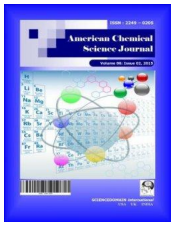

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Concentration of Organophosphorous Pesticide Residues in Water and Sediment Samples from River Ilaje, Nigeria

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Author's contribution

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

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ABSTRACT

The levels of organophosphorous pesticide residues were determined form water and sediment samples collected from two sampling point within river Ilaje during the dry and rainy seasons. The extracts were analyzed for the presence of organophosphorous pesticide residues using a Gas chromatography coupled with Mass Spectrometer (GC-MS) to identify and quantify the various organophosphorous pesticide residues. The result shows that all the samples analyzed were contaminated with some levels of organophosphorous pesticide residues. The pesticides detected include Diazinon, Phosphamidon, Dichlofenthion, Methyl Parathion, Pirimiphos-methyl, Parathion, Bromophos-ethyl, Ethion, Carbofenothion, Carbaryl and Fenthion. The mean concentration of the pesticide residue in water samples ranges from not detected to 7.087 mg/l (Phosphamidon) during the dry season and from not detected to 4.456 mg/l (Ethion) during the rainy season. For the sediment samples the mean concentration ranges from not detected to 2.256 µg/g (Phosphamidon) during the dry season and from not detected to 1.717 µg/g (Phosphamidon) during the rainy season. This shows that in the water samples, the concentration of Phosphamidon was highest during the dry season while the concentration of Ethion was highest during the rainy season. The concentration of Phosphamidon was the highest in the sediment samples for both seasons.

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1. INTRODUCTION

Pesticides are natural or synthetic agents that are used to kill unwanted plant or animal pests, Pesticides are indispensable in modern agriculture, but their use and/or misuse may lead to serious water quality problems, problems that could impair the use of water for crop and animal production or even human consumption. Pesticides and their metabolites are of great concern to the society as they are harmful to human health, pollute natural resources and disturb the equilibrium of the ecosystem [1]. Pesticides are of environmental concern in streams in both the water column and sediment. Those pesticides that are more hydrophobic tend to be detected more frequently in sediment; thus, measuring pesticides in sediment is important for tracking their fate in the environment and evaluating for potential toxicity.

The extensive use of pesticides has contaminated our soil, water and food, thus risking our wellbeing. Many persistent pesticides and their degradation products penetrate into the plant tissues or stay in the water and soil thus appearing in our food chain [2]. Groundwater and surface water is at risk of contamination from the use of some agricultural pesticides. In many circumstances pesticide contamination of water resources is more likely to result from point sources than from diffuse sources following approved application to crops in the field. Such point sources include areas on farms where pesticides are handled, filled into sprayers or where sprayers are washed down. Taking into account the rampant use of pesticides which has lead to the contamination of various strata, continuous monitoring of environmental and food samples is of utmost importance [3,4].

For the past three decades, organophosphorous pesticides have been the insecticides most commonly used by professional pest control bodies and home owners [5]. They are toxic to mammals but they are degraded in 2-4 weeks, Organophosphates (OP) are degraded by general esterases such as cholinesterases, phosphomonoesterases, carboxylesterases and oxidases, several of the organophosphates (OP) cause inhibition and elevation of cholinesterase due to the cumulative effect of pesticides and show the symptoms of neurotoxicity, hepato-toxicity, RTI and kidney dysfunctions [6]. Organophosphates in California came under scrutiny when they began to show up in groundwater samples, the U.S. Environmental Protection Agency (EPA) decided to eliminate certain uses of the organophosphorous pesticide insecticides because of their potential for causing toxicity in people, especially children [7]. Pesticide residues have been reported in water, sediment, Fin and Shell fish samples from Lagos Lagoon complex Nigeria [8]. Concentration of residues from organochlorine pesticide in water and fish from some rivers in Edo State Nigeria was has been reported [9]. Levels of organochlorine and organophosphorous pesticide residue in water, soil, sediment and cocoa beans in the cocoa producing areas of Nigeria have been reported [10-12].

Several reports have been given on the water analysis of river Ilaje [13-16]. Multielement analysis of water and sediment samples from river Ilaje has also been reported [17], Occurrence and Dynamics of Hydrocarbon in Periwinkles *(Littorina littorea*) as well as Occurrence and Toxicity of Hydrocarbon Residues in Crab (*Callinectes sapidus*) from Contaminated Site in river Ilaje has been documented [18,19]. The need for this research arises because there has been no report on the levels of organophosphorous pesticide residues in water and sediment samples from river Ilaje.

