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Assessment of Bacteriological and Metallic Contamination (Pb, Cd, As) and Analysis of Toxicological Risks in Houin Logbo (Lake Toho) in the Municipality of Lokossa

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Abstract

Heavy metals are dangerous pollutants for ecosystems, especially aquatic ecosystems, because of their concentration in certain living organisms and their presence in the food chain. This study aims to evaluate the bacteriological, metallic (Pb, Cd, As) and toxicological risks associated with houin logbo (toho lake) in the municipality of Lokossa. The results obtained concern everyone: Toho lake is contaminated by *Escherichia coli* and *faecal enterococci*, concerning the evaluation of the metallic contamination we have: water (Pb: 0.1032, Cd: 0. 046, As: 0); sediment (Pb: 14.79, Cd: 1.27, As: 0.800); *Oreochromis niloticus* (Pb: 0.143, Cd: 0.087, As: 0.466); soils (Pb: 8.528, Cd: 2.755, As: 0.833); *Solanum lycopersicum* (Pb: 0.098, Cd: 0.066, As: 0). Consumption of lake fish (*Oreochromis niloticus*) and market garden produce (*Solanum lycopersicum*) exposes populations, especially children, to the risk of As and Cd poisoning.

Keywords

Lead, Cadmium, Arsenic, Toxicological Risks

1. Introduction

In Africa, organic and bacteriological pollution constitutes a real risk for natural waters, causing several diseases [1]. Transmission of these pollutants occurs primarily through water through the oral route of feces [1]. In Benin, the defecation of populations in lakes, the establishment of "Acadjas" on water bodies [2] and wandering animals [3] are sources of pollution of aquatic environments [4]. The aquatic environment therefore receives discharges of animal or anthropogenic origin and the number and type of bacteria present make the water unfit for human use [5]. This can lead to water-borne illnesses such as diarrhea, cholera and malaria [6]. These diseases are most often transmitted by the oral route and human contamination occurs either by consumption of drinking water, or by consumption of food contaminated with water, or even during a bath or contact with waters for recreational use [7]. Every day, Metal Trace Elements (TME) are released into the environment, even though they are pollutants that are dangerous for the environment and human health. The contamination of the various Beninese aquatic compartments by metallic micropollutants is a reality [8]. Urban, industrial and agricultural activities are the main sources of pollution of aquatic environments. One of the risks associated with anthropogenic actions is the accumulation of heavy metals in water, soil and vegetables [3]. Most heavy metals are likely to accumulate in the body through food and thus generate oxidative stress which impairs its vital functions [9]. This study, entitled "Assessment of bacteriological and metallic contamination (lead, cadmium, arsenic) and toxicological risk analysis at Houin Logbo (Lake Toho) in the town of Lokossa" aims to assess bacteriological, toxicological and environmental contamination and that caused by lead, cadmium and arsenic in Houin Logbo (Lake Toho) in the municipality of Lokossa.

2. Materials and Methods

2.1. Materials

The samples used in this study are of several types:

- animals and plants: fish (*Oreochromis niloticus*); market garden products (*Solanum lycopersicum*);
- sediments: water; sediments and soils.

These samples were taken at Houin Logbo on the banks and on Lake Toho. **Figure 1** provides information on the geographical location of the lake.

2.2. Methods

2.2.1. Sample Collection

Water was collected in 1.5 liter bottles every 50 m and 15 m deep. The sediments were taken at a depth of fifteen (15) meters and these every twenty (20) meters. Soils (06 samples) were taken from three market gardening sites at six different locations at the rate of two (02) samples per site. And finally, six (06) fish of the same species were taken from Lake Toho. It is the most consumed species by the population which has been privileged.

