AJFAND ONLINE
Volume 10 No. 3
March 2010
ISSN 1684 5374
AFRICAN JOURNAL OF FOOD AGRICULTURE NUTRITION AND DEVELOPMENT

ASSESSMENT OF ORGANOCHLORINE PESTICIDES RESIDUES IN FISH SOLD IN ABIDJAN MARKETS AND FISHING SITES

Biego GHM*[1,2,3], Yao KD[1], Ezoua P[1] and LP Kouadio[2]

Henry Biego

*Corresponding author email: biegoh3@yahoo.fr

[1]Laboratory of Biochemistry and Food Science, UFR Biosciences, University of Cocody-Abidjan, 22 BP 582, Abidjan 22, Côte d'Ivoire

[2]Department of Public Health, Hydrology and Toxicology, UFR of Pharmaceutical andBiological Sciences, University of Cocody-Abidjan, BP V 34 Abidjan, Côte d'Ivoire

[3]Department of Public Health, Hydrology and Toxicology, UFR of Pharmaceutical andBiological Sciences, University of Cocody-Abidjan, BP V 34 Abidjan, Côte d'Ivoire

AJFAND ONLINE
Volume 10 No. 3
March 2010
ISSN 1684 5374
AFRICAN JOURNAL OF FOOD AGRICULTURE NUTRITION AND DEVELOPMENT

ABSTRACT
This study aimed to investigate the organochlorine pesticide residues in fish sold in markets and fishing sites in Abidjan, Côte d'Ivoire. Pesticides are not only used in agriculture but also in public health for the prevention of malaria. However, pesticide residues may be found in foodstuffs. Contamination of foods by pesticides can give rise to carcinogenic, mutagenic and teratogenic effects. Pesticides are also accountable for toxic effects on the nervous, immune, reproductive, renal, hepatic and hematopoietic systems. For the present study, one hundred fish specimens representing five fish species collected from markets and fishing sites were analyzed. Analyses were performed with the help of a Gas Chromatograph (GC), brand Agilent Instruments 6890N equipped with two micro-electrons capture detectors (µECD), two Zebron capillary columns (ZB-5MS and ZB-1701P; 30 m x 0.25 mm x 0.25 µm), an automatic injector and monitored by a microcomputer equipped with the ChemStation plus software version 2002. The injection was done in Splitless mode and Nitrogen N50 was used as vector gas. Of the 16 organochlorine pesticides considered in this study, 11 were present in the samples analyzed, at various concentrations ranging from 0.4 to 14.4 $\mu g.kg^{-1}$ of fresh product. Samples were mostly contaminated by Dichloro Diphenyl Dichloroethane (DDD). The catfish, with a total average concentration (27.2 $\mu g.kg^{-1}$ of fresh product) was the most contaminated species. Heads (27.8 $\mu g.kg^{-1}$ of fresh product) and viscera (17.5 $\mu g.kg^{-1}$ of fresh product) were, respectively the most contaminated parts of the fish species analyzed. The fishing port of Vridi was the most contaminated site. The species collected on this site presented a total average concentration of 24.4 $\mu g.kg^{-1}$ of fresh product. The comparison of total concentration mean of organochlorine pesticides in species collected, with the maximum residue limits (MRL) set for the fishery products, suggests that health risks faced by populations in Abidjan through fish consumption are currently low.
Key words: Organochlorine pesticides, GC, Fish, Consumption

INTRODUCTION
Pesticides are products used for the protection of plants, the fight against pests and the preservation of foodstuffs during storage. Residues deriving from their use may be found in food products. Among pesticides, organochlorines such as Dichloro Diphenyl Trichloroethane (DDT) and Hexachlorocyclohexane (HCH), though prohibited, are still used by some Ivorian farmers. Such lipophilic compounds are persistent in the environment and are readily conveyed over long distances or bioaccumulated through the food chain [1]. Moreover, they tend to accumulate in living organisms and are known to be responsible for carcinogenic, mutagenic and teratogenic effects. They also have toxic effects on the nervous, immune, reproductive, renal, hepatic and hematopoietic systems [2,3,4,5,6].
Despite the Ivorian government's accession to international agreements on pesticides, including the Conduct Code of FAO and the Principle of Prior Informed Consent, all designed for the regulation of pesticides use and sale, residues of organochlorine pesticide are still found in almost all the compartments of the environment [7-14]. The presence of pesticides, particularly in the aquatic environment, is worrying. In fact, fishing is a profitable activity for both fishermen and fish sellers as well as for the Ivorian State. What is more, fishery products account for a large part in the Ivorian

diet (fish is the first source of animal protein for the Ivorian and its consumption is estimated at 15 kg/inhabitant/year) [15].

