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Research Article

# Human Health Risk Assessment from Heavy Metal Exposure through Fish Consumption from the Red Sea and Gulf of Aden, Yemen

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## Abstract

Levels of heavy metals (Fe, Zn, Cu, Pb, Ni, and Cd) in five commercial fish species collected from the Red Sea and Gulf of Aden, mainly *Pomadasys argenteus, Aprion virescens, Valamugil sehli, Epinephelus areolatus* and *Thunnus tonggol* were measured to assess contamination and health risks. The flame Atomic Absorption Spectrophotometry (AAS) method was adopted for measuring all selected elements. The results showed that variations in heavy metal concentrations within the muscle tissues of the examined fish were mainly attributed to the geochemical nature of beach deposits rather than anthropogenic input. All muscle samples analyzed had concentrations of Fe, Ni, Zn, Cu, Pb, and Cd below the standards reported by the National Health and Medical Research Council (NHMRC). Thus it was concluded that the investigated heavy metals do not present an environmental hazard for the present time. Cd, Ni, and Pb are harmful and cause cancer diseases.

## Introduction

The concentration of trace metals in commercial marine fish has received much attention, The high exposure of heavy metals and metalloid elements in commercial fish species represents a potential human health hazard [1].

Pollution in the world has received considerable attention from forty years ago [2]. Heavy metals have been considered a serious global environmental threat [4]. In recent years, it has become a great problem with increasing human activity. Heavy metals are among the pollutants, which receive attention in various countries. In addition to the natural content of metals in the seawater from the geochemical background, the oceans and seas are considered major receivers, of industrial, agricultural, and sewage wastes [5-8].

Some of these metals are classified biochemically as essential elements. They are present in trace quantities in the bodies of living organisms. Among these elements Fe, Cu, Zn, and Mn are cited. Copper and Zinc play an important role in different physiological processes. On the other hand, lead and cadmium are non-essential elements with no vital role but are considered to be very toxic to the environment [9-11]. Marine fish can absorb toxic metals from the surrounding water and sediment as well as through their food [12]. According to Isangedighi and David [13], heavy metal toxicity as a result of fish consumption can result in damage or reduced mental and central nervous system function, lower energy levels, and damage to blood composition, lungs, kidneys, bones, liver, and other vital organs

The Red Sea of Yemen and the Gulf of Aden are characterized by fish productivity and along it, there are industries,



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which dispose of their wastes into the marine environment. In addition, huge amounts of drainage water mixed with pesticides affect the environment of Yemen. As for the effect of both environments on fish food sources and their quality, it appeared that the quality of those fish food resources has not been inversely affected by the slight pollution sources due to the vast dilution effect in the Red Sea and Gulf of Aden [5].

The aim of the study is to study the state of contamination in the muscle tissues of some commercially important fish species inhabiting the Red Sea and the Gulf of Aden in Yemen. The specific objectives are:

Identify the most important source/s of contamination to the region and shed some light on the sub-lethal effects of the most prominent contaminants upon the marine resources in the area, as well as its possible implications for human health who consume them.

Determine residue levels of potential heavy metals in the flesh of the five selected fish species compared with standards of maximum allowed concentrations of heavy metals in fish flesh.

## Material and methods

Five species of fish "*Pomadasys argenteus, Aprion virescens, Valamugil sehli, Epinephelus areolatus, Thunnus tonggol*" [14] were collected from the local commercial fishermen of Aden city and Hodiedah city during October 2023. All samples were weighted and measured (Tables 1,2). The samples were taken from the fish flesh for the determination of heavy metal concentrations. A part of the fish flesh samples (approximately 3 g) were taken then dried in the oven at 70 °C and stored until digestion. Soft samples were digested with concentrated $HNO_3$ and $HCLO_4$ acids. The digested samples were diluted with deionized distilled water. The determination of heavy metals residue was carried out following the flame Atomic Absorption Spectrophotometer (AAS) method approved by the Standard Methods Committee, 1985 [15] (Perkin-Elmer Model 2380) instrument, following the manufacturer's recommendations with only slight modifications. Calibration curves were constructed from commercial standards. Various *dilutions* were made on the clear digest solution to bring them within the calibration of the ASS. Standard reference materials and blanks were digested and analyzed within every batch of samples.

