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Concentrations en métaux toxiques des poissons comestibles du fleuve Congo au site Kinsuka à Kinshasa (RD Congo) et évaluation des potentiels risques sanitaires

[Concentrations of toxic metals in edible fish from the Congo river at the Kinsuka site in Kinshasa (DR Congo) and evaluation of potential health risk]

Nsimanda Ipey Camille[1] and Ingonda Bololo Soleil[1-2]

[1]Department of Environmental Sciences, Faculty of Sciences, University of Kinshasa, BP 190, Kinshasa XI, RD Congo

[2]Department of Environmental Sciences, Faculty of Sciences, University of Mbandaka, BP 10, Mbandaka, RD Congo

ABSTRACT: A total of 51 samples of *Distichodus fasciolatus* (Mboto in Lingala), *Mormyrops anguilloides* (Monzanda/Nzanda) and *Schilbe mystus* (Ndangwa/lilangwa) fish, gutted and separated from the gills, were captured from the Kinsuka fishing site in Pool Malebo on the Congo River in Kinshasa to determine lead and cadmium concentrations, and to assess the health risk associated with their continued consumption. After spectrophotometric analysis with HACH - DR 2400 in accordance with the laboratory's operating procedure, it appears that all the species of fish analyzed are contaminated with lead and cadmium at concentrations far above the European Union edibility standard. The continued consumption of 14.24 grams per day of fish from the Kinsuka fishing site poses the obvious risk of developing chronic disease throughout life, especially in children. The hazard quotients and the associated hazard quotients, whether for children or for adults, are far greater than 1. This risk could become even worse when the purchasing power of consumers is improved in the future. It is up to the government to ban the consumption of these fish and to take binding measures to reduce the contamination of aquatic ecosystems, to introduce national standards for the discharge of industrial wastewater and for foodstuffs intended for human consumption.

KEYWORDS: Concentration, toxic metals, edible, evaluation, health risks.

RESUME: Au total 51 échantillons des poissons *Distichodus fasciolatus (Mboto en lingala), Mormyrops anguilloides* (Monzanda/ Nzanda) et *Schilbe mystus* (Ndangwa/lilangwa), éviscérés et séparés des branchies ont été capturés du site de pêche de Kinsuka dans le Pool Malebo sur le fleuve Congo à Kinshasa pour déterminer les concentrations en plomb et cadmium, et d'évaluer le risque sanitaire lié à leur consommation continue. Apres analyse spectrophotométrique au HACH - DR 2400 conformément au mode opératoire du laboratoire, il ressort que toutes les espèces de poissons analysés sont contaminées en plomb et cadmium à des concentrations de loin supérieures à la norme de comestibilité de l'Union européenne. La consommation continue de 14.24 grammes par jours des poissons du site de pêche de Kinsuka expose aux risques évidents de développer une maladie chronique au cours de la vie, surtout des enfants. Les quotients de dangers et les quotients de danger associé, qu'ils soient pour les enfants ou pour les adultes sont de loin supérieurs à 1. Ce risque pourrait encore s'aggraver lorsque le pouvoir d'achat des consommateurs serait amélioré à l'avenir. Au gouvernement d'interdire la consommation de ces poissons et de prendre des mesures contraignantes pour réduire la contamination des écosystèmes aquatiques, d'introduire les normes nationales pour le rejet d'eaux usées industrielles et pour les denrées destinées à la consommation humaine.

MOTS-CLEFS: Concentration, métaux toxiques, comestibles, évaluation, risques sanitaires.

Corresponding Author: Ingonda Bololo Soleil

1 INTRODUCTION

Fish are an excellent source of vitamins, proteins, and also minerals essential for health, especially for pregnant women and children. 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 infarctions [1]. However, toxic metal contamination of fishery resources and their habitat remains a global concern; especially in developing countries, despite the awareness and recognition of the health, environmental and economic risks they generate. Studies carried out by various authors, notably in Togo [2], Senegal [3], Chad [4], [5] and Ivory Coast [6] are an illustration of this. These non-biodegradable and bioaccumulative metals are only toxic, even at low concentrations [7], [8]. In the Democratic Republic of Congo, the studies carried out in various sites of Pool Malebo on the Congo River and its tributaries in Kinshasa, in particular by [9], [10], [11]; [7] and [12], [13] have shown toxic metal contamination of fishery resources at generally high concentrations. However, no data on the health risk associated with the consumption of edible fish from the Kinsuka fishing site is available. However, by its position downstream from the Malebo pool on the Congo River, this site receives all untreated industrial and urban wastewater from the city of Kinshasa and its surroundings. The objective is to determine the average lead and cadmium concentrations of the few most consumed fish species and to assess the potential health risks associated with chronic exposure.

