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Determination of Minerals and Heavy Metals in Water, Sediments and Three Fish Species (*Tilapia nilotica*, *Silurus glanis* and *Arius parkii*) from Lagdo Lake, Cameroun

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Abstract: This study was carried out to investigate the impact of pollution of water and sediments on fish mineral and heavy metal load in Lagdo lake, Cameroon. Samples of water, sediments and 3 fish species were analyzed quantitatively for the presence of potassium (K), magnesium (Mg), sodium (Na), zinc (Zn), nickel (Ni), Cadmium (Cd) and lead (Pb) were determined using Atomic Absorption Spectrometer (AAS 50B, Australia). Results showed that major elements (K, Mg, Na) were detected in concentrations between 0.02±0.00 and 0.19±0.01 mg mL^{-1} in water between 0.15±0.01 and 10.95±0.08 mg g^{-1} in sediments and between 0.25±0.01 and 5.35±0.12 mg g^{-1} in different fish organs. For heavy metals (Zn, Ni, Cd and Pb), variable amounts were determined and were 0.68±0.07 to 4.96±1.23 μg mL^{-1} in water, 0.12±0.01 to 21.35±1.42 μg g^{-1} in sediments and 0.22±0.01 to 18.50±0.20 μg g^{-1} in fish organs. The sediment contained higher concentrations of minerals and heavy metals than water. The 3 fish species accumulated mineral and heavy metals with all elements most concentrated in the heads.

Key words: Water, sediments, fish organs, pollution, heavy metals, minerals

INTRODUCTION

The constructions of hydroelectric dams began in the 1960's for several African countries such as Ghana, Egypt, Zimbabwe and Zambia (Anne *et al*., 1991). A few years after, Cameroon joined the move with the construction of the Lagdo dam (build between 1977 and 1982) which had 2 objectives: to provide electricity to the Northern part of the country and to irrigate 15,000 ha of cultures downstream.

Now-a-days, the lake plays another very important role in supplyinglocal populations with animal proteins. The Lagdo lake is a veritable source of fisheries in Cameroon in general and the northern part of the country in particular.

Fishermen from different nationalities exploit its potential estimated at 175.6 kg ha^{-1} an^{-1} throughout the year. Recent decade witnessed increasing agriculture activities around the Lagdo lake both at small scale and at the industrial level. Thus, the main water reservoir receives daily effluents from drainages through farms. Pesticides as well as fuels and oils from fishing boats probably contaminate not only water but also sediments with possible hazards on fish quality. It has been reported that industrial and even domestic effluents constitute important source of heavy metals which contribute to metallic contaminant in aquatic environments, water and sediments (Olowu *et al*., 2010). Unfortunately, recent studies showed that most of these heavy metals accumulate in different organs of fish such as liver, head, trunk, tail, gills, intestine and muscles (Al-Kahtani, 2009; Olowu *et al*., 2010).

Surprisingly, given the above and considering the visible increase in industrial and domestic activities around the Lagdo lake, very little attention is paid to heavy metal contents of water, sediments and fish from this important fisheries source in Cameroon. The objective of this study was to determine the distribution of heavy metals in water, sediments and fish organs of Lagdo lake with the aim of providing data to interested scientists and to alert public authority on the need to take proper environmental actions.

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MATERIALS AND METHODS

Study area: The Lagdo lake is the most important artificial lake in the Northern region of Cameroon. It is situated at 8°53' Northern latitude and 13°58' Eastern longitude. The lake's surface is 700 km^2 while its depth is 11 m. The climate is dry and typically tropical with 2 seasons: a long dry season (8 months) and a short rainy season (4 months). The lake is supplied in water by Benoue river which an affluent of Niger river. The area is inhabited by fishermen mostly from Cameroon, Nigeria, Niger, Central Africa Republic and Chad. Increasing farmers' settlements are observed who mainly grow rice, corn, groundnuts and other fruits and vegetables. Industrial farms have been created around the lake.

