Ecological study of bioaccumulation of some heavy metals in muscles and gills of two kinds of fish

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Abstract
The current study aimed to know the suitability of two kind of fish shanik fish and common carp that have possible accumulation heavy metals (Cr, Cu, Zn, Pb, Cd) to consume by human after determined their concentration in water, sediments, muscles and gills. the samples where collection from artificial lake culture that located in Babylon governorate, the water and sediments also collected, and the samples were digested in probable oxidize solution and the concentration of heavy metals have been found by using ASS meter. The results appeared according to WHO and EPA that concentration of heavy metals in water were above standard limited, and according to FAO/WHO the concentration of study heavy metals in fish were also above standard limiting to consume safely with some exceptions. The results pointed by using BAF, BCF and BSAF values that these factors where below or in moderate rate (> 1,000 or < 1,000) value that permit to consume these organs separately by human, and can be above and dangerous when it consumed combined. The results showed a significant differentiation among data with some exception and positive correlation coefficient in level of probability 0.05.

Keywords: bioaccumulation, food safety, heavy metals, aquatic environment

1- Introduction

There are many chemical materials that have ability to accumulation throw food chain, and, there are some organisms that have capability to accumulate these materials more than others. The problems lie in this accumulation in that some of these accumulation materials can constitutes a problem health for life organism after accumulation within or a group of organisms after transited throughout. These prosses of foundation dependent on type of organism and accumulative chemical materials, period exposure, chosen organ to accumulate, and healthy state and sex for that organism in addition to many other factors that can control in ability of accumulation some materials in life organism. The kind of chemical materials, physical and chemical properties, their philic to some tissues (Savoca and pace, 2021 and Suhad, et al., 2018) and duration period can contribute in role of stability of chemical materials in body of life organism. The main problem in accumulation chemical materials in some organisms are it is a part of food chain and food web that reached to human or the human is final step in food pyramids, that make the human final receptor to some or in many cases to all chemical materials that accumulated in many kinds of organisms, which lead to serious health problems that aggregation with the time after consumed these materials from the edible parts of aquatic organisms in process called biomagnification (Chojnacka and Mikulewicz, 2014).

Fishes are important source for human nutrition specially in coastal regions or the countries that full dependent on seas and oceans foods, which the most world populations related on food meat seas in continuity of life, and many others countries dependent on fishing in their economy in addition to feed. Where according to some studies, the fish consumed to reduce the heart and vascular blood diseases (Maciel et.al., 2019 and Qassim, et al., 2021) also, the fish have been consumed around the world especially Asian countries as healthy and nutritive food (Olmedo et.al., 2013), where it considered semi-complete nutrition for human to provide from proteins, minerals, essential metals such as Zn, Fe, Cu that act as cofactor to many proteins and enzymes (Yap and Al-Mutairi, 2022) and sometimes vitamins such as omega 3 (Swanson et.al., 2012), with many other organic compounds. The food sea can contribute directly or indirectly in essential part of human nutrition for that it can reach to human in many ways.

Heavy metals can know as most dangerous chemical materials that can find in water naturally or by humanmade, because of their high ability to bioaccumulation within different organisms, non-degradation, high stability in front of light an decomposers, non-metabolism, and lower ability to excretion or in some state completely not excretion. Their massive or over normal doses accumulation in body life even if it is essential for life can cause many dysfunctions in many enzymes (Kumar et.al., 2024), or blocks some pathways (Jan et.al., 2015) which lead to stop or slower in the function of life or some time can cause hyperactivity that exhausted the organs such as kidney, liver or endocrine glands (Mohammed, et al., 2019 and Wang et.al., 2024). Also, there are many heavy metals that unknown their important to organisms however it can play roles in their health and caused enormous problems and diseases such as nerve damages, hepatotoxicity, osteoporosis and others (Ray and Vashishth, 2024). The organism response is variation to heavy metals dependent on differentiation of organs, which means the metals can choice and favorite some organs to accumulate than others, that also related to many properties that associated between metal and organ such as chemical structures and physiological of organ (Jadav, 2022).