Current bibliographic data available in Côte d'Ivoire concerning organochlorine pesticides are mostly about annuity products such as coffee, cocoa, cotton, kola nuts, milk and milk products [8,12,16]. As of now, only few studies concerning residual organochlorine pesticides in the aquatic environment in Côte d'Ivoire have been undertaken [10, 17]. Therefore, this study contributes critically to the study of food contamination by pesticides in Côte d'Ivoire. It answers the concern of updating data relevant to the presence of organochlorine pesticides in the aquatic environment in general, and in fish, in particular.

MATERIAL AND METHODS

Sampling

Sampling was done on three fishing sites (Vridi port, Abobo-Doumé and Port-Bouët) and two markets (Adjamé and Marcory) in the city of Abidjan. These sites were selected according to the significance of the turnover realized by fishermen and fish sellers. Sampling focused on five fish species among the most consumed by the local population: carp (*Plectorbiuchus mediterraneus)*, catfish (*Chrysichthys spp*), sardine (*Sardinella aurita*), mackerel (*Scomber japonicus*) and tuna (*Thunnus obesis*). Five fish batches per site containing 25 different samples of fish (head, flesh, viscera and whole fish gutted innards) were collected for analysis. A total of 100 samples were analyzed in triplicate.

Reagents

Hexane 95% and deionized water of analytical grade provided by SDS and a mixed standard solution of 16 organochlorine pesticides (EPA 608 Supelco) concentrated at 20 $\mu g.L^{-1}$ were used. The standard solution was made up of the following pesticides: aldrin, alpha HCH [cyclohexane, 1,2,3,4,5,6–hexachloro-,(1α, 2α, 3β, 4α, 5β, 6β)], beta HCH [cyclohexane,1,2,3,4,5,6–hexachloride,(1α,2β,3α,4β,5α,6β)],deltaHCH [cyclohexane,1,2,3,4,5,6–hexachloride,(1α,2α,3α,4β,5α,6β)], lindane or gamma HCH [cyclohexane,1,2,3,4,5,6–hexachloride,(1α,2α,3β,4α,5α,6β)], dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, heptachlor, epoxide heptachlor, 4,4'-DDD[benzene 1,1'-(2,2 dichloroethylidene) bis 4-chloro], 4,4'-DDE[benzene 1,1'-(dichloroethylidene) bis 4-chloro], and 4,4'-DDT[benzene 1,1'-(2,2,2-trichloroethylidene) bis 4-chloro].

Instrumentation

The apparatus used was a Gas Chromatograph (GC) from Agilent Technologies 6890N mark, including an Agilent automatic injector 7683, two microelectrons capture detectors (µECD), and two capillary columns of Zebron (ZB-5MS and ZB-1701P; 30 m x 0.25 mm x 0.25 µm). This apparatus was monitored by a computer equipped with ChemStation plus software, version 2002. The injection was done in Splitless mode and Nitrogen N50 was used as vector gas. The operating conditions of GC were: inlet temperature 250°C, detectors temperature 310°C and injected volume 2 µL. The oven analytical conditions are presented in Table 1.

Extraction of pesticides

The samples, previously dried in an oven at 60°C for 48 hours, were crushed in Moulinex robot then homogenized. Next, 5 g sample powder was introduced in a centrifuge tube. Thereafter, 5 mL of isooctane and 15 mL of deionized water were added and the tube was shaken for 10 minutes at Top-Mix, then it was subjected to a centrifugal action for 10 minutes at a speed of 3500 revolutions per minute by a Dynac centrifuge. After that, 2 mL of supernatant were filtered on a cartridge containing 300 mg of florisil then eluted with 2 mL of a mixture of isooctane/diethyl ether (V/V; 85:15 mL). The resulting solution was concentrated up to 1 mL in a vial with nitrogen and stored in a refrigerator at 4°C before analysis. Each sample was analyzed in triplicate.

