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Distribution of organochlorine pesticides and polychlorinated biphenyls in the sediments of a tropical lagoon (The Grand-Lahou lagoon, Côte d'Ivoire)

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ABSTRACT
Objectives: The present study reports the concentration levels and distribution patterns of the organochlorine pesticide and Polychlorinated biphenyls (PCBs) residues in the surface sediments of the Grand-Lahou lagoon (Côte d'Ivoire).
Methodology and Results: Sediment samples were collected during two consecutive years (from April 2003 to May 2005) in ten stations spread along the Grand-Lahou lagoon system. The sediment samples were dried and extracted using hexane and anhydrous sodium sulfate. The technique of purification by adsorption using florisil as adsorbent was applied. The gas chromatograph GC-14 (Shimadzu) equipped with ECD (Electron Captured Detector) mode and having fused silica capillary column (SPB-608) was used for analysis.
Conclusions and application of the findings: The results revealed contamination of the surface sediments with several persistent organochlorine pesticides and PCBs. DDT and its metabolites (DDE and DDD), aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide, lindane, endosulfan I, endosulfan II, endosulfan sulphate are detected in most of the sample. Concentrations of the sediments were important for DDT and its metabolites. PCBs are more present in the lagoon than the organochlorine pesticides. Highest concentrations of organochlorine compounds are encountered, in the areas where the Grand-Lahou is under the influence of the Boubo River and many other streams that carry pollutants generated by agro-industrial units located on the shores of these ecosystems. In the opposite, the sector of the lagoon under the oceanic influence relatively receives fewer pollutants.

INTRODUCTION

Polychlororinated biphenyls (PCBs) and organochlorine pesticides are chemicals widely used in the world as a weapon of choice for the control of crop diseases (Ware, 1989), endemic and epidemic diseases (malaria infections, filariasis). They are considered as micro-organic pollutants (Keith and Telliard 1979; Oxynos *et al.,* 1989) because of their toxicity, their ecological effects and toxicological hazards (Khan, 1977). They are lipophilic and hydrophobic and they can reach harmful

concentrations in the aquatic environment, which in the short term may result in high organism mortality (Dejoux, 1988) and in the long term, adverse modifications of biological balances through bioaccumulation and biogeochemical processes (Vandenbroek, 1979; Osibanjo and Bamgbose, 1990). The group of organochlorine pesticides and PCBs are known to be stable, highly toxic and more or less persistent. They are found in all compartments of the environment (soil, water, air.) (Wu *et al.,* 1999, Jiang *et al.,* 2000 and Gao *et al.,* 2005) and are of great interest due to their chronic toxicity and bioaccumulation through the food chain and their long-range transport (Tanabe *et al.,* 1982). Organochlorine pesticides are also present in the tissues of all terrestrial and marine organisms for which they have potential risks (Tanabe *et al,* 1994; Kelce *et al.,* 1995; Vrecl *et al.,* 1996; Longnecker *et al.,* 1997; Nakata *et al.,* 2002; Turusov *et al.,* 2002; Jaga and Dharmani, 2003; Kunisue *et al,* 2004).

Organochlorine pesticides and PCBs tend to accumulate in coastal and estuarine areas that form important receiving environments. In these areas, the biogeochemical fate is controlled by soil inputs, hydrodynamic dilution, sedimentation and exchange interfaces as well as the carbon cycle and primary production (Tronczynski *et al.,* 1999). In Côte d'Ivoire, the coastal region is characterized by the presence of a system of lagoons, of which the most important are, from west to east, the Fresco, the Grand-Lahou, the Ebrié and the Aby lagoons. These ecosystems play an important role in fish and shrimp reproduction and are irreplaceable habitats for migratory and local birds (Kouassi, 2005). They are also important for the Cote d'Ivoire economy since they are used for fisheries, aquaculture, touristic and transport activities. Nearly 6 million people live on the banks of the Ivorian coastal lagoon system. Almost all industrial units in the country are located in the coastal areas. Domestic and industrial wastes generated by various anthropogenic activities are discharged without treatment into the lagoon environment, resulting in intense natural habitats degradation and in valuable species extinction and in the contamination by chemical pollutants (heavy metals, pesticides, etc.) of the coastal waters. Besides the coastal areas experience a rapid development of agro-industrial plantations (coffee, cocoa, palm oil, rubber and coconut) characterized by intensive use of agricultural inputs and pesticides. Runoff has drained into the adjacent areas (especially the coastal lagoons) sediment flows, rich in chemicals (pesticide residues). Alongside this farming pressure, the coastal lagoons of Côte d'Ivoire also undergo chemical pollution due to the development of horticulture and vegetable crops known as great fertilizer consumers. In Côte d'Ivoire, the questioning of organochlorine pesticides and PCBs in the degradation of the quality of the environment, including diffuse pollution was highlighted by Dufour (1982), Martin and Marchand (1985); Kaba, 1992 and Kaba and Kouakou, 1997) for the Ebrié lagoon and Dejoux in 1988 for inland waters. Organochlorine pollutants are often present in significant concentrations in the above mentioned ecosystems. Apart from the lagoon Ebrié, very little information is available to the Grand-Lahou lagoon which has on its shores many agro-industrial plantations and units of coconut processing. Pollutants generated from these anthropogenic activities may disturb the ecological balance of the lagoon. In addition, the use of pesticides in illegal fishing may also lead to the introduction of many chemicals (fertilizers, pesticides, heavy metals) in the coastal ecosystem. The objective of this study is to determine the level of the Grand-Lahou lagoon sediments contamination by organochlorine pesticides and PCBs.

