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قياس بعض المعادن الثقيلة في النسيج العضلي لبعض الاسماك كمؤشر حيوي لتلوث البيئة البحرية

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Measurement of some heavy metals in the muscle tissue of some fish as a bioindicator of marine environmental

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الملخص:
من أجل تقييم المخاطر المحتملة على البيئة والصحة العامة تم دراسة تراكم المعادن الثقيلة في الأنسجة العضلية لثلاثة أنواع من الأسماك المحلية. قمنا بتحليل عينات الأسماك المأخوذة من السوق المحلية لمدينة بني وليد في ليبيا لتحديد تركيزات الرصاص (Pb) والكادميوم (Cd) والكروم (Cr) والنحاس (Cu) باستخدام تقنيات تحليلية متطورة. الأسماك التي تمت دراستها هي سمكة البوق (Boops Boops) والسردين (Sardina pilchardus) وسمك الشلبة. توجد هذه الأنواع بعيدًا عن الساحل وتم اختيارها لأهميتها البيئية والاقتصادية. الغرض من هذا البحث هو التأكد من درجة تراكم المعادن الثقيلة في أجسام هذه الأسماك وكذلك كيفية انتقال هذه المعادن إلى أسفل السلسلة الغذائية ودخولها في النهاية إلى أجسام البشر. تشير نتائجنا إلى اختلافات مهمة في تراكم المعادن الثقيلة بين الأنواع. تسلط النتائج الضوء على المخاطر الصحية المحتملة المرتبطة باستهلاك هذه الأسماك، وخاصة بالنسبة للفئات السكانية الضعيفة مثل الأطفال والنساء الحوامل. وتؤكد هذه الدراسة على ضرورة المراقبة المنتظمة لتركيزات المعادن الثقيلة في الأسماك المحلية وتنفيذ تدابير مكافحة التلوث لحماية النظم البيئية المائية والصحة العامة. وتتضمن التوصيات تعزيز الأطر التنظيمية وحملات التوعية العامة والمزيد من البحوث حول التأثيرات الطويلة الأجل للتعرض للمعادن الثقيلة على الأسماك والبشر.

الكلمات المفتاحية: النسيج العضلي، (الرصاص *Pb* والكادميوم *Cd*والكروم *Cr* والنحاس(*Cu*)

Abstract:
In order to evaluate possible hazards to the environment and public health, this study examines the buildup of heavy metals in the muscle tissue of three local fish species. We analyzed fish samples taken from the local market of Baniwaleed city in Libya to determine the concentrations of lead (Pb), cadmium (Cd), chromium (Cr), and copper (Cu) using sophisticated analytical techniques. The fish that were studied were trumpet fish (Boops Boops), sardines (Sardina pilchardus), and sarpa salpa. These species are found far from the coast and were chosen for their ecological and economic significance. The purpose of this research is to ascertain the degree of heavy metal buildup in these fish's bodies, as well as how these metals get passed down the food chain and eventually enter human bodies. Our findings point to important variations in heavy metal accumulation amongst species.

The findings highlight potential health risks associated with consuming these fish, particularly for vulnerable populations such as children and pregnant women. This study underscores the necessity for regular monitoring of heavy metal concentrations in local fish and the implementation of pollution control measures to protect both aquatic ecosystems and public health. Recommendations include enhanced regulatory frameworks, public awareness campaigns, and further research into the long-term effects of heavy metal exposure on fish and humans.

Keywords muscle tissue, lead (Pb), cadmium (Cd), chromium (Cr), and copper (Cu).

