



Content of seven metallic elements in water, sediment and in liver and gonads of *Lepomis gibbosus* Linnaeus, 1758 (Fish Centrarchid, perciforme, actinopterygiis) living in fourate lake (Morocco)

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Abstract

Lepomis gibbosus is a fish that lives in calm, shallow warm waters, among the moderately abundant vegetation of low or stagnant streams. It is a source of animal protein for humans. However, if it is contaminated with metals, it can be a health hazard.

In the present work, we have estimated the degree of concentration of seven metallic elements in the water and in the sediment of the biotope of life, and the liver and gonads of three sizes of *Lepomis gibbosus* individuals. The studied hydrosystem was the Fourate Lake which is located near the town of Kenitra and from which it receives liquid and solid waste.

The results showed that the sediment was contaminated by the majority of the metallic elements studied. Water is also contaminated but to a lesser extent than sediment.

The concentration of these metals varies depending on the organ and the size of the fish. The results also showed that for the liver and gonads were highly contaminated by these metals but, with the exception of chromium whose amount did not exceed the detectable threshold, the degree of this contamination varies according to the organ and depending on the age, otherwise the size of the fish. This contamination could stress the function of detoxification of the body ensured largely by the liver and the reproductive function provided by the gonads. Similarly, Also, *Lepomis gibbosus*, from the studied lake, can be dangerous for the consumer.

Keywords: metallic pollution, water, sediment, *Lepomis gibbosus*, lake fourate, Morocco

Introduction

With increasing human agricultural and industrial activities, the physical and chemical degradation of many hydrosystems is worsening. Thus, monitoring the quality assessment of these ecosystems is useful. This evaluation can be carried out by analyzing numerous physicochemical parameters capable of reflecting a first component of the quality of the studied hydrosystem or by a second so-called "biological" component whose principle is to carry out a qualitative and quantitative analysis of the fauna or flora of the environment. Primarily, the biological method relies on the qualitative and quantitative presence, and sometimes the absence, of certain so-called "indicator" species that make it possible to evaluate the environmental conditions. Among the biological methods of the evaluation of the ecosystem contamination by heavy metals or trace elements, the determination of the contents of these elements in the body of certain species called bioindicators. These species are characterized by their ability to progressively bioaccumulate, during their lifetime, quantities of heavy metals [1]. Thus, to evaluate the degree of contamination of a hydrosystem by heavy metals, the method

based on the use of so-called bio accumulative species is more reliable than that based on the determination of the physicochemical characteristics of the medium at a given date [2]. The evaluation of the quality of the environment by the biological method thus has an advantage over that based on the analysis of the abiotic components of the environment [3]. In addition, these metals and other micro pollutants are likely to accumulate in sediments deposited at the bottom of streams and in suspended solids transported them [4]. Exposed to these pollutants either by absorption or through the trophic chain, the life of several species is disrupted. Thus, in rivers and lakes, heavy metals are disrupters of life [5]. One aspect of this disturbance can be estimated by evaluating the concentration of heavy metal or trace elements in the body of so-called bioaccumulative species of these elements [5]. In this work, we have estimated the concentrations of 7 metal elements (Pb, Mn, Cd, Zn, Cu, Cr and Ni) in water, the sediment of the lake, and in the liver and gonads of a fish, *Lepomis gibbosus* L. (Centrarchidae, Perciforme, Actinopterygiis). The study area, Lac "Fourarat", is a stagnant or having very low flow in places, is located near the city of

Kenitra (Morocco). The fish is consumed by the riparian human population.

Material and Methods

The living environment of the studied fish: Fouarate Lake

It is located between 35 ° 15' north latitude and 6 ° 30' longitude north of the city of Kenitra (Morocco). Its impoundment is carried out mainly from the atmospheric precipitation water, the contributions of the Fouarat River and the inflow of waste water. Its waters are used for irrigating crops and watering livestock. Similarly, this lake is located near a major urban agglomeration "the city of Kenitra" which is experiencing a very large expansion, generating a significant amount of wastewater; this generates an important source of pollution and degradation of this biotope [6, 7] Note that this lake is a source of fishing of several species of fish caught and marketed in the region while constituting a possible source of danger to the health of the consumer.

In addition, the water and sediment samples analyzed were taken at S1 and S2 (Figure 1). Then, for each metallic element, the estimated concentration is calculated as the average of the two values recorded at S1 and S2.