2. METHODOLOGY

2.1 The Study Area

The study areas are Abereke and Ogogoro communities within the river Ilaje. The Ilaje coastal area of Ondo State, Nigeria is located on Latitude 5°50'N-6°09'N and on Longitude 4°45'E-5°05'E, river Ilaje is a deltaic region which takes its origin from river Oluwa in Ondo State. The Ilaje communities depend on river Ilaje for their economic and domestic activities. The Abereke sampling site which is both a farming and fishing community while the Ogogoro sampling site which is only a fishing community is far away from farmlands. The two sampling sites are very far apart.

2.2 Sampling and Pre-treatment of Samples

A total of 12 water samples were collected in a 2 L glass bottles while a total of 12 sediment

samples were collected using a soil hugger. The water and sediment samples were collected during the dry (December 2014) and rainy (May 2015) seasons, sampling points were geo-located using GPS (Global Position System) to ensure consistency. The water sample was acidified to pH 2 using HNO_3 and stored in a refrigerator at 4°C, extraction was done 2 days after sample collection. The sediment samples were air dried for two weeks and pulverized using laboratory mortar and pestle. It was later sieved using a 2 mm mesh size sieve. All chemical reagent used for this research were of analytical grade.

2.2.1 Extraction procedure

Liquid-liquid extraction of organophosphorous pesticide in water samples was carried out using Method 3510 as described by USEPA [20] was used to extract organophosphorous pesticide residues from the water samples. 50 ml of dichloromethane (DCM) was introduced into a separating funnel containing 100 ml of the water sample and shaken vigorously for 5 minutes. The sample was allowed to settle for 30 minutes to facilitate effective separation of the organic and aqueous phases. After separation, the organic layer was filtered into a 250 ml volumetric flask through anhydrous sodium sulphate (Na_2SO_4) that has been prewashed with DCM. The extraction was repeated twice using 50 ml of the extractant (DCM). The extracts were later combined to make a whole. The extracts were concentrated to 5 ml using a rotary evaporator at a temperature of 45°C, during concentration the solvent is exchanged with n-hexane. The level of organophosphorous pesticide residues in the water samples was determined using gas chromatography coupled with a mass spectrometer (GC-MS).

Solid-liquid extraction of organophosphorous pesticide residues in the sediment samples was carried out using the EPA 3550C method as described by USEPA [21]. A mixture of 20g of sediment samples and 20g of anhydrous sodium sulphate (Na_2SO_4) was thoroughly mixed with a mixture of 50 ml acetone and n-hexane (1:1 v/v). The mixture was sonicated for 30 minutes in a high frequency ultrasonic bath at 60°C, the organic extract was decanted. The extraction process was repeated twice using 50 ml of a mixture of acetone and n-hexane (1:1 v/v). The extracts were later combined to make a whole. The extracts were concentrated using a rotary evaporator at a temperature of 45°C.

2.2.2 Clean up procedure

The clean up procedure is required for the pesticide residues analysis in sediment sample in order to avoid interferences. The clean up was done using Method 3630 as described be USEPA [22]. The extracts from the sediment samples were clean up using a column packed with 2 g of activated silica gel and 2 g of anhydrous sodium sulphate (Na_2SO_4). Prior to the clean up, the column was conditioned with 20 ml of n-hexane. The extract was introduced into the column and eluted using a mixture of n-hexane and diethyl ether (1:1 v/v).The elute was concentrated to 5 ml using a rotary evaporator at a temperature of 45°C, during concentration the solvent is exchanged with n-hexane.

2.2.3 Gas chromatographic conditions

The following instrumentals conditions were maintained. Gas pressure was 60 psi and injector temperature was 220°C, GC column temperature was 190°C, detector temperature was 270°C, the carrier gas was nitrogen (at 30 ml/min), column length 200 cm, id 2 mm, the glass spiral column packed with 1.5% 0V - 17 and 1.95% 0V-210 on chromosorb WHP 80/100 mesh. There were no peaks when solvents and blanks were chromatographed, before the samples were analyzed under the same condition. Known standards, were also chromatographed, the retention time were used to identify the compounds present in the samples.