Validation procedure of the results

The quality control of GC and pesticides extraction was determined according to the International Standard Organization (ISO) method and included study of linearity, repeatability, detection limits, reproducibility, and extraction yield [18]. The linearity was tested between 0-15 $\mu g.L^{-1}$ with 4 calibration points (0, 5, 10 and 15 $\mu g.L^{-1}$). Ten separate assays with 5 µg of the standard solution added to the test solution were realized for the extraction yields. Thirty separate assays with 5 $\mu g.L^{-1}$ of standard solution were conducted for repeatability and reproducibility tests. Thirty assays from the blank were realized for detection limits according to the following formulae:

Limit of Detection (LD) = $m_b + 3\sigma$

Limit of Quantification (LQ) = $m_b + 10\sigma$

(m_b = average concentration with the blank ; σ = Standard deviation of blank values;

n=30)

Assessment of dietary intake of organochlorine pesticides

The appraisal of dietary intake was based on comparison of the Tolerable Daily Intake (TDI) established by the Joint FAO/WHO Expert Committee with the pesticide Daily Intake of a Great Consumer of fish (DIGC). The rule is that if a great consumer of fish is not exposed to health risks, the other individuals are not. The tolerable daily intake is a dose expressed according to the body weight and it alludes to the amount of a compound that can be ingested by an individual over a lifetime without appreciable health risks [19]. According to data by the Joint FAO/WHO Expert Committee, a great consumer of fish ingests at least 150 g of fish daily [20]. This figure times the total average concentration of a given pesticide equals the DIGC for this compound.

Statistical analysis

Statistical methods for the validation procedure

The average concentrations of pesticides were calculated with their standard deviations. The repeatability and reproducibility were assessed after the calculation of

variation coefficients. The Pearson correlation coefficient was also calculated to assess linearity. The extraction yield was deduced in comparison with the amount of pesticide added to the test solution.

Statistical method for the analysis of pesticides concentrations in samples

The criterion used to describe the level of samples contamination was the total concentration of organochlorine pesticides, calculated according to the collected fish species, the sampled parts of the fish and the sampling sites. The total concentration was obtained by summing the average concentrations of detected pesticides. The variability of total concentrations of organochlorine pesticides was studied by a one-way analysis of variance (species collected, sampled parts and sampling sites) that was performed according to the method ANOVA using the SPSS 12 software. The total average concentrations of pesticides were compared by the method of the least significant difference ($p<0.05$).

RESULTS

Validation procedure of the results

The detection limit of the 16 organochlorine pesticides considered was 2 $\mu g.L^{-1}$. The variation coefficients obtained for repeatability were between 1.0 and 1.6% and 2.4 and 4.2% for reproducibility. The extraction yields ranged from 94 to 97%. The limit of detection was 2 $\mu g.L^{-1}$ and the limit of quantification was 2.5 $\mu g.L^{-1}$.These results account for the accuracy of the gas chromatography technique used and the reliability of data obtained (Table 2).

Pesticides concentrations in fish samples

Fish species and sampled parts collected for analysis were slightly contaminated by organochlorine pesticides. The average pesticides concentrations found in the samples ranged from 0.4 to 14.4 µg/kg of fresh product (Table 3). Of the 16 organochlorine pesticides considered, five were not present in any sample of fish. The 11 pesticides found in the samples were lindane and its isomers (α, β and δ-HCH), heptachlor, epoxide heptachlor, aldrin, endosulfan II, endrin, DDD and methoxychlor. Of the 100 samples analyzed, 36 contained at least one of these 11 pesticides. DDD, heptachlor and δ-HCH were the most frequent pesticides in samples (Fig. 1).