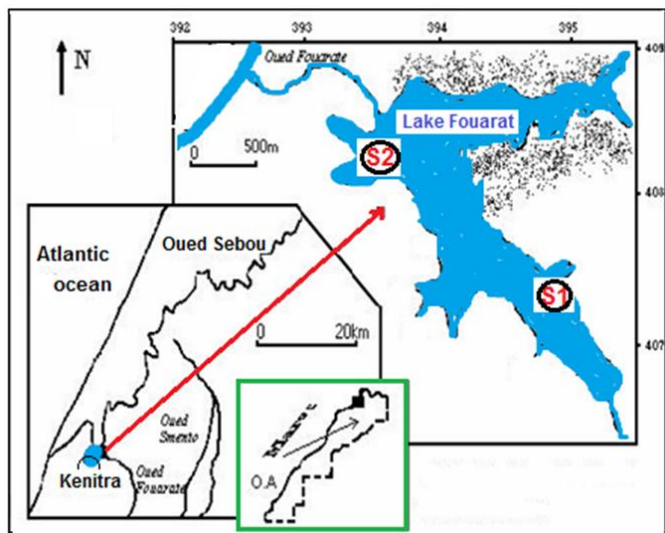


Fig 1: Location of the water and sediment sampling stations in the studied lake

The studied fish

The sunfish or *Lepomis gibbosus* L. belongs to the Family

Centrarchidae, Order Perciformes, Class Actinopterygiis. It is primarily carnivorous and feeds on aquatic insect larvae (Trichoptera, Coleoptera, etc.), snails, small fish fry and daphnia [8]. It lives in moderately abundant areas of warm, calm, shallow water or in low or stagnant streams [9].

The evaluated metallic elements

In the water of the biotope and in the liver and gonads of fish, we evaluated the contents of 7 metallic elements namely lead, cadmium, manganese, chromium, nickel, copper, and zinc. Note that all elements are potentially toxic once their concentration exceeds a so-called 'critical' threshold. This threshold depends on the species and the metal. For all metallic elements, the concept of toxicity is closely related to that of limit dose.

Methodologies for evaluating metallic elements:

For so-called bioaccumulative species, the amount of bioaccumulated metal in the body depends on the age of the individuals. Note that often the size of the individual correlates with its size.

Thus, for three size classes (= age classes) the content of the metal elements was carried out in the liver and gonads of the fish studied. For each class of liver or gonad tissues of four individuals were analyzed. It should be noted that the size of the studied fish rarely exceeds 15 cm and its growth varies according to the ecological conditions of the environment and that the three size classes in centimeters have been defined as follows: T1: [8-10 [, T2: [10-12 [and T3 [12-14].

The evaluation of the contents of the metallic elements was carried out by atomic absorption spectroscopy which consists of bringing the elements to their atomic state on the same path of a light ray and simultaneously making a measurement of the absorption at a length of the specific wave of atoms. The proportionality between the absorbance and the concentration makes it possible to calculate the contents of the previously mineralized samples.

Results and Discussion

1. Heavy metals in the aquatic environment, in the sediment

Figures 1 and 2 illustrate the concentrations of the metallic elements studied at the level of the water and sediment of the environment of the studied fish.

Table1: Content in µg / l of metallic elements in the water of Lake Fouarate

Stations	S1	S2	Average concentrations in water	Values quality standards (drinking water) according to WHO	Values Moroccan quality standards (irrigation water)	Decreasing ranking of average metal concentrations in lake water
Copper	10	11	10.5	70	2000	Pb>Mn>Cd>Zn>Ni> (Cu, Cr)
Zinc	140	2	70.5	3000	2000	
Chromium	10	11	10.5	1000	1000	
Lead	7100	2320	4710	100	5000	
Cadmium	171	10	90.5	3	10	
Nickel	40	52	46	1000	2000	
Manganese	168	123	145.5	400	200	

The results (tab 1 and 2) show that in water and sediment the contrasts vary greatly according to the metallic element and

weakly according to the stations. Depending on the station, the large variations in concentrations were noted for

concentrations in water for copper and cadmium, lead, manganese, and zinc. In addition, the ranking of the average concentrations of metals in the sediment in descending order differ from those recorded in water. This difference could be due to the phenomenon of release of metallic elements that exists between the sediment and the water and to the action of certain physicochemical factors on the circulation of certain metals between the water and the sediment of the hydrosystem [10]. It should also be noted that the results showed that, in water and sediment, three metallic elements were present in a remarkable way: Mn, Zn and Pb. This could be due to the abundance of these elements in the industrial water waste dumped into the lakes with prior treatment.

