African Journal of Environmental Science and Technology Vol. 7(3), pp. 81-86, March 2013
Available online at http://www.academicjournals.org/AJEST
DOI: 10.5897/AJEST11.368
ISSN 1996-0786 ©2013 Academic Journals

Full Length Research Paper

Contamination of boreholes water by 76 pesticides molecules in the cotton zone of Kérou

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Accepted 23 August 2012

Analysis campaign of underground water was done in 2010 on five boreholes water samples situated in agricultural cotton zone. The obtained results showed the presence of various active matters of at least 76 residues of pesticides, especially insecticides, herbicides and fungicides, with accumulated contents which could average 0.350 or 350 µg/L per borehole. Indeed, all the prospected boreholes were contaminated. Every molecules of pesticides analyzed were present with at least 1 µg/L, some molecules concentration such as: aldrine (7 ± 0.7 µg/L), dieldrin (2 ± 0.7 µg/Ls), phorate (7 ± 2 µg/L) and terbufos (7 ± 1 µg/L), highly exceeded maximum residue limits. The most affected zones of the contamination of the underground water by pesticides were those areas where the cotton faming is practiced.

Keywords: Kérou, cotton farming, water of boreholes, pesticides.

INTRODUCTION

Human consumption, health and all activities depend on sufficient availability of quality water. Ground waters which are the main source of drinking water are supplied by the rainwater which penetrates with gravity in the pores and cracks of rocks. Ground waters are formed in the impermeable layers; the tablecloths (Bennabidate, 2000). One could access this subsoil through wells and drillings. In the study area there are 102 boreholes and 30 wells (Elegbede, 2007). This work proposes to focus on boreholes for certain reasons. First of all, the greater part of water consumption comes from boreholes in this big cotton area. The chemicals used for the protection of the cotton farming largely contributed to increase and regularize the agricultural outputs.

However, the agrochemical products were incriminated to be the cause of the degradation of the quality of surface and ground waters (Hani et al., 1997). Thus, insecticide residues of weed killers and fungicides were already detected in water reserves, for example, lakes, lagoons and even in the food (Calvert, 1992; Traore et al., 2003). The contamination of surface water was the consequence of pollution of the grounds by the plant health treatment (Bedding et al., 1983; Cabrindec, 1988). The infiltration of the polluted water into ground waters constitutes one of important subject nowadays. Especially when the plant health products were suspected to have undesirable side effects for human health and the environ-

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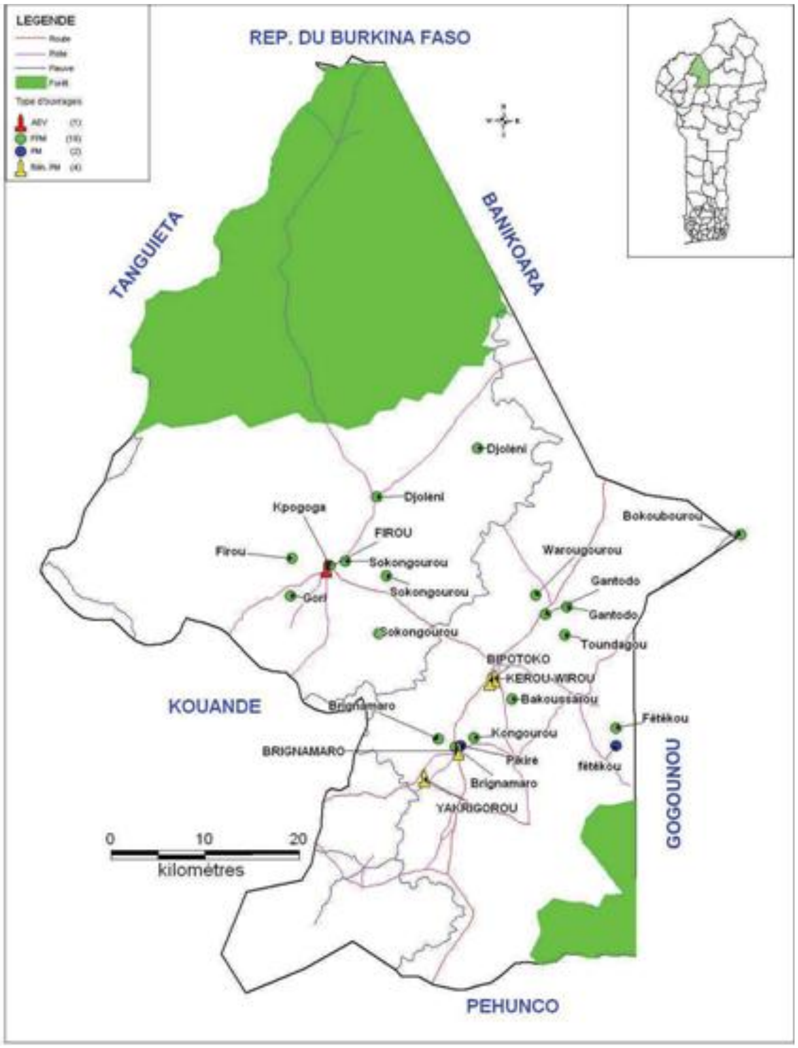