3. RESULTS AND DISCUSSION

Table 1 shows the results for the concentration of organophosphorous pesticide residues in water samples from Abereke sampling site in river Ilaje. Diazinon, Phosphamidon, Dichlofenthion, Methyl Parathion, Pirimiphos-methyl, Parathion, Bromophos-ethyl, Ethion, and Carbofenothion were all detected during the dry season with their mean concentration 0.488±0.368 mg/l, 3.476±2.141 mg/l, 0.101 mg/l, 0.475 mg/l, 0.790±0.329 mg/l, 0.500±0.038 mg/l, 0.669 mg/l, 0.908±0.457 mg/l, 1.162 mg/l respectively. Dichlorvos, Mevinfos, Carbaryl, Dimethoate, Pirimicarb, Fenthion, Isofenphos and Malathion were not detected. During the rainy season it was observed that Diazinon, Phosphamidon, Methyl Parathion, Pirimiphos-methyl, Parathion, Bromophos-ethyl and Ethion were all detected with their mean concentration 0.482±0.530 mg/l, 3.654±3.276 mg/l, 0.515±0.557 mg/l,

0.391±0.155 mg/l, 0.219±0.127 mg/l, 0.933 mg/l, 0.456 mg/l respectively. Dichlorvos, Mevinfos, Carbaryl, Dimethoate, Dichlofenthion, Fenthion, Isofenphos, Carbofenothion and Malathion were all not detected. The TOPP ranges from 2.519-10.464 mg/l during the dry season and 1.071-10.80 mg/l during the rainy season.

Table 2 included the results of the concentration of organophosphorous pesticide residues in water samples from Ogogoro sampling site of river Ilaje. Diazinon, Phosphamidon, Dichlofenthion, Methyl parathion, Pirimiphos-methyl and Parathion were all detected during the dry season with their mean concentration 1.453±1.236 mg/l, 7.087 mg/l, 1.570±0.966 mg/l, 1.338±0.079 mg/l, 0.925±0.299 mg/l and 0.646±0.165 mg/l respectively. Dichlorvos, Mevinfos, Carbaryl, Dimethoate, Pirimicarb, Fenthion, Isophenfos, Bromophos-ethyl, Ethion, Carbofenothion and Malathion were not detected. During the rainy season Carbaryl, Diazinon, Phosphamidon, Dichlofenthion, Methyl parathion, Pirimiphos-methyl, Fenthion, Parathion, Bromophos-ethyl, Ethion and Carbofenothion were all detected with their mean concentration 0.29 mg/l, 0.094±0.019 mg/l, 1.030±0.258 mg/l, 0.067±0.001 mg/l, 1.052±0.555 mg/l, 0.358±0.408 mg/l, 0.217 mg/l, 0.259±0.123 mg/l, 1.955 mg/l, 0.652 mg/l, and 0.639 mg/l respectively. While Dichlorvos, Mevinfos, Dimethoate, Pirimicarb, Isophenfos, and Malathion were all not detected. The TOPP ranges from 7.325-3.393 mg/l during the dry season and 4.009-1.421 mg/l during the rainy season.

Table 3 shows the result obtained from the analysis of organophosphorous pesticide residues in sediment samples from Abereke sampling point in river Ilaje. Diazinon, Phosphamidon, Dichlofenthion, Methyl parathion, Pirimiphos-methyl and Parathion were all detected with their mean concentration 0.137±0.057 µg/g, 2.246 µg/g, 0.087 µg/g, 0.194±0.096 µg/g, 0.168±0.006 µg/g, 0.753±0.99 µg/g respectively. While Dichlorvos, Mevinfos, Carbaryl, Dimethoate, Pirimicarb, Fenthion, Isofenphos, Bromophos-ethyl, Ethion, Carbofenothion and Malathion were all not detected. During the rainy season Diazinon, Phosphamidon, Dichlofenthion, Methyl parathion, Pirimiphos-methyl and parathion with their mean concentration 0.479±0.533 µg/g, 0.399 µg/g, 0.294 µg/g, 0.519±0.545 µg/g, 0.251 µg/g, 0.312±0.265 µg/g.