## Results and discussion

The weight, and length of fish collected from the Red Sea of Yemen and the Gulf of Aden during the present study are presented in Tables 1,2 respectively. All samples were within the range of 250 - 480 g in weight except for *Epinephelus* which is smaller 65 - 77 g.

As for the concentrations of heavy metals in the muscles of the sampled fish, Tables 3,4 illustrate the mean values and standard error of values measured in the five fish species from the Red Sea and Gulf of Aden respectively. Values recorded in the present study for various elements did not exceed the levels recorded for health risk standards. Recommendations of

**Table 1:** The weight and length of fish collected during October, 2023 From the Red Sea of Yemen.

| Fish Species | No. of fish | Total Weight (g) | Total length (cm) | Standard length (cm) |
|---|---|---|---|---|
| *Pomadasys argenteus* | 15 | 350-400 | 95-110 | 85-95 |
| *Aprion virescens* | 10 | 250-480 | 80-95 | 60-73 |
| *Valamugil sehli* | 20 | 370-450 | 45-53 | 33-45 |
| *Epinephelus areolatus* | 30 | 65-73 | 23-38 | 25-30 |
| *Thunnus tonggol* | 15 | 350-450 | 66-93 | 62-75 |

**Table 2:** The weight and length of fish collected during October, 2023 from the Gulf of Aden.

| Fish Species | No. of fish | Total Weight (g) | Total length (cm) | Standard length (cm) |
|---|---|---|---|---|
| *Pomadasys argenteus* | 15 | 360-480 | 97-110 | 90-100 |
| *Aprion virescens* | 10 | 330-480 | 85-97 | 66-87 |
| *Valamugil sehli* | 20 | 450-430 | 45-55 | 28-38 |
| *Epinephelus areolatus* | 30 | 70-77 | 28-40 | 23-322 |
| *Thunnus tonggol* | 15 | 353-410 | 70-88 | 67-80 |

**Table 3:** Mean Concentration ± SE of Fe, Zn, Cu, Pb, Ni and Cd in different, fish species in the Red Sea of Yemen (ppm dry Wt.).

| Metal | *Pomadasys argenteus* | *Aprion virescens* | *Valamugil sehli* | *Epinephelus areolatus* | *Thunnus tonggol* |
|---|---|---|---|---|---|
| Fe | 1.85 ± 0.09 | 1.86 ± 0.08 | 1.88 ± 0.08 | 1.70 ± 0.09 | 1.70 ± 0.08 |
| Ni | 0.08 ± 0.07 | 0.08 ± 0.06 | 0.08 ± 0.06 | 0.08 ± 0.08 | 0.07 ± 0.07 |
| Zn | 2.35 ± 0.08 | 2.89 ± 0.06 | 1.90 ± 0.08 | 0.88 ± 0.07 | 3.57 ± 0.06 |
| Cu | 0.36 ± 0.07 | 0.70 ± 0.08 | 0.53 ± 0.07 | 0.27 ± 0.06 | 0.45 ± 0.07 |
| Pb | 0.28 ± 0.03 | 0.38 ± 0.09 | 0.80 ± 0.06 | 0.08 ± 0.04 | 0.38 ± 0.08 |
| Cd | 0.20 ± 0.08 | 0.28 ± 0.08 | 0.07 ± 0.08 | 0.08 ± 0.05 | 0.22 ± 0.03 |

**Table 4:** Mean Concentration ± SE of Fe, Zn, Cu, Pb, Ni and Cd in different, fish species in the Gulf of Aden (ppm dry Wt.).