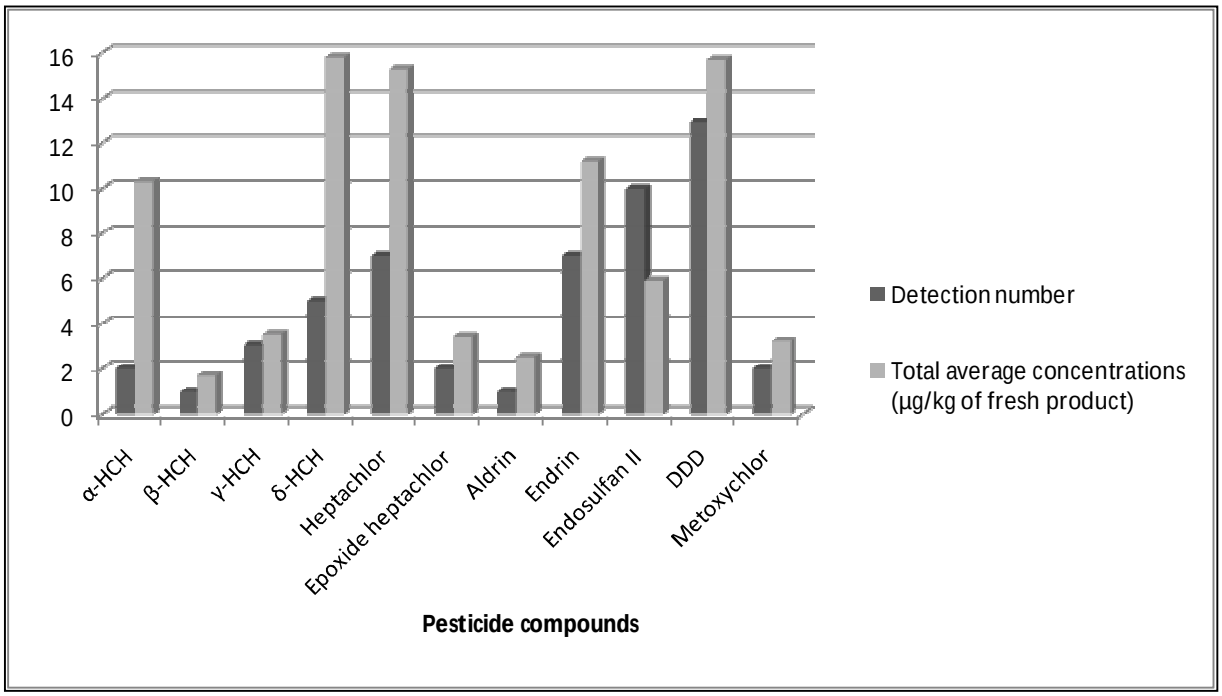

Figure 1: Incidence and amount of organochlorine pesticides detected in fish samples analyzed by gas chromatography

Contamination of sampled parts taken from fish

Heads (26.6 $\mu g.kg^{-1}$ of fresh product) and viscera (19.8 $\mu g.kg^{-1}$ of fresh product) were the most contaminated parts of fish species collected (Table 4). Organochlorine pesticides are lipid soluble compounds that naturally gather at the heads and viscera that appear to be richer in lipids. In fact, distribution of contaminants in the body depends on the lipid concentration of the different organs [21].

Contamination of the sampling sites

Vridi port (pesticides concentration: 24.4 $\mu g.kg^{-1}$ of fresh product) and Port-Bouët (pesticides concentration: 23 $\mu g.kg^{-1}$ of fresh product) are the sites from where the most contaminated samples were collected (Table 5). Indeed, fish collected from both sites reflected the actual contamination level of the Ivorian coastline whereas on the other sites, the contamination level was diluted by species from different origins.

The variability of total concentrations of organochlorine pesticides studied by a one-way analysis of variance revealed a significant difference ($p<0.05$) between the sampling sites, between the species and between parts of fish (Table 6).

Evaluation of health risks for consumers

Risks associated with the consumption of the collected species

Levels of organochlorine pesticides in the collected species were below the Maximum Residues Limits (MRL) established by the Joint FAO/WHO Experts Committee for fishery products (Table 7). According to this, the species considered could be

marketed. However, their consumption contributes to the daily intake of a great fish consumer in proportions that ranged from 0.02 to 21%. Endrin and heptachlor showed the highest percentage contributions. Indeed, the consumption of mackerel, carp and catfish contributed, respectively to 12, 20 and 21% of the Tolerable Daily Intake (TDI) in heptachlor while the consumption of tuna contributed to 17.8% of the TDI in endrin. All these fish species (mackerel, carp, catfish and tuna), readily available in most restaurants, are very much appreciated by all social strata in Abidjan. Tuna especially is essential for the concoction of Garba, one of the most appreciated meals in Côte d'Ivoire. Thus, the potential risks in case of a significant contamination would affect a large proportion of the population and specifically the most underprivileged. Except for endrin and heptachlor, the fish species consumption did not pose a health hazard.

Associated risks with the consumption of the edible parts

The consumption of the edible parts (heads and flesh) contributed to the daily intake of organochlorine pesticides of a great fish consumer at proportions between 0.03 and 16.8%. The contribution of the heads and flesh to Tolerable Daily Intake in heptachlor (respectively 15.9 and 10.5%) and in endrin (respectively 16.8 and 13.5%) were the most significant. The consumption of the flesh lessens the daily intake in endrin and heptachlor, respectively by 5.4 and 3.3%. Therefore, when it comes to choosing what part of the fish to consume, it seems less hazardous to eat the flesh rather than the heads of the fish species collected (Table 8).

