically or biologically (Otitoju *et al.*, 2022). The need for treating larger volumes of water is increasing and the task of meeting this demand is becoming complicated in terms of technology and costlier in terms of capital investment especially in developing countries. The measurement of organic pollution levels from nonpoint source either from farm, business or home which affect the quality of water in River Donga is of concern in this study.

With reference to table 1, twelve organic pollutants were detected in each sampling point designated as river bank1, middle of the river, river bank2 and well water. The organic pollutants detected were mostly pesticide except for PCB, dioxins and furans. The pesticides detected are: aldrin, dieldrin, DDT, toxaphene, chlordane, mirex, heptachlor, hexachlorobenzene and eldrin.

From the statistical analysis performed, the mean concentration of aldrin at river bank1, middle and well has almost the same mean concentration except in samples collected at river bank2 which has a higher value (0.0074±0.002 µg/L). However, all were present in minute quantities compared to EPA standard for aldrin toxicity (0.05ppb). This result is much lower compared to the findings of Adeboyejo et al. (2011), with 242.5±361.5 µg/L for aldrin. Aldrin is a highly effective insecticide for soil-dwelling pests and for the protection of woods structure against termites. Higher levels are attributed to contamination from industrial effluents and soil erosion during agricultural use (WHO, 1989). Aldrin is highly toxic to human, the target organs being the central nervous system and the liver (Abah *et al.*, 2021).

Dieldrin has mean concentration of 0.0015±0.0003 µg/L, 0.0016±0.0002 µg/L 0.0025±0.0004 µg/L, 0.0 019±0.0003 µg/L at river bank1, middle, river bank2 and well respectively. This shows that the concentrations of these pollutants are not significantly different within the row at ($p<o.05$) except at the middle of the river which has 0.0025 µg/L indicating that dieldrin is more concentrated at middle than the rest sampling points and less concentrated at the river bank1 which has 0.0015 µg/L (table 1). The results are also lower compared to 102.4±81.5 µg/L values obtained by Adeboyejo et al. (2011), and it is within the permissible limits of river water by environmental protection agency (2006). Higher levels above or within 0.05ppb is considered to be carcinogenic to humans. Chlordane has the highest concentration at river bank2 with 0.0191±0.0001 µg/L and the lowest at river bank1 and middle with 0.0172±0.0005 µg/L respectively. All showed no significant difference within the row at ($p<0.05$). The results are also within the permissible limit set by EPA, 2006 and far lower compared to result obtained by Adeboyejo et al. (2011) which was 393.7±287.9 µg/L in Lagos lagoon.

DDT recorded the highest concentration at river bank1 and lowest at river bank2 with 0.0154 µg/L and 0.0123 µg/L respectively. DDT in higher doses causes sperm decline, eggshell thinning of birds and birth defects in many animals, which have been linked to near elimination of some species of animal. Bald eagle, a carnivore, is an example of what damage a POP like DDT can do (Navratil & Minarik, 2005). Endrin was more concentrated at the middle of the river and river bank2 with mean concentration of 0.0055±0.0009 µg/L and less concentrated in the well (control) with mean concentration of 0.0041±0.0008 µg/L, indicating that the level of endrin in river water is higher as compared to the control. The results are also lower compared to 959±138.3 values obtained by Adeboyejo et al. (2011). Mirex, a pesticide appeared higher in concentration at the middle of River Donga with mean concentration of 0.0250±0.0044 µg/L and the least was recorded at river bank2 with a mean concentration value of 0.0115±0.0000 µg/L. This result is also higher in the river compared to the control (well). Heptachlor recorded the highest mean concentration value in the control (0.0271±0.0028 µg/L) while the least was recorded at the middle sample collection point with a mean concentration value of 0.0255±0.0009 µg/L, indicating how high this pollutant appeared in the well compared to the river water. Hexachlorobenzene appeared less at the middle with a mean concentration of 0.0099±0.0006 µg/L and higher in the middle with a mean concentration of 0.0109±0.0012 µg/L. This also shows that the level of concentration of hexachlorobenzene is slightly higher in the well as compared to the river water samples. PCB appears with significance difference at ($p<0.05$) when compared between groups (multiple comparisons). Comparing the level of PCB in river bank with the rest of the samples showed no significance difference, but when samples from the middle were compared with the control a significance different appeared between the two samples with the middle having a mean concentration of 0.0024±0.0008 µg/L while well water gave a mean concentration of 0.0064±0.0028 µg/L indicating a significance difference between the samples at ($p<0.05$). A significant difference was also recorded when river bank2 was compared with the control at ($p<0.05$). River bank2 has 0.0010±0.0000 µg/L while the control indicated 0.0064±0.0028 µg/L. PCB enters the human body through eating of meat or fish containing PCB and gets converted to other metabolites. Some of which are excreted naturally, but others stay in fatty tissues and in the liver for months or years. Inclusion of PCBs into breast milk fat and their subsequent entries into babies have been reported (Darnerud, 2003; Tue *et al.*, 2010). Toxaphene showed the lea st mean concentration in the well and highest at middle with values of 0.0080±0.0023 µg/L and 0.0085±0.0022 µg/L respectively. Dioxins recorded the highest concentration at river bank1 with mean concentration of 0.0085±0.0022 µg/L and the least in the well with mean concentration value of 0.0081±0.0011 µg/L indicating higher level in river water compared to well water. Trace amount of dioxins at parts per trillion levels may cause hormone disruption; it also causes numbness, fluctuations in liver enzymes levels, nausea, etc (Pal *et al.*, 2010).

Furans which are considered to be more toxic than PCBs were present in higher quantities in the middle of the river with a mean concentration value of 0.0097±0.0047 µg/L and occurred in lesser quantities in well water. This indicates that river water is more polluted in some cases as compared to underground water. In multiple comparison (comparisons between and within the groups), significant difference was recorded between samples collected from the middle and the control (well) with mean concentrations of 0.0097±0.0047 µg/L and 0.0278±0.0095 µg/L respectively. River bank2 and the control also showed significant difference at ($p<0.05$) with mean concentrations of 0.0053±0.0000 µg/L and 0.0278±0.0095 µg/L. Furans which are more toxic than PCBs can cause severe form of acne called chloracne, followed by fatigue, nausea, and liver disorders (Ross, 2004).

IV. CONCLUSION

The study shows that pesticides were the predominant organic pollutants present in the samples which show clear indication that agricultural activities are prevalent around the river. The concentration of these pesticides in River Donga and the control (well) are much lower compared to EPA and WHO standards for toxicity level of pesticides. Therefore, drinking water from River Donga may be associated with certain health effects when consumed in higher amount.

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