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Étude préliminaire de la contamination en métaux toxiques des poissons du fleuve Congo pêchés au port de Socopla-Lomata à Mbandaka (RD Congo)

[Preliminary study of toxic metal contamination of Congo river fish caught at the port of Socopla-Lomata in Mbandaka (DR Congo)]

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ABSTRACT: Fish *Tilapia nilotica*, *Mormyrops anguilloides* and *Schilbe mystus*, captured at port Socopla-Lomata on the Congo River in Mbandaka were analyzed by X-ray fluorescence spectrometer, brand Xepos III in accordance with the laboratory's operating mode; to assess lead, cadmium and mercury contamination. The results showed concentrations higher than the edibility standards of the European Union and the concentrations observed in the water of the fishing site. The species Mormyrops anguilloides accumulates more cadmium while lead and mercury are more accumulated in Tilapia nilotica.

KEYWORDS: Contamination, Socopla-Lomata, toxic metals.

RESUME: Les poissons *Tilapia nilotica*, *Mormyrops anguilloides* et *Schilbe mystus*, capturés au port de Socopla-Lomata sur le fleuve Congo à Mbandaka ont été analysés par spectromètre de fluorescence X, marque Xepos III conformément au mode opératoire du laboratoire; pour évaluer la contamination en plomb, cadmium et mercure. Les résultats ont montré des concentrations supérieures à la norme de comestibilité de l'union européenne et aux concentrations observées dans les eaux du site de pêche. L'espèce *Mormyrops anguilloides* accumule plus le cadmium alors que le plomb et mercure sont plus accumulés par *Tilapia nilotica*.

MOTS-CLEFS: contamination, Socopla-Lomata, métaux toxiques

1 INTRODUCTION

Fish are an excellent source of vitamins, proteins, and also minerals essential for a healthy diet on which health depends, especially of pregnant women and children. Long-chain omega-3 fatty acids are essential for the neurological development of children and for the prevention of cardiovascular diseases such as high blood pressure and myocardial infarction [1]. However, the contamination of the various species of the Congo River with toxic metals of anthropogenic origin has been demonstrated by [2-4] at the Malebo pool and tributaries in Kinshasa. In Mbandaka, on the other hand, no data is available on the state of health of the most consumed species, caught in port sites. Yet, for decades, the latter have been a receptacle for untreated urban wastewater, runoff from wild dumps of various kinds, the accidental spillage of used oils from motorized boats and the ashes of daily open air burns. Solid waste produced by each plot. The contamination of fishery resources is a serious problem, not only health, but also global environmental. Heavy metals are non-biodegradable, bioaccumulative and only toxic [5]. To respond to the community's concern about a possible contamination of these resources, the study aims to contribute to the preliminary assessment of the lead, cadmium and mercury contamination of some of the most consumed fish species, caught at the port site of Socopla-Lomata in order to respond to the concerns of the community and thus constitute a bank of reference scientific data.

2 Environment, Material And Methods

2.1 Environment And Material

The species of fish *Oreochromis niloticus* (or *Tilapia nilotica*), *Mormyrops anguilloides* and *Schilbe mystus*, commonly called and respectively in lingala Libundu, Monzanda or Nzanda and Ndangwa or lilangwa, as well as the waters of the Congo river collected at the port site of Socopla-Lomata constitute study material. These species are chosen according to their feeding behavior (herbivorous, carnivorous and omnivorous) and their availability in the fishing site. The site is located on the left bank of the Congo River in downtown Mbandaka in Equateur province at 00 ° 03'36.4 "North latitude, 18 ° 15'17.8" East longitude.