MATERIALS AND METHODS

Study Site: The Grand-Lahou ecosystem (Figure 1), with an area of about 190 km², is located between 5°25'W and 5°10'N. It is actually a complex of four small lagoons (Figure 1) comprising:

- The Tagba lagoon located at the eastside, with a mean depth of 3 m. It covers an area of approximately 57 km². However, there are some areas (close to the inlet) as deep as 8 m. It communicates with the Atlantic Ocean and receives the Bandama River;
- The Mackey lagoon, with up to 2 m depth, is the shallowest. It receives waters from the Gô and Boubo

Rivers, has an area of about 28 km² and is connected to the Tagba and Tadjo lagoons;

- The Tadjo lagoon with an area of 90 km², is the largest. It is strongly influenced by the Boubo river;
- The Niouzoumou lagoon directly communicates with theTadjo lagoon. It is parallel to the barrier beach. It has an area of 15 km² and a maximum depth of 3 m. It connects to the Tagba lagoon by an artificial channel called Groguida canal. The Grand-Lahou lagoon is fed by the Bandama and the Boubo Rivers. The Bandama River has a total length of 1,050 km (Laé, 1982), a total catchment area of 97,000 km² and an annual average rate of about 172 m³/s (Girard *et al.,* 1971). The Grand-Lahou lagoon receives almost 10.10^9m³ of freshwater per year. According to Durand and Chantraine (1982), the Bandama River alone contributes to 95% of the continental inputs. The Boubo River is characterized by two flood seasons with an average flow of 29.10 m³/s in June and about 16 m³/s in November. Between the two flood periods, an inter-flood usually occurring during the month of August with an average flow of 13.01 m³/s. The Grand-Lahou lagoon also directly receives rainfall, which represents 5% of the continental inputs (Durand and Chantraine, 1982). It is connected to the Atlantic Ocean by a channel (Hie, 1986) whose width is between 150 and 200 m (Abe *et al.,* 1993). The oceanic waters volume penetrating in the lagoon has not been assessed.

The Grand-Lahou lagoon system is supplied with sediment from rivers, streams and runoff. The sediment is composed of sand and silt grain from 1.6 to 45.10^{-6} m. The channels, with depths between 3 and 5 m are covered with vases and clay to fine grains less than median 5.10^{-6} m (Abe *et al.,* 1993). The water content of these vases is high: 200 to 700% by weight of dry sediment. Minerals are found in decreasing order of importance, kaolinite and illite and montmorillonite swelling illite inter-layered; the calcite content of 0 to 15% depending on the presence of shells and molluscs. Pyrite is present in vases rich in organic matter. The organic matter is relatively abundant in fine sediments found in channels and ditches where its accumulation is related to the hydrodynamics, and in areas with high inputs of continental plant or planktonic debris. The concentrations are between 0 and 1% in sandy sediments and exceed 20% in vases (Abe *et al.,* 1993).

Sampling: The sediment sampling campaigns were conducted during two consecutive years (from April 2003 to May 2005) in ten stations (Figure 1) spread along the Grand-Lahou lagoon system. Sediment samples were collected using a metal tipper, packaged in aluminium foil and transported in an ice box to the laboratory. At the laboratory, the sediment samples were dried on aluminium foil at room temperature and stored in a refrigerator at 4°C for extraction.