DISCUSSION

The catfish, with a total average concentration of 27.4 $\mu g.kg^{-1}$ of fresh product, was the most contaminated species considered in this study. Organochlorine pesticides tend to accumulate in living organisms especially in aquatic organisms and they substantially settle on the sediments [10]. The catfish is a freshwater species whose habitat is at the level of sediments where it gets most of its food [22]. Thus, this fish and the freshwater species are naturally more exposed to contamination by organochlorine pesticides. The species collected were mostly contaminated by HCH (alpha, beta, delta and gamma), cyclopentadienes (aldrin, endrin, heptachlor and epoxide heptachlor) and DDD. The total average concentrations of these compounds were, respectively 31.3, 29.9 and 15.7 $\mu g.kg^{-1}$ of fresh product. DDD, like DDT from which it derives by degradation, is highly soluble in lipids and more accumulated in aquatic organisms [23]. The low concentrations of lindane are due to its quick breakdown by aquatic organisms [24]. A study conducted in 2003 by Traoré and collaborators [17] on 3 freshwater species (*Tilapia ziili, Chrysichthys walkeri et Niloticus spp*) from lake of Buyo (West of Côte d'Ivoire), revealed a significant contamination of these species by HCH (58.4-167.9 $\mu g.kg^{-1}$), dieldrin (31.6-436.8 $\mu g.kg^{-1}$), heptachlor (8.7-59.9 $\mu g.kg^{-1}$) and DDT (36.2-227.8 $\mu g.kg^{-1}$). The levels of contamination of the species they analyzed are above those established in the study. The high concentrations of organochlorine pesticides in Buyo Lake species can be explained by the location of this lake in an area where cocoa and coffee plantations are prevalent. Such plantations are known to use huge amounts of organochlorine

pesticides [8]. Another study by Marchand and Martin revealed a sizeable contamination of sediments in the Ebrie lagoon in Abidjan with DDD rather than DDT, demonstrating in this way a decreasing contamination by DDT [10]. Data from the present study seem corroborating the downwards trend of contamination of the aquatic environment in Abidjan by DDT. However, as suggested by Benbakhta the presence of DDD in all fish species collected in the markets of Abidjan originates from an ancient contamination with DDT, which gradually breaks down into DDD [19, 25, 26].

CONCLUSION

This study revealed a contamination of fish sold in markets and fishing sites in Abidjan by organochlorine pesticides, but not at risky levels. However, given that these toxic compounds are stable, soluble, and persistent in the environment, their presence in food, even in trace amounts, should be avoided. Furthermore, exposure to organochlorine pesticides is not only due to fish consumption. Consequently, in order for this study to be more informative and exhaustive, it would be helpful to extend it to the whole country and to other pesticides and foods. All these approaches will reveal the actual global exposure level of the Ivorian population to pesticides in order to assess short, medium and long term health risks. Preventive safety measures could be taken up accordingly.

Table 1: GC Oven analytical conditions

Oven ramp	°C/minute	Next °C	Hold minute	Run time
Initial	-	80	0.5	0.5
Ramp 1	30	175	0.0	3.67
Ramp 2	1.5	200	0.0	20.34
Ramp 3	3.5	280	4.0	47.2
Ramp 4	40	300	10	57.7
Post run	-	60	-	57.7

Table 2: Results of the validation procedures

Organochlorine pesticides	standard equation	r^2	CV (%) Repeatability	CV (%) Reproducibility	Extraction yield (%)
Alpha HCH	Y=717.86x	0.9932	1.3	3.6	96.1
Lindane	Y=706.19x	0.9981	1.0	3.3	97.3
Beta HCH	Y=355.26x	0.9952	1.5	2.6	9 9.0
Heptachlor	Y=855.17x	0.9988	1.2	2.6	94.9
Delta HCH	Y=719.8x	0.9994	1.4	3.1	96.0
Aldrin	Y=774.19x	0.9933	1.3	3.6	98.9
Endosulfan I	Y=711.19x	0.9968	1.5	2.4	96.6
Epoxide Heptachlor	Y=700.99x	0.9983	1.6	3.0	97.2
Endosulfan II	Y=1408.2x	0.9984	1.1	2.7	97.1
DDE	Y=636.28x	0.9944	1.2	3.9	98.4
Dieldrin	Y=1.0013x	0.9990	1.0	3.3	96.0
Endrin	Y=1.0030x	0.9990	1.3	3.3	94.0
DDT	Y=0.9983x	0.9990	1.2	4.2	95.3
Aldehyde endrin	Y=0.9995x	0.9990	1.4	2.6	98.6
DDD	Y=0.9981x	0.9990	1.2	3.9	98.4
Sulfate endosulfan	Y=0.9992x	0.9990	1.2	3.3	95.2

Table 3: Average concentrations (µg.kg^{-1} of fresh product) of organochlorine pesticides in fish species collected in Abidjan markets and fishing sites