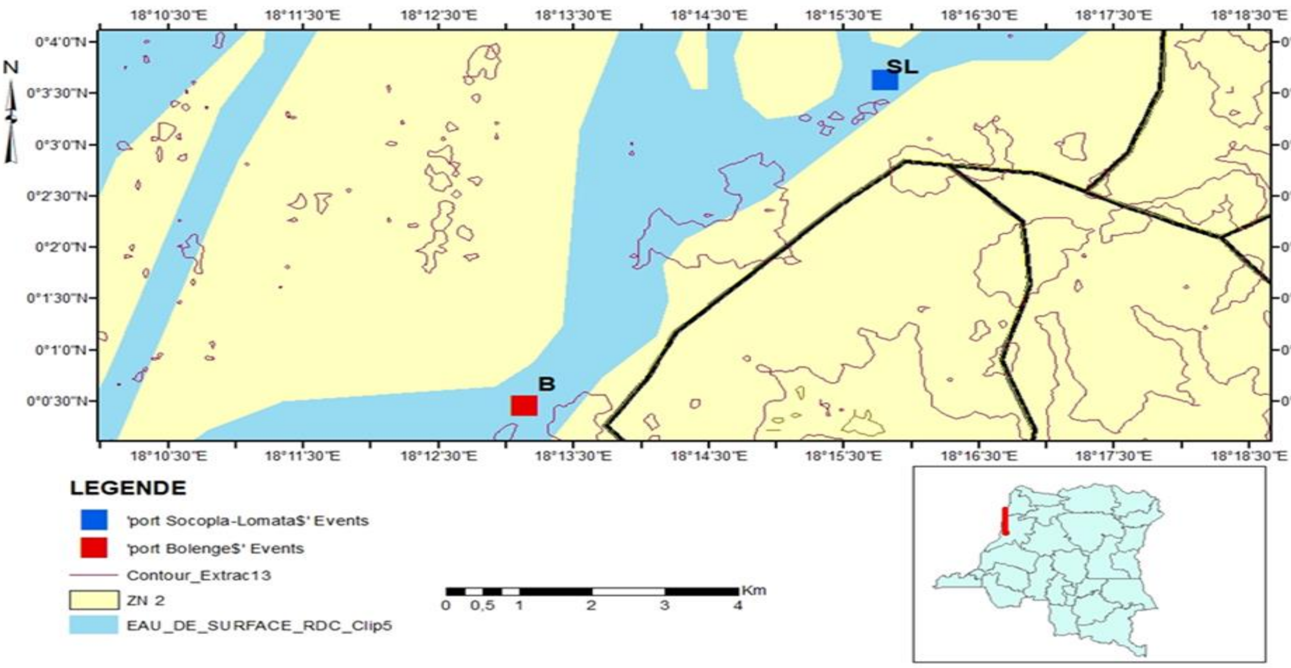

Fig. 1. Geolocation of the Socopla-Lomata port fishing site

2.2 Methods

Three fish individuals per species and three water samples in one-liter glass bottles were taken from June 20 to July 20, 2020 and transported in a cooler at 4 ° C to the laboratory of the Kinshasa Regional Nuclear Studies Center (CREN-K). The lead, cadmium and mercury were analyzed by an X-ray fluorescence spectrometer, energy dispersive version (ED-XRF), brand XEPOS III, after treatment of the samples (water and fish) in accordance with the laboratory procedure. The temperature (°C), the hydrogen potential (pH) and the electrical conductivity (µS/cm) were taken in situ at each sampling site using a multi-parameter Combo pH-mètre brand HANNA pH /ORP /EC /DO n° HI 9828. The mean and Student's t test at the 5% significance level were used as statistics; and Microsoft Excel 2007 and SPSS software for data processing. [6] served as a basis for the interpretation of the results of physico-chemical analyzes. The bioaccumulation factor (BAF) which designates the ratio at equilibrium between the concentration of a contaminant in the tissues of an organism and its total concentration (dissolved or dissolved + particulate) in the environment where the organism finds its food is determined according to the following equation [7]: BAF = BCF x BMF1 x BMF2. Where: BCF is the bioconcentration factor defined by the ratio at equilibrium between the concentration of contaminant in the organism (CB) on the concentration of contaminant dissolved in water (CED). BMF is the Biomagnification factor which represents the ratio at equilibrium between the concentration of a chemical substance in the organism of the predator (Cpr) and that of its prey (Cpa); (BAF = Cpr / Cpa) [8]; BMF1 and BMF2 correspond to the different biomagnification factors along the trophic chain.