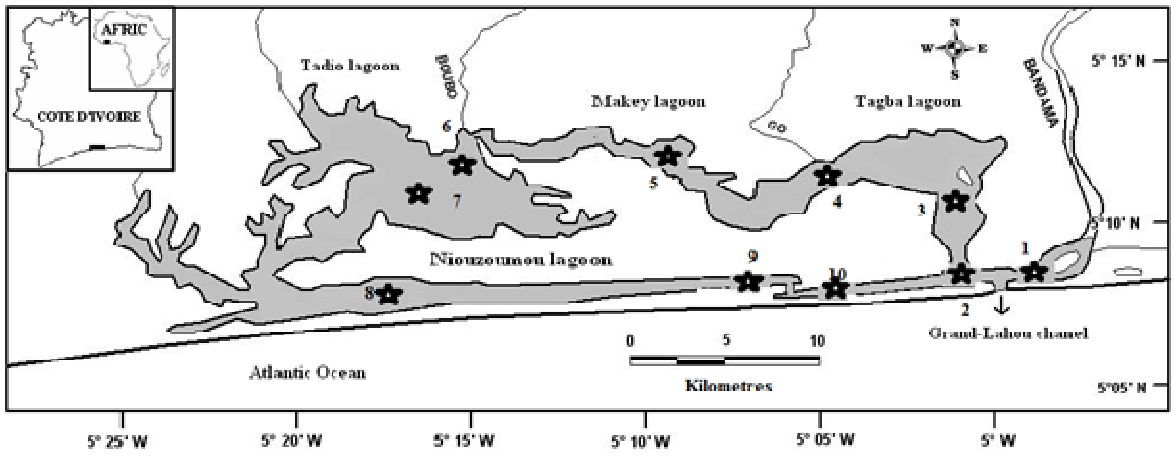

Figure 1: Sampling stations in the Grand-Lahou lagoon

Extraction and purification of organochlorine: Fifty grams (50g) of each dried sediment sample were weighed using a Mettler electronic balance in a glass Erlenmeyer previously washed and dried in the oven at 105°C for 24 hours. The dry sediment sample was ground in a porcelain mortar until a powder was obtained. The powder was sieved on 1 mm mesh to remove plant debris and greater diameter fractions having in order to obtain a homogeneous phase. Ten grams (10g) of homogenous powder were weighed in a beaker to which 25 ml of hexane was added. This was brought to a Ping-pong shaker for half an hour at room temperature. The

substrate obtained was allowed to stand for 10 min and heated in a separatory funnel to a liter equipped with Teflon tap to extract the organic phase. This phase was then filtered through anhydrous sodium sulfate in a 250 ml flask. This extraction process was repeated and brought to stirring for 1 hour. The extracts obtained during both extraction phases (25ml + 25ml) were evaporated to dryness under vacuum at 30-45° C using a rotary evaporator Buchi type until 1ml was obtained. The dry residues were taken up in 5 ml of hexane to be purified. The technique of purification by adsorption was used. It is based on the clean-up method in which florisil is used as adsorbent. Twenty grams (20 g) of florisil (60-100 Mesh ASTM/0.15-0.25 mm) were activated overnight in an oven at 130°C and then partially deactivated with 5% distilled water, agitated and equilibrated for 1 hour. The glass column, fitted with a Teflon valve with an internal diameter of 1 cm previously washed with distilled water and dried in an oven (130°C), is washed with 10 ml methanol and 10 ml of solvent (hexane). The column was filled in succession with glass wool, 20 g of florisil premixed with 100 mL hexane and 1g of anhydrous sodium sulfate obtained by heating at 500°C for more than 4 hours. The column was subsequently washed with 25 ml of hexane. The concentrated extract, thus obtained, was processed on the florisil chromatographic column. The extract was introduced in the column and the elution carried out with 25 ml of solvent. The migration of the solvent was drop wise. The eluate collected in a 250 ml flask was evaporated to dryness using a rotary evaporator Buchi type 45°C and concentrated with 1-2 ml of hexane, then kept in 5 to 10 ml-flasks and further treated with copper chips. To avoid interference of the peak due to the presence of sulfides, sediment samples were treated with copper chips.

Table 1: Mean recovery, standard deviation and detection limit of organochlorine pesticides and PCBs

Etalons	% de purity	c (µg/ml)	C (µg/ml)	Ci (µg/ml)	SD	J%	F%
α-HCH	99	20	19.64	19.66	0.188	1.800	0.957
β-HCH	99	20	19.72	19.74	0.246	1.400	1.247
δ-HCH	99	20	19.6	19.63	0.278	2.000	1.418
γ-HCH	99	20	19.61	19.62	0.214	1.950	1.091
ALDRINE	99	20	19.64	19.66	0.285	1.800	1.451
DIELDRINE	99	20	19.4	19.5	0.32	3.000	1.649
α-ENDOSULFAN	99	20	19.2	19.23	0.346	4.000	1.802
β-Endosulfan	99	20	19.52	19.55	0,419	2.400	2.147
Endosulfan sulfate	99	20	18.98	19.04	0.53	5.100	2.792
Endrine	99	20	19.9	19.94	0.608	0.500	3.055
Endrinealdehyde	99	20	19.6	19.67	0.543	2.000	2.770
Heptachlore	99	20	19.69	19.73	0.326	1.550	1.656
Heptachloreepoxyde	99	20	19.58	19.62	0.325	2.100	1.660
4,4' DDD	99	20	19.28	19.3	0.525	3.600	2.723
4,4' DDE	99	20	19.44	19.46	0.426	2.800	2.191
4,4' DDT	99	20	19.41	19.45	0.573	2.950	2.952
PCB (Aroclor 1260)	99	20	19.76	19.8	0.425	1.200	2.151

c	Weight of the standards obtained on a scalecalibratedto±10% uncertainty. This weight is equivalent to the concentration (µg/ml) of the mother solution.
C	Mean concentration of the standards obtained using the GC (µg/ml). The concentration was calculated from three (03) chromatographic measurements. Uncertainty±15%.
Ci	Mean standards concentrations (µg/ml) determined during the installation of the GC. Uncertainty±15%.
SD	Calculated standard deviation.
J%	Accuracy of the chromatographic measurements
F%	Fidelity of the chromatographic measurements