Species / Pesticides	Carp (*Plectorbiuchus mediterraneus)*	Sardine (*Sardinella aurita*)	Catfish (*Chrysichthys spp*)	Tuna (*Thunnus obesis*)	Mackerel (*Scomber japonicus*)
α-BHC	-	-	-	3,0 ± 0	7,3 ± 0
β-BHC	-	-	-	-	1,7 ± 0
γ-BHC	-	-	0,8 ± 0	0,8 ± 0	1,9 ± 0,4
δ-BHC	-	2,2 ± 0	8,3 ± 0	-	5,3 ± 0
Heptachlor	4,6 ± 0	-	6,7 ± 2,2	-	4,0 ± 2,1
Ep. Hept.	2,4 ± 0	1,0 ±0	-	-	-
Aldrin	-	-	2,5 ± 0	-	-
Endrin	-	1,3 ± 0	1,4 ± 0,2	7,1 ± 5,2	1,4 ± 0
Endosulfan II	1,0 ± 0,1	2,1 ± 0	0,6 ± 0	1,6 ± 0,2	0,6 ± 0
DDD	3,5 ± 2,4	2,4 ± 1,1	6,7 ± 3,	1,5 ± 0	1,6 ± 0
Métoxychlor	2,8 ± 0	-	0,4 ± 0	-	-
TOTAL	**14,3**	**9,0**	**27,4**	**14,0**	**23,8**

Ep. Hept. : Epoxide Heptachlor

Table 4: Average concentrations (µg.kg^{-1} of fresh product) of organochlorine pesticides in fish body parts collected in Abidjan markets and fishing sites

Fish parts / Pesticides	Head	Flesh	Viscera
α-BHC	-	-	5,2 ± 2,2
β-BHC	-	-	-
γ-BHC	2,4 ± 0	0,8 ± 0	1,2 ± 0,4
δ-BHC	5,3 ± 0	-	5,3 ± 3,1
Heptachlor	5,3 ± 0,2	6,5 ± 2,3	1,1 ± 0
Ep. hept.	-	-	2,4 ±
Aldrin	2,5 ± 0	-	-
Endrin	6,7 ± 5,8	5,4 ± 3,2	1,2 ± 0
Endosulfan II	2,1 ± 0	1,6 ± 0,2	0,8 ± 0,2
DDD	2,3 ± 1,0	2,1 ± 1,1	2,2 ± 1,0
Métoxychlor	-	-	0,4 ± 0
TOTAL	**26,6**	**16,4**	**19,8**

Ep. Hept. : Epoxide Heptachlor

Table 5: Average concentrations (µg.kg^{-1} of fresh product) of organochlorine pesticides accorging to the sampling sites

Sites / Pesticides	Adjamé	Vridi-port	Marcory	Port-bouët	Abobo-doumé
α-BHC	3,0 ± 0	-	-	7,3 ±0	-
β-BHC	-	-	1,7 ± 0	-	-
γ-BHC	1,2 ± 0,4	2,1 ± 0,3	-	0,8 ± 0	-
δ-BHC	-	5,3 ± 0	5,3 ± 5,9	-	-
Heptachlor	5,2 ± 0,3	-	1,1 ± 0	9,7 ± 0	-
Ep. Hept.	1,0 ±0	2,4 ± 0	-	-	-
Aldrin	2,5 ± 0	-	-	-	-
Endrin	1,7 ± 0,4	11,4 ± 2,9	5,3 ± 3,0	1,5 ± 0,1	3,0 ±0
Endosulfan II	1,4 ±0	1,8 ± 0	1,1 ± 0,2	-	-
DDD	1,5 ± 0	1,4 ± 0,1	4,6 ± 2,4	3,6 ± 3,0	-
Métoxychlor	-	-	1,6 ± 1,2	-	-
TOTAL	**17,5**	**24,4**	**20,7**	**22,9**	**3,0**

Ep. Hept. : Epoxide Heptachlor

Table 6: Separation test of organochlorine pesticides concentrations (µg.kg^{-1} of fresh product): method of the least significant difference

Fish species	**POC**	**LSD**
Carp	9.0 α	3.4
Sardine	14.0 β	
Catfish	14.3 β	
Tuna	23.8 γ	
Mackerel	27.4 δ	
Fish parts	**POC**	**LSD**
Head	26,6 c	3.0
Viscera	19,8 b	
Flesh	16,4 a	
Sampling sites	**C**	**LSD**
Abobo-Doumé	3.0 v	3.4
Adjamé	17.5 w	
Marcory	20.7 wx	
Port-Bouët	22.9 xy	
Vridi-Port	24.4 y	