2 MATERIAL AND METHODS

2.1 MATERIAL

According to their respective feeding behavior (herbivorous, carnivorous and omnivorous), the fish species Distichodus fasciolatus, Mormyrops anguilloides and Schilbe mystus, commonly and respectively called in lingala Mboto, Monzanda / Nzanda and Ndangwa / lilangwa constitute the study material. These species are caught at the Kinsuka fishing site, located on the left bank of the Congo River in the city of Kinshasa.

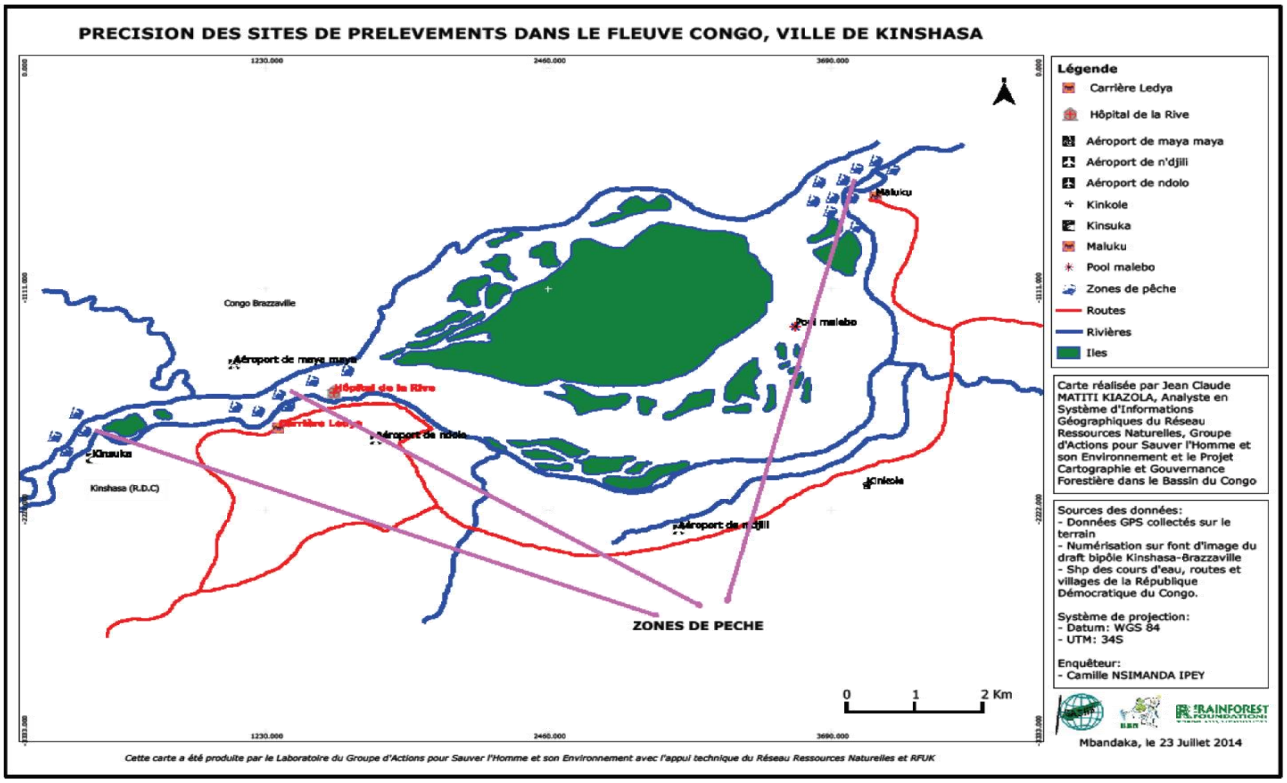

Fig. 1. Geolocation of fish capture sites (Nsimanda, 2015)

2.2 METHODS

A total of 51 fish individuals, 17 per species, were collected and transported in refrigerated boxes to the ERGS ecotoxicology and environmental biotechnology laboratory of the Faculty of Sciences of the University of Kinshasa for analyzes. Individuals less than 10 cm in length are considered juveniles (immature) and others as adults (mature). The gills and internal abdominal organs have been separated from the body remains which are edible. These were oven dried at 105 ° C to constant weight before being separately incinerated at 550 ° C in the oven. For each individual cremated, a sample of 1g of ash was taken in plastic bags for spectrophotometric analysis with HACH - DR 2400 in accordance with the laboratory procedure. The Microsoft Excel 2007 and SPSS software for data processing. [14] was used as the basis for the interpretation of the results of the metal analyzes, and the hazard quotient (HQ) or risk index (RI) for the estimation of health risks. A pre-survey was carried out by interviewing 30 households of fishermen at the study site to estimate the daily frequency of fish consumption.