Table 1. Concentration (mg/l) of organophosphorous pesticide residues in water samples from Abereke site, river Ilaje, Nigeria

OPPs/Sample code	Dry season					Rainy season				
	A_1	A_2	A_3	Mean	S.D	A_4	A_5	A_6	Mean	S.D
Dichlorvos	N.D	N.D	N.D			N.D	N.D	N.D		
Mevinfos	N.D	N.D	N.D			N.D	N.D	N.D		
Carbaryl	N.D	N.D	N.D			N.D	N.D	N.D		
Dimethoate	N.D	N.D	N.D			N.D	N.D	N.D		
Diazinon	0.227	N.D	0.748	0.488	0.368	0.070	1.080	0.296	0.482	0.530
Pirimicarb	N.D	N.D	N.D			N.D	N.D	N.D		
Phosphamidon	1.310	3.526	5.592	3.476	2.141	0.552	7.080	3.331	3.654	3.276
Dichlofenthion	N.D	N.D	0.101	0.101		N.D	N.D	N.D		
Methyl Parathion	0.475	N.D	N.D	0.475		N.D	0.121	0.908	0.515	0.557
Pirimiphos-methyl	0.460	0.794	1.117	0.790	0.329	0.320	0.284	0.568	0.391	0.155
Fenthion	N.D	N.D	N.D			N.D	N.D	N.D		
Parathion	0.507	0.534	0.460	0.500	0.038	0.129	N.D	0.308	0.219	0.127
Isofenphos	N.D	N.D	N.D			N.D	N.D	N.D		
Bromophos-ethyl	N.D	N.D	0.699	0.699		N.D	N.D	0.933	0.933	
Ethion	N.D	1.231	0.585	0.908	0.457	N.D	N.D	4.456	4.456	
Carbofenothion	N.D	N.D	1.162	1.162		N.D	N.D	N.D		
Malathion	N.D	N.D	N.D			N.D	N.D	N.D		
TOPP	2.519	6.085	10.464	6.356	3.980	1.071	8.565	10.80	6.812	5.096

TOPP= Total organophosphorous pesticide, OPP= organophosphorous pesticide, S.D= standard deviation, A= Abereke sampling site, N.D= not detected

Table 2. Concentration (mg/l) of organophosphorous pesticide residues in water samples from Ogogoro site, river Ilaje, Nigeria

OPPs/Sample code	Dry season					Rainy season				
	O_1	O_2	O_3	Mean	S.D	O_4	O_5	O_6	Mean	S.D
Dichlorvos	N.D	N.D	N.D			N.D	N.D	N.D		
Mevinfos	N.D	N.D	N.D			N.D	N.D	N.D		
Carbaryl	N.D	N.D	N.D			N.D	N.D	0.260	0.260	
Dimethoate	N.D	N.D	N.D			N.D	N.D	N.D		
Diazinon	0.931	2.864	0.563	1.453	1.236	0.073	0.109	0.099	0.094	0.019
Pirimicarb	N.D	N.D	N.D			N.D	N.D	N.D		
Phosphamidon	7.087	N.D	N.D	7.087		0.899	1.328	0.864	1.030	0.258
Dichlofenthion	N.D	2.253	0.887	1.570	0.966	0.068	0.066	0.066	0.067	0.001
Methyl Parathion	1.393	N.D	1.282	1.338	0.079	1.171	1.538	0.447	1.052	0.555
Pirimiphos-methyl	1.159	0.589	1.028	0.925	0.299	0.088	0.828	0.159	0.358	0.408
Fenthion	N.D	N.D	N.D			0.217	N.D	N.D	0.217	
Parathion	0.554	0.548	0.837	0.646	0.165	0.117	0.326	0.334	0.259	0.123
Isofenphos	N.D	N.D	N.D			N.D	N.D	N.D		
Bromophos-ethyl	N.D	N.D	N.D			N.D	N.D	1.955	1.955	
Ethion	N.D	N.D	N.D			N.D	N.D	0.652	0.652	
Carbofenothion	N.D	N.D	N.D			N.D	N.D	0.634	0.634	
Malathion	N.D	N.D	N.D			N.D	N.D	N.D		
TOPP	11.120	6.254	4.597	7.325	3.393	2.633	4.195	5.47	4.099	1.421

TOPP= Total organophosphorous pesticide, OPP= organophosphorous pesticide, S.D= standard deviation, O= Ogogoro sampling site, N.D= not detected

while Dichlorvos, Mevinfos, Carbaryl, Dimethoate, Pirimicarb, Fenthion, Isofenphos, Bromophos-ethyl, Carbofenothion and Malathion were all not detected. The TOPP ranges from 0.301-2.158 µg/g during the dry season and N.D-2.804 µg/g during the rainy season.