The means followed by the same letters are not significantly different at p<0.05

C: Organochlorine pesticide concentration (µg/kg of fresh product)
LSD: Least Significant Difference

Table 7: Comparison of Tolerable Daily Intake (TDI) with the Daily Intake of a Great Consumer of fish (DIGC)

		DDT	Lindane	Aldrin	Endrin	BHC	Heptachlor
	MLR[1]	200	100	200	10	200	200
	TDI [2]	1200	480	7	6	42	5
Head	Concentrations	2,3	2,4	2,5	6,7	5,3	5,3
	DIGC	0,3	0,4	0,4	1,0	0,8	0,8
	%TDI	0,03	0,08	5,36	16,75	1,89	15,9
Flesh	Concentrations	2,1	0,8	-	5,4	-	3,5
	DIGC	0,3	0,1	-	0,8	-	0,5
	%TDI	0,03	0,03	-	13,50	-	10,50

[1] Directive CE /22/2001 [27]

[2] Codex Alimentarius [20]

MLR: Maximum residue Limit ($\mu g.kg^{-1}$ of fresh product)

Concentrations: µg/kg of fresh product

TDI: Tolerable Daily Intake (µg/individual/day)

DIGC: Daily Intake of Great Consumers of fish (µg/individual/day) = 0.15 * C

%TDI: (DIGC/TDI)*100

Table 8: Comparison of Tolerable Daily Intake (TDI) with the Daily Intake of Great Consumer of fish (DIGC)

		DDT	Lindane	Aldrin	Endrin	BHC	Heptachlor
	MLR	200	100	200	10	200	200
	TDI	1200	480	7	6	42	5
Carp	Concentrations	3,5	-	-	-	-	7,0
	DIGC	0,5	-	-	-	-	1,1
	%TDI	0,04	-	-	-	-	21,0
Sardine	Concentrations	2,4	-	-	1,3	2,2	1,0
	DIGC	0,4	-	-	0,2	0,3	0,20
	%TDI	0,03	-	-	3,3	0,80	3,0
Catfish	Concentrations	6,7	0,8	2,5	1,4	8,3	6,7
	DIGC	1,0	0,1	0,4	0,2	1,2	1,0
	%TDI	0,08	0,03	5,36	3,5	2,96	20,1
Tuna	Concentrations	1,5	0,8	-	7,1	3,0	-
	DIGC	0,2	0,1	-	1,1	0,5	-
	%TDI	0,02	0,03	-	17,8	1,07	-
Mackerel	Concentrations	1,6	1,9	-	1,4	14,3	4,0
	DIGC	0,2	0,3	-	2,1	2,1	0,6
	%TDI	0,02	0,06	-	3,5	5,1	12,0

TDI: Tolerable Daily Intake (µg/individual/day)
Concentration (C): $\mu g.kg^{-1}$ of fresh product
DIGC: Daily Intake of Great Consumers of fish= 0.15 * C
%TDI: (DIGC/TDI)*100

REFERENCES

1. **Guzzella L, Roscioli C, Vigano L, Saha M, Sarkar SK and A Bhattacharya** Evaluation of the concentration of HCH, DDT, HCB, PCB and PAH in the sediments along the lower stretch of Hugli Estuary West Bengal, northeast India. *Environ Int.* 2005; **31 (4):** 523-534.

2. **Weisenburger DD** Human health effects of agrochemical use. *Hum Pathol*. 1993; **24 (6):** 571-576.

3. **Tanabe S, Tatbukawa R and H Hidaka** Global distribution and atmospheric transport of chlorinated hydrocarbons: HCH (BCH) isomers and DDT compounds in the Western Pacific, eastern India and Antarctic oceans. *J Oceanogr Soc Japan*. 1982; **38 (3):** 137-148.

4. **Dewailly E** Susceptibility to infectious and immune status in Inuit infants exposed to organochlorines. *Environ Health Perspect*. 2000; **108 (3)**: 205-211.

5. **Vine MF** Plasma 1.1 Dichloro-2.2-bis (p-chlorophenyl) ethylene (DDE) Levels and Immune Response. *Am J Epidemiol*. 2001; **153 (1)**: 53-63.

6. **Nordström M, Hardell L, Lindström G, Wingfors H, Hardell K and A Linde** Concentrations of Organochlorines Related to Titers to Epstein - Barr virus Early Antigen IgG as Risk Factors for Hairy Cell Leukemia. *Environ Health Perspect.* 2000; **108 (5)**: 441-445.

7. **PNM.** Plan National de mise en œuvre de la convention de Stockholm sur les polluants organiques persistants. Ministère de l'Environnement, des Eaux et Forêts. Côte d'Ivoire, Abidjan. 2006.

