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Full Length Research Paper

Pollution of aquatic ecosystems by heavy metals at Ganvié's lacustrine city (Benin)

Hounkpatin[1*] A.S, Edorh[1,2] A.P, Sèzonlin[3] M, Guédénon[1] P, Elégbédé[4] B, Boni[1] G, Dougnon[1] V, Montcho[1] S, Kéké E, Boko[1] M.

[1]Interfaculty Centre of Formation and Research in Environment for the Sustainable Development (CIFRED), Laboratory of Toxicology and Environmental Health, University of Abomey-Calavi (UAC), 03 BP 1463, Jéricho, Cotonou, Benin
[2]Department of Biochemistry and Cellular Biology, University of Abomey-Calavi (UAC), 01 BP 526 Cotonou, Benin
[3]Genetic's Laboratory, Faculty of Sciences and Techniques, University of Abomey-Calavi (UAC), 01 BP 526 Cotonou, Benin
[4]Direction Départementale de l'Hydraulique, Ouémé-Plateau, 04 BP 1412, Bénin

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The lake city of Ganvié is facing environmental problems. Indeed, the deposition of all kinds of domestic and solid wastes, the fraudulent traffic of leaded gasoline through pirogues, the runoff waters from Cotonou city, and the effluents from Ouémé River are source of heavy metals contamination of the ecosystem. These toxic metals constitute a risk for this aquatic ecosystem through the chronic effects they are known to cause. The aim of this study is to assess the level of contamination of this ecosystem by heavy metals (lead and cadmium). Therefore, samples of water, sediment, and fish were collected and mineralized before their heavy metals (lead, cadmium) content were analysed using an atomic absorption spectrophotometer (Thermo Orion assisted by Solar S2 software) at the laboratory of Management, Valorisation and Treatment of wastes, Lomé University (Togo). The results revealed high concentrations in lead and cadmium above the safety norms in most of the samples. The different values expressed in mg/kg (fish, sediments) or mg/L for water) are: 0.56 and 0.03 (water), 54.04 and 0.74 (sediment), 26.85 and 2.01 (fish) for lead and cadmium, respectively. These results have shown the pollution of Ganvié aquatic ecosystem by lead and cadmium.

Keywords: Heavy metals, Lead, Cadmium, Pollution.

INTRODUCTION

Environment is contaminated by many chemicals of which the heavy metals, rejected by industries, agriculture and urban communities (Miquel, 2001). And Benin is not free from this plague (ABE/MEHU, 1998). The marine ecosystems, under strong anthropic influence, are very touched by this contamination. The pollution of the environment by heavy metals constitutes a significant source of concern for the international community. In the natural marine ecosystems, metals are with weak concentrations, generally of the order of the nanograms or micrograms per liter (Calamarie *et al.,* 1994). Nowadays, the presence of heavy metals is noted with concentrations higher than the natural loads. Several research tasks carried out revealed the presence with strong amounts of contaminants, in particular heavy metals in the moulds (Moustaid *et al.,* 2005); the snails (Agonkpahoun *et al., 2009)*; the water fishes (Hounkpatin *et al.,* 2012) (Gnandi *et al.,* 2007); (Adam *et al.,* 2010), the sediments (Edorh *et al.,* 2009). The marine ecosystems are vulnerable to metals, because these

*Corresponding author E-mail: harmelle2007@yahoo.fr; harmelle2011@gmail.com Tel: 00 (229) 93 91 64 64 / 95 49 35 77