Fish can have heavy metals from surrounding environment as form of food or through breathing or any other providing pathways, for that it can be act as attractive body to enormous essential and nonessential heavy metals that concentration in fish tissues according to heavy metals properties and tissues and organs histophysiological properties that play as target (Abbas, et al., 2020 and Rehman et.al., 2021) and many factors that contributed to stability of heavy metal in tissues or organs. There are many studies that deals with fishes as bioindicators to heavy metals that can be found as pollutants in water body as a normal ability to their ability of bioaccumulation these heavy metals within their body such as study of Elbeshti et.al., (2018) that study the ability to bioaccumulation and biomagnification of heavy metals and their effects on many types of fish and other aquatic organisms in black sea where the results showed that heavy metals caused severe damage on fish and it can be danger to human health. Also, there are study of Salman et.al., (2023) that deal with two types of fish in Al-Musayyib River in Babylon Governorate to determine some heavy metals (Fe, Pb, Zn, Cr, Ni, Cd, Cu) in muscles of fish, were the results found that higher concentration of heavy metals was iron and lower concentrations was nickel. The study of Oros, (2025) using marine fish as bioindicators of heavy metals to control public health risks of heavy metal pollution.
Also, some studies referred to its heavy metal ability to favor some organs than other in bioaccumulation such as study of Ray and Vashishth, (2024) that study the accumulation of heavy metals in different organs, were the results found there are differentiation in accumulation heavy metals within organs tissues that studied and the liver was most organ accumulation to heavy metals then intestine or stomach depending on sample location and type of fish and many other factors that can be lead to toxic effect on human health. In study of Leonard et.al., (2022) of two type of fish to assessment of heavy metals in different organs of fish the results showed that gills of fish were higher concentration from Cr, Zn, Cu, Pb than fins, guts and muscles. While the study of Rajeshkumar and Li (2018) that determined with edible part of two species of fish where found that heavy metals were concentration in different organs were Cr was concentrate in kidney and liver, Cu higher in gills, Pb higher in liver and Cd was some in all study organs. Also, the study of Younis et.al., (2015) to determine some heavy metals (Cd, Cu, Pb, Zn, Hg) in muscle, gills and liver of ten fish species the results found that concentration of heavy metals were higher in study organs compare to muscles and metal Zn was more accumulation within fish tissues than other metals Khleif et.al., (2020).
This study aimed to know the quality and the ability of two organs to bioaccumulation of some heavy metals in some kind of fish cultured after measured the concentration of heavy metals in water, sediments and organs and finally after that find BCF, BAF and BSAF values to identify suitability these organs to consume by human and animals. There important of fish samples came from which that types of fish were enormous used as human food by local street sealers.

2- Materials and methods

2-1 Location of sample collection

Two types of fish have been used where the fish cultured samples have been collection from fish lake that sending to local street sealers in Hilla city, Babylon governorate, in fact 30 fish for each type shank fish (Acanthopagrus sp.) and common carp (Cyprinus sp.) that their sources from artificial fish lakes, that have one- and two-month-old, with average weight (450) g and (1.25) kg respectively. The samples were collected during the summer. The samples washing first with normal water then with deionized water many times and left to dry few minutes before storage in cold places until using in test.

2-2 Preparation of fish samples

The samples left to dry after washing samples with deionized water, then recording their weight before beginning to cut the parts of fish to separating different tissues from each other, and separating edible parts from inedible parts, with recognizing of the parts and tissues that was determined to the study.
The muscles tissues and gills tissues were selected for the study after separating these parts from other parts. The wet weight has been taken before dried these parts in oven 110 C^{o} for 36 hours, the weight was taken from time to time until reached to stable dry weight to insure from losing all water content from tissue parts. From 30 parts of tissues for each sample, every 10 parts have been mixed to for 3 replications to prepare for incineration. All part samples have been incinerated in furnace in 450 C^{o} after it was grounded with an electric grinder, the weight of formed ash has been taken for preparation to digest (Mert et.al., 2014; Mensoor and said, 2018).

2-3 Digestion and extraction of heavy metals

The way that mentioned in (Saxena, 2024) has been flowed, where the weight of 1 gm from ash has been taken and digested with mixture of strong acids from 5 ml HNO3, 2.5 ml HClO4 and 10 ml HF that has been left to digest slowly on hot plate in open area to release gases and fumes, the addition are continuing until all fumes are disappeared. The samples are cooling, then 5 ml of 1:1 ratio of distil water and HCl has been added twice and left to dry by evaporation to reach to pure salts, that finally dissolved with 20 ml of 0.1 N HCl and complete to 50 ml from distil water to preparation for measurement by atomic absorption spectrophotometer AAS.

2-4 Collection of water samples

The way that followed by (Hussein et.al., 2014 and Qassim, et al., 2019) has been used, where water samples have been collected from artificial fish lakes that the fish were taken from, the water taken twice, about 5 L from each lake that has different type of fish have been evaporated until near drying, then 5 ml of 1:1 ration of distil water and HCl has been added many times to complete digestion, and before full drying, about 20 ml of 0.1 N HCl has been added and completed to 50 ml distil water to preparation for measurement by atomic absorption spectrophotometer ASS.

***2-5* Calculation of B.A.F and B.C.F**

To determine the ability of muscle and gills of fish to accumulation some heavy metals, the bioaccumulation factor **(**BAF), bioconcentration factor **(**BCF) and biota sediment accumulation factor (BSAF) to the heavy metals have been found after calculated the ratio of heavy metals concentration in study edible organs for BAF or as in BCF in all study edible or inedible organs or tissues to heavy metals concentration in water body and sediment environment or in water only or sediment only as in BCF and BSAF respectively, after using the equation below as mention by (Karlsson et.al., 2002; Tong et.al., 2018; Savoca and Pace, 2021) with some modifications where are;

$$\mathbf{BAF = C_O / C_{W\ and\ S}}$$

Where;

BAF ; Bioaccumulation Factor is calculated by experimental data, the value of coefficient calculated in wet weight