The concentrations of toxic metals in the waters of the Congo river at the port of Socopla-Lomata (CED) are: (cadmium: 0.003mg/l, lead: 0.01mg/l, mercury: 0.003mg/l)

3 RESULTS

The results of the physico-chemical analysis of the samples of the different species of fish are presented in the following tables.

Table 1. Average concentrations (mg/kg) of cadmium, lead and mercury in samples of fish species analyzed from the Socopla-Lomata site

Toxic Metals	***Tilapia nilotica***	***Mormyrops anguilloides***	***Schilbe mystus***
Cadmium	1.87±1.95	5.97±7.73	5.133±6.69
Lead	4.73±4.01	0.3±0.52	3.666±3.81
Mercury (Hg^{2+})	0.125±0.11	0.104±0.06	0.097±0.07

From table 1, it is observed an increase of the average cadmium concentrations in all the analyzed fish species. However, mercury levels remain low. High average lead concentrations are observed only in *Tilapia nilotica* and *Schilbe mystus.* However, in descending order, the average cadmium concentration is highest in the *Mormyrops anguilloides* species, followed by *Schilbe mystus* and *Tilapia nilotica*. On the other hand, the highest average lead concentration is observed in *Tilapia nilotica*, followed by *Schilbe mystus* and *Mormyrops anguilloides*. As for mercury, the highest average concentration is observed in *Tilapia nilotica*, followed by *Mormyrops anguilloides* and *Schilbe mystus*. The Student's t test applied at the 5% significance level showed no significant difference in the mean concentrations of cadmium, lead and mercury between the *Tilapia nilotica* and *Mormyrops anguilloides* samples (p=0.423, p=0.130, p=0,777), between the *Mormyrops anguilloides* and *Schilbe mystus* samples (p=0,895, p=0,204, p=0,714) and between the *Tilapia nilotica* and *Schilbe mystus* samples (p=0,462, p=0,755, p=0,900).

Table 2. Bioconcentration factors of cadmium, lead and mercury in different fish species of the Socopla-Lomata fishery

Toxic Metals	**Bioconcentration factors (BCF)**		
	Tilapia nilotica	***Mormyrops anguilloides***	***Schilbe mystus***
Cadmium (Cd^{2+})	622	1988.67	1711
Lead (Pb^{2+})	430.27	27.27	333.27
Mercury (Hg^{2+})	41.67	34.67	32.33

According to the results in Table 2, the highest cadmium bioconcentration factor value is found in *Mormyrops anguilloides* fish, followed by *Schilbe mystus* and finally *Tilapia nilotica*. That of lead is higher for *Tilapia nilotica*, followed by *Schilbe mystus* and finally for the fish *Mormyrops anguilloides*. For mercury, the highest bioconcentration factor is found in *Tilapia nilotica* followed by *Mormyrops anguilloides* and finally *Schilbe mystus*.

Table 3. Cadmium, lead and mercury bioaccumulation factors for the species Mormyrops anguilloides and Schilbe mystus from the Socopla-Lomata site

Toxic metals	**Bioaccumulation Factor (BAF ou FBA)**	
	Mormyrops anguilloides	***Schilbe mystus***
Cadmium (Cd^{2+})	6343.85	4693.96
Lead (Pb^{2+})	332.69	256.15
Mercury (Hg^{2+})	32.24	24.95

The values of bioaccumulation factors shown in table 3 are respectively higher for cadmium, lead and mercury in *Mormyrops anguilloides* than in *Schilbe mystus*.