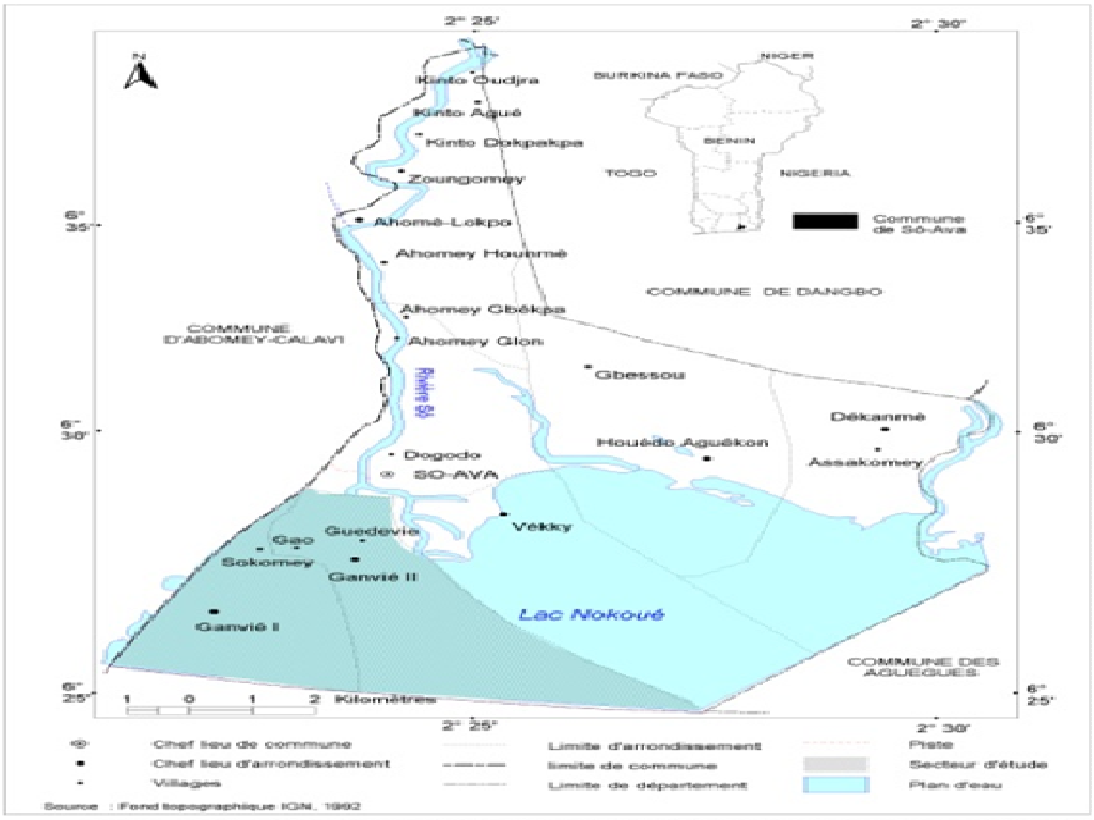

Fig. 1: Geographical situation of the lacustrine city of Ganvié in the township of Sô-Ava.

Insoluble metal's compounds can accumulate in the sediments, then to be released in pore water and to thus increase consumption of soluble metals or in suspension. This situation presents a real danger to marine fauna and the flora like for the man of made phenomena of bio-accumulation in the food chain (CEDA, 1997).

The human and industrial activities added to the demographic growth in the African countries particularly at Benin generated enormous environmental problems. They especially entrainé a fast increase in various pollutants (heavy metals) in the receiving urban water masses such as the lagoons, the rivers, the seas and the lakes (Salvad *et al.,* 2006); (Edorh *et al.,* 2011). This situation has adverse effects on the various components of the watery environment such as water, the sediments and the products halieutics (Saad *et al.,* 1985) and by rebound on human health. Indeed, lead, toxic element (Le Roux et al., Shotyk, 2005), can cause disorders neurological, hematologic, gastro-intestinal, reproductive's, immunological and apoptotic (Patrick, 2006); (Xu *et al.,* 2008). Recent studies, showed that lead inhibits the activity of the enzymes implied in the oxidative stress (Ercal *et al.,* 2001); (Bolin *et al.,* 2006). Other *in vitro studies* showed the increase in the production of the free radicals after treatment with inorganic Lead (Chen *et al.,* 2003). As for cadmium, it is toxic for the man because an excessive exposure could caused death (Othumpangat, *et al*., 2005). It is introduced into the cells and accumulates in great concentration in cytoplasmic and nuclear space (Satoh *et al.,* 2003). It has a strong affinity for the liver and the kidneys (Cai *et al.,* 2001). At the Man, the phenomenon of acute toxicity is known since 1950 under the name of syndrome of Itai-Itai defined by the association of a renal insufficiency with osteoporosis and osteomalacia. It is carcinogenic (Satoh *et al.,* 2002)*;* (Banerjee *et al.,* 2005) and teratogenic (Hovland *et al.,* 2000). The effect genotoxic and apoptotic was observed in several types of cells (Kim *et al.,* 2005); (Mondal *et al.,* 2005)