Figure 1. Location Map of the Study Area Showing Sampled boreholes.

ment (Gibons et al., 1987; Fournier et al., 2000). To evaluate the level of contamination of ground waters, a sampling campaign of borehole water was carried out last December 2010 in Kérou's Commune. The objective of this work is based on the identification of the residues of pesticides and their impacts on the quality of water.

MATERIAL AND METHODS

Study area

Figure 1 depicts the study area. Kerou lies on latitude 10°49′29″ North of the Equator and on longitude 2°06′30″ east of the Greenwich median. Kerou stands on the attitude of about 326 m above the sea level. Kerou municipality is limited at North- West by the Municipality of Tanguieta with which it shares the Pendjari Park and at North-East by the Municipality of Banikoara which is the largest producer of cotton at the national level. In the South, it shares its borders with the cotton belt of Pehonco, and Kouande Gogounou. It is divided into four districts that are Brignamaro, Kerou, Centre Kaobagou and Firou. The climate of the region is governed by the North Sudanese regime characterized by two distinct seasons: a dry one from October to April and a rainy one from May to September. The study area Kerou is the second largest producer of cotton at the national level; it is located in the water-shed of the Niger which is controlled by the stream tributaries of Pendjari such as Sota and Mekrou Rivers. Annual rainfall is around 900 to 1000 mm.

Its hydrogeology is dominated by Precambrian granitic-gneiss covered with a thick layer of clay-altered lateritic. Infiltration of rainwater is very intense due to the high density of the fracture network and the nature of the soil generally clay lateritic with high permeability. The crystalline basement consists of igneous and metamorphic rocks and is waterproof, facilitating runoff chemicals substances in the beds of rivers. These geological formations explain the nature and properties of soils which are extremely fragile. The area is dominated by cotton cultivation with uncontrolled use of pesticides and fertilizers. They are sometimes undeniable traces of metals found in the river and in groundwater.

Sampling and analysis

For economic reasons, water from four (4) boreholes and Mekrou River were chosen for the study and their waters were collected and analyzed.

Table 1. Distribution of drillings (F) in the districts of Kérou.

Borehole	District	Populations (PDC, 2006)	Area
F1	Firou	10.204	Gone Firou
F10	Kérou	27.889	Konigourou Centers
F14	Brignamaro	12.687	Ouinra-center
F16			Banbaba
F19			Mékrou River

The river Mékrou (F19) was chosen as control because the exchanges between the rivers and the underground water were permanent. Moreover the water of the Mékrou River is largely consumed by the cotton farmers because of difficult access to drinking water in spite of the efforts of different Government authorities of Benin.

These water samples were collected in December which was dry season in order to have a better assessment of the increment of the concentration of the molecules of pesticides. The water samples were collected with a sampler of glass and were transferred in ambers bottles washed thoroughly and decontaminated (Rodier, 1976; Keith, 1990; Saliot et al., 1992). An aluminum foil was placed on the neck in order to prevent every contact between the samples and the plastic stoppers. Samples were preserved in the ice during their movement and then preserved at 4°C till the time of analyses.

Measurements of temperature, pH, total hardness and electrical conductivity were performed in situ. The pH and the temperature were measured with the help of WTWLF-340 multi-parameter by submersing the sensor in the water. The conductivity was measured by a conductivity meter (WTWLF-340). Nearly, all the values of temperature, pH and conductivity recorded in the boreholes compared favorably with WHO standards for drinking water.

Analyses of residues of pesticides has been carried out by means of chromatography (gaseous phase) and spectrometry (CPG-5M and CPG- ECD). In order to detect several residues, CPG-SM has been added. A total of 76 molecules were found.