C_O ; is the heavy metal concentration in edible organs (mg/kg dry weight);

$C_{W\ or\ S}$; is the heavy metal concentration in the water (mg/l) and sediments (g/kg) and any source of diets.

$$\mathbf{BCF = C_O / C_W}$$

Where;

BCF ; Bioconcentration Factor is calculated by experimental data, the value of coefficient calculated in wet weight

C_O ; is the heavy metal concentration in all edible or inedible organs or tissues that studies (mg/kg dry weight);

C_W ; is the heavy metal concentration in the water (mg/l).

$$\mathbf{BSAF = C_O / C_S}$$

Where;

BSAF ; Biota sediment accumulation Factor is calculated by experimental data, the value of coefficient calculated in wet weight

C_O ; is the heavy metal concentration in edible organs (mg/kg dry weight);

C_S ; is the heavy metal concentration in the sediments (g/kg).

Data analysis

A completed randomized design (CRD) has been used. Data analyzed statistically by using less significant differentiation (LSD) at 0.05 after subjection the analysis of variance (Devore and Farnum, 2014).

3- Results and discussion

3-1 Heavy metals in aquatic environments

According to results that showed in table (1) the concentration of heavy metals where within limited standard of WHO (2004; 2011), EPA (2005) in drinking water except of copper and zinc that have high concentration in water and sediment (2359, 24227) µg/l in water and (3394, 32061) µg/kg in sediments respectively, which it can be returned to as some studies to the sources of these heavy metals were human activity such as study of (Al-Rubaiee and Al-Owaidi, 2022), with low level water in stream with high evaporation (Al-Asadi and Al-Kafari, 2022) that can concentrate some heavy metals in column of water, and land erosion to the sources of water (Issa and Alshatter, 2018; Angon et.al., 2024), also with the most important factor was the time of changing water in lake, the type of food that used to feed fish and the source of water that feeding the lake, all these factors can be caused raising of some heavy metal concentration in water and sediments in this study. Also, the results showed high concentration of heavy metals in sediments than water with a significant differentiation (LSD=62.37), these can be returned to high PH of river that make many heavy metal by precipitation to sediment to become non-bioavailability (Al-Asadi, 2016) to aquatic life, in another words, remove heavy metals toxicity from surrounding water, these depending on capacity of sediments to occupied heavy metals and the amount of heavy metals that can enter the water also the results showed high correlation coefficient (r=0.99) between water and sediment in aquatic environment, that means both water and sediment can make heavy metals available in aquatic environments, and with the most important factors the ability of aquatic organisms to take these metals.

Table (1) showed heavy metals concentrations in water µg/l and sediments µg/kg of lakes (LSD=62.37; r=0.99)

Heavy metals	**Water (µg/l)**	**Sediments (µg/l)**	**Total aquatic environment (µg/l)**	**WHO mg/l**	**EPA mg/l**
Cr	1.347	3.604	4.951	0.05	
Cu	2359	3394	5753	1	1.3
Zn	24227	32061	56288	5	-
Pb	2.38	4.789	7.169	0.005	-
Cd	1.29	2.3	3.59	0.005	0.005
Sum	26591.02	35465.693			

3-2 Heavy metals in fish

Table (2) showed the concentration of heavy metals in muscles and gills of two types of study fish. Where the muscles and gills organs appeared high concentration of some heavy metals than that found in water, and lower concentration that found in sediments, the results showed that study heavy metals were above standard limited of FAO/WHO to that can permeable in fish with exception of chromium and lead (Derakhshan et.al., 2018; Samantara et.al., 2023; WHO, 2010; 2011) that make these tissue of fish unhealthy to consume. Generally, the accumulation of heavy metals in fish can be due to direct consume of water and food or indirect digestion through permeable membrane of gills (Hu et.al., 2019) or skin of fish, because of that the fish can have heavy metals from many sources if it can be found bioavaibility to take by fish. The results pointed to high activity of gills to concentration heavy metals than muscles where the results pointed to find a significant differentiation between muscles of two type of fish with their gills (LSD=29.19; 26.98), with sum average of all heavy metals concentration in muscle (9250.69) µg/kg and (7871.721) µg/kg while in gills (18157.391) µg/kg and (16668.44) µg/kg for both shanik and common carp respectively. Also, results showed that some organs of fish can be accumulation heavy metals in high concentration that can be reached to above surrounded water environments, such as muscles and gills with high correlation coefficient (table, A; figure, 1) and can concentration of heavy metals from sources of sediments (figure, 2), and these sometimes can lead to toxic effect (Garai et.al., 2021) to carnivores that ate these parts of fish in addition to human as a reason of metabolism processes, organ storage and detoxication, some study refer to these fact such as study of Bontas et.al., (2020) that pointed to accumulation of heavy metals in gill and muscle organs that can lead to harmful other consumer organisms including human. Results also pointed to find high correlation coefficient between muscles and surrounding environments. The accumulation of heavy metals in high concentration in gills than muscles can be return to direct connection to organ (Emon et.al., 2023), or indirectly by differentiation of osmosis pressure between the outer and inner gills membrane (Aldoghachi et.al., 2016), or high activity of gills as main source of entering heavy metals (Aly, 2016; Olsson et.al., 2013), or solubility some heavy metals in fatty parts of gills (Mert et.al., 2014), or in some studies can some organic pollutants attributed in penetrate of heavy metals in cells (Mohamed and Aly, 2023).