The hazard quotient (HQ) is determined according to the formula used by [15]:

HQ = DED /ADI

Where: DED corresponds to the daily dose of exposure to toxic metals (mg/kg/d); and ADI, the Admitted or Tolerable Daily Intake or toxicological reference value (TRV) (mg/kg/d) which represents an exposure level considered to be without risk for the consumer throughout his lifetime.

If HQ ≤ 1: the occurrence of a toxic effect is very unlikely, the exposure does not reach the only dose above which adverse effects for the human health of consumers may appear [16];

If HQ > 1: toxic effects can occur in the population.

The daily exposure dose (DED) in mg/kg/day is quantified by the formula applied by [17], [16]:

DED = C x Q x F/P

Where: C: average concentration in mg/kg of pollutant in fish likely to be ingested;

Q: amount of fish ingested in mg/kg weight. It is estimated at 5.2 kg/year/ Congolese democrat (i.e. 0.014kg/day/inhabitant) (FAO, 2009, quoted by [18].

The scenario retained for this exposure estimate is that of chronic exposure, for which the average daily quantity of fish ingested (Q) by a child is considered equal to that of an adult; and all species are eaten without particular preference.

F: frequency of exposure. According to our survey, the average frequency is once a day for the population of Mbandaka;

P: weight in kilograms by consumer age group. By convention, it is estimated to be 28 kg for the age group from 0 to 15 years, and 70 kg for an adult (USEPA, and quoted by [2].

The associated hazard quotient (AHQ) is the sum of the hazard quotients (AHQ) for a mixture of toxic elements [17], [16].

3 RESULTS

The results of this study are presented in the following tables.

Table 1. Average concentrations (mg / kg) of toxic metals (cadmium and lead) in samples of the different fish species analyzed

Toxic Metals	*Distichodus fasciolatus*		*Mormyrops anguilloides*		*Schilbe mystus*	
	young's	Adults	young's	Adults	young's	Adults
Cadmium (Cd^{2+})	4.48±0.952	4.3±1.0738	7.1±1.832	7.06±1.658	10.4±2.249	10.74±2.192
lead (Pb^{2+})	9.22±1.642	8±1.293	14.22±3.726	15.20±4.367	17.2±5.287	15.98±5.235

According to the results in Table 1, cadmium and lead are much accumulated in the young and adults of *Schilbe mystus* fish, followed by the young and adults of *Mormyrops anguilloides* and finally in the young and adults of Distichodus.

Table 2. Presentation, by age group, of daily exposure doses (DED) linked to the consumption of fish at the Kinsuka site

Toxic Metals		DED (mg/kg/day)	
		Children	Adults
Cadmium	*Distichodus fasciolatus*	0.002	0.0009
	Mormyrops anguilloides	0.0035	0.0014
	Schilbe mystus	0.0052	0.002
Lead	*Distichodus fasciolatus*	0.0046	0.0018
	Mormyrops anguilloides	0.007	0.0028
	Schilbe mystus	0.0086	0.0034

According to the results in Table 2, the daily dose of exposure to cadmium and lead by consumption of *Distichodus fasciolatus* fish from the Kinsuka site varies respectively between 0.002 and 0.0046 mg/kg/day for children, and between 0.0009 and 0.0018 mg/kg /day for adults. It is respectively between 0.0035 and 0.007 mg/kg/day in children, and between 0.0014 and 0.0028 mg/kg/day in adults consuming *Mormyrops anguilloides* fish. Finally, it varies between 0.0052 and 0.0086 mg/kg/day in children, and from 0.002 to 0.0034 mg/kg/day in adults exposed to the consumption of Schilbe fish.

Table 3. Presentation of toxicological reference values (TRV) for cadmium and lead

Toxic Metals	TRV (ADI or TDI one mg/kg/day)
Cadmium	Acceptable Daily Intake (ADI): 0.001 mg/kg/day, or Tolerable Provisional Weekly Dose (TPWD): 0.007mg/kg/week) (OMS/FAO, 2010b) [15]
Lead	Acceptable Daily Intake (ADI): 0.0035mg/kg/day, or Tolerable Provisional Weekly Dose (TPWD): 0.025 mg/kg/week) (OMS, 2006) [15]

According to Table 3, the acceptable or tolerable daily intake for cadmium is 0.001 mg/kg/day, and 0.0035mg/kg/day for lead.