Analysis Procedures

Quality control: From concentrated standard organochlorine insecticides and PCB solutions (Aroclor 1260), standard solutions of known concentration (20 mg/ml) were prepared for external calibration. The calibration was checked by analysis of control solutions (calibration solutions) that determines the retention time for the identification of separated compounds (Traoré, 2000). The results allows the determination of the accuracy (J %) and repeatability (F %) of chromatographic measurements (Table 1). The results of the accuracy and the repeatability are less than 6% reflecting the good quality standards of analysis defined by the European Committee of Expertise (Traoré *et al.,* 2003). These results show the good quality of the analysis (their accuracy and repeatability).**Identification and quantification of PCBs and organochlorine:** The gas chromatograph GC-14 (Shimadzu) equipped with ECD (Electron Captured Detector) mode and having fused silica capillary column (SPB-608) was used for analysis. The column was of 30 m length, 0.53 mm internal diameter (ID) and film thickness: 0.25 microns. The carrier gas used was nitrogen (N_2> 99%) at a pressure of 1 bar and hydrogen (H_2> 99%) at a pressure of 1.5 bar. The injector and detector were respectively programmed to 220°C and 330°C. The column temperature was programmed gradually with time. It changes from 100°C to 150°C at 40°C/min; from 150°C to 230°C at 2°C/min and from 230°C to 250°C at 10°C/min. The initial time was 1 minute and the program time for the temperature of the column is 0 mn from 100°C to 150°C; 0 mn from 150°C to 230°C and 5 minutes from 230°C to 250°C. The attenuation is 8 and the inductor current is 0,5nA. The rate of progress of recording was 0.02 mm / min. The manual injection was performed in split less mode and the injection volume 1µl. The chromatograms obtained from the standard mixed solution were used as a reference and compared to those provided by the samples analyzed from the retention times of each compound. Compounds that were not on the chromatograms of the sample were either absent in the sample or their concentrations are lower than the retention limit (LD). The standard mixture solution is prepared from a commercial solution. This is used as dilute solutions girls. Quantification was done based on area count match with those known concentrations of the standards.

RESULTS AND DISCUSSION

The organochlorine pesticides found in the Grand-Lahou lagoon sediments were DDT and its metabolites (DDE and DDD), aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide, lindane, endosulfan I, endosulfan II, endosulfansulphate(Table 2 - 6). Mean lindane concentrations in surface sediments of the Grand-Lahou lagoon vary between 6.31 and 27 ng/l (Table 2). The sediments of the Tagba lagoon are relatively richer in lindane (9.62 to 27.04 ng/l) than the Mackey (10.3 to 20.5 ng/l), the Nioumouzou (6.41 - 11.27 ng/l), and the Tadio (7.06 to 10.2 ng/l) lagoons. Residual values of lindane in sediments studied in this work were lower than those reported in the lagoon in Ebrié 500-19000 ng/l (Marchand and Martin, 1985) and waters in Giza, Egypt (20,700 to 86,200 ng/l) (El-Kabbany *et al,* 2000.) and higher than those of the coastal waters of Alicante in Spain (1.3 - 2.3 ng/l) (Prats *et al*., 1992).

Table 2: Concentration (ng/L, dry wt) of lindane residues in the surface sediments of the Grand-Lahou lagoon

	α - BHC				**β - BHC**				**γ-BHC**				**δ - BHC**			
Lagoons	**m**	**min**	**max**	**Ec**	**m**	**min**	**max**	**Ec**	**m**	**min**	**max**	**Ec**	**m**	**min**	**max**	**Ec**
Tagba	13.69	2	30	7.34	26.21				27.40	1	100	33,19	9.62	2	30	7.46
Mackey	11	3	20	6.42	16	2	30	7.83	20.5	3	100	25,19	10.3	2	30	8.27
Tadio	9.81	2	30	8.39	7.06	2	10	3.49	9.31	2	30	7.19	10.23	2	20	6.35
Nioumouzou	10.3	2	30	6.79	11.27	2	30	7.42	10.85	2	20	6.31	6.41	2	20	4.88

Table 3: Concentration (ng/L, dry wt) of heptachlor residues in the surface sediments of the Grand-Lahou lagoon

	Heptachlor				Heptachlor (Epoxide)			
Lagoons	m	min	max	Ec	m	min	max	Ec
Tagba	9.16	2	30	7.62	23.15	2	100	39.48
Mackey	9	2	30	8.04	6.8	2	30	7.61
Tadio	8.41	2	E0	7.50	7.41	2	20	6.72
Nioumouzou	5.10	2	20	4.38	6.08	2	30	7.39