The water samples were collected with a glass sampler and were transferred in amber bottles which were washed and sterilized beforehand (Rodier, 1976; Keith, 1990; Saliot et al., 1992). An aluminum foil is placed on the neck in order to prevent any contact between the sample and the stopper of plastic. These samples were stored in ice during their transport and then preserved at 4°C until their analyses.

RESULTS

Table 1 illustrates the distribution of drillings (F1, F10, F14, F16 and F19) in the districts of Kerou.

The results of proportioning were presented in Table 2 and on Figure 2 (contents of different pesticides in water samples of boreholes), and Figure 3 showed cumulated contents of pesticides in water of boreholes. The analysis of the water samples of 5 drillings in the cotton zone of Kérou showed that 76 residues of pesticides were detected in approximately the totality of the drillings sampled close to the cotton plantations. As a whole, according to Table 2 and Figure 2, all the five prospected drillings were contaminated by pesticides. Different pesticides were detected at the same time in the water samples, which were main source of drinking water. The detected residues of pesticides (76) including: insecticides, weed killers and fungicides, with cumulated contents reaching a mean concentration of 0.345 mg/L per drilling, that is, 345 µg/L. The totality of prospected drillings is contaminated.

DISCUSSION

All the molecules of pesticides analyzed were present and the lowest concentration recorded was 1 µg/L. For some pesticides molecules, the concentrations largely exceed the permissive limit which is for aldrin (7 ± 0.7 µg/L), dieldrin (2 ± 0.7 µg/L), phorate (7 ± 2 µg/L) and terbufos (7 ± 1 µg/L).

Additionally, other insecticides such as DDT and its metabolites were also found in the analyzed samples. The weed killers and certain fungicides were detected with at trace levels. However, higher concentrations of these chemicals reaching 9 µg/L were found in some samples; this could be undoubtedly connected to the level of contamination of the grounds. The concentrations recorded in the drillings were relatively in the range of (345 µg/L); they were largely above the maximum permissive limits (2 µg/L). Average contents of HCH, one of the isomers of lindan, which was detected in all drillings were higher than the standard limit (0.1 µg/L). The endosulfan was detected in all contaminated samples of water. It was presented in its both isomer forms: α endosulfan and β endosulfan. The maximum concentrations measured in all the samples were respectively 1 and 4 µg/L. With regard to endosulfan sulphate, the concentrations were 7 µg/L in the water of Mékrou and 6 µg/L in drillings. Their presence in all drillings lets predict of a generalized use of these products despite the restrictions of their use. In addition, the persistence and the remanence of certain pesticides cannot alone explain the values recorded even if several concentrations do not exceed the standard for drinking water. According to Figure 3, the comparison of the concentrations recorded between zones makes it possible to identify the commune of Kérou with its 27,889 inhabitants as the most contaminated commune since it hosts the most contaminated drillings (363 µg/L). This concentration is 726 times higher than the permissive value which is 0. 5 µg/L. The other found residues of pesticides were sometimes specific to certain zones: dieldrin was especially recorded in Mékrou while aldrin was everywhere in the zone. Dieldrin concentrations were respectively 9 µg/L in the river and

Table 2. Results of proportioning of the water samples in pesticides.