2.2.2. Assessment of Bacteriological Contamination

The microbiology was carried out using the surface seeding method adapted to

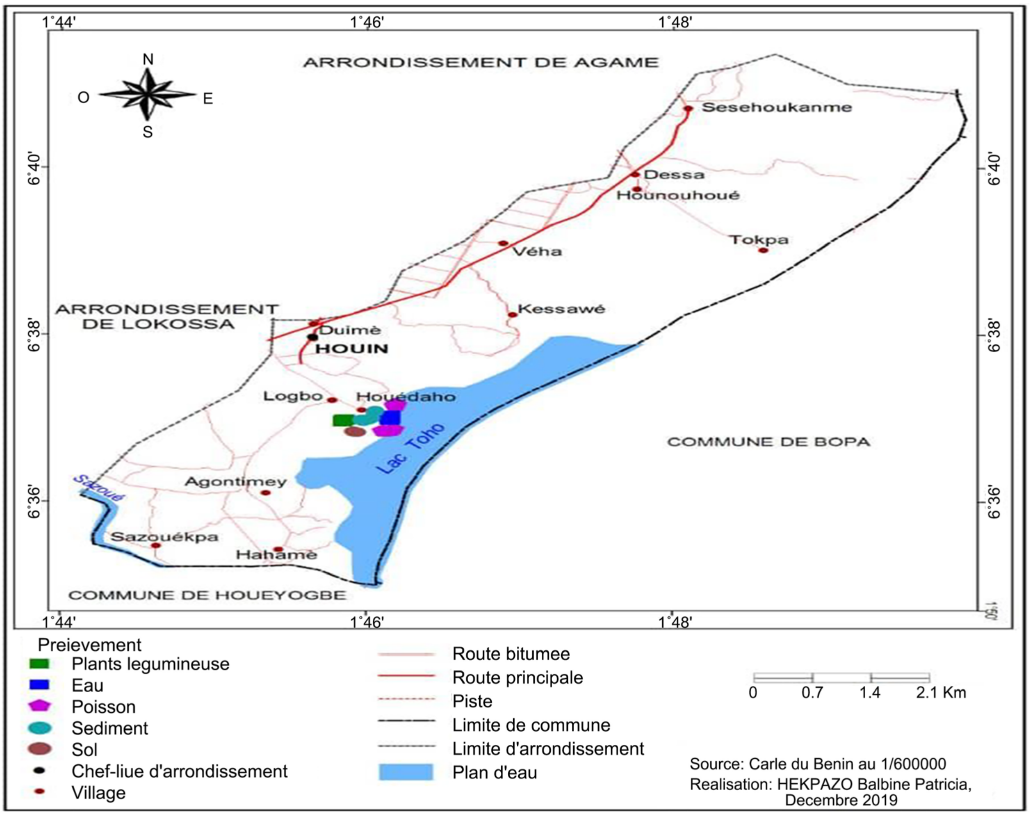

Figure 1. Geographical location of the study area.

the conditions of the Food and Water Quality Control Laboratory (LCQEA) of the Ministry of Health in Benin.

2.2.3. Evaluation of the Contamination of Metal Trace Elements (TME)

Defining the evaluation of the contamination of (ETM) was made by the technique of Physico-chemical analysis. It took into account the determination of lead and cadmium by the dithizone method and arsenic by the silver diethyldithiocarbamate method using the Molecular Absorption Spectrophotometer (SAM) (DR 2800). To calculate the toxicological risks associated with the consumption of the species *O. niloticus*, and *S. lycopersicum*, the formula used [10]

- $DJE = C \times Q/P$
- $QD = DJE/DJA$
- If $QD < 1$, the occurrence of a toxic effect is very unlikely;
- If $QD > 1$, the occurrence of a toxic effect cannot be excluded.

2.2.4. Statistical Analyzes

The data collected was processed using Excel 2010 spreadsheet software and statistical analyzes were performed using IBM SPSS statistics 19 and Epi info. The Chi-square test made it possible to see the different links between water contamination and fish and market garden products. The standards used for the comparison are the standards set by GESAMP (1982) [11], by WHO/FAO (2005) [12] and by WHO (2001) [13].