Water samples: Surface water samples were collected at four sampling points (5 and 50 m upstream and downstream, respectively from the dam) using clean plastic bottles. About 5 mL of concentrated hydrochloric acid was added to 250 mL of each water sample and evaporated to 25 mL. The concentrate was filtered using a cellulose membrane (0.45 μm) and transferred to a 50 mL flask and diluted to mark with distilled water. Minerals and heavy metals (K, Mg, Na, Zn, Ni, Cd and Pb) were determined using Atomic Absorption Spectrometer (AAS 50B, Australia).

Sediment samples: Sediments were collected from same sampling points as water into pre-cleaned polythene bottles. Samples were dried, ground and sieved with 200 mm mesh screen. For each sample, 5 g of sediment were taken into 150 mL flasks.

About 50 mL of 0.1 M HCl was added and the flasks were agitated for 30 min at 200 rev min^{-1}. The mixture was filtered into 50 mL flask and made up to mark with distilled water.

Same minerals and heavy metals were determined as for water using Atomic Absorption Spectrometer (AAS 50B, Australia).

Fish samples: Total 3 fish species were used for this study based on their important captures and consumption at the beginning of rainy season (end of July to beginning of August): *Tilapia nilotica*, *Silurus glanis* and *Arius parkii*. Each fish species were caught by local fishermen, conditioned under vacuum in sterile plastic bags and carried to the laboratory in ice boxes. The samples were then rinsed with distilled water wrapped in plastic bags and frozen at -10°C prior to analyses.

For analyses, the fish samples were defrosted for 6 h. For each fish, head, flesh and skin were separated according the method described by Dybem (1983). The various parts were dehydrated in a ventilated drying oven at 103±1°C until constant weight then ground using a Culatti hammer. Approximately, 5 g G of each sample were weighed and ashed in a muffle furnace at 550°C for 4 h. About 0.1 g of ash was dissolved in 5 mL of concentrated nitric acid and made up to 20 mL with distilled water. The mixture was heated on a plate until obtaining the 3rd of total volume. The solution was then filtered as previously and minerals (K, Mg, Na, Zn, Ni, Cd and Pb) were determined by Atomic Absorption Spectrometry (AAS 50B, Australia) according to the methods described, respectively by Maltida *et al*. (1991) and Atta *et al*. (1997). The values obtained for 3 repetitions were expressed in means±standard deviation.

RESULTS AND DISCUSSION

The concentrations of minerals and heavy metals in water from Lagdo lake are shown in Table 1 and 2. For the studied samples, major elements (K, Mg, Na) were detected in water and in sediments. However, trace elements (Zn, Ni, Cd and Pb), except for Nickel were exclusively found in sediments. The concentrations varied with minerals and depended also on the sampling point. The most important values were noted in all the sediments in general and particularly in those collected 5 m from the bank. The potassium content ranged between 8.57±0.00 mg g^{-1} in sediments collected at 5 m

Table 1: Mineral contents in water

	Sampling distance from the lake bank				
	5 m		50 m		Threshold values
Minerals	Wup	Wdo	Wup	Wdo	(WHO, 1985)
K (mg mL^{-1})	0.14±0.01	0.310±0.02	0.09±0.00	0.190±0.01	-
Mg (mg mL^{-1})	0.04±0.01	0.020±0.00	0.03±0.01	0.130±0.01	-
Na (mg mL^{-1})	0.02±0.00	0.040±0.01	0.02±0.00	0.030±0.00	-
Zn (μg mL^{-1})	nd	4.960±1.23	nd	nd	5.00
Ni (μg mL^{-1})	2.56±0.95	1.350±0.72	3.42±0.12	0.689±0.07	-
Cd (μg mL^{-1})	nd	nd	nd	nd	0.05
Pb (μg mL^{-1})	nd	nd	nd	nd	0.05

NB: Wup (Water upstream) Wdo (Water downstream) nd (not detected)