Introduction

Heavy metals are considered one of the pollutants that enter the environment and cause an imbalance in the environmental balance [1]. Even at low concentrations, heavy metals in the environment have major ecological effects, particularly for fish species[2, 3, 4, 5]. Humans either directly or indirectly reflect this [6]. In addition to their individual harmful effects, lead and cadmium are both regarded as carcinogenic substances and genetic toxins. In addition to depositing in the skeleton, lead accumulation can harm the nervous system and even result in paralysis if it takes the form of lead phosphate in the tissues, which obstructs nerve signal transmission. Cadmium, on the other hand, has the capacity to alter the enzyme's overall structure and thereby reduce its efficiency. Additionally, osteoporosis is caused by advanced cases of poisoning with it. Low quantities of heavy metals, normally less than 50 mg/L, are observed obviously in unpolluted aquatic environments where wastes are not dumped into the water and the water is far flung from sources of pollutants. Behra et al. (2002) pronounced that human uses of water for civil, commercial, industrial, and agricultural functions lead to heavy steel pollutants of the aquatic surroundings. Numerous studies have additionally proven that heavy element infection in rivers comes from a spread of sources, along with home trash, mining operations, and agricultural practices like applying pesticides and fertilizers, which upsets the aquatic ecosystem's delicate equilibrium [7]. due to the fact heavy metals are used considerably in lots of exclusive industries, they're therefore seemed as the most unsafe contaminants in aquatic environments. Untreated contaminated water is released into the surroundings, where it collects in water assets and offers rise to the maximum hazardous sorts of pollution, which includes lead, copper, zinc, cadmium, mercury, and so on. Fish is an essential, cheap and widespread food source in various parts of the world [8]. Because of its high nutritional content, more people are eating fish[9]. The human body needs it permanently and continuously. It is easy to digest, low in calories and saturated fatty acids, unlike red meat. [10]. Since heavy metals cause harm to ecosystems as they go up the food chain, fish are typically employed to assess the health of aquatic structures. Fish can accumulate pollution in higher proportions than in water and sediments because they consume algae and other microscopic organisms in addition to other types of pollution. Natural substances that are present in aquatic environments. either directly via meals or circuitously through gills, heavy metals locate their way into aquatic food chains, mainly the ones of fish [11]. with the aid of feeding thru the food chain, heavy metals can spread their toxic effects from one organism to some other until they attain the human consumer, who is on the top of the food pyramid [12, 13]. As a result, a number of studies have cautioned that freshwater and marine fish can be used as critical indicators of heavy metal pollution within the aquatic environment [14, 15, 16]. locating out how a whole lot pollution fish have been exposed to at some point of their lives and how much pollution their aquatic surroundings has been exposed to, in addition to how heavy metals affect fish increase, replica, and dietary fee, are all made viable through researching the bioaccumulation of heavy metals in fish organs and tissues [17, 19]. three sorts of fish determined in neighborhood markets, that are thought to be the maximum ate up by way of humans, have been chosen for the reason of studying the bioaccumulation of a few heavy metals in the muscles of those fish, as their use is crucial evidence of pollution. The Mediterranean Sea is uncovered to diverse pollutants, such as heavy metals that have a tendency to build up in aquatic organisms.

1 Materials and Methods

Collect fish samples: The samples of three different kinds of fish that are sold in the neighborhood market were gathered in order to investigate the bioaccumulation of certain heavy metals in fish tissues. This is a useful biological tool for researching the heavy metal pollution of the aquatic environment. The fish in question have comparable sizes, lengths between 15 and 20 cm, and ages no more than a year. Scales, with three replicates per species, were used to calculate age in accordance with the information provided in [26]. After being thawed at room temperature, frozen fish samples were dissected using stainless steel scalpels. One gram of muscle was carefully weighed, and then the cut samples were placed in a Teflon beaker and acid-digested (digested in a Kenstar microwave tube) using five milliliters of 65 percent nitric acid. After the samples were fully digested, they were chilled to room temperature. All digested samples were subjected to three separate analyses for metals such as lead, copper, chromium, and cadmium using an atomic absorption spectrophotometer. To calibrate the equipment, standard solutions consisting of easily accessible commercial chemicals were utilized. A blank solution that containing all the similar digestion inputs except sample was prepared by following standard procedure.