4 DISCUSSION

From the results presented in table 1, it appears that in general all the fish species analyzed are contaminated with cadmium and lead at concentrations higher than the maximum concentrations set by [6] for herbivorous fish (or non-predatory fish: cadmium: 0.05mg/kg, lead: 0.2mg/kg, inorganic mercury: 0.5mg/kg), carnivores and omnivores (or predators: cadmium: 0.1mg/kg, lead: 0.4mg/kg, inorganic mercury: 1mg/kg); although mercury concentrations remain low. Toxic metals contamination of fish in the Congo River and its tributaries has been reported by various authors. Our results confirm those reported by [2] in Congo River *Mormyrops anguilloides* captured at Ngwelé/Kingabwa (1.933 mg/kg of lead, cadmium not detected) and Baramoto sites in Kinshasa (2.193 mg/kg of lead, cadmium not detected); [9] in *Tilapia nilotica* from the Taobo farm on the Bandama River in Ivory Coast (lead: 0.077 mg/kg and cadmium: 0.021 mg/kg) and those reported by [3] in species from the Congo River in Kinsuka in the city of Kinshasa (28.86 mg/kg of lead and 9.44 mg/kg of cadmium in young *Mormyrops anguilloides*, while 28.96mg/kg of lead and 9.81mg/kg of cadmium have been observed in adults. In young *Schilbe mystus*, 37.59 mg/kg of lead and 15.29 mg/kg of cadmium while in adults 37.68 mg/kg of lead and 15.72mg/kg of cadmium). The presence of high concentrations of cadmium and lead in the different fish species analyzed is thought to be due to the contamination of their habitat, more influenced by the acidity of the environment which increases the solubility and bioavailability of metals [10-13]. Contamination of fish with toxic metals exposes consumers to health risks. Accidental spills of used oils during engine maintenance, whalers and motorized canoes, discharges of used cells and batteries, domestic and urban wastewater, atmospheric deposition due to daily air burning free of waste from each plot and forest fires, illegal dumping runoff by rainwater is the main source of environmental contamination. Analyzes carried out on household waste internationally have found levels of around 450 mg/kg of lead [12]. The different values of bio-concentration factors observed in Table 2 as well as those of bioaccumulation (Table 3) have shown that there is indeed a bioconcentration and bioaccumulation of each pollutant in the different species of fish analyzed. The average concentrations of each element in the different species of fish are higher than those in the waters of the site concerned. The same is true for bioaccumulation, the factors of which, in particular for cadmium in the *Mormyrops anguilloides* and *Schilbe mystus* species of the Socopla-Lomata fishing site, are greater than 4000. However, a bioaccumulation factor of a value of 1 000 or 2 000 may be sufficient reason for a thorough examination of the bioaccumulation potential of a given chemical [14]. This high level of bioaccumulation would put consumers at obvious risk of chronic illnesses, including kidney disease and high blood pressure. In addition, the average concentrations levels of cadmium, lead and mercury in the different species of fish caught at the Socopla-Lomata fishing site, in general, do not respect the logic of bioamplification of metals along the food chain (Table1). The logic states that: « the accumulation of a metal in a species with a primary diet (the herbivores) is less than that of a species with a secondary diet (carnivores), and in the latter, less than that of a species with a tertiary diet (omnivores) » [8], [15], [3]. The logic noted in this study differs from that reported by [16] in the fish species of the Togolese lagoon system, and [3] at the sites of Maluku and Kinsuka on the Congo River in Kinshasa, for the same species of fish. For this study, it could be explained by the fact that some fish individuals analyzed, in particular those of the species *Mormyrops anguilloides* and *Schilbe mystus*, came from the right bank of the river, far from the source of contamination.

However, the concentrations of toxic metals observed in all of the fish species analyzed, regardless of the rationale for bioamplification, generally remain higher. These species do not meet European Union edibility standards for predatory and not predatory fish. They expose consumers to health risk since these species of fish are the most appreciated and most consumed by the population of Mbandaka for their taste.

5 CONCLUSION

In conclusion, there is a real contamination in toxic metals of the fish species of the Congo River in the port sites of the city of Mbandaka. The average concentrations of cadmium, lead and mercury observed in the different species of fish at the Socopla-Lomata site are generally higher than the edible standards of the European Union. They are also higher than those observed in the water. Bioaccumulation values are high for *Mormyrops anguilloides* and *Schilbe mystus*; although the logic of bioaccumulation along the trophic chain is not respected. The *Mormyrops anguilloides* accumulates more cadmium while lead and mercury are more in *Tilapia nilotica*. However, the consumption of these fish would expose to significant health risks. The government should prohibit, as a precautionary principle, the consumption of fish caught in port sites, implement measures to reduce the contamination of aquatic ecosystems, and initiate an in-depth health risk assessment study.

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