LEVELS OF ORGANOCHLORINE PESTICIDE RESIDUES IN BIOTIC AND ABIOTIC COMPONENTS OF THE LAGOS LAGOON, NIGERIA

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ABSTRACT
High concentrations of organochlorine pesticides (OCs) in a marine environment such as the Lagos Lagoon demands great attention since this Lagoon serves as a major source of sea foods to the people of lagos and its environs. This work examined the levels of OCs in both biotic and abiotic components of Lagos Lagoon. Surface water, sediment, zooplankton, phytoplankton, benthic invertebrates and fishes from four locations on Lagos lagoon were analysed for OCs using gas chromatograph equipped with Ni Electron capture detector. The concentrations were as follows: sum BHC (Benzene Hexachloride) 1777.80µg/kg, heptachlor epoxide (1134.39µg/kg), sum DDT (Dichloro Diphenyl Trichloroethane) 207.13µg/kg, methoxychlor 85.43µg/kg, chlorothalonil 83.84µg/kg, heptachlor 69.89µg/kg, aldrin 223.87µg/kg, endosulfan1 11.09µg/kg, di-eldrin 46.50µg/kg, endosulfan2 16.59µg/kg, endrin 16.23µg/kg endosulfan sulfate 3.95µg/kg, γ-cyhalothrin 53.65µg/kg. The high concentrations of DDT and BHC suggested their recent usage in the study area or recent transport through rivers and canals that discharge into the lagoon. Sediment was found to have the highest percentage OCs of 78.08%, water had the lowest of only 0.09%, phytoplankton/zooplankton had 5.09%, benthic invertebrate had 8.76% and fishes 7.97%. The percentage distribution indicated the level of transfer as the OCs biomagnified along the aquatic food webs from lower tropic level to higher tropic level.

KEYWORDS: Lagos lagoon, organochlorine pesticides, biotic and abiotic components, human health.

INTRODUCTION

Organochlorine pesticides (OCs) are a group of toxic chemicals of interest as their presence in the environment contributes greatly to many acute and chronic illnesses. Studies have found a correlation between organochlorine exposure and various types of modern day diseases such as cancer, neurological damage, Parkinson's disease, birth defects, respiratory illness, and abnormal immune system function (IARC, 2006).
According to Alani et al. (2013b), organochlorine pesticides like DDT, lindane, etc, are still very much in use for pest control and as insecticides in Nigeria. Their usage in developing countries, including Nigeria, is not unconnected to lack of appropriate regulatory control and management (Darko and Acquaah, 2007).

Chlorinated pesticide residues enter aquatic environment through effluent release, discharges of domestic sewage and industrial waste water, atmospheric deposition, runoff from agricultural fields, leaching, equipment washing, and disposal of empty containers and direct dumping of waste into the water system (Xue et al., 2006).

Pollution by persistent chemicals such as OCs is potentially harmful to the organism at higher trophic level in the food chain. Research has shown that more than 80% of the total intake of pesticide residues in human beings is through the food chain (Trotter and Dickson, 1993; Martinez et al., 1997). It has been reported that the consumption of contaminated fishes and edible benthic organism is one of the important pathways of human exposure to OCs (Zhou et al., 2007; Muralidharan et al., 2008).
Assessment of OCs in the biota is useful in establishing a good link to risks related to human exposure to these compounds in the lagoon (Alani et al., 2013b). The investigation of the distribution pathways of pesticide residues and the level of their transfer within the food webs is highly important.

The city of Lagos spreads along more than 30 km of the Lagoon's south-western and western shoreline. In Lagos, pollution by urban and industrial waste is a major problem as a large amount of wastewater is released into the Lagoon daily (McArthur, 2008). Huge amounts of wastes are dumped in the lagoon as seen at the sample locations (plate 1 and 2). This location is therefore expected to have an appreciable level of OCs.

According to Alani et al. (2013b), OCs are highly used by people that live at the shores of Lagos Lagoon for the control of insects that are vectors of diseases, including malarial mosquitoes and the ectoparasites that transmit typhus. Such is the situation at one of the sampling locations (plate 2) at Okobaba, which is a slum settlement that is highly exposed to mosquitoes and other vectors of diseases. This location is also expected to have an appreciable level of OCs.

