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Levels of Chromium and Copper in Liver and Muscle Tissues of the Round Sardinella *Sardinella aurita* (Valenciennes) from the Oran Coastline, Algeria

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Abstract

The aim of the present study is to determine the levels of two heavy metals (Chromium and Copper) in the liver and muscle tissues of *Sardinella aurita* from the Oran coastline. Metal levels in fish samples were analyzed by using atomic absorption. 400 readings were carried out between May and October 2007. The order of heavy metal accumulation in the fish were in the order of magnitude as Cu > Cr. The average concentrations recorded in the fish, in this study, ranged, respectively, between 1.9 to 3.97 mg/kg for Copper, and between 0.07 to 0.12mg/kg for Chromium. The levels measured in liver tissue are higher than those reported for muscle tissue. The present study confirms that the round Sardinella *Sardinella aurita* (Valenciennes, 1847), from the Oran coastline, can bioaccumulate heavy metals from a polluted environment. The average concentrations of Cr (0.083±0.01mg/kg) and Cu (2.78±2.92, recorded in our study, were above FAO limiting standards for food fish.

Key words. *Sardinella aurita;* Pollution, Heavy Metals, Chromium, Copper; Oran coastline.

1. Introduction

Heavy metal pollution has become a serious environmental and public health issue (Venkatramreddy *et al*., 2009). Heavy metals are commonly found in natural waters and some are essential to living organisms. Yet they may become highly toxic when present in high concentrations (Ibok *et al.,* 1989). The toxicity for humans is mainly caused by their persistence in the environment. This situation is a result of the rapid growth of population, intense industrialization and other anthropogenic activities, like the exploration and exploitation of natural resources, the extension of irrigation and modern agricultural practices (FAO, 1992). Due to their bioaccumulative and non-biodegradable properties, heavy metals constitute a core group of aquatic pollutants.

The objective of the present study is to determine the level of two heavy metals: chromium and copper in organs of *Sardinella aurita* from gulf of Oran.

Sardinella aurita (Teleosten; Clupeidae) was selected for the present study. It is a small pelagic fish that lives in tropical and subtropical waters of the western and eastern Atlantic Ocean, the Pacific Ocean, the Mediterranean and, occasionally, the Black Sea (Sabate's, 2006). In the Algerian coasts; it is very common and very abundant (Benamar, 2011). It is also considered, in Oran, the most consumed fish after sardine *Sardina pilchardus* and bug *Boops boops* (Benamar, 2011).

For the purposes of the present paper, two metals were detected: copper and chromium. It has been established that copper is one of the most abundant trace metals and for almost all organisms; it is an essential micronutrient (Duffus, 1980). The aquatic toxicology of Cr depends on both biotic and abiotic factors. The biotic factors include the type of species, age and developmental stage. When bioconcentrating in the food chain, heavy metals, including Cr, are potentially cytotoxic to aquatic biota. Therefore, an early detection and ecotoxicologic evaluation of a sensitive biomonitoring system comprising both in vivo and in vitro test systems is essential (Venkatramreddy *et al*., 2009).

The Chromium was also shown to accumulate mainly in metabolically active organs such as liver, gill and kidneys at high concentrations. It was shown that fish go under some behavioral alterations such as suspending feeding, irregular swimming and accelerated operculum movement when first encountered with chromium (Svecevicius, 2009). Chromium also caused structural changes such as hypertrophy and hyperplasia at gill epithelium, degeneration in fin rays and weakening of immune system (Synder and Valle, 1991; Bennani *et al.,* 1996; Arunkumar *et al.,* 2000).

2. Materials and Methods

2.1. Study Area

The gulf of Oran, on the Algerian Mediterranean coast , is located between the industrial gulf of Arzew in the east, and the un spoilt Andalouses Coast in the west (Figure 1). More than 90 million m3 of untreated wastewaters are discharged annually by the Oran metropolis and many industrial units. Generally, these industries shall carry out the evacuation of their waste without any processing. Chemical releases, discharges of hydrocarbons of petrochemical origin (industrial zone of Arzew), and dissolved mineral and metal waste are thrown more heavily in effluents from various industries. The sea constitutes a major receiving area for waste water in Oran, as is the case for the majority of Algerian coastal towns. The sea is also the direct discharge system for effluents from the town of Oran. Total waste-water discharge along the bay of Oran can be estimated for industrial plants (with water consumption of more than 1000 m3/year) and domestic discharge (SOGREAH Engineering, 1998).