Pesticide	Result on the level of drillings (mg/l)					Result on the level of drillings (mg/l)					Pesticide
	F10	F16	F1	F14	F19	F10	F16	F1	F14	F19	
2,4-DDE	0.005	0.003	0,007	0.004	0.003	0.008	0.006	0.009	0.009	0.009	Fensulfothion
2,4-DDE	0.002	0.009	0.001	0.006	0.006	0.007	0.008	0.004	0.004	0.004	Fenthion
2,4-DDT	0.003	0.004	0.004	0.002	0.002	0.001	0.001	0.001	0.001	0.001	Fonofos
4,4-DDE	0.009	0.006	0.009	0.006	0,006	0,005	0,004	0.006	0.006	0.006	Formothion
4,4-DDE	0.004	0.006	0.008	0.001	0.001	0.004	0.006	0.008	0.008	0.008	HCH alpha
4,4-DDT	0.006	0.001	0.004	0.004	0.005	0.004	0.002	0.002	0.002	0.002	HCH beta
Aldrin	0.006	0.008	0.007	0.009	0.009	0.008	0.006	0.004	0.004	0.004	Heptachlor
Azinphos-ethyl	0.001	0.002	0.001	0.001	0.001	0.005	0.001	0.002	0.002	0.002	Epoxy Heptachlor has
Azinphos-methyl	0.008	0.009	0.006	0.005	0.005	0.006	0.004	0.006	0.006	0.006	Heptachlor epoxy B
Bromophos	0.002	0.004	0.004	0.004	0.004	0.001	0.009	0.006	0.006	0.006	Hexachlorobenzene (HCB)
Bromophos-methyl	0.009	0.005	0.008	0.008	0.008	0.005	0.001	0.008	0.008	0.008	Iodofenphos
Carbophenothion	0.004	0.006	0.001	0.001	0.001	0.004	0.005	0.001	0.001	0.005	Isofenphos
Chlorbenside	0.005	0.004	0.006	0.006	0.006	0.006	0.004	0.005	0.005	0.005	Lindane (gamma HCH)
Chlorfenvinphos	0.006	0.008	0.004	0.004	0.004	0.007	0.008	0.004	0.004	0.004	Malathion
Chlormephos	0.004	0.002	0.003	0.003	0.003	0.009	0.001	0.004	0.004	0.004	Mecarban
hlorpyriphos ethyl	0.008	0.005	0.005	0.005	0.005	0.001	0.006	0.001	0.001	0.001	Methidation
Chlorpyriphos-methyl	0.002	0.004	0.001	0.001	0.001	0.006	0.004	0.005	0.005	0.005	Mevinphos
Chlorthiophos	0.005	0.006	0.006	0.006	0.006	0.008	0.003	0.004	0.004	0.004	Omethoate
Demeton-s-methyl-sulfone	0.004	0.007	0.009	0.009	0.009	0.002	0.005	0.001	0.001	0.001	Parathion
Dialiphos	0.006	0.009	0.002	0.002	0.002	0.006	0.001	0.006	0.006	0.006	Parathion-methyl
Diazinon	0.007	0.002	0.009	0.009	0.009	0.004	0.006	0.009	0.009	0.009	Pentachloroaniline
Dichlofenthion	0.009	0.004	0.001	0.001	0.001	0.009	0.009	0.006	0.006	0.006	Phorate
Dichlorvos	0.002	0.001	0.004	0.004	0.004	0.005	0.002	0.005	0.005	0.005	Phosalone
Dicofol	0.004	0.006	0.004	0.004	0.004	0.008	0.009	0.008	0.008	0.008	Phosmet
Dieldrin	0.001	0.009	0.001	0.001	0.001	0.008	0.001	0.006	0.006	0.006	Phosphamidon
Diethion Dimethoate	0.006	0.004	0.006	0.006	0.006	0.001	0.004	0.001	0.001	0.001	Profenofos
Dosimfptp.	0.009	0.006	0.009	0.009	0.009	0.004	0004	0.004	0.004	0.004	Propetamphos
Dotamoùfps	0.004	0.001	0.004	0.004	0.004	0.004	0.001	0.009	0.009	0.009	Pyrazophos
Edifenphos	0.006	0.004	0.006	0.002	0.002	0.008	0006	0.001	0.001	0.001	Pyridafenthion
Endosulfan alpha	0.001	0.001	0.001	0.001	0.001	0.004	0009	0.001	0.001	0.001	Pyrimiphos ethyl
Endosulfan beta	0.004	0.004	0.004	0.004	0.004	0.006	0.001	0.009	0.009	0.009	Pyrimiphos methyl
Endosulfan sulphates	0.001	0.002	0.001	0.001	0.001	0.007	0.006	0.001	0.001	0.001	Quinalphos
Endrin	0.004	0.001	0.008	0.008	0.008	0.006	0.004	0.005	0.005	0.005	Quintozene (PCNB)
Ethoprophos	0.002	0.008	0.002	0.002	0.002	0.001	0.003	0.005	0.005	0.008	Sulfotep
Etrimphos	0.001	0.002	0.005	0.005	0.005	0.004	0.005	0.004	0.004	0.004	Tecnazene
Fenamiphos	0.004	0.004	0.004	0.004	0.004	0.005	0.001	0.008	0.008	0.008	Terbufos
Fenchlorphos	0.001	0.002	0.003	0.003	0.003	0.001	0.006	0.006	0.006	0.006	Thiometon