Table (2) showed heavy metals concentrations (µg/kg) in study parts of fish

Heavy metals	**Acanthopagrus sp.**			**Cyprinus sp.**				
	Muscles (µg/kg)	**Gills (µg/kg)**	**Total (µg/kg)**	**Muscles (µg/kg)**	**Gills (µg/kg)**	**Total (µg/kg)**	**WHO In fish mg/kg**	**FAO In fish mg/kg**
Cr	0.988	1.065	2.053	0.785	1.143	1.928	0.05	0.05
Cu	1478.74	2892.34	4371.08	1345.39	2453.53	3798.92	-	-
Zn	7768.41	15259.46	23027.87	6523	14209	20732	-	3
Pb	1.721	3.25	4.971	1.818	3.328	5.146	0.3	0.01
Cd	0.831	1.276	2.107	0.728	1.439	2.167	-	-
Sum	9250.69	18157.391		7871.721	16668.44			

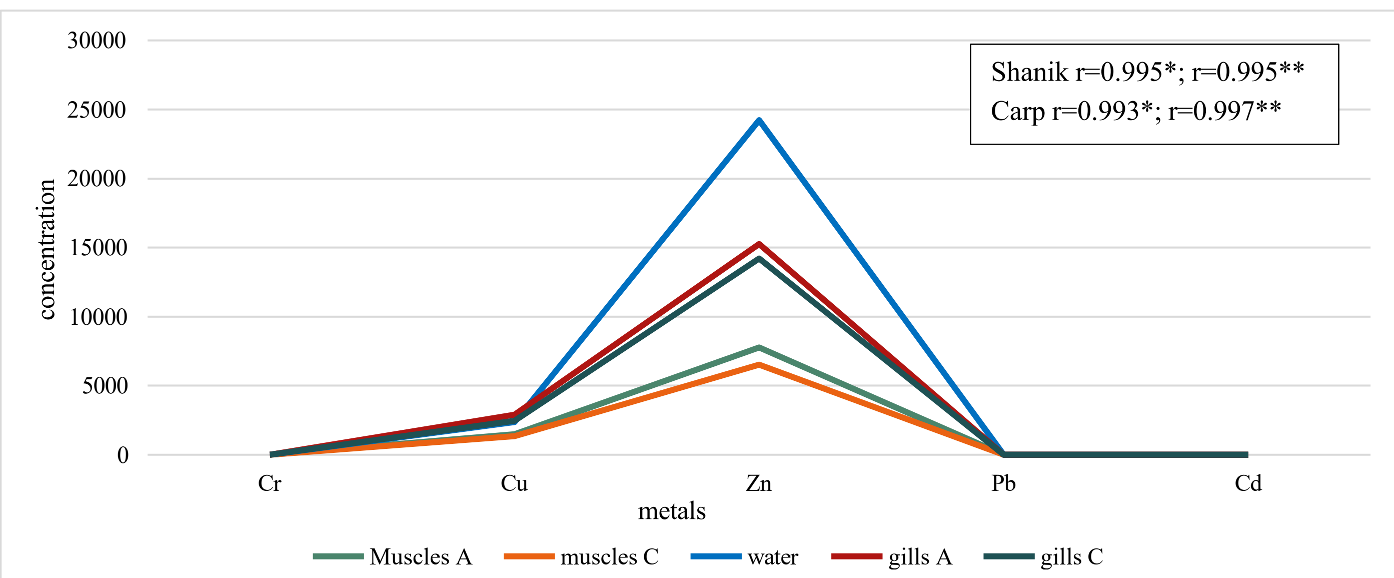

Figure (1) showed heavy metals concentrations in water (µg/l) compare to their concentration in muscles* and gills of two types of fish**