| Metal | *Pomadasys argenteus* | *Aprion virescens* | *Valamugil sehli* | *Epinephelus areolatus* | *Thunnus tonggol* |
|---|---|---|---|---|---|
| Fe | 1.83 ± 0.08 | 2.65 ± 0.07 | 1.35 ± 0.09 | 1.42 ± 0.06 | 175 ± 0.08 |
| Ni | 0.09 ± 0.07 | 0.08 ± 0.06 | 0.08 ± 0.05 | 0.07 ± 0.07 | 0.06 ± 0.05 |
| Zn | 2.80 ± 0.08 | 3.88 ± 0.07 | 1.75 ± 0.07 | 0.77 ± 0.05 | 3.55 ± 0.07 |
| Cu | 0.90 ± 0.07 | 0.85 ± 0.06 | 0.85 ± 0.05 | 0.25 ± 0.06 | 0.45 ± 0.06 |
| Pb | 0.87 ± 0.08 | 0.87 ± 0.08 | 0.78 ± 0.04 | 0.85 ± 0.05 | 0.36 ± 0.06 |
| Cd | 1.30 ± 0.05 | 0.50 ± 0.05 | 0.09 ± 0.06 | 0.06 ± 0.04 | 0.20 ± 0.05 |

the National Health and Medical Research Council (NHMRC) specify that the concentrations of Fe, Ni, Zn, Cu, Pb, and Cd in the edible parts of fish should not exceed 1500.0, 0.1, 1000.0, 90.0, and 2.0 ppm wet weight respectively [16]. In our study, all the muscle samples analyzed had concentrations of Fe, Ni, Zn, Cu, Pb, and Cd below the NHMRC standards.

Variations in the concentrations of some metals (Cu, Pb, and Cd) in the fish tissues between the two environments are mainly due to the geochemical nature of beach deposits rather than anthropogenic source/s [5]. Under natural conditions, the most important inputs of metals to coastal regions are



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the mechanical and chemical weathering of rocks [17]. Heavy minerals are usually common and represent 50% or more of the beach deposits in some places along the Red Sea coast of Yemen [18,19]. These beach deposits are mainly derived from the mountainous region, which drains from the Yemen highlands to the sea through numerous rivers.

The marine environment may also be polluted with effluent waste containing trace elements from both anthropogenic and natural processes. Such input could results from treated and/ or untreated municipal and industrial wastes, agricultural runoff, and input from the atmosphere [20-22] and may quantitatively alter the natural biochemical cycle [7,8,23-25]. However, due to the physico-chemical properties of most metals, the concentrations in seawater very rarely reach a level which, in polluted waters may accumulate toxic trace elements via their food chains. This agrees with, abubaker, et al. [26]; Al-Shwafi, [27], Ba-Isa, et al. [28]; Shriadah, [29]; Al-Shwafi, et al. [30]. The heavy metals are considered to be potentially harmful to the marine environment. In some cases (e.g. Cu, Pb, and Cd) serious dumping has occurred with harmful effects on marine life (fish kills, green oysters, etc.). In the Red Sea and the Gulf of Aden, industrial, agricultural, economic, and social changes occurred recently, in addition to an increase in population growth, thereby increasing environmental pollution year by year.

## Conclusions and recommendations

It can be concluded from the present investigation that levels of heavy metals in the fish of the Red Sea and the Gulf of Aden are within the safe range for human health. The impact of human activities on the marine environment is relatively low. Beach deposits are the main source of heavy metals in the Red Sea of Yemen/Gulf of Aden environment.

It is recommended that a continuous monitoring program for the Red Sea and Gulf of Aden region should be formulated and conducted to ensure that the concentrations of heavy metals are within the baseline levels established in the present study. Further future studies regarding the levels of mercury (Hg) are highly recommended due to its high toxicity and health risk.

### Ethical consideration

The authors declare hereby that the present study followed standard guidelines for humane animal care issued by the ethical board of Sana'a and Basrah University.

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