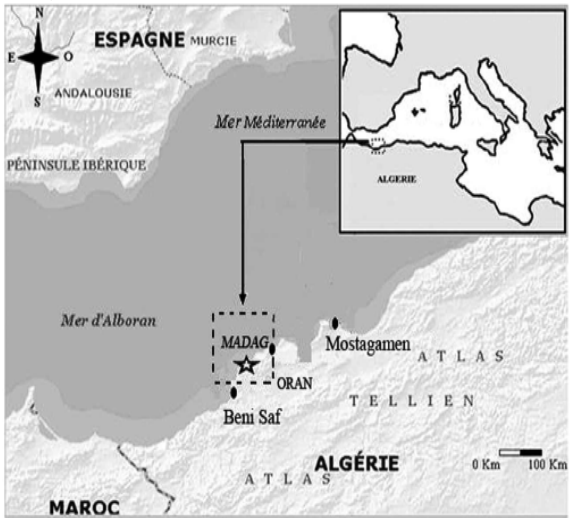

Figure 1. Geographical location of the site bay, Oran, Algeria

2.2. Sample Collection and Treatment

Samples of *Sardinella aurita* were collected between May 2007 and October 2007. Samples were placed in polyethylene bags and transported in a polystyrene ice-chest to the laboratory. The total lengths (cm) and weights (g) of the fish species were measured and after measurements, livers and muscles were removed, weighed and frozen until the time of their chemical analysis. Samples were prepared for trace metal analysis (UNEP, 1984a). Wet mineralization of samples was performed according to the method of Amiard *et al*. (1987) using a mineralizator type VELP. One ml of nitric acid is added to 1g wet weight of fish sample and then adjusted to 4 ml of bidistilled water after one hour at 95°C. The trace metals were determined by flame atomization (UNEP, 1984b) using a Perkin Elmer, Analyst 100 Atomic Absorption Spectrophotometer. To ascertain the accuracy of the results, blanks were included in every batch of nine samples analyzed. Analytical quality control measures adopted by the International Atomic Energy Agency (IAEA-350) – the intercomparison run which uses tuna fish homogenate as a certified reference material was used. The statistical analyses were made by means of the software Statistica version 5.0 (Co Microsoft).

3. Results

In this study, the concentrations of metals copper and chromium were detected in all samples. The average concentration in mg/kg wet weight, in the liver and muscles of the round *Sardinella*, are summarized respectively in figure 2.

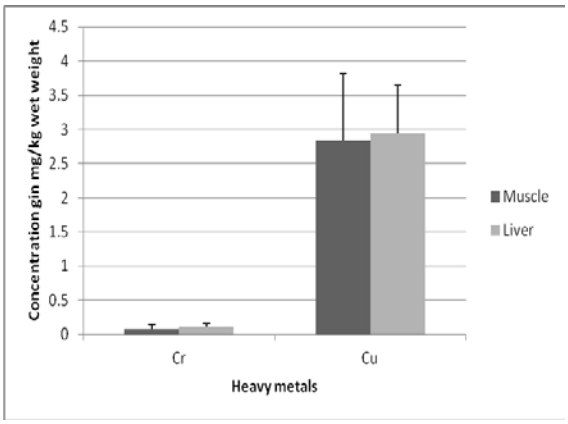

Figure 2. The average concentration of copper and chromium in organs of *Sardinella aurita* (mean ± standard deviation)**.**

The results showed that the values of copper were higher than that of chromium. The distribution patterns of Cr and Cu in the tow organs of the *Sardinella* followed the order: liver > muscles.

The mean concentrations of copper in all examined tissues varied from 1.90±0.4 to 3.96±1.54 mg/kg (figure 3). The higher concentration level in the two organs was observed in August (figure 3). Meanwhile, the chromium concentration ranged from 0.07±0.1 to 0.12 ±0.04 mg/kg. The highest mean concentration level of chromium was observed between June and August, as shown in figure 4.