Table 2: Mineral contents in sediments

	Sampling distance from the lake bank				
	5 m		50 m		Threshold values (WHO,1985; USEPA, 1986)
Minerals	Sup	Sdo	Sup	Sdo	
K (mg g^{-1})	8.57±0.000	10.95±0.080	4.81±0.220	8.97±0.000	-
Mg (mg g^{-1})	0.69±0.020	0.01±0.000	0.15±0.010	0.15±0.040	-
Na (mg g^{-1})	1.73±0.030	1.927±0.18	1.72±0.000	1.92±0.170	-
Zn (µg g^{-1})	758.87±49.14	404.26±76.71	446.81±21.28	539.01±24.57	200.0
Ni (µg g^{-1})	14.40±2.070	18.045±1.99	16.09±0.090	15.22±2.010	50.0
Cd (µg g^{-1})	21.35±1.420	14.92±0.070	14.25±1.330	9.37±2.100	0.8
Pb (µg g^{-1})	0.32±0.010	0.32±0.010	0.12±0.010	0.27±0.020	50.0

NB: Sup (Sediment upstream) Sdo (Sediment downstream)

Table 3: Mineral distribution in the three fish species

	Arius parkii			*Tilapia nilotica*			*Silurus glanis*		
Minerals	Flesh	Skin	Head	Flesh	Skin	Head	Flesh	Skin	Head
K (mg g^{-1})	2.70±0.11	3.78±0.15	4.89±0.12	2.81±0.07	3.80±0.09	4.82±0.12	2.89±0.09	3.87±0.07	5.35±0.12
Mg (mg g^{-1})	0.30±0.02	0.32±0.05	0.45±0.03	0.25±0.03	0.27±0.01	0.44±0.04	0.36±0.03	0.39±0.02	0.56±0.04
Na (mg g^{-1})	0.28±0.01	0.29±0.02	0.36±0.03	0.25±0.01	0.27±0.02	0.34±0.05	0.31±0.04	0.34±0.03	0.39±0.03
Zn (µg g^{-1})	15.31±1.41	17.52±2.10	19.50±1.20	11.61±1.40	13.80±0.11	18.50±1.70	16.80±1.21	19.81±0.80	23.50±0.90
Ni (µg g^{-1})	0.70±0.02	1.41±0.05	7.40±0.04	0.22±0.01	3.60±0.07	8.43±0.05	2.02±0.06	5.00±0.02	11.01±0.61
Cd (µg g^{-1})	2.01±0.03	3.81±0.14	12.72±0.28	1.10±0.05	3.62±0.02	11.10±0.14	3.93±0.20	5.42±0.12	18.50±0.20
Pb (µg g^{-1})	5.10±0.07	7.64±0.10	11.00±1.17	2.62±0.60	4.72±0.33	10.31±0.82	7.64±0.72	8.91±0.44	13.20±0.81

and 4.81±0.22 mg g^{-1} for samples taken at 50 m from the bank. For cadmium, the concentrations were comprised between 21.35±1.42 and 14.25±1.33 µg g^{-1} for samples taken at the same distances. With regard to major elements, potassium was the most important with contents ranging between 0.31±0.02 mg L^{-1} in water and 10.95±0.02 mg g^{-1} in the sediments. On the other hand, magnesium and sodium were detected at the lowest concentrations with respective concentrations of 0.01 mg g^{-1} in the sediments and of 0.02 mg g^{-1} in water. For trace elements in the sediments, zinc was most concentrated with contents varying from 404.26±76.71 and 758.87±49.14 µg g^{-1} followed by cadmium (between 9.37 and 21.35 µg g^{-1}). Among analyzed heavy metals, only nickel was detected at high concentration in water taken at the entrance of the lake (between 2.56 and 3.42 µg mL^{-1}).