Table 4 shows the result of the concentration of organophosphorous pesticide residues in sediment samples from Ogogoro sampling site in river Ilaje. Diazinon, Phosphamidon, Dichlofenthion, Methyl parathion, Pirimiphos-methyl and Parathion were all detected with their mean concentration 0.126±0.009 µg/g, 1.127 µg/g, 0.093 µg/g, 0.452±0.427 µg/g, 0.101 µg/g and 0.330 µg/g. while Dichlorvos, Mevinfos, Carbaryl, Dimethoate, Pirimicarb, Fenthion, Isofenphos, Bromophos-ethyl, Ethion, Carbofenothion and Malathion were all not detected. During the rainy season Diazinon, Phosphamidon, Dichlofenthion, methyl parathion, Pirimiphos-methyl and parathion were all detected with their mean concentration 0.601±0.664 µg/g, 1.717 µg/g, 0.071 µg/g, 1.257 µg/g, 0.661±0.619 µg/g, and 0.333-0.158 µg/g. while Mevinfos, Carbaryl, Dimethoate, Pirimicarb, Fenthion, Isofenphos, Bromophos-ethyl, Ethion, Carbofenothion and Malathion were all not detected. The TOPP ranges from N.D-2.524 µg/g in the dry season to 0.076-4.879 µg/g during the rainy season. The result shows a wide variation with season in the levels of organophosphorous pesticide residues detected in the water and sediment samples from river Ilaje.

The solubility of organophosphorous pesticide in water is variable but higher than with the solubility of organochlorines in water. Residues generally break down quite quickly in water and are not generally detected except where the contamination is quite recent. Soil residues are similarly short lived, the residues are only of interest probably only for 5-15 days after spraying unless in shaded areas or where the concentration applied are high. The residents of the study areas are not well educated concerning the use of organophosphorous pesticide as a result of this, in order to control the rapid growth of weeds during the rainy season there is an increase in the indiscriminate use of organophosphorous pesticides in the active ingredient form of 480 g/L Glyphosate-isopropylamine salt. The topography of Ilaje community consist of low lands which are less than 15 m above sea level, the geomorphological units of the sampling sites being a creek and riverine areas include sand ridges, lagoons,

swamp flats, creeks and the anatomizing distributaries of the western Niger Delta. The water ways of river Ilaje flowing southwards to the Atlantic Ocean drain the study areas [23]. The TOPP for the water samples from Abereke sampling site has a mean value of 6.812 mg/l during the rainy season, this value is higher than that of the dry season which has a mean value of 6.356 mg/l, and for the sediment samples the TOPP has a mean value of 1.782 mg/l for the rainy season which is lower than that of the dry season with a mean value of 1.863 mg/l. This variation can be attributed to the flooding which occurs during heavy rainfall as pesticide recently applied to farmland are often washed away from the farmland into water bodies, thereby leading to an increase in the concentration of pesticide residues in water bodies and decrease in the concentration of pesticide residue in sediment close to the farmland during the period of heavy rainfall (rainy season) compared to the dry season of little or no rainfall where there is adsorption of the pesticide residues into the river sediment [24,25]. As several report indicated that point source (spill, run off or washing from farmlands) can contribute to between 18-84% increase in pesticide load in measured in catchment area because the pesticides are transported from the area of application to another areas [26-29]. The TOPP for the water samples from Ogogoro sampling site has a mean value of 7.325 mg/L during the dry season, which is higher than the mean value of 4.099 mg/L obtained during the rainy season. This variation can be attributed to the dilution factor as a result of the heavy rainfall during the rainy season which leads to an increase in the volume of water in the river at the sampling site which is far from the point source pesticide application area in the farmlands, dilution factor plays a major in the seasonal variation of the concentration of pesticide residue in surface water when comparing the dry and wet seasons [30,31]. The TOPP for the sediment samples from Ogogoro sampling sites has a mean value of 2.272 mg/L during the rainy season which is higher than the mean value of 1.403 mg/L obtained during the dry season. The increase in the mean value of TOPP during the rainy season could be attributed to the continuous deposition of organophosphorous pesticide residues which has been transported by air and water flood in a high concentration from farmlands where there has been indiscriminate application of the pesticides [32,33].