The objective of this study is to investigate the occurrence of organochlorine pesticide residues in the biotic and abiotic components of Lagos lagoon.

MATERIALS AND METHODS

Sample locations

All samples were collected from four different locations namely, UNILAG lagoon front (UNLF), Okobaba, Iddo, and UNILAG Highrise lagoon frontage (UNHRLF). A Global Positioning System (GPS) was used to identify the coordinates of the sample locations.

Fig. 1: Sample location at Iddo

Fig. 2: Sample location at Okobaba

Sample collection

Surface water sample was collected with the use of a well cleaned and sterilized amber bottle submerged at the water surface by hand. Randomly taken sample was homogenized to form a composite sample (1L) per location. The samples were stored at 4°C in a refrigerator, until they were ready for analysis.

Sediment samples were collected from the 0.5–10 m depth using a Van veen Grab sampler operated from a boat. Samples were air-dried and sieved through 2.0 mm stainless steel sieve. Then less than 63 μm soil samples were prepared using the 63 μm stainless steel sieve prior to analysis.

The phytoplankton and zooplankton were collected by the aid of sieve (Plankton net) dipped inside the water to up to 50 cm depth while the boat was on motion round the location for about 10 minutes**.** The samples were stored at 4°C in a refrigerator, prior to analysis.

Fish and benthic invertebrate samples were collected by trapping overnight; to give a representative sample of frequently consumed type. The samples were identified, weighed, measured, and stored below 4^{o}C prior to preparation and analysis.

Table 1: Fish and benthic invertebrate samples

S/N		**Sample location**	**Number of samples**	**Average Length (cm)**	**Average Body weight (g)**
1	*Pomadasys jubeluni* (*ikekere*)	Okobaba	2	18.30cm	81.g
2	*Chrysichthys nigrodigitatus* (silver catfish)	Okobaba	2	19.30cm	45.70g
3	*Tilapia guineensis* (tilapia)	Unilag lagoon front	2	13.20cm	44g
4	*Eleotris vittata* (orobo)	Unilag lagoon front	2	15.20cm	39.60g
5	*Sarotherodon melanotheron* (tilapia)	Unilag High rise	2	21.40cm	78g
6	*Pomadasys jubeluni (ikekere*)	Unilag High rise	2	14.90cm	34.40g
7	*Pomadasys jubeluni (ikekere*)	Iddo	2	15.58cm	47.70g
8	*Peneaus keraturus* (shrimp)	Okobaba	2	64.20cm	109.30g
9	*Machrobranchium Vollenloevensi* (shrimp)	Unilag lagoon front	2	23.80cm	13.0g
10	*Callinectes amnicola* (crab)	Iddo	2	19.30cm	50.0g
11	*Callinectes amnicola* (crab)	Unilag lagoon front	2	8.60cm	5.0g

Sample extraction

5g of sediment sample was weighed into a mortar and ground with 10g sodium sulphate anhydrous (previously muffled at 450^{o}C for 24 hours). This was extracted with 300 ml n-hexane/acetone (ratio 1:1) for 24 hours by soxhlet method. The extract was concentrated to approximately 2mL with rotary vacuum evaporator.

Fish, shrimp and crab samples were extracted based on United State – Environmental Protection Agency (US-EPA) method 8082A with a slight modification. 5 g of samples were weighed into a mortar and ground with 10 g sodium sulphate anhydrous (previously muffled at 450^{o}C for 24 hours) by column chromatography. This was extracted with 50 mL n-hexane/acetone (ratio 2:1) for 3 hours twice. The extract was concentrated to approximately 2 mL with rotary vacuum evaporator.

For water samples, separating funnels were used for extraction. 200 mL of water sample was extracted using separating funnel and 100 mL of dichloromethane twice. The extracts were combined and collected over glass funnel, glass wool and sodium sulphate anhydrous. The extract was concentrated using rotary evaporator to approximately 2 mL.

Two organisms, phytoplankton and zooplankton, in the water sample were filtered and then washed into a separating funnel and made up to 200mL with the filtrate and later extracted in a similar manner as the water sample.