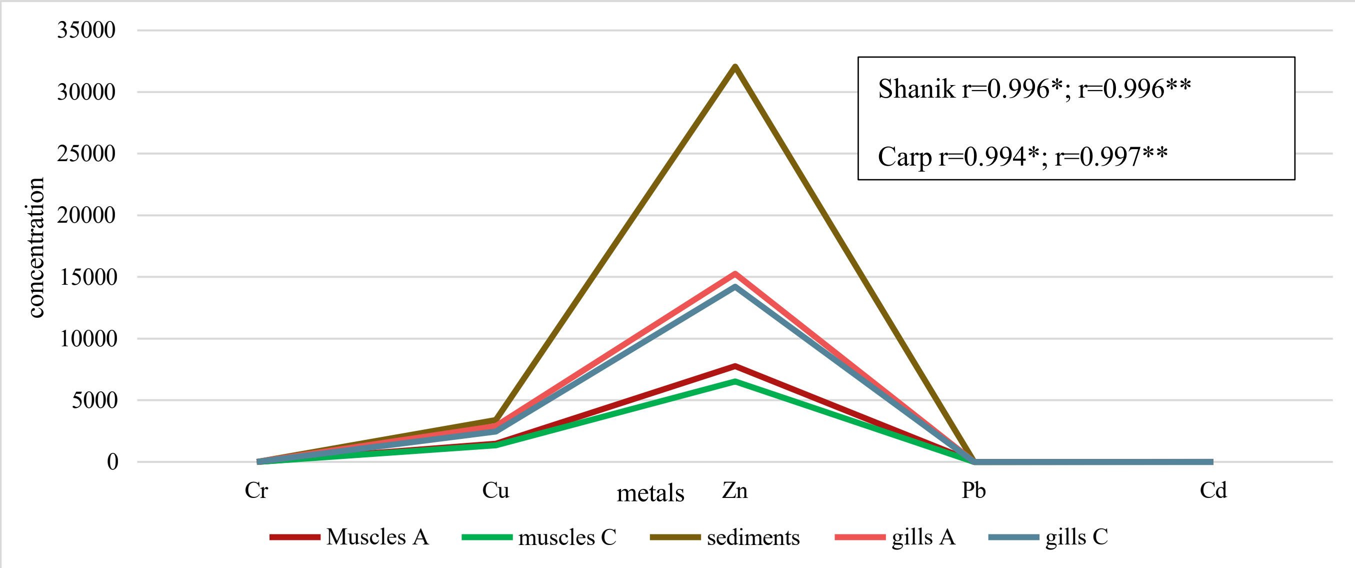

Figure (2) showed heavy metals concentrations in sediments (µg/kg) compare to their concentration in muscles* and gills of two types of fish**

3-3 Bioaccumulation factors in fish

Table (3) showed BAF in muscles and gills of two kinds of fish, in this study the heavy metals can enter to fish organs from many sources through direct consuming of water or breathing or feeding on sediments or near the sediments (Danovaro et.al., 2023), for that the heavy metal can accumulation on fish tissues from different ways, and because of persistence (Banaee, 2024) and unable of excretion or degradation of heavy metals, the fish organs developing mechanisms to remove toxic effects of these heavy metals from organs by binding it to specific compounds in different organs (Shekh et.al., 2021; Kwong, 2024), or storaging in low active tissues such as muscles or in organs that work as storage to pro-product metabolisms such as liver or spleen (Amiard et.al., 2006; Bawuro et.al., 2018), or trying to excrete through skin, glands, digestive system or urinary system (younis et.al., 2015), or in some cases accumulation in inert removal parts of fish such as scales and fins (Leonard et.al., 2022). The continuous bioavailability of heavy metals to fish means more accumulation heavy metals in organs with lower ability for binding or removing heavy metals from fish body. In current study, the gills were first target to heavy metals accumulation where the results showed (table, 6; figure, 3) high value of BAF in their tissues that can be returned to rich blood vessels and permeable membrane of gills that facilitated oxygen exchanging, and because of higher activity with continuous uptaking heavy metals from surrounding environment, the gills activity of removing or transiting heavy metals can be decreased which lead to accumulate heavy metals in gills more than other organs. The process of accumulation heavy metals in fish organs depending on type of metal, chemical properties, equivalent, and attracted to target organs, also, with type of fish tissues and their function (Moiseenko et.al., 2020) which can different from metal to metal and from tissue to tissue. The muscle was the important part of edible fish, where in this study showed also, high values of BAF which means both water and sediment can attribute in accumulations heavy metals in different type of fish organs, and depending on value of BAF the fish unhealthy to human consumption and unsuitable to consume by human or any organisms. The results pointed to find high correlation coefficient (table, B; figure, 4) to accumulation heavy metals in muscles, which means the heavy metals pollution surrounding environment can play important role in concentration and accumulation heavy metals in fish tissues for that the BAF can changed depending on these factors (Gómez-Regalado et.al., 2023; Saha et.al., 2021).

Table (3) showed BAF in muscles and gills compare to aquatic environment for two kinds of fish

Heavy metals	**Acanthopagrus sp.**			**Cyprinus sp.**		
	Combined all parts	**muscles**	**gill**	**Combined all parts**	**muscles**	**gill**
Cr	5.382646	4.33748181	4.33748181	5.237552	4.18677654	4.18677654
Cu	4873.966	3394.62685	3394.62685	4740.43	3394.570322	3394.570322
Zn	39830.04	32061.3207	32061.3207	38584.59	32061.26925	32061.26925
Pb	7.875546	5.51210924	5.51210924	8.005319	5.552865546	5.552865546
Cd	4.120147	2.94418605	2.94418605	4.143504	2.864341085	2.864341085