Fish selected for study

Shalba fish

- Sarpa Salpa Linnaeus

  It lives on the beach, not exceeding 20 meters deep. It feeds on marine algae and herbs and is seen in large flocks near rocky shores. It breeds during the spring until the end of the autumn. Trumpet fish... coral family (Sparidae).

- Boops boops

  It feeds on crustacean larvae, worms, fish larvae, and algae. It lives between the surface and the bottom of areas covered with grass.

- Sardines (Sardina pilchardus)

  Sardines, one of the most abundant pelagic fish, which lives far from the coast and whose fat content is considered blue fish. They are found mainly in warm, salty waters, grouped in large banks on marine surfaces.

2 Results and discussion

Growing populations and economic development are major contributors to the current global degradation of water quality, which includes seasonal accumulation of heavy metals like copper, chromium, cadmium, and lead. Essential and nonessential metals have been shown to accumulate along the food chain in freshwater environments [27, 28]. Non-essential metals can be dangerous to humans even at very low doses because of their bioaccumulation in fish, even though they are not known to have any metabolic functions [29]. In terms of human diet, fish has a significant amount of heavy metals. The cutting-edge observer mentions the build-up of heavy metals in three different fish species. However, mining, farming, and the release of commercial waste might cause concentrations in coastal environments to explode. Although other aquatic organisms are similarly inclined, fish are more frequently affected than other species in terms of heavy metal deposition in their bodies [17, 18]. This observation looked into a number of heavy metals, including lead, copper, chromium, and cadmium. Tables 1, 2, 3, and 4 demonstrate those metals' concentrations.

Table 1: Cadmium (Cd, µg/g)

Fish Species	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Overall Average	Max	Min
Sardina Pilechar	0.03	0.027	0.026	0.03	0.029	0.027	0.032	0.033	0.029	0.036	0.022
Sarpa Salpa	0.022	0.022	0.021	0.019	0.019	0.018	0.02	0.019	0.02	0.026	0.017
Boops Boops	0.012	0.012	0.013	0.013	0.011	0.012	0.013	0.012	0.012	0.015	0.01

Table 2: Copper (Cu, µg/g)

Fish Species	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Overall Average	Max	Min
Sardina Pilechar	0.56	0.6	0.55	0.58	0.55	0.59	0.57	0.6	0.58	0.63	0.52
Sarpa Salpa	0.43	0.4	0.4	0.45	0.44	0.47	0.44	0.45	0.44	0.49	0.36
Boops Boops	0.36	0.37	0.34	0.4	0.37	0.38	0.34	0.34	0.36	0.42	0.3

Table 3: Chromium (Cr, µg/g)

Fish Species	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Overall Average	Max	Min
Sardina Pilechar	0.032	0.035	0.033	0.033	0.035	0.035	0.035	0.038	0.034	0.039	0.03
Sarpa Salpa	0.026	0.023	0.024	0.027	0.024	0.023	0.026	0.022	0.024	0.028	0.02
Boops Boops	0.014	0.016	0.014	0.014	0.013	0.014	0.013	0.014	0.014	0.019	0.011

Table 4: Lead (Pb, µg/g)

Fish Species	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Overall Average	Max	Min
Sardina Pilechar	0.057	0.057	0.054	0.057	0.058	0.057	0.052	0.057	0.056	0.061	0.05
Sarpa Salpa	0.048	0.048	0.041	0.041	0.041	0.044	0.045	0.048	0.045	0.052	0.038
Boops Boops	0.036	0.03	0.034	0.026	0.034	0.037	0.033	0.036	0.033	0.039	0.026