The γ-BHC and β - BHC are more present in sediment samples than the other lindane components (α - BHC and δ - BHC). This suggests that the γ-BHC and β - BHC are resistant to biodegradation (Dannenberger, 1996). The heptachlor epoxide was detected in the sediment samples of the Grand-Lahou lagoon (Table 3) at concentrations ranging between 6.08 and 23.15; while the concentrations of heptachlor, the precursor compound, vary between 5.10 and 9.16. The sediments of the Tagba lagoon are richer in heptachlor epoxide than those of the Mackey, the Tadio and the Niouzoumou lagoons. Sediment from the Tagba, Mackey and Tadio lagoons have the same concentrations in heptachlor. The level of heptachlor epoxide and heptachlor in the Nioumouzou lagoon is relatively low. Heptachlor epoxide concentrations in the Grand-Lahou lagoon are much lower than those observed in Nigeria 1845000 ng/l (Ojo, 1991) and in sediments of the Akumadan river sector in the Ashanti Region in Ghana with a concentration of about 6300 ng/L (Ntow 2001). Concentrations of endosulfan I, endosulfan II and endosulfan sulfate in the Grand Lahou lagoon sediments (Table 4) are respectively between 5.72 and 16.2 ng/l; 3.54 and 17 ng/l and 6 and 16 ng/l. The Mackey lagoon is richer in endosulfan than the other lagoons. Residual levels of aldrin detected in sediments of the Grand Lahou lagoon range from 2.2 to 10.6 ng/l. The values of dieldrin in sediments range between 4.32 and 7.4 ng/l. The sediments of the Mackey lagoon are relatively richer than those of the Tadio (5.07 ng / l), the Nouzoumou (5.48 ng/l) and the Tagba (4.32 ng/l) lagoons. These values are lower than those reported in Nigeria from 190,000 to 8,460,000 ng/l (Ojo, 1991), in the Ebrie lagoon (Côte d'Ivoire) (125 800 ng/l) (Kaba, 1992), in Lake NyumbayaMungu in Tanzania (3000-6000 ng/l) (Paasivirta *et al,* 1988) and in lakes in Uganda from 2000 to 39,000 ng/l (Sserunjoji, 1974; Sserunjoji-Ssebalija, 1976). The values of endrin in the sediment samples range from 3.70 ng/l to 6.9 ng/l (Table 5). The Tagba, the Mackey, and the Tadio lagoons have the same endrin concentrations. The sediments of the Nioumouzou lagoon are relatively poorer.

Table 4: Concentration (ng/L, dry wt) of endosulfan residues in the surface sediments of the Grand-Lahou lagoon

	Endosulfan I				**Endosulfan II**				**Endosulfan Sulfate**			
Lagoons	**m**	**min**	**max**	**Ec**	**m**	**min**	**max**	**Ec**	**m**	**min**	**max**	**Ec**
Tagba	5.72	2	20	5.71	7.47	2	30	8.17	8.34	2	20	5.87
Mackey	16.2	2	100	28.26	17	2	100	26.65	16	3	30	11.55
Tadio	10.87	2	10	9.09	3.54	2	10	3.20	6	2	10	4.27
Nioumouzou	6.45	2	30	8.22	9.18	2	39	6.62	10	2	20	6.92

Table 5: Concentration (ng/L, dry wt) of aldrin, dieldrin, endrin and endrin aldehyde residues in the surface sediments of the Grand-Lahou lagoon

	Aldrin				**Dieldrin**				**Endrin**				**EndrinAldehyde**			
Lagoons	**m**	**min**	**max**	**Ec**	**m**	**min**	**max**	**Ec**	**m**	**min**	**Max**	**Ec**	**m**	**min**	**max**	**Ec**
Tagba	9.57	2	40	10.52	4.32	2	20	3.,89	6.39	2	20	5.29	7.78	2	20	6.99
Mackey	10.6	3	30	9.66	7.4	2	20	5.55	6.9	2	10	3.52	21	2	200	54.13
Tadio	2.22	2	3	0.44	5.07	2	20	5.31	6.72	2	20	6.94	9.2	2	20	6.48
Nioumouzou	4.73	2	10	2.72	5.48	2	40	9.02	3.70	2	10	2.28	6.29	2	30	5.99