The mean concentrations of Cr and Cu in liver and muscle of the round *Sardinella* showed that the females accumulate more than the males but without statistical significance (figure 5).

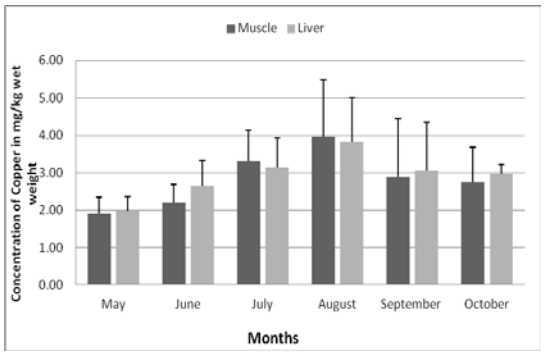

Figure 3. The monthly average concentration of copper in organs of *Sardinella aurita* (mean ± standard deviation)**.**

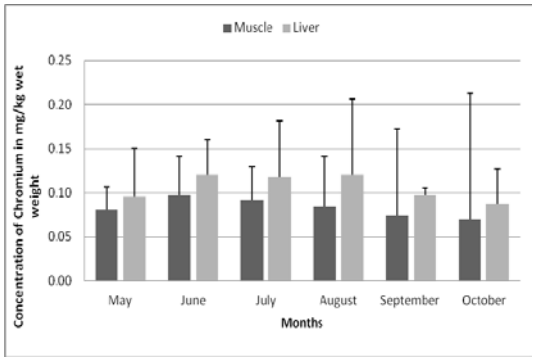

Figure 4. The monthly average concentration of chromium in organs of *Sardinella aurita* (mean ± standard deviation)**.**

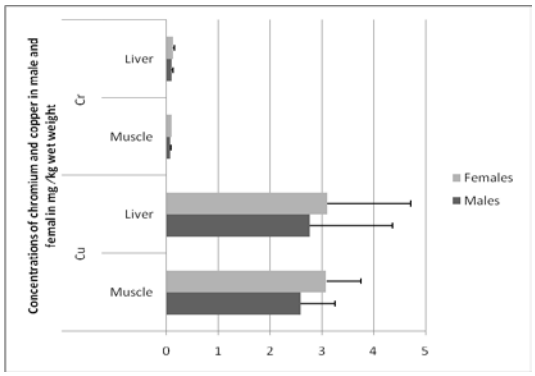

Figure 5. The average concentration between males and females of copper and chromium in organs of *Sardinella aurita* (mean ± standard deviation)**.**

4. Discussion

Concentrations of heavy metal, detected in the muscle and liver samples, showed different capacities for accumulating. The observed variability of heavy metal levels in *Sardinella aurita* depends on the level of exposure (water, food) and physiological factors (age, metabolic activity), together with factors related to environment such as temperature, physical-chemical parameters, presence of other metals (Kim et *al.*, 2004).

Metals accumulate in higher concentrations in the liver of *Sardinella aurita*, compared with muscle tissue. A similar result was found in the sardine *Sardina pichardus* fishing in the Bay of Oran (Merbouh, 1997). In fish, the most toxic metals tend to accumulate in the liver or kidneys (ICES, 1991). It has been established that the liver is a target organ for the accumulation of heavy metals, and the higher levels of these metals in the liver, compared to other organs, may be attributed to the high coordination of metallothionein protein with the metals (Hogstrand and Haux, 1991). In addition, the liver is the principal organ responsible for the detoxification, transportation and storage of toxic substances and an active site of pathological effects induced by contamination. The muscle is not considered an active tissue in accumulating heavy metals (Yilmaz, 2003). However, it has been proven that all trace metals concentration in the muscle tissue of *Saradinella aurita* was positively correlated to lipid content in the muscle tissues (Wafica and Aboul Naga, 1996). As for regulation and guideline levels, the Food and Agriculture Organization (FAO) has set permissible limits for heavy metals in the muscle of fish (because it is the part consumed). The mean levels found in *Sardinella aurita* samples are 2,8 mg/kg for Copper and 0.08 mg/kg for Chromium .