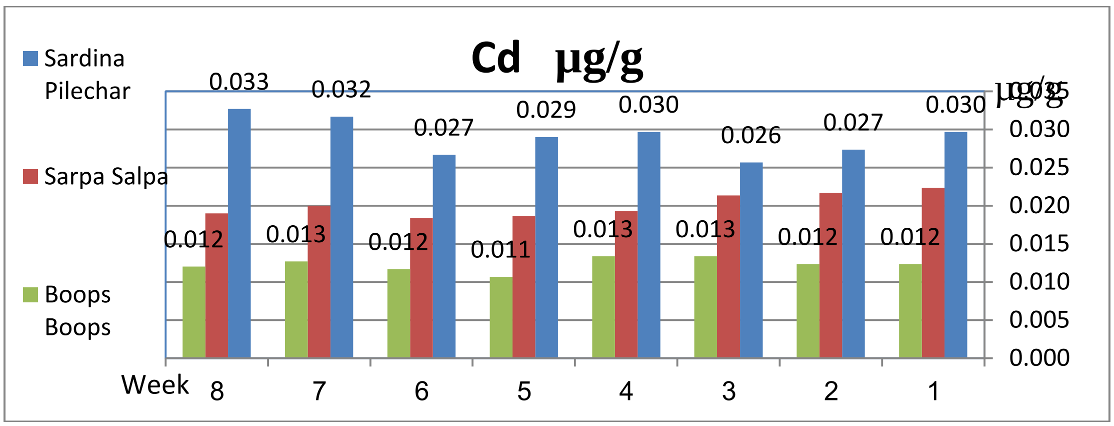

figure. 1 shows the concentration of cadmium (µg/g) in the muscle tissue of the fish studied in this research.

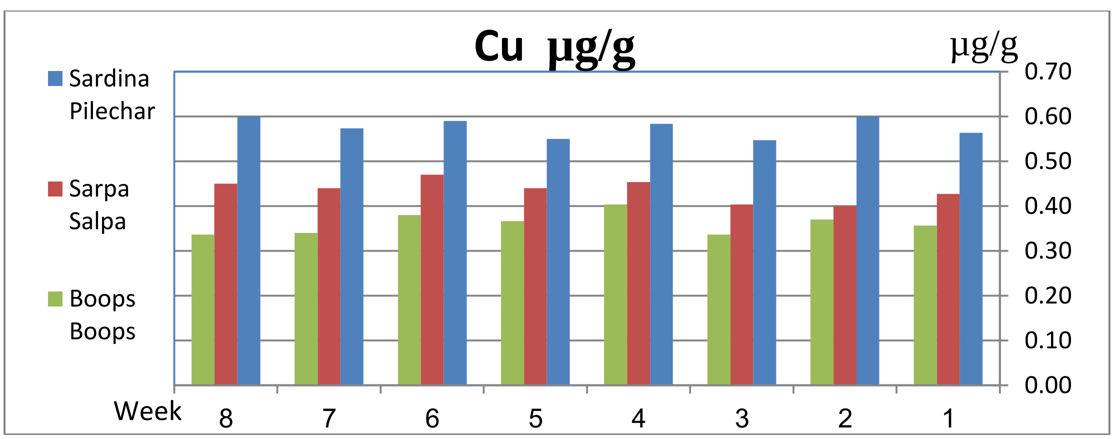

figure. 2 shows the concentration of copper (µg/g) in the muscle tissue of the fish studied in this research.