In addition, the population of Ganvié always estimated that water of the lake, their immediate environment constitute an ideal receptacle for the waste produced during their various natural, domestic or professional activities (Folal and Gonou, 2001). Indeed, the rejection of the household refuse and solid residues of any kind, the traffic of the petroleum products by dugout, discharges of petroleum products in the lake, pollution by excessive use of the motorized boats, the rejections of

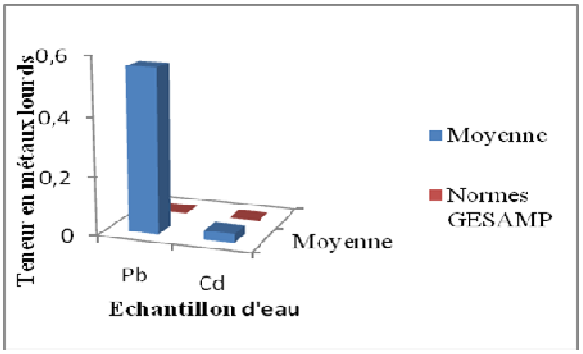

Fig. 2: Average content (mg/L) of Pb and Cd in the water samples

the drain pipes of rain water coming from the town of Cotonou, the contributions of the river, cause contamination potential of this ecosystem by heavy metals (Elégbédé, 2011).

About the risks of contamination of this watery system, even of the human organism via the consumption of halieutics products also contaminated by toxic metals, the evaluation of the pollution of the lake city of Ganvié is a need. The general objective of this study is to contribute to a better knowledge of the contamination degree of Ganvié by toxic metals (lead and cadmium) through the toxicological characterization of water, the sediments and some fish taken in the lake. The finality is to consider an evaluation and a prevention of the possible medical risks to which the population would be exposed.

MATERIALS AND METHODS

Setting of survey

The lacustrine city of Ganvié is situated on the Northwest of the lake Nokoué at Cotonou, to the West outlet of the Sô-Ava strand in the lake and on 11 kilometers of the Abomey-Calavi pier. It is limited: to the North by Sô-Ava, to the Northeast by the lacustrine village of Vekky, to the Northwest by the waters of the lake, to the East by the lacustrine village of Aguégué. At Benin, the Nokoué, situated in middle of the Cotonou city, sudden inevitably a telluric contribution importing but especially of dismissal of worn-out water, of fecal matters, of garbage of all ways. It represents the biggest plan of continental water of Benin and present two particularities to know: a production in fishes very elevated (18.046.22 tons on average from 1987 to 1997) (Folal and Gonou, 2001) and a strong lacustrine population organized in several villages with dwellings constructed on stilt directly implanted in water. Ganvié, one of villages most important of this lacustrine dwelling system has been kept for this survey. It has a population of 20568 inhabitants (INSAE, 2004) and represent a tourist place visited by many tourists what generates numerous anthropic activities.

Sampling and dosage

Ten samples of water and sediments; 6 samples of 5 different species of fishes have been taken at various points of the lacustrine city of Ganvié with a dugout. After the country samples of fishes collected have been cut up and been dried to the electric oven in a first time to 50°C during 12 hours past to 120°C during 24 hours. The level of contamination of sediments, water and fishes in lead and in cadmium has been determined by dosage to the atomic absorption spectrophotometer according to the method of Moustaid *et al.*, (2005). These works have been achieved to the Laboratory of Management, Treatment, and Valorization of Garbage (GTVD) at the University of Lomé (Togo).

Analysis and treatment of results

All data underwent some statistical treatments. The used software is SPSS, version 17.0. Averages, standard deviations have been calculated as statistical descriptive. Tests of conformity have been achieved with the test of Student to the doorstep of mistake of 5%.

After that, the gotten averages have been compared to norms fixed by GESAMP for water and sediments and to the norm CE 466/2001 for fishes.