For the comprehension of each of the metals in the different compartments studied, the results showed:

Lead

In water, relative to the concentrations of other metals that of lead is very high. Moderately it is very close to the standard value set for irrigation water. In sediment, its concentration comes in third place after manganese and zinc. These high levels can be attributed to the discharge of gas-rich sewage from vehicles in the city of Kenitra and the sewage from service stations supplying these vehicles with fuel. Also, the leaching water from roads near the lake is a potential source of this lead.

Manganese

In water, the concentration of this metal is less important than that of lead but in the sediment, it is this concentration which is more important. It should be noted that manganese is an element sufficiently answered in nature which, consequently, constitutes a source of natural pollution; it can also prevent fertilizers or dyes or dyes from the effluents of a nearby textile unit.

Cadmium

In water, the concentration noted is high and exceeds the value set by WHO for drinking water and even the value set by Morocco for irrigation water. In the sediment the value noted is low relative to the concentrations of the other metals.

The difference in concentration noted in water and that noted in the sediment could be explained by the degree of solubility of Cd in water and its low participation in the sediment.

The Zinc

In water, the concentration of zinc is average relative to the concentrations of other metals. In sediment, the concentration of zinc is very high. Wastewater could be a major source of this metal element. The difference in the importance of the concentration of zinc in water and that noted in the sediment can be explained by the ease with which this metal accumulates on the surface of the sediment [6].

Copper, chromium, nickel

In the water, these elements have very low concentrations and which approach each other in the two stations while remaining low compared to the concentrations of the other elements. In the sediment, the concentrations of these three are very high especially chromium and nickel.

Industrial wastewater discharged into the lake could be the source of these three metals.

It should be noted that copper deficiency can cause diseases in animals [11, 12].

In addition, the results showed that the water and sediment of Lake Fouarate contain the seven metals studied. The metal concentrations vary according to the metal and the liquid or solid phase of the biotope. For the same metal, the difference in concentration in water and the concentration in the sediment could be due mainly to three types of phenomenon: the degree of hydrosolubility of the metal, the action of certain physicochemical factors on the adsorption and the resorption of the metal, the phenomenon of release of the metallic elements of water and sediment, and the degree of assimilation of the metal by the different kinds of aquatic plants. Indeed, because of their high water solubility, zinc and cadmium chlorides and sulfates are the compounds that present the most danger for certain aquatic animals such as fish in which these elements easily accumulate [6].

2. Heavy metals in the liver and gonads

According to the results (Table 3 and 4), the average lead concentration is higher in the liver than in the gonads. In addition, in the liver this concentration varies less according to the sizes of the fish, in other words, according to their ages. In the gonads, the concentration of lead is higher in medium-sized individuals. For cadmium, in the liver and in the gonads, the concentration does not vary much according to the age of the individuals. The concentration of nickel varies with the size of individuals and the size of its distribution varies according to the organ. Large individuals have less nickel in their liver but in the gonads the importance of their concentration increases proportionally with the size of the individual. For chromium, both in the liver and in the gonads, the concentration was not detectable in any size of the fish studied. For zinc, in the liver the importance of the concentration increases proportionally with the size of the individual whereas in the gonads this importance is inversely proportional to the size of the individuals. For manganese, in the liver and in the gonads the concentrations of manganese do not vary much according to the size of the individuals. However, these concentrations are higher in the liver than in the gonads. For copper, the concentrations do not vary much according to the size of the individuals or the organ of bioaccumulation.

Thus, as the results show, the importance of the concentration of metal elements studied differs according to the metal element itself, depending on the organ and depending on the size, otherwise the age, of the fish.

Similarly, as shown in Table 4, according to the decreasing ranking of the concentrations of the metals studied, four metal elements have the highest concentrations in the liver and in the gonads namely zinc, manganese, nickel and copper. In addition, zinc is still in first place in this ranking and manganese is often in the second position.

Moreover, the heavy metals pollution of the studied environment is attributed to the impact of the pollution sources in this zone, mainly the discharges of urban and industrial waste water that have not been previously treated before being discharged into the lake [7]. As Jakimska *et al.*

(2011) [13] heavy metals enter organisms via food, respiratory tract or skin. Then, other factors determine their bioconcentration and their concentration in the organs of the same organism. In *Cyprinus carpio* (Common carp), for example, heavy metals enter the body in three possible ways: by gills, body surface and digestive tract [14].