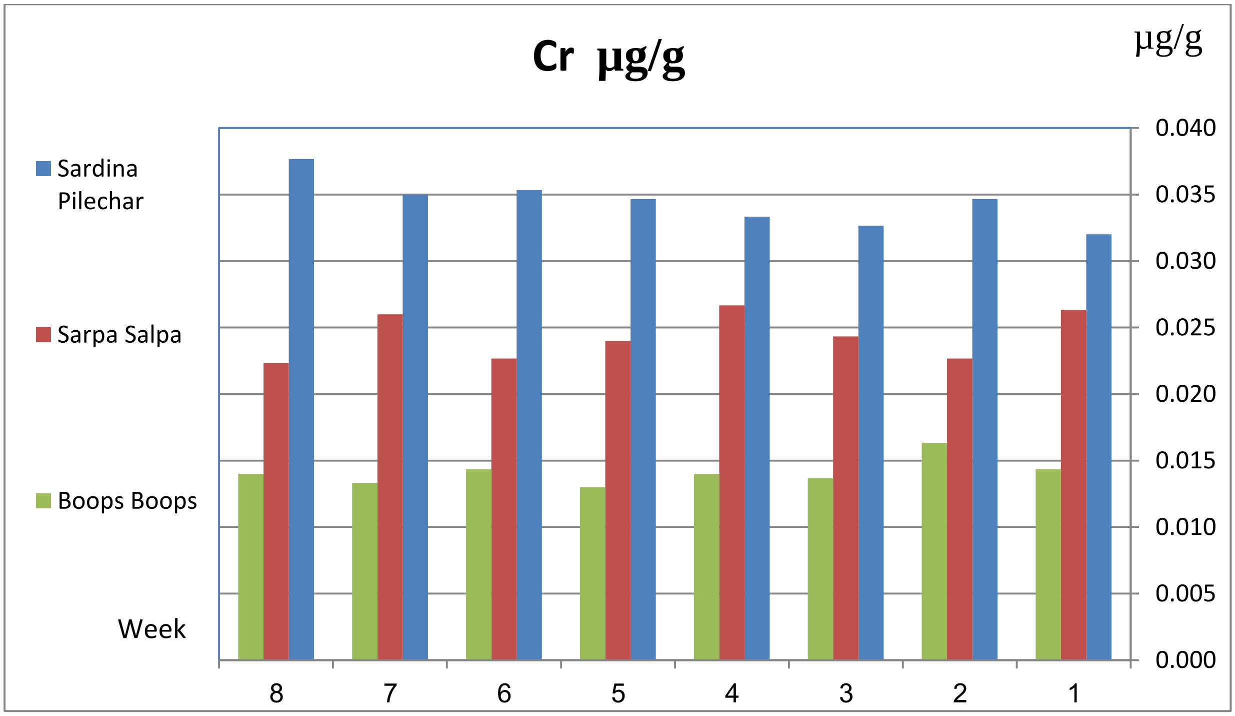

figure. 3 shows the concentration of chromium (µg/g) in the muscle tissue of the fish studied in this research.