Individual levels of DDT and its metabolites (DDE, DDD) in the sediment samples are between 5.84 and 23.19 ng/l (Table 6). They remain small compared to the values observed in the Lekki Lagoon in Nigeria where the concentrations range from 449,000 to 566,000 ng/l (Ojo, 1991), in Lake Kariba in Zimbabwe with a level of about 740 10^3 ng/l (Matthiessen, 1982) and in the Ebrié lagoon (997 10^3 ng/l of total DDT) (Marchand and Martin, 1985). However, the concentrations are higher than those of the sediments from Alicante (<0.01 - 0.35 ng/l) (Prats *et al,* 1992.). The concentrations of 4,4 '-DDE and 4,4' DDT in the sediments of the Tagba and Mackey lagoons are highest. This shows that 4.4 DDE and 4.4 DDT are the most important metabolites of DDT; therefore resistant to degradation. The sediments of the Mackey lagoon are richer than those of the other lagoons presenting are more or less the same concentrations. The PCB concentrations vary between 93.55 and 312 ng/l (Table 6). The Mackey and Tadio lagoons are the most contaminated. The lowest concentration of PCB is recorded in sediments of the Niouzoumou lagoon. PCBs are synthetic materials having a common basic structure. They contain carbon, hydrogen and chlorine. Combinations of these atoms are multiple; hence, it is possible to form up to 209 different PCB, some more harmful than others. PCBs are generally very stable chemicals; this is what explains their persistence in the environment. At high temperatures, they can burn and generate hazardous by-products such as dioxins. Typically, the PCBs do not evaporate and will not readily dissolve in water. Nevertheless, they are readily soluble in fats and in other similar substances. Table 7 shows that the highest concentrations of organochlorine compounds are encountered, for all sampling campaigns in the Tagba and Mackey lagoons. These lagoons are located in the "so-called continental" part of the lagoon (Konan *et al.,* 2008) where the Grand-Lahou is under the influence of the Boubo river and many other streams that carry pollutants generated by agro-industrial units located on the shores of these ecosystems. The so-called "oceanic" sector represented by the Tadio and the Niouzoumou lagoons relatively receives less pollutants; it is under the influence of the oceanic waters.

Table 6: Concentration (ng/L, dry wt) of DDT and its metabolites and PCB residues in the surface sediments of the Grand-Lahou lagoon

	4,4' DDE				4,4' DDD				4,4' DDT				PCB (1260)			
Lagoons	**m**	**min**	**max**	**Ec**	**m**	**min**	**max**	**Ec**	**m**	**min**	**Max**	**Ec**	**m**	**min**	**max**	**Ec**
Tagba	23.19	2	100	38.54	6.7	1	20	6.31	21.92	2	100	31.18	144.19	10	500	125.98
Mackey	15.8	2	100	28.10	12	2	40	10.75	18	2	100	22.29	312	20	3400	687.33
Tadio	8.58	2	30	9.48	6.58	2	20	5.51	6.69	2	20	5.49	224.13	2	700	205.95
Nioumouzou	5.84	2	10	3.13	7.20	2	20	4.69	6.29	2	20	4.38	93.25	10	400	96.19

Tableau 7: Summary of organochlorine pesticides residues detected in the Grand-Lahou lagoon at different sampling location

	Lagoons			
Organochlorine Pesticides	**Tagba**	**Mackey**	**Tadio**	**Nioumouzou**
α - BHC	13.69	11	9.81	10.3
β - BHC	26.21	16	7.06	11.27
γ-BHC	27.4	20.5	9.31	10.85
δ - BHC	9.62	10.3	10.23	6.41
Heptachlor	9.16	9	8.41	5.1
Heptachlor (Epoxide)	23.15	6.8	7.41	6.08
Endosulfan I	5.72	16.2	10.87	6.45
Endosulfan II	7.47	17	3.54	9.18
Endosulfan Sulfate	8.34	16	6	10
Aldrin	9.57	10.6	2.22	4.73
Dieldrin	4.32	7.4	5.07	5.48
Endrin	6.39	6.9	6.72	3.7
EndrinAldehyde	7.78	21	9.2	6.29
4,4' DDE	23.19	15.8	8.58	5.84
4,4' DDD	6.7	12	6.58	7.2
4,4' DDT	21.92	18	6.69	6.29
∑(Pesticides Organoclorés)	210.63	214.5	117.7	115.17

This difference in concentration between the two above-mentioned poles can also be attributed to the quality of the sediment. The 'continental' sector is characterized by muddy sediments; while the ocean sector is much sandy. Hydrophobic residues that come into the aquatic environment are largely adsorbed by sediment. The adsorption depends on both the characteristics of the sediment, organic matter content (Pavilion, 1990 Sauvergain, 1981; Sarkar and Gupta, 1987, Herrmann and Thomas, 1984; Abarnou and Loizeau, 1994), of the particle size (Marchand *et al,* 1983 Marchand and Martin, 1985 Sauvergain, 1981) and the chemicals. The grain size greatly affects the level of contamination, because it determines the surface area available for adsorption of hydrophobic pollutants. The more the sediment grain size is fine, the more the concentrations of organochlorines are high (Herrmann and Thomas 1984; Abarnou and Loizeau, 1994). This study provides the preliminary information on the current contamination status of the Grand-Lahou lagoon by organochlorine pesticides and PCBs. The organochlorine pesticides found in the Grand-Lahou lagoon sediments are DDT and its metabolites (DDE and DDD), aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide, lindane, endosulfan I, endosulfan II, endosulfansulphate. The sector of the lagoon, under the influence of the rivers and streams and characterized by muddy sand, is more contaminated than the area under the oceanic influence with great size grain sediment.

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REFERENCES

Abarnou A and Loizeau V, 1994.La bioaccumulation : l'exemple des PCB. Oceanis. 20: 29-45.