3. Results and Discussion

3.1. Assessment of Bacteriological Contamination

Figure 2 and Figure 3 show the results of microbilogical contamination.

Analysis of these figures revealed the presence of Escherichia coli and fecal enterococci in all samples. The presence of thermotolerant coliforms including *Escherichia Coli* shows that the contamination is either recent or continuous because the *Escherichia Coli* germ does not last in the environment. The highest value obtained for *Escherichia coli* is 1200 CFU/100 mL. The results hereby differ from those obtained at Lake Nokoué, the values of which vary between 4000 CFU/100 mL and 6000 CFU/100 mL [4]. Indeed, we could have had a high dose of *Escherichia Coli* and *faecal enterococci* in Houin Logbo since the environment is humid, and very favorable to the multiplication of these bacteria. However, after observation in the field, we observed that market gardeners and farmers use herbicides such as glyphosate, a very effective vectorial but classified since March 20, 2015 as "probably carcinogenic" by the International Agency for Research on Cancer (IARC), an agency of the WHO. These elements, hostile to life, could also act on the bacteriological density.

3.2. Evaluation of Metal Contamination (Pb, Cd, As) at Houin Logbo

Tables 1-5 show the results obtained after determinations of metal trace elements (MTE) in water, sediments and soils.

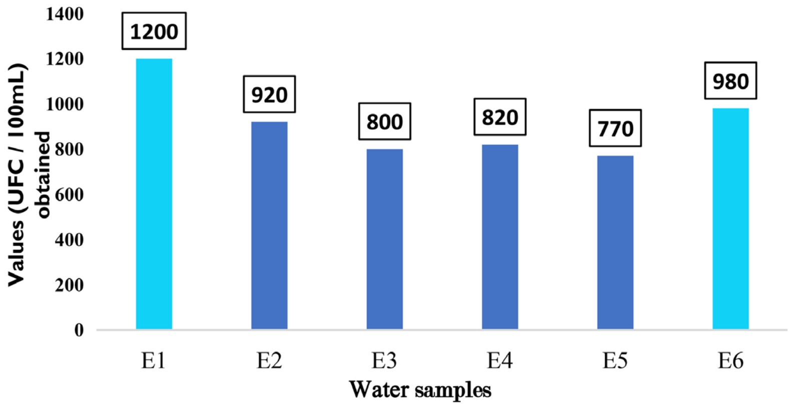

Figure 2. Evaluation of contamination by *E. coli*.

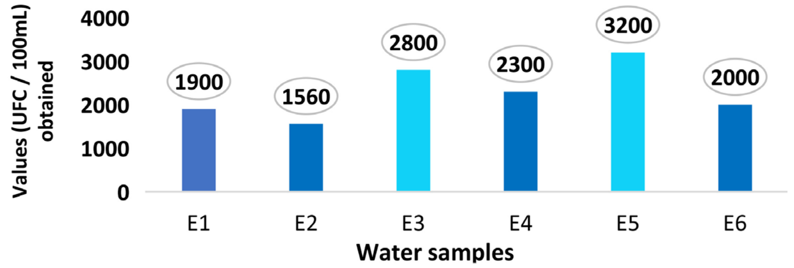

Figure 3. Assessment of contamination by *faecal enterococci*.

Table 1. Average content (mg/kg) in MTE (Pb, Cd, As) (water).

MTE dosed (Water)	Results (ppm)	Standards (GESAMP) (ppm)	Report
Pb	0.1032	0.0004	≈258
Cd	0.046	0.00021	≈219
As	Undetermined	0.0001	-

Table 2. Average content (mg/kg) in MTE (Pb, Cd, As) (sediments).

MTE dosed (Sediments)	Results (ppm)	Standards (GESAMP) (ppm)	Report
Pb	14.79	19	≈1.28
Cd	1.27	0.11	≈11
As	0.800	17	≈21.25

Table 3. Average content (mg/kg) in MTE (Pb, Cd, As) (fish).