Sample cleanup

The column chromatography was performed to remove interfering organic and polar species. A silica gel column (250 mm x 25 mm) was packed from the bottom up with glass wool, approximately 20g of activated silica gel and 5.0g anhydrous sodium sulphate used to capped it. The column was pre-rinsed with 30 mL of n-hexane before the sample was loaded. The first fraction was eluted with 20 mL of pentane for removal of aliphatic hydrocarbons and was discarded. The second fraction was eluted with 50 mL of n-hexane for OCs. The eluted extract was concentrated using a rotary vacuum evaporator to 2 mL.

Sample analysis

This was carried out using a Gas Chromatograph (Hewlett Packard 5890 series II) equipped with a ^{63}Ni Electron Capture Detector (ECD). A fused capillary column (RT x 5) of 30 m x 0.25 mm id with 0.5μm of stationary phase (5% diphenyl-95% dimethyl polysiloxane) was used for all the analysis. The column oven temperature was initially maintained at 180^{o}C for 1 min and programmed to increase at 10^{o}C/min to 225^{o}C then held for 10mins, and ramped to 250^{o}C at 10^{o}C min^{-1} and held for 10 min. The injector and detector temperature were maintained at 250^{o}C and 325^{o}C respectively. Purified nitrogen gas (99.99% purity) was used as carrier gas with flow rate of 1.0 mL/min.

Quality control

Certified standards (AccuStandards Inc, USA) with up to 18 congeners were used for calibration of the instrument. Resolved peaks were integrated using Agilent workstation software. The concentrations of analytes were determined by comparing the peak area of the samples and five level calibration curves of the OC standards. The correlation coefficient of the calibration curves ranged from 0.9975 to 0.9980. The peak identification was conducted by the accurate retention time of each standard.

RESULTS AND DISCUSSION

Percentage distribution of OCs in all samples

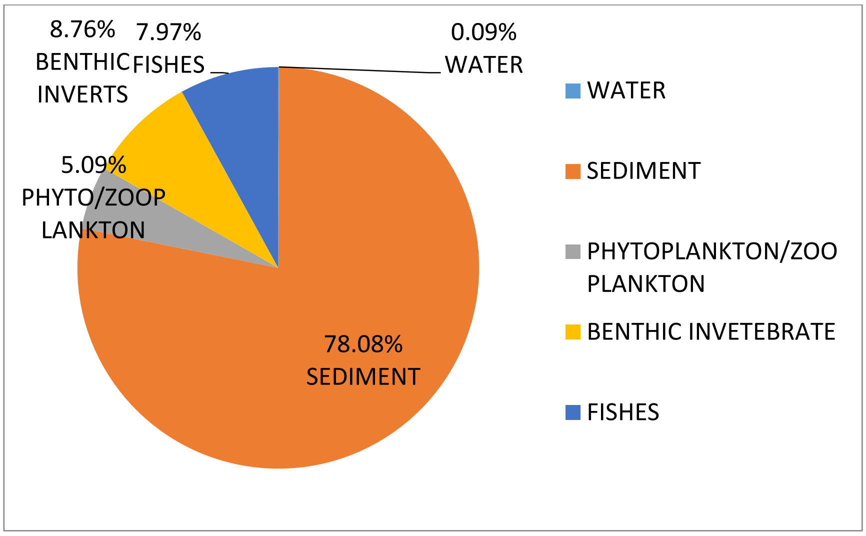

Fig. 3: Percentage Distribution of different OCs in different sample types

Figure 3 shows that sediment sample had the highest OC concentration of 78.08 %, water has the lowest of only 0.09 % phytoplankton/zooplankton had 5.09 %, benthic invertebrates had 8.76 %, and fishes 7.97 %. The percentage distribution indicated the level of organochlorine pesticide residues in the biotic and abiotic components of the Lagos Lagoon.

The organochlorines pesticides in water are absorbed by particulate matter and sedimented to the bottom of lagoons and lakes. (Murty, 1986). Moreover, organochlorine pesticide are hydrophobic, having less affinity for water and this could explain the reason why the level of OCs concentration is relatively low (only 0.09 %) in water when compared with other samples.