Table 4. Presentation of the hazard quotient (HQ) for chronic threshold exposure linked to the ingestion of different fish species analyzed

HQ by age group Metals by species		Hazard Quotient (HQ)			
		Child		Adult	
		HQ	AHQ	HQ	AHQ
Distichodus fasciolatus	Cadmium	2	3.3	0.9	1.4
	Lead	1.3		0.5	
Mormyrops anguilloides	Cadmium	3.5	5.5	1.4	2.2
	Lead	2		0.8	
Schilbe mystus	Cadmium	5.2	7.6	2	2.97
	Lead	2.4		0.97	

According to table 4, the danger quotients (HQ) for the child who continuously consumes the fish *Distichodus fasciolatus*, *Mormyrops anguilloides* and *Schilbe mystus* fished at Kinsuka site are respectively 2, 3.5 and 5.2 for cadmium, 1.3, 2 and 2.4 for lead. The associated hazard quotients (AHQ) for the mixture of cadmium and lead in children are: 3.3 for the consumption of *Distichodus fasciolatus* fish, 5.5 for *Mormyrops anguilloides*, and 7.6 for *Schilbe mystus*. For adult, the hazard quotients (HQ) for continuous exposure to *Distichodus fasciolatus*, *Mormyrops anguilloides* and *Schilbe mystus* fish caught at the Kinsuka site are respectively 0.9, 1.4 and 2 for cadmium, 0.5, 0.8 and 0.97 for lead. The associated hazard quotients for the mixture of cadmium and lead in adults are: 1.4 for the consumption of *Distichodus fasciolatus*, 2.2 for *Mormyrops anguilloides*, and 2.97 for caught *Schilbe mystus*.

4 DISCUSSION

The analyzes show that all the fish species are contaminated with cadmium and lead at concentrations far above the edibility standards of [14] for predatory fish (or carnivores and omnivores) (cadmium: 0.1mg / kg, lead: 0.4mg / kg) and non-predators (or herbivores) (cadmium: 0.05mg / kg, lead: 0.2mg / kg). The concentrations observed are higher than those reported by [9] on Mormyrops anguilloides from the Kingabwa sites (1,933 mg / kg of lead, cadmium not detected) and Baramoto on the Congo River in Kinshasa (2,193 mg / kg of lead, cadmium not detected). Our results confirm the work of [10] on the fishes Distichodus fasciolatus and Schilbe mystus from the Congo River in the urbanized area of Kinshasa. The presence of high concentrations of toxic metals in the different fish species analyzed is explained by the contamination of the waters of the Congo River and its tributaries by discharges of untreated industrial and urban wastewater [9], [13], [11], [12]. This situation characterizes the absence of national standards for the discharge of wastewater and the lack of application of existing national legal texts on environmental protection; this, despite the awareness and recognition by the political and administrative authorities of the health, ecological and economic risks that this contamination of aquatic ecosystems can generate. Kinsuka is the outlet for all untreated industrial and urban wastewater from the city of Kinshasa and its surroundings which drain the Pool Malebo. The painting, cosmetic, scrap metal recycling industries, battery and cell factories, the numerous garages, as well as urban washing are the main sources of toxic metals in the city of Kinshasa and which end up in the Pool Malebo at the level of Kinsuka. This confirms the thesis of [13]. The results of Table 3 show that the hazard quotients for a mixture of lead and cadmium (AHQ), whether for children or for adults living near them who consume one of the fish species analyzed (Distichodus fasciolatus, Mormyrops anguilloides or Schilbe mystus), are far greater than 1. The probability that a toxic effect on health will occur with continued consumption is therefore obvious because, the level of exposure being high [16], [17]. Our results corroborate the work of [10] for consumers of Distichodus fasciolatus and Schilbe mystus fish from the Congo River in the urbanized area of Kinshasa. They differ, however, from the results of [9] for consumers of fish from the Kingabwa site at the Malebo pool on the Congo River in Kinshasa. This high level of potential health risk can be explained more by the high average concentrations of lead and cadmium observed in the samples of the different species of fish analyzed than by the quantity of fish consumed by the neighboring families. The latter consume only a small amount of the young fish on a daily basis. Those with high market value are intended for trade to the major consumption centers of Kinshasa for survival. The high values of the hazard quotients for children are explained by the low weight of children compared to those of adults. Also by the quantity considered to be overestimated of fish consumed daily by children compared to adults.

5 CONCLUSION

Fish from the Congo River from the Kinsuka fishing site on the Malebo pool in Kinshasa are contaminated with toxic metals (cadmium and lead) at average concentrations far greater than the maximum concentrations set by the European Union for predatory fish (carnivores and omnivorous) and non-predatory (herbivorous). The likelihood of a toxic health effect occurring with continued consumption is therefore obvious. The associated hazard quotients, whether for children or for adults who consume one of the fish species analyzed, are far greater than 1. This risk could worsen further when the purchasing power of consumers would be improved in the future. To the government to take binding measures to reduce the contamination of aquatic ecosystems, to introduce national standards for the discharge of industrial wastewater and for foodstuffs intended for human consumption.

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