RESULTS AND DISCUSSION

It is evident from the analysis of the fig. 2, the lead

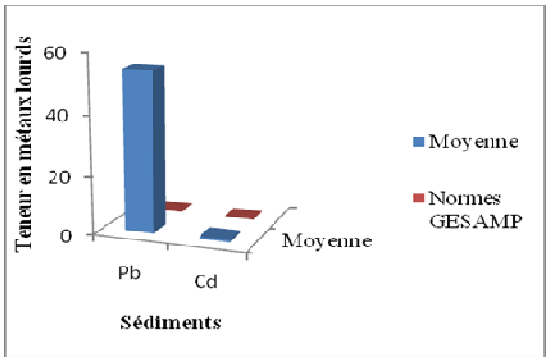

Figure 3: Average content (mg/L) of Pb and Cd in the Sediments

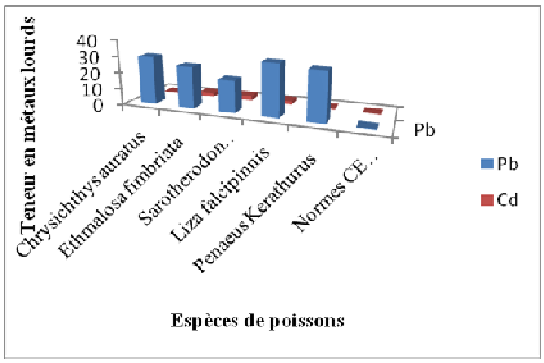

Figure 4: Comparison of rates (mg/kg) out of heavy metals in the various studied fish species

content (0.56mg/L) on the different sites of withdrawal are very raised in relation to the norm fixed by GESAMP (0,0004mg/L). On the same way, the content of cadmium (0.03mg/L) is more raised than the norm fixed by GESAMP (0,00021mg/L). These results showed that the water of Ganvié is very polluted by lead and cadmium.

The fig. 3 indicates that the content of lead (54.04 mg/kg) in sediments of the different sites of withdrawal is very raised and systematically superior to the norm fixed by GESAMP (0.019 mg/g). On the same way, the content of cadmium (0.74mg/kg) is more raised that the norm fixed by GESAMP (0.00011mg/g). It is evident from these analyses that the water of Ganvié is strongly polluted by lead and in cadmium.

The comparison of heavy metals contents (mg/kg) (fig. 4) showed that all species have accumulated exaggerated lead. *Liza falcipinnis* has accumulated it the most (31,7mg/kg) against *Chrysichthys auratus* (29.52 mg/kg), *Penaeus kerathurus* (29.52 mg/kg), *Ethmalosa fimbriata* (25.46 mg/kg) and *Sarotherodon melanotheron* (19.18mg/kg). All these values recorded for the lead passed the norm fixed by the French Regulation CE 466/2001(0.2 to 0.4mg/kg).

It is evident from the analysis of the fig. 4 that cadmium has also been accumulated by fishes. *Sarotherodon melanotheron* (2.193 mg/kg), *Ethmalosa fimbriata* (2.12mg/kg) and *Liza falcipinnis* (2.11mg/kg), *Chrysichthys auratus* (0.3mg/kg) and *Penaeus Kerathurus* (0.3mg/kg) present contents values above of the norm CE 466/2001 (0.01 to 0.05mg/kg).

The Factor of contamination (F = middle concentration / concentration of norms) reveals the degree of contamination of water, sediments and fishes by the lead and the cadmium. These factors of contamination recorded at the lacustrine city of Ganvié are: Water (FPb: 1400; FCd: 143); Sediment (FPb: 2844; FCd: 6727) fish (FPb: 67; FCd: 40).

From the analysis of fig. 5, sediments have more accumulated lead, follow-up by fishes and water. While considering the fig. 6, fishes accumulated more cadmium than sediments and water.

The contents of lead (0.56mg/L) and cadmium (0.03mg/L) recorded in the water of Ganvié are meaningfully more elevated than norms fixed by GESAMP (mixed Group of experts assigned to study the Scientific Aspects of the Protection of the Marine

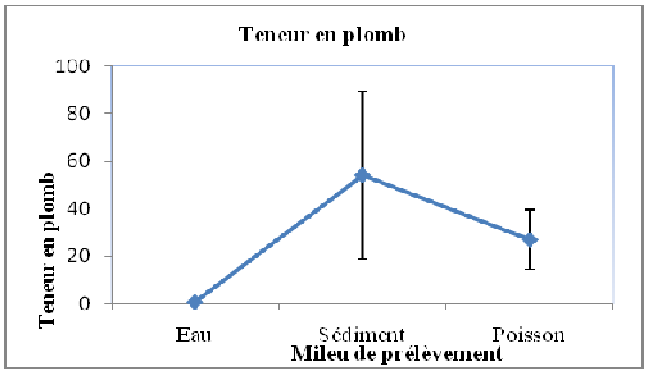

Fig. 5: Variation of the Pb content in water, the sediments and fish.