MTE dosed (*O. niloticus*)	Results (ppm)	Standards (WHO) (ppm)	Report
Pb	0.143	0.2	≈1.4
Cd	0.087	0.05	≈1.7
As	0.466	0.1	≈4.6

Table 4. Average content (mg/kg) in MTE (Pb, Cd, As) (ground).

MTE dosed (Ground)	Results (ppm)	Standards (PNEC INERIS) (ppm)	Report
Pb	8.528	19	≈2.23
Cd	2.755	12	≈4.35
As	0.833	15	≈18

Table 5. Average content (mg/kg) in MTE (Pb, Cd, As) (market garden products).

MTE dosed (*S. lycopersicum*)	Results (ppm)	Standards (WHO) (ppm)	Report
Pb	0.098	0.1	≈1.02
Cd	0.066	0.05	≈1.32
As	0	0.01	-

From these tables, it appears that the water of Lake Toho in Houin Logbo is polluted by lead, cadmium respectively 258 times and 219 times higher than GESAMP standards. As for the fish species *Oreochromis niloticus*, the most consumed by the natives, it has accumulated cadmium and arsenic in its flesh, respectively 1.4 and 1.7 times higher than WHO standards. The MTE determined by the present study were not found at ground level, but market garden products (*Solanum lycopersicum*) are contaminated by lead and cadmium. The consumption of the fish species *Oreochromis niloticus* and *Solanum lycopersicum* market garden products by the population constitute a real health risk for them. The average levels of lead (0.1032 mg/kg), cadmium (0.04673 mg/kg) in water are different from those obtained by Hounkpatin *et al.*, [9] (Pb: 0.56 mg/L; Cd: 0.03 mg/L) and Montcho *et al.*, [14] (Pb: 0.12 mg/kg; Cd: 0.03 mg/kg); As: 7.36 mg/kg); respectively in the lakeside city of Ganvié and in the Ouémé river. The average lead contents (14.79 mg/kg) are lower than that obtained by Hounkpatin *et al.* [15] (Pb: 54.04 mg/kg) in the lakeside town of Ganvié but higher than those of Dimon and al., [16] (Pb: 0.12 mg/kg) at Lake Ahémé. As for the concentrations of arsenic (0.800 mg/kg) and cadmium (1.27 mg/kg) in the sediments obtained by the present study differ from those obtained by Hounkpatin *et al.*, [15] (Cd: 0.74 mg/kg) in the lakeside city of Ganvié but also those of Dimon *et al.* [16] (Pb: 0.12 mg/kg; As: 29 mg/kg) in Lake Ahémé. The average levels of lead, cadmium and arsenic in the sediments of Lake Toho in Houin (Pb: 14.79 mg/kg; Cd: 1.27 mg/kg; As: 0.800 mg/kg) are higher than the average levels lead, cadmium and arsenic from water (Pb: 0.1032 mg/L; Cd: 0.04673 mg/L; As: 0 mg/L) from the same lake. This could be explained by the fact that these metals are absorbed on the particles of the sediments, are then released by the mixing of the sediments and dissolve in the aqueous medium [15]. The levels obtained in fish (*Oreochromis niloticus*) at Houin Logbo (Pb: 0.143 mg/kg; Cd: 0.87 mg/kg; As: 0.466 mg/kg) are higher than those in water (Pb: 0.1032 mg/L; Cd: 0.04673 mg/L; As: 0.0025 mg/L) from the same lake. This would indicate the phenomenon of bioaccumulation. Because soils have the property of fixing MTE, in particular in surface horizons rich in organic matter [17]. Regarding market garden products, the values obtained are all lower than those found at soil level (Pb: 8.528 mg/kg; Cd: 2.755 mg/kg; As: 0.93 mg/kg). Indeed, plants can absorb MTE from the soil through their roots, transport them through the xylem and accumulate them in the various tissues of all organs (root, stems, leaves) [17]. This can lead to direct risks to human health through food plants or indirectly due to accumulation in the food chain through fodder.