OCs residues were found to be significantly higher (78.08 %) in sediment samples than water and other samples analysed and this could be attributed to the fact that OCs are sequestered in water over time being denser than water and most significantly due to their hydrophobic properties. Phytoplankton as important biological indicator uptake OCs molecules from water by adsorption, absorption and partition between water and the phytoplankton intracellular constituents (lipids). OCs can eventually be transferred to zooplankton as they directly feed on phytoplankton. The relative lower concentration of OCs (5.08 %) in both phytoplankton and Zooplankton is an indication that they represent the lower aquatic tropic levels. Most benthic invertebrate feed directly on the phytoplankton, zooplankton and other invertebrates. They inhabit the sediment layers and are constantly exposed to elevated concentrations of organochlorine pesticides. This explains the reason for higher concentration (8.76 %) of OCs in benthic invertebrate compared with the level detected in fish samples. The percentage concentration of the OCs in fish was 7.97 %. The pesticides uptake in fish is either through bioconcentration from water through gills or epithelial tissues and bioaccumulation from water and through food leading to eventual biomagnification in different organisms, occupying successive trophic levels (Murty, 1986).

Level of organochlorine pesticides in Lagos lagoon water samples

Table 2: Distribution of OCPs in water sample

OCs	**Sample location and OC concentrations (µg/l)**				
	UNLF	**Okobaba**	**lddo**	**UNHRLF**	**Av. conc.**
α -BHC	0.15	0.15	0.15	0.15	0.15
β-BHC	0.48	1.24	0.30	0.02	0.52
lindane	0.00	0.69	0.00	0.00	0.17
δ-BHC	0.38	0.00	0.36	0.38	0.28
chlorothalonil	0.99	0.77	0.87	0.98	0.91
heptachlor	0.18	0.19	0.17	0.20	0.19
aldrin	0.02	0.04	0.01	0.01	0.02
heptachlor epoxide	0.01	0.00	0.00	0.00	0.01
endosulfan 1	0.05	0.05	0.00	0.02	0.03
dieldrin	0.03	0.03	0.03	0.03	0.03
p,p' -DDD	0.07	0.04	0.00	0.05	0.04
endosulfan 2	0.14	0.00	0.00	0.01	0.04
endrin	0.11	0	0.12	0.13	0.09
endosulfan sulphate	0.06	0.060	0.00	0.00	0.03
p,p' -DDT	0.12	0.00	0.00	0.00	0.03
methoxychlor	0.46	0.46	0.44	0.45	0.45
λ - cyhalothrin.	0.042	0.42	0.42	0.40	0.32
permethrin	0.00	0.00	0.00	0.00	0.00
Total	3.30	4.14	2.87	2.85	3.29

The result of water analysis indicated the occurrence of 17 out 18 standard OCs used for analysis. On average concentration; Chlorothylonil (0.9 µg/L), β-BHC (0.51 µg/L), methoxyclor (0.45 µg/L), λ-cyhanothrin (0.32µg/L), δ-BHC (0.28 µg/L), heptaclor (0.19µg/L), lindane (0.17µg/L), were detected in a relatively significant amount. DDT and its metabolites (DDE and DDD) were found in low concentrations. Water had only 0.9 % of the OCs present. The highest sum OC concentrations (4.14µg/L and 3.30 µg/L) were found in slum settlements of Okobaba and Unilag lagoon front (by the Ilaje end of Bariga) respectively. This showed that the use of organochlorine pesticides for insect vectors and pest control was relatively high around these two locations. At Unilag lagoon front, 0.12 µg/L p,p' –DDT was found. This value exceeded 0.00059 µg/L, which is the limit set by the USEPA water quality guidelines to protect the aquatic ecosystems (USEPA 1984). It also exceeded Environmental Quality Standard (EQS) concentration of 0.01 µg/L for water (Cole et al., 1999). This result is in agreement with that of Alani et al., 2013b, that reported 0.16 µg/L p,p' –DDT in Lagos lagoon water at Okobaba. High concentration of OCs at this location could therefore be attributed to the pattern of use, which is one of the factors that influence OC distribution, according to (Mackay et. al, 1997). The highest concentration of individual OC, 1.24 µg/L of β-BHC, was also found at Okobaba. OCs are very useful for the treatment of timber against wood boring insects (Walker, 2009). This was also a likely source of OCs at Okobaba where wood business is the major business of the inhabitants.