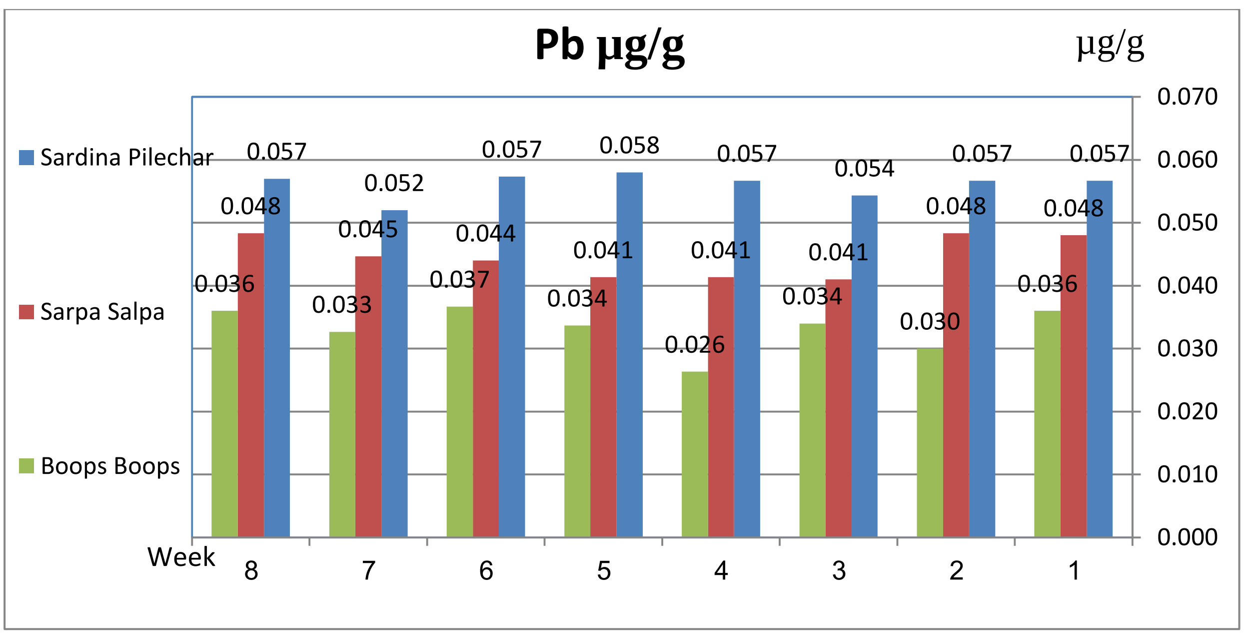

figure. 4 shows the concentration of lead (µg/g) in the muscle tissue of the fish studied in this research.