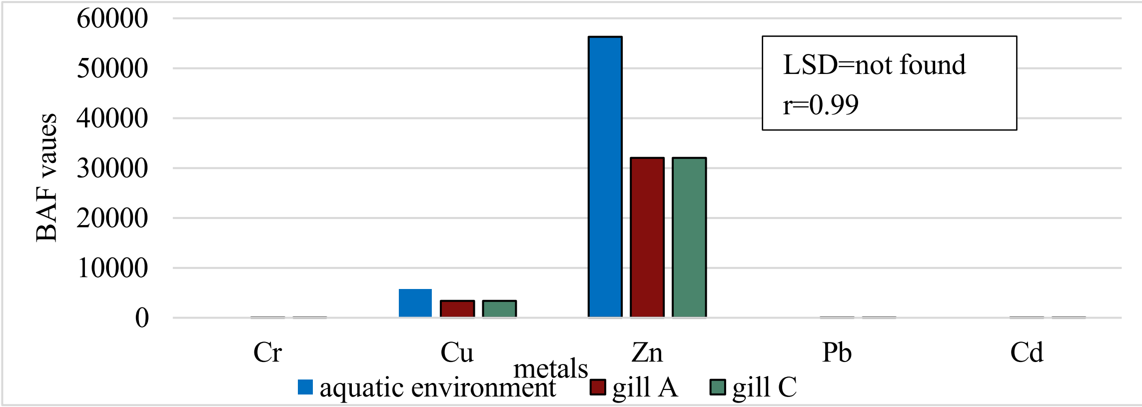

Figure (3) showed BAF values in aquatic environment compare to their concentration in gills of two types of fish

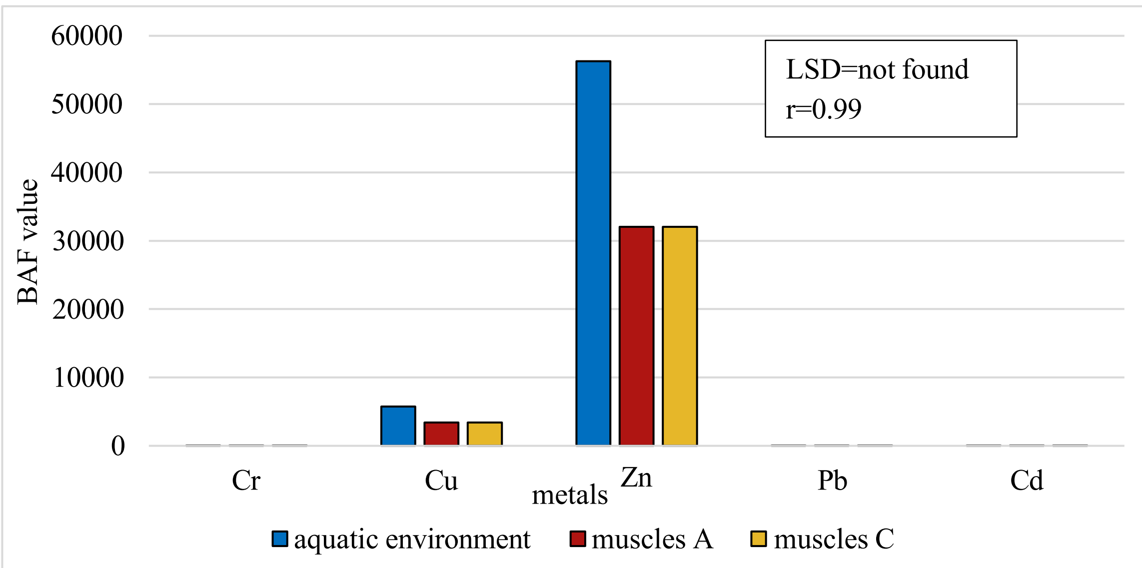

Figure (4) showed BAF values in aquatic environment compare to their concentration in muscles of two types of fish.'

3-4 Bio-concentration factors in fish

Table (4) showed BCF in muscles and gills of two types of fish compare to water. Bio-concentration of heavy metals in fish means the accumulation of heavy metals in fish tissues which that depending on concentration of heavy metals in fish tissues compare to their concentration in surrounding environment, in some studies the high values of BCF can cause problem health to secondary consumers that feed on fish (Arnot and Gobas, 2006), in this study the value of BCF have been calculated depending on heavy metal concentrations in two parts of fish and their concentration in surrounding water environment, the results in table (4; 6) appeared that the value of BCF in moderate rate which means the concentration of heavy metals are nearly to become hazard to fish and human health or any consumers that can be consumed the fish tissues. Also, the results showed the BCF were in high value (BCF > 1) (Brković et.al., 2021) if the organs have been combined, that referred to risk of consuming both muscle and gills of the fish that studied. Results (table, C; figure, 5) pointed to find high correlation coefficients and a significant differentiation among the BCF values, which means the concentration of heavy metals in muscles and gills depending on pollution of water with heavy metals, and the ability of muscles and gills to concentrate these heavy metals in their tissues (figure, 6).