The levels of (Cu) in the fish sampled were higher than those of (Cr). This is because it represents an essential homeostatically regulated metal in all living organisms (Goyer, 1996). Cu as a microelement is essential for the normal growth and metabolism of plants, animals and most microorganisms (Schroeder et *al*., 1996). Additionally, it is the third largest trace element found in a living organism's body after iron and zinc. It is a component of many enzymes like cytochrome-c oxidase, superoxide dismutase, tyrosinase, dopamine beta hydroxylase ferrooxidases and amine oxidase. Copper is involved in neurotransmitter regulation, nutrient metabolism, collagen synthesis, cellular respiration and immune function.

The copper contents in the samples were less than the FAO-permitted level of WHO (3.0mg/kg) (Onianwa *et al*., 2001). Excessive intake of copper may lead to liver cirrhosis, dermatitis and neurological disorders (Onianwa *et al.*, 2001). Cu compounds, such as copper sulphate, are widely used as biocides to control macrophytes, freshwater snails that may harbour schistosomiasis or other disease pathogens, ectoparasites of fish and mammals, marine fouling organisms (Eisler, 1998).

On the other hand, Chromium does not normally accumulate in fish, and hence, low concentrations of Cr were reported even from different industrialized parts of the world (Moore and Ramamoorthy, 1984). Cr bioaccumulation in fish has been reported to cause impaired respiratory and osmoregulatory functions through structural damage to gill epithelium (Heath, 1991). The values of Cr recorded in *Sardinella aurita* in this study were above FAO limiting standards of 0.15mg/kg for food fish. The WHO has proposed that chromium (VI) is a human carcinogen. Several studies have shown that chromium (VI) compounds can increase in risk of lung cancer. Animal studies have also shown an increase in risk of cancer (Moore and Ramamoorthy, 1984).

In this study, higher concentrations of metals were observed in *Sardinella* collected between June and August, which coincide with the summer's months. During this period, peak temperature of the seawater is observed, in the bay of Oran. According to the Algerian National Office of Meteorology, the temperature attained between 26-27 ºC (Benamar, 2011).

The relationship between metal accumulation and sex, found in this study, may be due to the difference in the metabolic activities between the males and the females. According to Mortet (1988), an ovarian sequence for *Sardinella aurita* begins in the Bay of Oran during summer. It is characterized by an intense vitellogenic activity. Vitellogenesis is accompanied by an accumulation of reserves for the growth of eggs, but at the same time, by the metallic pollutants found in the biota (Mortet, 1988).

When comparing the rate of metal traces found in the muscle of *Sardinella aurita* with those found in *Sardinella* from the Strait of Messina (Sicily, Italy) and *Sardinella* from Alexandria waters, we notice that our samples are the least contaminated by chromium. Contrary to the levels of copper which appears to be high in *Sardinella aurita* from Oran coastline (Table 1).

Table 1. Comparative concentrations of copper and chromium in muscles of *Sardinella aurita* from different areas.

Areas studies	Chromium	Copper	Authors
Sardinella aurita from the Strait of Messina (Sicily, Italy)	0,36 ± 0,07	0,373 ±0,012	Lo Turco *et al* ., (2013)
Sardinella aurita from Alexandria waters	0,1± 0,04	0,98 ± 0,3	Wafica and Aboul-Naga (1996)
Sardinella aurita from Oran coastline	0,08± 0,06	2,83 ± 0,9	Present study

5. Conclusion

Compared to the muscle tissue, the liver tissue of *Sardinella aurita* from bay of Oran, contained elevated concentrations of the metals Cu and Cr. This capacity of metal sequestering highlights differences in elemental bioavailability between sites and thereby makes the liver more suitable for biomonitoring purposes than the muscle tissue.

This study shows that the concentration of heavy metals in different fish organs is still below the allowable limits. This means that the measured fish is healthy.

However**,** accumulation of heavy metal in tissues of fish species, that are consumed as protein sources, passed cumulatively along the food chain and can constitute, after a long time, a public health problem.

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