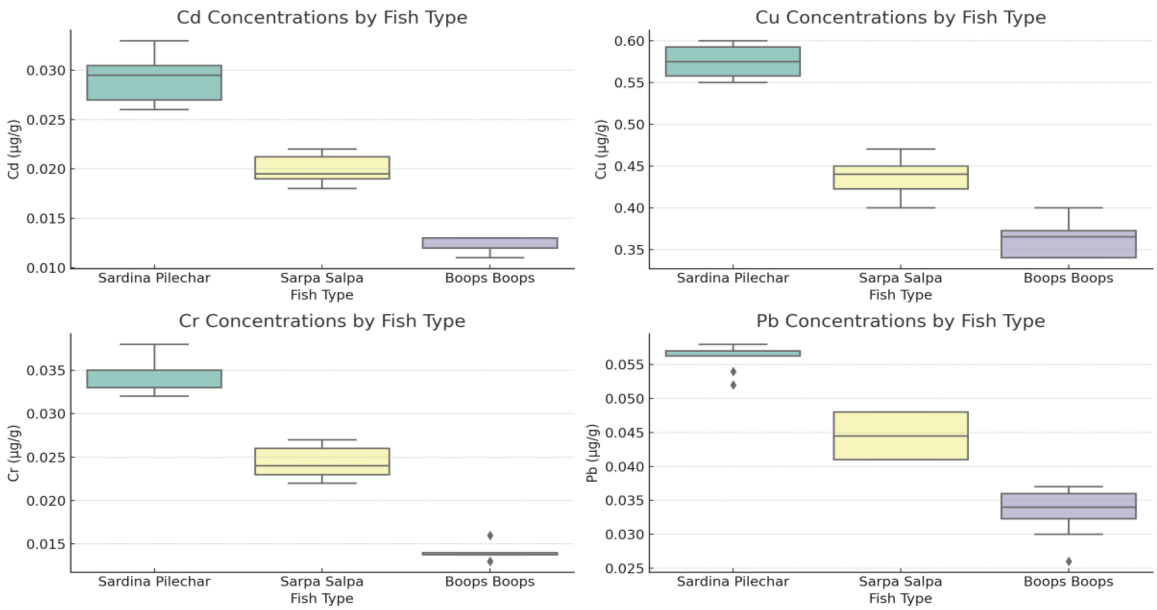

Figure 5 Heavy metal concentrations of different studied fish species

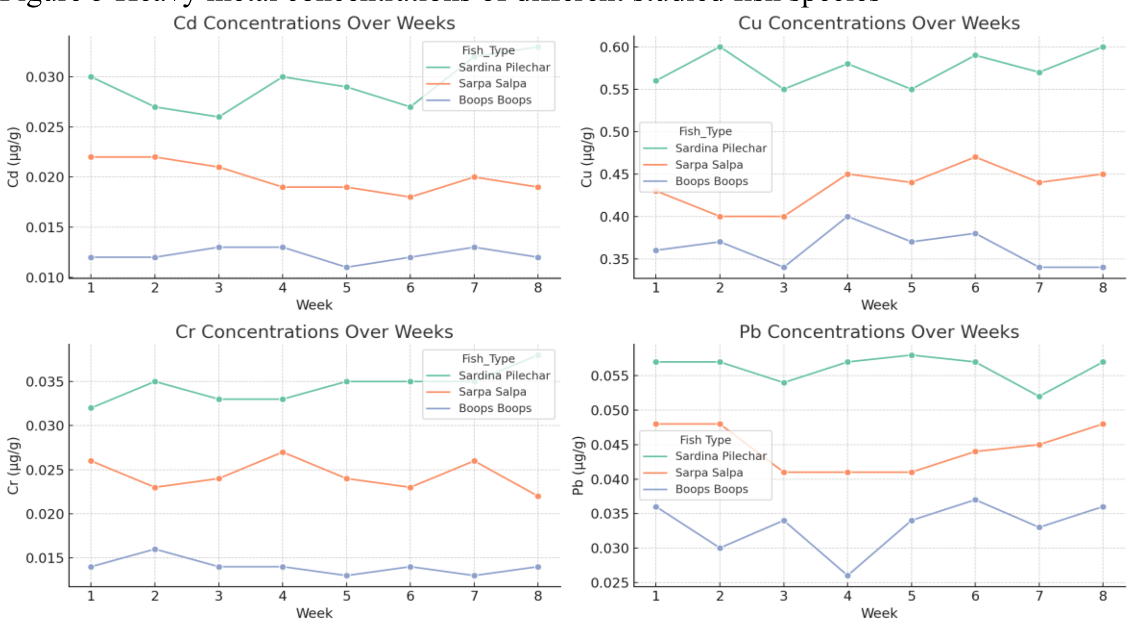

Figure 6heavy metal concentrations across sampling weeks for each fish species

Cadmium (Cd)

Although it is not a necessary element, cadmium competes with calcium ions at the places where the organisms make enzymes. The liver has the highest concentration of cadmium, followed by the gills and muscles. The highest allowable limit of cadmium concentration is 0.5 mg/kg, under FAO regulation [20]. The concentration of Cd ranged from 0.036- 0.010 µg/g in all types of fish. The mean concentration of Cd 0.029, 0.020 and 0.012 µg/g in Sardina Pilechar, Sarpa Salpa and Boops Boops respectively which were within the allowable level stated by the different international organizations [21-22].

Copper (Cu)

Copper known to be an essential element, copper is required for many different kinds of enzymes and other cellular components that play crucial roles in the functioning of all living things. On the other hand, excessive copper consumption is bad for human health because it can cause toxicity and other related conditions. According to the current study, muscles had the highest quantities of copper 0.63, 0.49 and 0.42 µg/g in Sardina Pilechar, Sarpa Salpa and Boops Boops respectively. The mean concentration of copper in fish tissue samples ranged from 0.58- 0.36 µg/g.

Chromium (Cr)
One of the frequent heavy metal contaminants that finds its way into waterways is chromium, which is discharged by the printing, dyeing, and electroplating industries. One substance that can lead to both cancer and affective teratogenicity is human chromium. WHO (1985) and FEPA (2003) have established acceptable ranges of 0.05 and 0.15 µg/g, respectively, for chromium [23-24-25]. The chromium contents in all the species were comparatively lower, ranging from 0.039 µg/g to 0.011 µg/g in the muscles. As a result, none of the samples had chromium contents over the 0.05 mg/kg WHO-recommended level (Table 2).

Lead (Pb)
Lead (Pb) is an element that is not necessary for life and has a number of negative effects such as fast behavioral dysfunction, neuro and nephrotoxicity, and reductions in growth, metabolism, and survival rate. The Health Organization states that adults should not eat more lead than 0.3 µg/g (wet weight basis) and should not take more than 450 µg of lead per day [26]. The current study found that the muscles in Sardina Pilechar had the highest concentration of lead (0.061µg/g), while the muscles in Boops Boops had the lowest concentration (0.039µg/g). Lead (Pb) concentrations in muscle tissue samples from fish varied between 0.061 and 0.026 µg/g.