When compared to water, minerals contents in sediments were very high for samples taken upstream and downstream the dam. In this respect, K values in sediments was between 35 fold that in water downstream and 61 fold the concentration in water upstream. Similar trend was noted for all minerals and heavy metals analyzed. These findings corroborate earlier studies by Atta *et al*. (1997) and Adeniyi and Yusuf (2007) who showed that sediments constitute the major repository of heavy metals in aquatic systems. The higher concentrations recorded in the sediment may be attributed to human activities such as agriculture and fishing. In effect, pesticides and other inputs used by individual farmers and industrial farms not far from the lake are easily drained in the water and accumulate mostly in sediments. In this respect, earlier studies showed that sediments form the major deposit of heavy metals in aquatic system that are influenced by industrial and domestic effluents (Olowu *et al*., 2010). If most of minerals contents in this study remain lower than threshold values indicated by WHO (1985), contamination of aquatic flora and fauna should be expected through bioaccumulation. It is known that the presence of these pollutants disturbs significantly the balance of the aquatic ecosystem and consequently turn into ecological concern.

The minerals such as potassium (K), magnesium (Mg), sodium (Na), zinc (Zn), nickel (Ni), cadmium (Cd) and lead (Pb) were analyzed in different organs like flesh, skin and head of the fish taken from the lake to assess the level of bioaccumulation in these organs (Table 3). The range of K was 2.70±0.11 to 5.35±0.12 mg g^{-1}, Mg was 0.25±0.03 to 0.56±0.04 mg g^{-1}, Na was 0.25±0.01 to 0.39±0.03 mg g^{-1}, Zn was 11.61±1.40 to 23.50±0.90 µg g^{-1}, Ni was 0.22±0.01 to 11.01±0.61 µg g^{-1}, Cd was 1.10±0.05 to 18.50±0.20 µg g^{-1}, Pb was 2.62±0.60 to 13.20±0.81 µg g^{-1} irrespective of the organs. The results show that mineral contents varied between organs but also between the fish species. With regard to organs, all minerals including heavy metals increased progressively from flesh (lowest values) to head (highest values). The heavy metal higher accumulation in head raise the issue of their toxicity since most people from the region appreciate eating fish head. For species, *Silurus glanis* had the greatest mineral contents in all its organs compared with *Tilapia nilotica* and ***Arius parkii***. The contents of major elements (K, Mg, Na) in the various parts of the 3 species were variable from low values like (0.25±0.03 mg g^{-1} of Mg in the flesh of *Tilapia nilotica*) to more important values (5.35±0.12 mg g^{-1} of K in the head of *Silurus glanis*). Similarly, heavy metals ranged between low value (0.22±0.01 µg g^{-1} of Ni in the flesh of *Tilapia nilotica*) and high content (18.50±0.20 µg g^{-1} of Cd in the head of *Silurus glanis*). The contents of some heavy metals determined in the most consumed part (the flesh) for this study are higher than those obtained by Vinodhini and Narayanan (2008) for fresh water fish in India and by Olowu *et al.* (2010) for fish from Epe and Badagry lagoons in Nigeria.

At the whole, the concentration of minerals and heavy metals in fish indicate the level of pollution of the water and sediments from Lagdo lake. Most elements were detected in water at important concentrations both upstream and downstream from the dam (Table 1). Other studies showed that fish collected from polluted water had levels of heavy metals greater than in the water (Al-Kahtani, 2009).

Cd and Pb were not detected in water but highly concentrated in fish. This may be due to fish feed taken from the plankton. The high level of minerals accumulation observed in organs of *Silurus glanis* compared to the other species could be due to its habitat and its food taken from the sediments of the mud.

The concentrations of the majority of the heavy metals detected in different fish organs are above the threshold values indicated by WHO (1985) and USEPA (1986). Given that fish constitute the main source of protein in the Lagdo area, the risk associated with their consumption most not be neglected.

CONCLUSION

The present results showed that Lagdo lake (water and sediments) is polluted by minerals and heavy metals which are highly accumulated in fish. The levels of heavy metals in different fish organs, especially in head are worrisome because of their possible health implications for the local populations who depend on the lake for their fish requirements. The findings of this study suggest that adequate measures most rapidly be taken to monitor the water quality and to prevent fish contamination.

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