1 µg/L in the districts. No residue was detected with concentrations lower than 0. 1 µg/L enforced by international organizations (standard for only one residue). Certain organophosphorous pesticides present the average concentrations highest in average sample, all zones together taken, with in particular the malathion (7 to 9 µg/L). The levels of these concentrations, could find their explanations in the abusive frequent use of these active molecules for the treatment of the cultures (Quinio, 1981, Diallo, 1993). Their detection in the medium, despite their capacity of being degraded quickly in the environment (Tomlin, 1997) represented not only their strong use but also the proximity of the plantations and sometimes the weak protection of the drillings. Organochlorine pesticides were also present in all contaminated water. The mean concentrations in the sample were 5 µg/L for lindane, 6 to 7

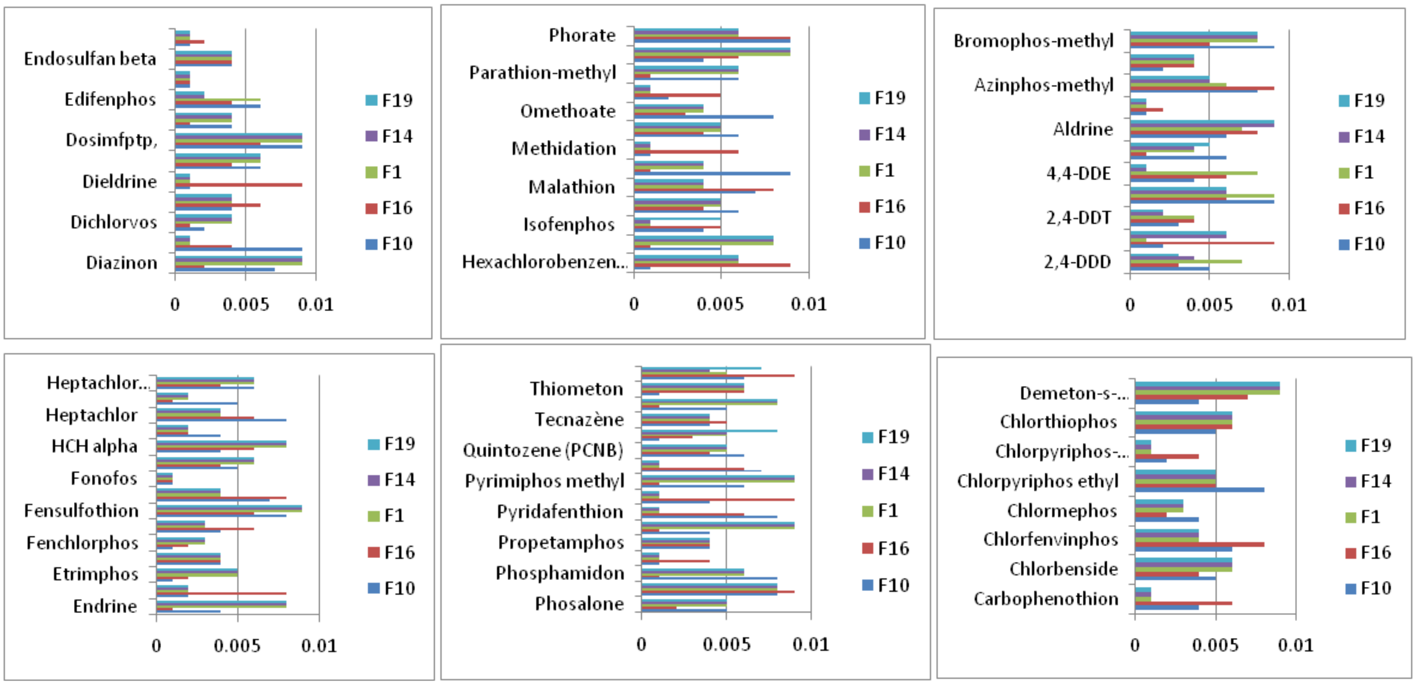

Figure 2. Contents of pesticides in water samples of boreholes.