3.3. Assessment of Toxicological Risks Associated with the Consumption of Fish (*Oreochromis niloticus*) and Market Garden Products (*Solanum lycopersicum*)

Figure 4 and **Figure 5** present the Danger Quotients (DQ) linked to the consumption of fish (*Oreochromis niloticus*) and market garden products (*Solanum lycopersicum*).

Analysis of the figures shows that the hazard quotients (DQ) obtained in children are all higher than those in adults, whether it is fish (*Oreochromis niloticus*) or market garden produce (*Solanum lycopersicum*). This is why children are always the most exposed to metallic trace elements due to their low body weight and their physiological fragility since contaminants are easily absorbed by their bodies [18]. Children's bodies potentially absorb more contaminants and remain unable to eliminate them than those of adults because their elimination systems are less developed [15]. The hazard quotients for lead through the consumption of fish and market garden products (*Solanum lycopersicum*) are less than 1 in both children and adults. This confirms that the fish species *Oreochromis niloticus* from Lake Toho in Houin

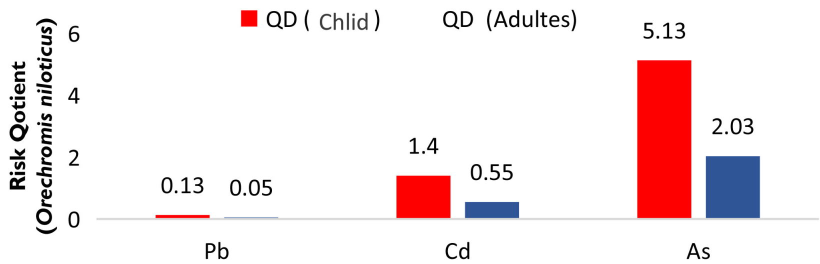

Figure 4. RQ *(Oreochromis niloticus)* for children and adults.

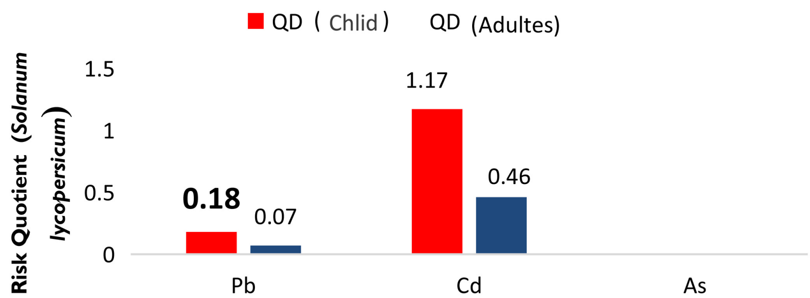

Figure 5. RQ (*Oreochromis niloticus*) for children and adults.

Logbo and *Solanum lycopersicum* market garden products are not contaminated by lead.

The consumption of fish, in particular the *Oreochromis niloticus* species from Lake Toho in Houin Logbo, exposes the population to the risk of cadmium and arsenic poisoning, while the consumption of market garden products, in particular *Solanum lycopersicum*, exposes the population to risks cadmium poisoning.

4. Conclusion

Most pollutants always end up in aquatic environments whether they are discharged directly into surface water, emitted into the atmosphere, discharged into wastewater or spilled on soils. These pollutants are mainly the Metal Trace Elements (TME) and microorganisms. The results of this study revealed that Lake Toho in Houin Logbo is contaminated by germs from human and animal faecal contamination. The determination of the metallic trace elements also revealed contaminations of these waters with lead and cadmium. As for the sediments studied, in addition, these results reveal that the population consuming fish (*Oreochromis niloticus*), and market garden products (*Solanum lycopersicum*) are exposed to risks of arsenic and cadmium poisoning, especially children due to their low body weight, and their physiological vulnerability.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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