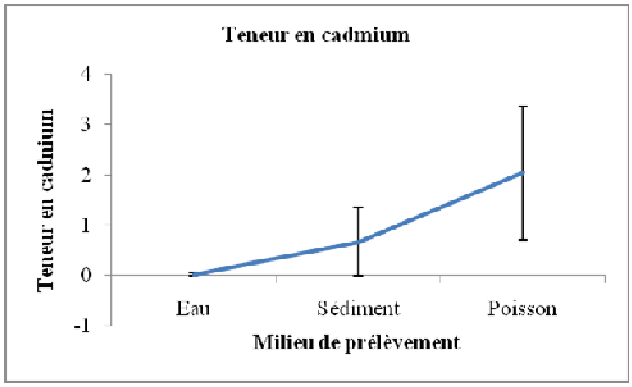

Fig. 6: Variation of the Cd content in water, the sediments and fish.

environment) (Pb: 0.0004mg/L and Cd: 0.00021mg/L). In comparison with results gotten in different works at Benin, our results defer those found by Agonkpahoun (2006) (Pb: 0.043; Cd: 0.0043), Edorh *et al.,* 2011) (Pb: 0.000379; Cd: 0.000073), respectively in the Okpara river and in the Nokoué lake. The middle contents in lead (54.04 mg/kgs) and in cadmium (0.74 mg/kgs) recorded in sediments to Ganvié are meaningfully more elevated than those gotten in water (Pb: 0.56; Cd: 0.03) of the same lake. These observations have been approved by other authors as (Lau *et al.;* 2005) and (Eja *et al.,* 2003) that demonstrated that sediments accumulate more poisonous metals than water. It could been explained by the fact that these metals accumulated in sediments, contaminate the aqueous environment. In sediments, the middle concentrations in cadmium gotten by Guédénon (2011) (3.309 mg/kgs; 3.112 mg/kgs) respectively in the Ouémé stream and in the Nokoué lake, Edorh *et al.*, (2009) (0.93 mg/kgs) in the Nokoué lake, Agonkpahoun (2006) (0.93mg/kg) in the Nokoué lake are superior to those found at the time of the present survey (0.74 mg/kgs). On the other hand, those gotten by (Djossou, 2009) (0.39 mg/kgs) in the Azili lake, Edorh *et al.*, 2008) (0.17 mg/kgs) in the Nokoué lake are lower. These variations of results could be owed at seasons, to the period of sampling, to sites of withdrawals and also in relation with the different anthropic activities. In fishes, the studied metal contents (Pb: 26.80mg/kg; Cd: 2.03 mg/kgs) are superior to the norm CE 466/2001 (Pb: 0.2mg/kg; Cd: 0.01mg/kg). These contents are considerably more elevated than those in water (Pb: 0.56; Cd: 0.02). It indicates the phenomenon of bioaccumulation [(Ademoroti, 1996); (Karadede and ÜnlÜ, 1998); (Çalta *et al.,* 2000); (Farkas *et al.,* 2005).

The stake in parallel of a relation between contaminations of fishes and an environmental pollution in sediments is not an obvious priority. In certain cases, sediments contain more poisonous metals than fishes. It is the case of the lead in this survey where the content in sediments are 54.04mg/kg and 26.80mg/kg with regard to fishes. In other cases, as the one of the cadmium, fishes accumulated more (2.04 mg/kgs) than sediments (1.32mg/kg). The species *Penaeus kerathurus* accumulated the same content in lead (29.52mg/kg) than

Chysichthys auratus; but *Liza falcipinnis* with its strong content (31.7 mg/kgs) have revealed to be the more accumulator species of lead. This large capacity of heavy metal accumulation observed in particular at certain species of bottom has been brought back by Nicolas *et al.,* 1987)

About the consumption of this water polluted and these contaminated fishes, the contents present risks for the health of populations. Otherwise, the lead can cause neurological, hematological, gastro-intestinal, reproductive, immunological unrests [14]; [15]. An excessive exhibition to the cadmium would be able to kill [19].

CONCLUSION

Water, sediments of Ganvié are polluted by lead and cadmium. All the various fish species accumulated strong cadmium and lead contents. An evaluation followed by a prevention of the risks and a regular monitoring of the state of pollution proves to be necessary in order to reconcile environmental protection and sustainable human development.

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