8. **Fleischer G, Andoli V, Coulibaly M and T Randolph** Analyse socio économique de la filière des pesticides en Côte d'Ivoire. Faculté d'Horticulture. Institut des Sciences Economiques. Université de Hanovre. Belgique, Hanovre. 1998.

9. **Direction Générale de l'Alimentation (DGAL)** Autorisation de mise sur le marché des produits phytosanitaires: guide des procédures. Institut National de Recherche Agronomique (INRA). Paris. 2000.

10. **Marchand M and JL Martin** Détermination de la pollution chimique (hydrocarbures, organochlorés, métaux) dans la lagune d'Abidjan, Côte d'Ivoire, par étude des sédiments. *Océanogr Trop*. 1985; **20 (1)**: 25-39.

11. **Mroueh M** Contribution à l'étude de la contamination des aliments par les pesticides en Côte d'Ivoire: dosage des insecticides organochlorés dans les céréales. Thèse de Pharmacie. UFR des Sciences Pharmaceutiques et Biologiques, Université de Cocody. Côte d'Ivoire, Abidjan. 1992.

12. **Houenou PV** De la Forêt aux Champs en Côte d'Ivoire: améliorer la gestion des ressources, améliorer la santé. Initiative de Programme Ecosystèmes et Santé Humaine. Centre de Recherches pour le Développement International (CRDI). Côte d'Ivoire, Abidjan. 2003.

13. **Sapozhnikova Y, Mawardi O and D Schlenk** Pesticides and PCBs in sediments and fish from the Saton Sea, California, USA. *Chemosphere*. 2004; **55 (6):** 797-809.

14. **Biego GH, Oga ASS, Claon JS, Agbo NG and LP Kouadio** Détermination des résidus de pesticides organochlorés dans les produits maraîchers retrouvés sur les marchés d'Abidjan. *Cah Santé Publique*. 2005; **4 (1):** 17-25.

15. **FAO.** Profil de la pêche par pays: cas de la Côte d'Ivoire. Food Agriculture Organization report FID/CP/CIV. Côte d'Ivoire, Abidjan. 2008.

16. **Traore SK, Dembele A, Mamadou K, Mambo V, Lafrance P, Bekro Y and P Houenou** Contrôle des pesticides organochlorés dans le lait et produits laitiers: Bioaccumulation et risques d'exposition. *Afr Sci*. 2008; **04 (1):** 87-98

17. **Traoré SK, Mamadou K, Dembele A, Lafrance P, Banton O and P Houenou** Etude 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-Afr Chim*. 2003; **16:** 137-152.

18. **ISO.** General requirements for the competence of testing and calibration laboratories. Report of International Organization for Standardization ISO/IEC 17025. 2005.

19. **Benbakhta B, Fekhaoui M, El Abidi A, Idrissi L and P Lecorre** Résidus de pesticides organochlorés chez les bivalves et les poissons de la lagune de Moulay Bousselham (Maroc). *Afr Sci*. 2007; **03 (1):** 146-168.

20. **FAO.** Residues in Food. Report of Joint FAO/WHO Food Standard Program.Vol.2B. Rome, (2005): 61-81.

21. **Serghini A, Mehdaoui O, Fekhaoui M and Y Venant** Le rôle des lipides dans l'accumulation des organochlorés: cas de l'anguille. *Biol Santé*. 2004; **4 (1):** 35-42.

22. **Amal EA** Le fumage du poisson en Côte d'Ivoire: étude du machoiron, fumage traditionnel et essais de four moderne. Thèse de Doctorat, Université Nationale de Côte d'Ivoire. Abidjan. 1963.

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

24. **Kammann U, Landgraf O and H Steinhart** Cyclic organochlorines in benthic organisms from the North Sea and the German Bight. *Analysis Magazine*. 1992; **20:** 70-73.

25. **Galindo-Bect MS and P Flores-Baez** DDT in *Mytilus edulis*: spatiotemporal variations in the Punta Banda estuary, Baja California, Mexico. *Bull Environ Cont Toxicol*. 1991; **46:** 179-184.

26. **Scrimgeour CJ, Wicklum D and SD Pruss** Selection of an aquatic indicator specifies to monitor organic contaminations in tropically simple lotic food webs. *Arch Environ Cont Toxicol*. 1998; **35 (4):** 565-572.

27. **Directive européenne**. Règlement CE N°22 portant fixation des teneurs maximales pour certains contaminants dans les denrées alimentaires. 2001,20p.