Level of organochlorine pesticides in Lagos lagoon sediment samples

Table 3: Distribution of OCs in sediment samples

OCs	**Sample Location and OCs concentration (µg/kg)**				
	UNLF	**Okobaba**	**lddo**	**UNHRLF**	**Av. conc.**
α -BHC	4.86	3.63	3.39	2.78	3.67
β-BHC	50.21	25.44	36.89	34.95	36.87
lindane	1197.33	3147.63	2045.53	303.83	1673.58
δ-BHC	8.36	0.00	0.00	0.00	2.09
chlorothalonil	21.78	0.00	0.00	16.12	9.47
heptachlor	116.50	8.38	5.65	3.47	33.50
aldrin	0.11	0.00	24.67	1.10	6.47
heptachlor epoxide	0.39	4490.49	0.030	0.038	1122.74
endosulfan 1	1.71	0.00	0.31	0.41	0.61
dieldrin	103.91	0.48	0.54	22.32	31.81
p,p' -DDD	3.52	3.36	0.13	0.23	1.81
endosulfan 2	2.79	2.84	2.91	3.02	2.89
endrin	3.59	2.36	3.11	2.39	2.86
endosulfan sulphate	2.80	1.29	1.45	1.11	1.66
p,p' –DDT	8.75	1.82	1.92	1.52	3.51
methoxychlor	15.21	11.60	11.95	9.01	11.95
λ -cyhalothrin.	16.68	8.51	0.00	8.09	8.32
permethrin	0.00	0.00	0.00	0.00	0.00
Total	1558.51	7707.84	2138.51	410.42	2958.82

Of all the OCs, only permethrin was not detected in the sediment samples. Just as in the water samples, the highest sum OC concentrations (7707.84 µg/kg and 1558.51 µg/kg) were found in the slum settlements of Okobaba and Unilag lagoon front respectively. Lindane was detected in highest amount at Okobaba while the occurrence of heptachlor epoxide (1122 µg /kg), and heptachlor (33.5 µg /kg), were also detected at higher concentration. α, β and γ BHCs were also detected but at lower average concentration. Endosulfan was observed to present at lower concentration. OCs residues were found to be significantly higher in sediment samples than water and other samples analysed and this could be attributed to the fact that OCs are sequestered from water over time.

Level of organochlorine pesticides in Lagos lagoon phytoplankton and zooplankton samples

Table 4: Distribution of OCs in Phytoplankton/Zooplankton samples

OCs	Sample Location and OCs concentration (µg/kg)				
	UNLF	Okobaba	lddo	UNHRLF	Av. conc.
α -BHC	0.54	0.25	1.44	0.95	0.79
β-BHC	2.27	18.64	3.93	2.64	6.87
lindane	0.65	0.19	42.38	1.42	11.16
δ-BHC	1.61	0.36	4.44	2.64	2.26
chlorothalonil	33.03	1.22	53.31	11.99	24.89
heptachlor	2.40	0.46	6.09	3.88	3.21
aldrin	8.69	4.06	22.20	14.81	12.42
heptachlor epoxide	5.08	12.58	1.33	5.62	6.15
endosulfan 1	7.25	5.39	0.00	10.64	5.82
dieldrin	10.12	34.85	0.00	0.00	11.24
p,p' -DDD	109.10	69.95	0.00	0.00	44.76
endosulfan 2	8.96	6.36	0.00	0.00	3.84
endrin	20.43	17.35	0.00	0.00	9.45
endosulfan sulphate	0.00	0.00	0.00	0.00	0.00
p,p' -DDT	0.00	0.00	0.00	0.00	0.00
methoxychlor	181.31	11.45	0.00	0.00	48.19
λ - cyhalothrin.	8.66	0.00	0.00	0.00	2.16
permethrin	0.00	0.00	0.00	0.00	0.00
Total	400.07	183.11	135.10	54.59	193.22