Table 3. Concentration (µg/g) of organophosphorous pesticide residues in sediment samples from Abereke site, river Ilaje, Nigeria

OPPs/Sample code	Dry season					Rainy season				
	A_1	A_2	A_3	Mean	S.D	A_4	A_5	A_6	Mean	S.D
Dichlorvos	N.D	N.D	N.D			N.D	N.D	N.D		
Mevinfos	N.D	N.D	N.D			N.D	N.D	N.D		
Carbaryl	N.D	N.D	N.D			N.D	N.D	N.D		
Dimethoate	N.D	N.D	N.D			N.D	N.D	N.D		
Diazinon	0.097	N.D	0.176	0.137	0.056	N.D	0.102	0.856	0.479	0.533
Pirimicarb	N.D	N.D	N.D			N.D	N.D	N.D		
Phosphamidon	N.D	N.D	2.246	2.246		N.D	0.399	N.D	0.399	
Dichlofenthion	N.D	N.D	0.087	0.087		N.D	N.D	0.294	0.294	
Methyl Parathion	N.D	0.126	0.262	0.194	0.096	N.D	0.133	0.904	0.519	0.545
Pirimiphos-methyl	0.164	N.D	0.172	0.168	0.006	N.D	N.D	0.251	0.251	
Fenthion	N.D	N.D	N.D			N.D	N.D	N.D		
Parathion	1.897	0.175	0.188	0.753	0.991	N.D	0.125	0.499	0.312	0.265
Isofenphos	N.D	N.D	N.D			N.D	N.D	N.D		
Bromophos-ethyl	N.D	N.D	N.D			N.D	N.D	N.D		
Ethion	N.D	N.D	N.D			N.D	N.D	N.D		
Carbofenothion	N.D	N.D	N.D			N.D	N.D	N.D		
Malathion	N.D	N.D	N.D			N.D	N.D	N.D		
TOPP	2.158	0.301	3.131	1.863	1.438	N.D	0.759	2.804	1.782	1.446

TOPP= Total organophosphorous pesticide, OPP= organophosphorous pesticide, S.D= standard deviation, A= Abereke sampling site, N.D= not detected

Table 4. Concentration (µg/g) of organophosphorous pesticide residues in sediment samples from Ogogoro site, river Ilaje, Nigeria

OPPs/Sample code	Dry season					Rainy season				
	O_1	O_2	O_3	Mean	S.D	O_4	O_5	O_6	Mean	S.D
Dichlorvos	N.D	N.D	N.D			N.D	N.D	N.D		
Mevinfos	N.D	N.D	N.D			N.D	N.D	N.D		
Carbaryl	N.D	N.D	N.D			N.D	N.D	N.D		
Dimethoate	N.D	N.D	N.D			N.D	N.D	N.D		
Diazinon	0.132	N.D	0.119	0.126	0.009	0.076	1.347	0.379	0.601	0.664
Pirimicarb	N.D	N.D	N.D			N.D	N.D	N.D		
Phosphamidon	N.D	N.D	1.127	1.127		N.D	N.D	1.717	1.717	
Dichlofenthion	N.D	N.D	0.093	0.093		N.D	0.071	N.D	0.071	
Methyl Parathion	0.150	N.D	0.754	0.452	0.427	N.D	N.D	1.257	1.257	
Pirimiphos-methyl	N.D	N.D	0.101	0.101		N.D	0.223	1.099	0.661	0.619
Fenthion	N.D	N.D	N.D			N.D	N.D	N.D		
Parathion	N.D	N.D	0.330	0.330		N.D	0.221	0.445	0.333	0.158
Isofenphos	N.D	N.D	N.D			N.D	N.D	N.D		
Bromophos-ethyl	N.D	N.D	N.D			N.D	N.D	N.D		
Ethion	N.D	N.D	N.D			N.D	N.D	N.D		
Carbofenothion	N.D	N.D	N.D			N.D	N.D	N.D		
Malathion	N.D	N.D	N.D			N.D	N.D	N.D		
TOPP	0.282	N.D	2.524	1.403	1.585	0.076	1.862	4.879	2.272	2.428

TOPP= total organophosphorous pesticide, OPP= organophosphorous pesticide, S.D= standard deviation, O= Ogogoro sampling site, N.D= not detected

4. CONCLUSION

The results of this study have provided insight into the levels of organophosphorous pesticide contamination in water and sediment samples from river Ilaje. The high level of pesticide may be as a result of extensive and repeated use of the pesticides for farming and domestic activities, the high level of pesticide may be a matter of concern in the future due to ability of pesticides to bioaccumulate in aquatic organisms, therefore there is a need for continuous monitoring of the water and sediment of the river. It is also recommended that extensive research on the bioaccumulation of pesticide residue in plant and aquatic organisms in the Ilaje coastal area be conducted.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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