Abe, J, Bakayoko, S, Bamba, SB, Koffi, KP, 1993. Morphologie et hydrodynamique à l'embouchure du fleuve Bandama. J.Ivoir. Océano.Limnol. Vol. 2(2): 9-24

Dannenberger, D and Lerz, A, 1996. Polychlorinated biphenyls (PCB) and organochlorine pesticides in sediments of the Baltic Sea and coastal waters of Mecklenburg-Vorpommerns. Deutsche Hydrographische Zeitschrift (German Journal of Hydrography) Vol 48 '1996) N°1

Dejoux, C, 1988.La pollution des eaux continentales africaines. Expérience acquise, situation actuelle et perspectives. Trav.Doc.Inst.Fr.Rech.Sci.Dév.Coop., (213): 513p.

Dufour P, 1982. Les frontières naturelles et humaines du système lagunaire Ébrié. Incidences sur l'hydroclimat. Hydrobiologia, 94: 105-120.

Durand J R and Chantraine JM, 1982. L'environnement climatique des lagunes ivoiriennes, Rev. Hydrobiol. Trop., 15 (2): 85-113.

El-Kabbany, S, Rashed,MM,Zayed,MA, 2000. Monitoring of the pesticide levels in some water supplies and agricultural land, in El-Haram, Giza (A.R.E.). Journal of Hazardous Materials. 72: 11-21

Gao, HJ, Jiang, X, Bian, YR, Wang, DZ, Deng, JC, Yan, DY, 2005. Residual levels and new inputs of chlorinated POPs in agricultural soils from Taaihu Lake region. Pedosphère. 15(3): 301 - 309

Girard,G, Sircoulon,J,Touchebeuf, P, Guillaumet,JL, Adjanohoun,E, Perraud, A,1971, (Eds.) : Le milieu naturel de la Côte d'Ivoire. Mémoire ORSTOM, Paris, 50: 109 – 155

Guzzella, L, De Paolis, A, 1994.Polycyclic aromatic hydrocarbons in sediments of the Adriatic Sea. Marine Pollution Bulletin 28, 159–165.

Herrmann, R and Thomas, W,1984.Behaviour of some PAH, PCB and organochlorine pesticides in an estuary, a comparison-exe. Devon Anal Chem; 319 : 152-9.

Hié, DJP, 1986. La pêche artisanale maritime. Rapp. Centre. Rech. Océanogr. Abidjan : 77-82

Jaga, K and Dharmani, C, 2003. Global surveillance of DDT and DDE levels in human tissues, Int. J. Occup. Med. Environ Health: 16: 7-20.

Jiang, X, Martens, D, Schramm, K, Kettrup, A, Xu, SF, Wang, LS, 2000. Polychlorinated organic compound (PCOCs) in waters, suspended solids and sediments of the Yantse River. Chemosphere. 41: 901 – 905.

Kaba, N, 1992. Résidus organochlorés dans les sediments de la lagune Ebrié autour d'Abidjan (Côte d'Ivoire). J. Ivoir. Océanol. Limnol. Abidjan 2,1.

Kaba N andKouakou,R, 1998. Accumulation of organochlorine compounds in oyster (CassostreaGasar) of estuarine environment:

Case of a tropical lagoon in the Gulf of Guinea. Chemistry and Ecology, 133: 1-13

Keith, LH andTelliard,WA, 1979.Priority pollutants. 1. A perspective view. Envir. Sci. Technol., 13:416–23.

Kelce, WR, Stone, CR, Laws, SC, Gray, LE, Kemppainen, J, Wilson, EM, 1995. Persistent DDT metabolite p, p'-DDE is a potent androgen receptor antagonist. Nature 375: 581-585

Khan, MAQ, 1977.Pesticides in aquatic environments. New York, Plenum Press, 257 p.126

Konan, SK, Kouassi AM, Adingra AA, Dongui BK, Gnakri D, 2008.Variations saisonnières des paramètres abiotiques des eaux d'˜une lagune tropicale : la lagune de Grand-Lahou, Côte d'Ivoire. European Journal of ScientificResearch, 21 (3) : 376-393.

Kouassi AM, 2005. Hydrochimie et qualité des eaux de deux lagunes tropicales de Côte d'Ivoire (Ébrié, Grand-Lahou).Thèse de Doctorat, Université de Cocody, Abidjan, 242 p.

Kunisue, T,Someya, M, Kayama, F, Jin, Y, Tanabe, S, 2004.Peristentorganochlorines in human in breast milk collected from primiparae in Dalian and Shenyang, China, Env. Pollut. 131:381 – 392.

Lae, R, 1982.Premières observations sur la pêche en lagune de Grand-Lahou. DEA Océanographie tropicale (Université de Brest), 30 p.

Longnecker, MP, Rogan, WJ, Lucier, G, 1997.The human health effects of DDT (dichlorodiphenyl-trichloroethane) and PCBs (polychlorinated biphenyls) and an overview of organochlorines in public health. Ann Rev Public Health 18:211–244.