These two organisms are at the lowest trophic level in aquatic food webs and as expected most of OCs were detected in their samples. Phytoplankton as an important biological indicator easily binded with OCs molecules from water and the OCs can eventually be transferred to zooplankton as they directly feed on phytoplankton. All the OCs except permethrin, Endosulfan sulphate and DDT were detected in these samples. The average concentration was in the range (Non detected to 48.19 µg /kg). Methoxychlor was discovered to be at highest concentration of (48.19 µg /kg). It was followed by DDD-metabolite of DDT (44.76 µg/kg), chlorothalonil (24.88 µg/kg), aldrin (12.43 µg/kg), dieldrin (11.23 µg/kg), lindane (11.15 µg/kg), and endrin (9.44 µg/kg), (44.76 µg/kg), α, β, and δ, BHC detected were (0.79 µg/kg), (6.86 µg/kg), and (2.26 µg/kg) respectively.

Level of organochlorine pesticides in Lagos lagoon benthic invertebrate samples

Table 5: Distribution of OCs in benthic invertebrate samples

OCs	Sample Location and OCs concentration (µg/kg)			
	UNLF-crabs	Okobaba-shrimps	Iddo-crabs	Av. conc.
α -BHC	5.81	4.71	5.91	5.48
β-BHC	3.072	10.12	0.32	4.50
lindane	6.75	12.04	6.71	8.50
δ-BHC	14.71	17.80	15.59	16.03
chlorothalonil	35.58	58.29	33.64	42.51
heptachlor	12.54	65.42	8.67	28.87
aldrin	1.93	10.48	0.56	4.32
heptachlor epoxide	0.22	13.86	0.36	4.82
endosulfan 1	1.36	9.02	1.78	4.05
dieldrin	2.22	5.43	1.34	3.00
P,P' -DDD	2.20	40.95	2.98	15.38
endosulfan 2	6.03	14.45	5.35	8.61
endrin	4.95	0.00	5.12	3.36
endosulfan sulphate	1.99	0.00	3.94	1.98
P,P' -DDT	2.98	328.31	34.65	121.98
methoxychlor	18.97	24.41	21.84	21.74
λ - cyhalothrin.	19.04	76.62	16.83	37.50
permethrin	0.00	0.00	0.00	0.00
Total	140.34	691.95	165.61	332.63

Crabs and shrimps, representing the benthic invertebrate were found to contain all OCs except Permethrin with total average concentration of (332.63 µg/kg). The most significant of all OCs detected was DDT (121.98 µg/kg), followed by chlorothalonil (42.50 µg/kg), λ-yhalothrin (37.49 µg/kg), heptachlor (28.87 µg/kg). Endosulfan sulphate (1.97 µg/kg), di-eldrin (2.99 µg/kg) were observed to be at low concentrations. BHC content in benthic invertebrate was (34.51 µg/kg)-all isomers added together. Relatively, the benthic invertebrate samples contain a substantial level of OCs and this indicates the level of transfer of OCs from water, sediment and organism from lower trophic level. This showed that benthic invertebrates are good biological indicators for aquatic pollution.