Graph Observations:
1. Cadmium (Cd):
○ All species show values well below the FAO-recommended limit of 0.5 µg/g.
○ Sardina Pilechar has the highest levels, suggesting possible environmental or dietary sources.
2. Copper (Cu):
○ Copper concentrations are relatively higher in all species but remain within safe levels.
○ Sardina Pilechar again has the highest values, likely reflecting its specific feeding or environmental exposure.
3. Chromium (Cr):
○ Levels are significantly below WHO's safe threshold (0.05 µg/g).
○ This indicates minimal chromium pollution in the region.
4. Lead (Pb):
○ Although below the health threshold of 0.3 µg/g, Sardina Pilechar's lead levels approach the highest recorded values, highlighting a need for continuous monitoring.

Boxplots (figure 5):
• Each boxplot illustrates the distribution of heavy metal concentrations (Cd, Cu, Cr, Pb) across the three fish species:
• Sardina Pilechar generally shows the highest concentrations for most metals.
Variability in metal accumulation differs across species, as indicated by the spread of the boxes.

Line Charts (figure 6):

• Line charts depict the trends of heavy metal concentrations across sampling weeks for each fish species:

Concentrations remain relatively stable over the weeks, with minor fluctuations.

• Species-specific patterns are evident, such as higher copper levels in Sardina Pilechar compared to others.

3 Conclusions

Human health and aquatic ecosystems are seriously threatened by the buildup of heavy metals in fish tissues. Chromium (Cr), lead (Pb), cadmium (Cd), and copper (Cu) are among the heavy metals that can build up in fish tissues through a variety of processes, such as bioaccumulation through the food chain, sediment contamination, and water pollution. Fish that are exposed to these metals on a regular basis may experience toxic effects such as stunted growth, problems with reproduction, and higher mortality rates. Furthermore, eating tainted fish puts people at risk for harmful health consequences like neurotoxicity, kidney damage, and cancer. Important conclusions from research on the build-up of heavy metals in fish tissues. Variations in habitat, feeding patterns, and metabolic rates can all have an impact on the amount of heavy metal accumulation found in different fish species. Eating fish that contains high concentrations of heavy metals puts people's health at serious risk, especially those who are already vulnerable, like young children and pregnant women.

This study looks on the construct-up of heavy metals within the muscle tissues of three local fish species to be able to evaluate feasible dangers to the surroundings and public health. We analyzed fish samples collected from the local marketplace of Baniwaleed city in Libya to determine the concentrations of lead (Pb), cadmium (Cd), chromium (Cr) and copper (Cu) the usage of state-of-the-art analytical strategies.

Sardina Pilechar, Sarpa Salpa, and Boops Boops had mean Cd concentrations of 0.029, 0.020, and 0.012 µg/g, respectively, all falling within the allowable limits as stated by different international organizations. Fish tissue samples had an average copper concentration of 0.58–0.36 µg/g. All species had relatively lower chromium contents, ranging from 0.039 µg/g to 0.011 µg/g. The levels of chromium in none of the samples were higher than the 0 point05 mg/kg WHO recommended level. The concentrations of lead (Pb) ranged from 0.061 to 0.026 µg/g. According to the health organization, adults should consume no more than 0.3 µg/g. According to this study, fish muscle tissue and organs can serve as vast indicators of pollution in environmental tracking programs with the aid of reflecting the amount and kind of pollution present in the aquatic surroundings. The diploma of pollution in the Mediterranean, especially in Libya, can also be predicted. it's far essential to identify their assets and causes for you to reveal and save you them.

Environmental and Public Health Implications:

○ The findings confirm the presence of heavy metals in fish but at levels deemed safe for human consumption based on international guidelines.

○ Sardina Pilechar emerges as the species most exposed to metal accumulation, warranting closer scrutiny of its habitat and diet.

Recommendations:

○ Regular monitoring of metal concentrations in fish to prevent potential health risks.

○ Identifying and mitigating sources of contamination, especially for lead and copper.

○ Raising public awareness about the potential risks of heavy metal exposure through dietary intake.

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