Table (4) showed BCF (L/Kg) in study parts compare to water µg/l for two kinds of fish

Heavy metals	Acanthopagrus sp.			Cyprinus sp.		
	Combined parts	muscle	gills	Combined parts	muscle	gill
Cr	1.778646	0.733482	0.790646	1.633552	0.582777	0.848552
Cu	1479.966	0.62685	1.226087	1346.43	0.570322	1.040072
Zn	7769.04	0.320651	0.629853	6523.586	0.269245	0.586494
Pb	3.086546	0.723109	1.365546	3.216319	0.763866	1.398319
Cd	1.820147	0.644186	0.989147	1.843504	0.564341	1.115504

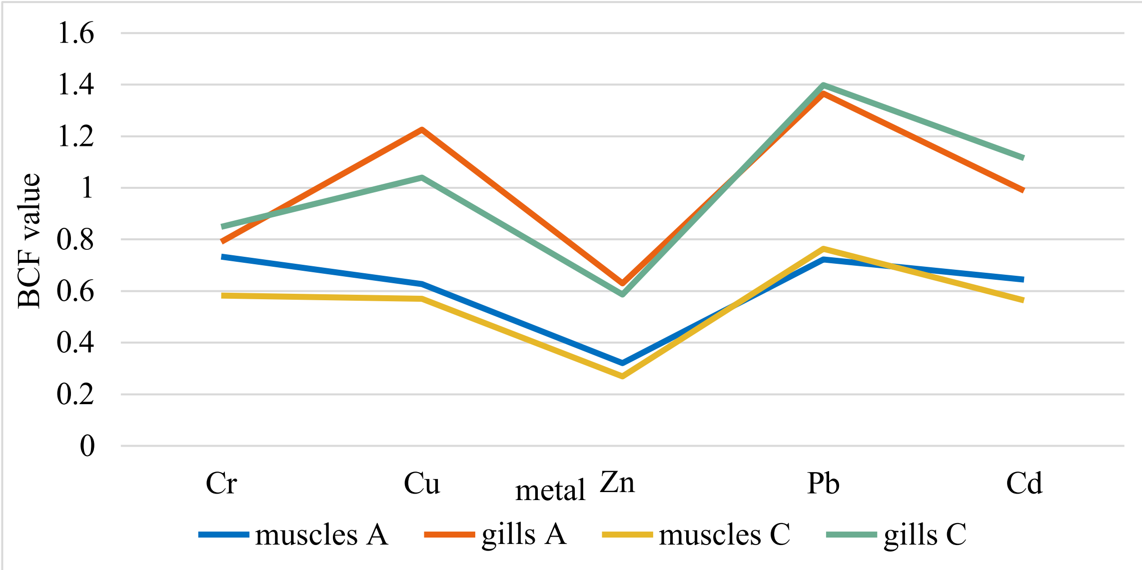

Figure (5) showed BCF values in water compare to their concentration in muscles and gills of two types of fish (muscles LSD=0.0039; gills LSD=0.004; r=0.99)

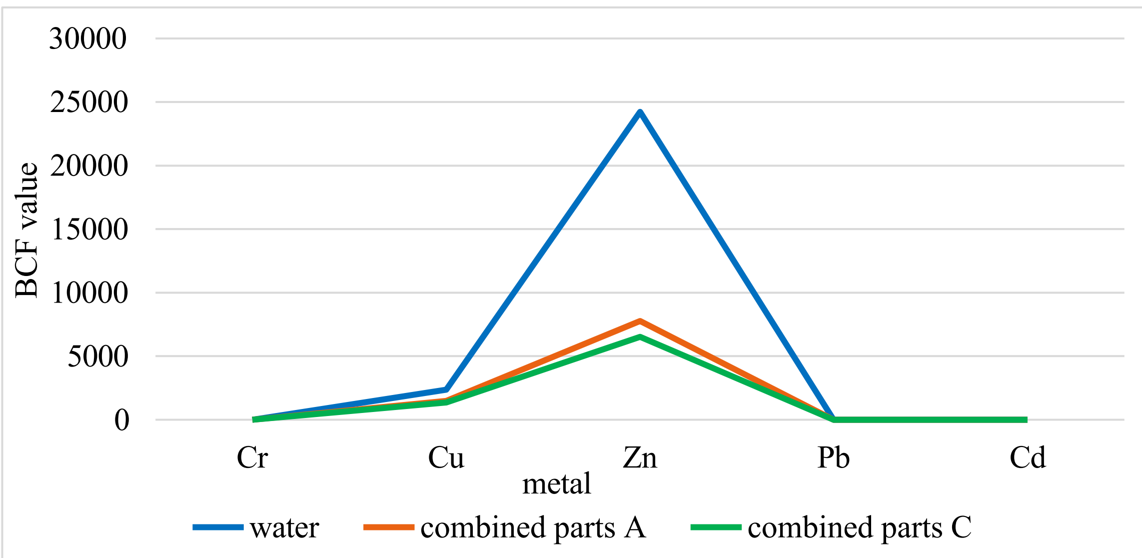

Figure (6) showed BCF values in water compare to their concentration in two types of fish (LSD=13.824; r=0.99).