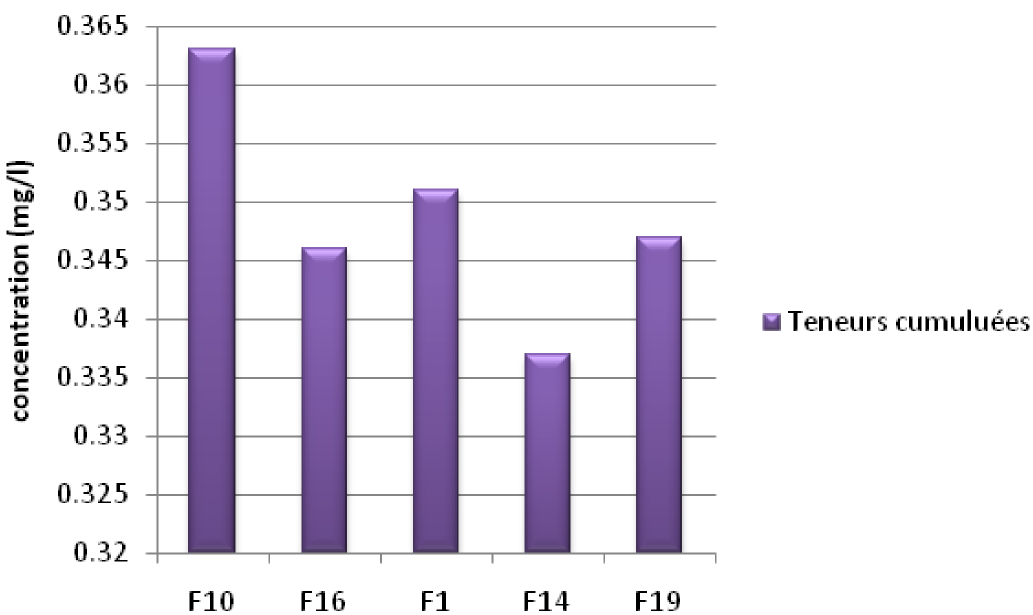

Figure 3. Cumulated contents of pesticides in water of boreholes.

µg/L for dosulfan, 4 to 8 µg/L for heptachlore and dieldrin rising up to 9 µg/L in the drilling of Brignamaro (F16). Their presence nowadays in spite of various bans on their use (Ramade, 1992; Tomlin, 1997) could be due to their persistence in the environment (Vennetier, 1988) or to a fraudulent use. The residues of pesticides are omnipresent in the majority of the sampled tablecloths. Approximately, some of the detected pesticides are prohibited since years (Vennetier, 1988) which indicates that they are no biodegradable and still persist in the ground and that they infiltrate slowly in ground waters or that they are still used fraudulently nowadays especially due to the leniency of the borders with Nigeria. In fact the case of organochlorine (endosulfan, lindane and heptachlor) pre-

prevails in water of the cotton zones. Elsewhere, the most remarkable pesticides are organophosphorous (profenofos and malathion) and others finally are insect-cides. This shows that in the zone, the cultures are very diverse (Vennetier, 1988) and occupy of large surfaces. That testifies to the many plant health problems that the cultures meet. Also they receive very intensive chemical treatments, in particular with the nematicides and fungici-des, the weed killers. The results of our analyses show that the subsoil water was of good quality contrary to the traditional belief which supposes that the ground removes from water all its contaminants at the time of its infiltration towards the underground tablecloth.

The moisture-holding capacity of the micropolluants by the ground was related to its chemical nature, with its lithographic structure, its high content in organic matter and the depth of the underground tablecloth. These re-sults were alarming in comparison with the recommen-dations on the quality of the water intended for human consumption (WHO, 1994).

These values of residues of pesticides in water obtained are higher than those recorded in Oueme River by Pazou et al. (2010) in Benin, aldrin (7 ± 0,7 µg/L), dieldrin (1 ± 0,7 µg/L), phorate (5 ± 2 µg/L) and terbufos (3 ± 1 µg/L).

The value for aldrin (7 ± 0.7 µg/L) obtained by N'Dong in the cotton zone of river Senegal is similar to that of Pazou et al. (2010).

However the results in the present investigation are by far lower than those of Adam et al. 2010, who recorded a mean value of 4 µg/L for dieldrin.

Conclusion

The analyses carried out on boreholes water showed a contamination of water by the pesticides with low dispa-rities of contamination according to the zone of culture considered, even if some boreholes were contaminated than others. Concentrations sometimes are higher than the maximum residue limits relative to the drinking water. This report constitutes one of the main public health pro-blems in the study area, because of the cumulative effects of these products on health. It is a growing concern, kno-wing that water is consumed in great quantity. There is thus a real risk to health. And this risk is higher as the molecules present were used more and more in signi-ficant quantity in the zone of studies and also stable in water. Added to this, the risk related to the vulgarizing made of the use of pesticides. It is advisable to recall that the most effective means to reduce the health risk remains the decline of the use of chemicals.

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