Marchand, JC, Caprais, MA, Cosson-Mannevy, P,1983.Apports et distribution des résidus organochlorés à haut poids moléculaire dans la rade de Brest (milieu marin semi-fermé). Oceanol Acta; 6 : 269-82.

Marchand, M and Martin, JL, 1985. Détermination de la pollution chimique (hydrocarbures, organochlorés, métaux) dans la lagune d'Abidjan (Côte d'Ivoire) par étude des sédiments. Oceanogr Trop; 20: 25-39.

Nakata, H, Kawazoe, M, Arizono, K, Abe, S, Kitano, T, Shimada, H, Li, W, Ding, X,2002.Organochlorine pesticides and polychlorinated biphenyl residues in foodstuffs and human tissues from China: status of contamination, historical trend, and human dietary exposure. Archives of Environmental Contamination and Toxicology 43, 0473 – 0480

Ntow, WJ, 2001.Organochlorine pesticides in water, sediment, crops and human fluids in a farming community in Ghana. Arch. Environ. Contam. Toxicol. 40, 557-563.

Ojo, OO, 1991.Bottom sediments as indicators of chemical pollution in Lekki Lagoon. MSc. Thesis. Department of Chemistry, University of Ibadan, Nigeria

Osibanjo, O andBamgbose,O, 1990. Chlorinated hydrocarbons in marine fish and shellfish of Nigeria. Mar. Pollut. Bull., 21:581–6

Oxynos, K, Schmitzer,J, Kettrup,A,1989.Guidelines for environmental specimen banking in the Federal Republic of Germany, Federal Environmental Agency, Berlin

Paasivirta, J, Palm H,Paukku, R, 1988.Chlorinated insecticide residues in Tanzanian environment. Tanzadrin. Chemosphere, 17(10):2055–62

Pavillon, JF, 1990.Problématique de la biodisponibilité des polluants dans les sédiments. Oceanis. 16 : 287-304.

Prats, D, Ruiz, F, Zarco, D, 1992. Polychlorinated biphenyls and organochlorine pesticides in marine sediments and seawater along the coast of Alicante, Spain. Marine Pollution Bulletin 24 (9): 441 - 446

Sarkar Aand Gupta, RS, 1987.Chlorinated pesticide residues in sediments from the Arabian sea along the central West Coast of India. Bull EnvContamToxicol. 39 : 1049-54.

Sauvergain, P,1981. Les micropolluants organiques dans les eaux superficielles continentales. Rapport n° 2. Association francaise pour l'étude des eaux; 225 p.

Sserunjoji, JMS, 1974. A study of organochlorine insecticide residues in Uganda with special reference to dieldrin and DDT. Comparative studies of food and environmental contamination. Vienna, IAEA, STI/PUB/348, pp 43–8

Sserunjoji-Ssebalija, J, 1976.Environmental insecticide residues from tsetse fly control measures in Uganda. Dans Trace contaminants of agriculture, fisheries and food in developing countries. Vienna, IAEA, STI/PUB/454, pp 69–71

Tanabe, S, Tatsukawa, R, Kawano, M, Hidaka, H, 1982.Global distribution and atmospheric transport of chlorinated hydrocarbons: HCH

(BHC) isomers and DDT compounds in the western Pacific, eastern Indian and Antartic oceans, J. Ocean. Soc. Japan 38, 137–148.

Traoré, SK, Mamadou, K, Dembele, A, Lafrance, P, Banton, O,Houenou,P, 2003. Étude comparative du niveau de résidus des pesticides organochlorés chez trois espèces de poissons du lac de Buyo (sud-ouest de la Côte d'Ivoire) et estimation du potentiel de risque pour la santé humaine. J Soc Ouest-AfrChim. 16:137-152.

Tronczynski, J, Munschy, C, Moisan, K, 1999. Les polluants organiques qui laissent des traces: sources, transport. Programme Scientifique Seine-Aval , Fascicule 12, Ifremer, 39p

Turusov, V, Rakitsky, V, Tomatis, L, 2002. Dichlorodiphenyltrichloroethane (DDT): Ubiquity, Persistance, and Risks. Environmental health perspectives, 110: 125-128

Vandenbroek, WLF, 1979. Seasonal level of chlorinated hydrocarbons and heavy metals in fish and brown shrimps from the Medway estuary, Kent. Environ.Pollut., 21:21

Vrecl M, Jan J,Pogacnik, A, 1996.Transfer of planar and non-planar chlorobiphenyls, 4,4'-DDE and hexachlorobenzene from blood to milk and to suckling infants. Chemosphere 33(11):2341–2346.

Ware, GW, 1989.The pesticide book. 3rd Ed. Fresner, C.A., Thomson Publ., 336 p

Wu, Y, Zhang, J, Zhou, Q, 1999. Persistent Organochlorine residues in sediments from Chinese river/estuary systems. Environmental Pollution 105: 143 - 150