Level of organochlorine pesticides in Lagos lagoon fishes samples

Table 6: Distribution of OCPs in Fishes Samples

OCs	Sample Location and OCs concentration (µg/kg)						
	UNLF		Okobaba		Iddo	UNHRLF		Av. conc.
	Tilapia	*Orobo*	*Igangan*	*Ikekere*	*Ikekere*	*Tilapia*	*Ikekere*	
α -BHC	5.61	7.65	5.96	6.03	5.70	6.21	5.55	6.10
β-BHC	0.67	10.30	10.30	3.83	0.89	22.66	1.07	7.10
lindane	6.69	11.90	6.71	68.54	7.24	0.00	7.43	15.50
δ-BHC	33.89	17.46	14.32	15.20	14.46	15.28	14.76	17.91
chlorothalonil	14.53	72.97	31.45	41.26	33.65	40.01	34.72	38.37
heptachlor	10.44	64.02	7.70	7.97	9.96	7.31	26.48	19.13
aldrin	1.40	12.05	0.47	5.03	1.45	0.62	0.95	3.14
heptachlor epoxide	0.48	14.83	0.00	3.19	0.69	0.01	0.57	2.83
endosulfan 1	1.91	15.94	1.18	3.89	1.06	1.53	1.22	3.82
dieldrin	1.94	10.12	1.24	4.72	1.72	1.50	1.51	3.25
P,P' -DDD	5.16	82.80	0.34	19.4	0.34	4.22	4.34	16.66
endosulfan 2	5.87	17.74	5.65	13.95	5.28	6.14	7.98	8.95
endrin	4.95	16.57	0.00	8.32	4.42	4.47	0.00	5.53
endosulfan sulfate	19.77	23.28	3.36	9.46	2.02	2.33	0.00	8.62
P,P' -DDT	8.18	210.94	11.63	84.29	8.80	3.25	17.40	49.21
methoxychlor	18.96	49.50	21.38	25.08	183.24	18.35	20.00	48.07
λ - cyhalothrin.	18.15	169.20	26.40	77.85	17.68	15.68	16.25	48.75
permethrin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	158.63	807.28	148.11	398.03	298.62	149.59	160.24	302.93

Apart from permethrin, all the OCs were detected in the fish samples with an average concentration ranging from (2.82 to 49.21 µg/kg). The most significantly detected are DDT (49.2 µg/kg), λ-cyhalothrin (48.74 µg/kg), methoxychlor (48.07 µg/kg), chlorothalonil (38.37 µg/kg), heptachlor (19.12 µg/kg). Comparatively low level of heptachlor epoxide (2.82 µg/kg), aldrin (3.13 µg/kg), and dieldrin (3.25 µg/kg) were detected. In all *orobo (Eleotris vitata)* has the the total highest concentration of all OCs while *igangan* (*chrysichthys nigrodigitatus)* has the lowest concentration. The total average concentration in all fishes sample detected was 302.93 µg/kg. This was lower than the concentration of OCs in sediment and benthic invertebrate but higher than the average concentration detected in water and phytoplankton/zooplankton samples. This is an indication that OCs as persistent organic compound is transferable from lower trophic to higher trophic level along the food chain in aquatic environment and can as well bioaccumulate as the trend goes higher.

Sum OCs in all samples

Sum BHC was detected in highest concentration (1777.8 µg/kg). Followed by heptachlor epoxide (1134.39 µg/kg), sum DDT (207.13 µg/kg), methoxychlor (85.43 µg/kg) and chlorothalonil (83.84 µg/kg). Others present are Heptachlor (69.89 µg/kg), aldrin (223.87 µg/kg), endosulfan 1 (11.09 µg/kg), di-eldrin (46.50 µg/kg), endosulfan 2 (16.59 µg/kg), endrin (16.23 µg/kg) endosulfan sulphate (3.95µg/kg), λ- cyhalothrin (53.65 µg/kg). Permethrin was not detected at all in any of the Lagoon components. The high concentration of

DDT and BHC detected suggest an indication of their recent usage in the study area or might have recently transported through rivers and canals that discharge into the lagoon.

CONCLUSION

From the findings of this study, it can be concluded that organochlorine pesticides residues in the abiotic components of the Lagos Lagoon are high at locations close to slum settlements such as Okobaba and Ilaje end of Bariga, where these chemicals are highly used for wood treatment against pests and for combating insect vectors. The pesticide residues levels detected in the biota were below maximum residue limits and acceptable daily intake possibly due to their non-sedentary nature. The presence of organochlorine pesticide residues however indicates the need for continuous monitoring of pesticide levels in the environment for safety purpose.

RECOMENDATIONS

1. There is need for pesticides regulation and enforcement for the protection of the people and the environment.

2. Alternative options to control pests and vectors of human disease should be embraced.

3. Use of Integrated Pest Management (IPM) and Integrated Vector Management (IVM) approached should be adequately encouraged.

4. Continuous monitoring procedures to control solid waste and effluent discharged into the rivers and Lagos Lagoon should be put into place for safety.

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