At the level of the organism of an animal species living in a hydrosystem contaminated by heavy metals, once entering the organism, the metals could vary in quantity and quality with the location, the genus, the size and the tissues [15]. In *Cyprinus carpio* (Common carp), for example, the estimated accumulation of heavy metals in the liver and gills was of the order of Pb> Cd> Ni> Cr and Cd> Pb> Ni> Cr whereas the order in the flesh and kidney tissues was Pb> Cr> Cd> Ni and Pb> Cd> Cr> Ni [14]. Our results (Table 4) showed that, as for *Cyprinus carpio*, this organ can vary according to the organ of bioaccumulation and that zinc and the most bio accumulated metal. This latter finding is in part consistent with results from a research conducted on *Mytilus edulis* by Swaleh *et al.* (2016) [15] who reported that in this species, the results showed that zinc and iron were the most abundant metals tested [15]. As well as for *Mytilus edulis*, a significant temporal variation was observed for the zinc, copper and, lead [16]. For *Sepia spp.* and

Cardium edule, results obtained by Abdel-Salam and Hamdi (2014) [17] revealed significant variations in Fe, Cu, Zn, Co, Hg, Pb and Cd levels in edible muscles.

Table 3: Content in µg / g of the fresh liver chair or gonads of Lac Fouarate

Organ	Metal	Sizes of individuals		
		T1	T2	T3
Liver	Pb	0.49	0.47	0.49
	Cd	Ld	0.005	0.017
	Ni	6.32	5.34	1.2
	Cr	Ld	Ld	Ld
	Zn	12.66	17.78	19.12
	Mn	7.34	8.76	9.23
	Cu	2.29	3.62	3.56
Gonads	Pb	0.21	0.45	0.20
	Cd	Ld	Ld	Ld
	Ni	3.43	6.11	5.54
	Cr	Ld	Ld	Ld
	Zn	24.66	17.23	19.12
	Mn	5.2	4.89	5.82
	Cu	3.11	2.12	2.19

Table 4: Ranking in descending order of the contents in the fresh liver meat or the gonads meat of different sizes of the studied fish

Organ	Liver	Gonads
Size I		
Classification of metals according to their grades decreasing concentrations	Zn>Mn>Ni>Cu	Zn>Mn>Ni>Cu
Size II		
Classification of metals according to their grades decreasing concentrations	Zn>Mn>Ni>Cu	Zn>Ni>Mn>Cu
Size III		
Classification of metals according to their grades decreasing concentrations	Zn>Mn>Cu>Ni	Zn>Mn>Ni>Cu

In addition, heavy metal intoxication involves disruption of the reproductive function or affects the physical integrity of the offspring of intoxicated individuals [2]. Indeed, Maïui *et al.* (2000) [18] reported that carbon monoxide and lead, present in the exhaust and detected in the blood of animals exposed to these pollutants, cause sexual, renal and hematological disturbances, and blood lead had a significantly positive association with developmental delays [19]. In addition, heavy metals are recognized as neurodevelopmental toxins since they can be responsible for fetal damage that leads to neurological abnormalities, developmental delays, learning difficulties and behavioral abnormalities [20]. It should be noted that it has been shown that heavy metals such as cadmium, arsenic, mercury, nickel, lead and zinc can exhibit endocrine disrupting activity in animal experiments [21]. Also, by bioaccumulating metals in the gonads the estrogen receptor can be replaced by several heavy metal molecules such as copper, cobalt, Ni and Cd. By replacing the Zn atom with Ni or copper, the binding from the estrogen receptor to the hormone-sensitive elements DNA in the cell the nucleus is prevented [21].

Conclusion

The water and sediment of the studied lake were metallically contaminated. This pollution concerns the majority of the

metallic elements analyzed. It is, therefore, a degradation of the physicochemical quality of the lake. The liver and gonads have shown the presence of the majority of these metal elements. The degree of this presence varies according to the organs, depending on the metal element and the size or age of the fish. Indeed, the concentration of lead is higher in the liver than in the gonads, regardless of the size of the fish; the concentration of cadmium varies slightly in the liver and gonads. In contrast, the concentration of nickel varies according to the organ and in function of the size of the individual. Nickel is more concentrated in the gonads, especially in older individuals; chromium did not have a significant presence in either the liver or the gonads; the concentration of zinc, in the liver the importance of the concentration increases proportionally to the size of the individual whereas in the gonads this importance is inversely proportional to the size of the individuals; the copper concentrations do not vary much, either according to the size of the individuals or according to the organ of bioaccumulation.

The results have shown that for the liver, which is a very active organ in the body's detoxification, metallic pollution contributes to the functional stress of this organ, and for the gonads, the load of metallic elements of this organ can alter its functioning.

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