3-5 Biota sediment accumulation factor

Table (5) showed BSAF in muscles and gills compare to sediment, which sediments can aggregation heavy metals in a huge amount as a reason of high capacity and differentiation of electro-charges that have, for that it considered reservoir for different pollutants including heavy metals. The sediment can resolution heavy metal in water environment when the concentration in water has been decreased as type of sediment-water environment balance or as activity of microorganisms in sediments (Yi et.al., 2021) and these processes make sediment a primary potential source for heavy metals specially the toxic metals. Also, the aquatic life such as different type of fish can feeding directly on sediments, or on biota that live in sediments, or breathing and feeding near the sediment which some studies pointed to this region as water – sediment boundary (Ochoa-Esteso et.al., 2024) and can become important source of entering heavy metals to fish by gills or guts and accumulation in different organs such as muscles, for that, current study focus on sediments as potential sources of heavy metals that accumulation in fish, and calculated these pollutants as a part of calculation BSAF that determined heavy metals in fish compare to that found in sediment which was considered as primary source of directly or indirectly feeding of fish. The results showed a significant differentiation with positive correlation coefficient among data (table, D; figure, 7) that means the BSAF values in study organs depending on concentration heavy metals in sediments that contributed in accumulation these pollutants in muscles and gills organs of fish. Also, there are some studies that pointed to exposure aquatic life to more toxic concentration of heavy metals by breathing and feeding in a few centimeters from bottom of aquatic environments because of redox reaction in sediments that release heavy metals in different shapes (Yatawara et.al., 2010). In this study, the results pointed to find BSAF values less than (1) (Melake et.al., 2023) in separated organs, which means the muscles can concentration in muscles and gills but not accumulation heavy metals from sediment that make muscles of fish in moderate safety to consume, while the gills as some study prefer to not consume by human in any condition or using it as diets for animals (Gwimbi et.al., 2020), in the other hand, the results showed (table, 6; figure, 7) that consuming two part of fish as calculation in BSAF can be courage to accumulation with the time that make tissues fish unhealthy to consumers.

Table (5) showed BSAF in muscles and gills compare to sediments µg/kg for two kinds of fish

Heavy metals	Acanthopagrus sp.			Cyprinus sp.		
	Combined parts	muscle	gills	Combined parts	muscle	gill
Cr	1.283505	0.27414	0.295505	1.102148	0.217814	0.317148
Cu	1479.592	0.435692	0.852192	1346.113	0.396402	0.722902
Zn	7768.886	0.242301	0.475951	6523.443	0.203456	0.443186
Pb	2.399639	0.359365	0.678639	2.512926	0.37962	0.694926
Cd	1.385783	0.361304	0.554783	1.353652	0.316522	0.625652

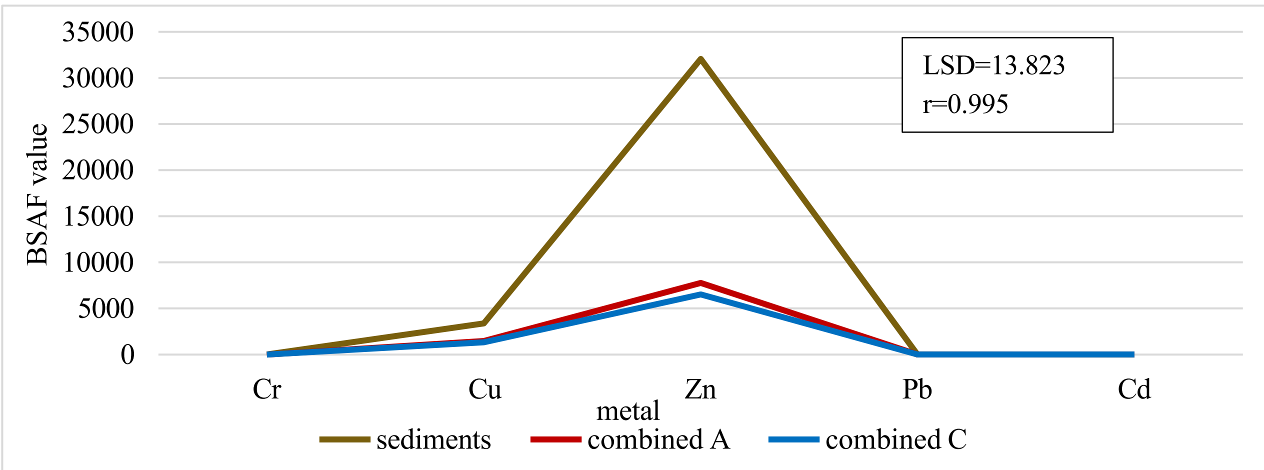

Figure (7) showed BSAF in combined organs compare to sediments µg/kg for two kinds of fish.

Table (6) showed BCF, BAF and BSAF as mention by Brković et.al., 2021; Saha et.al., 2021 and Melake et.al., 2023 respectively.

BCF		BAF		BSAF	
Value	**Description**	**Value**	**Description**	**Value**	**Description**
> 1	Intensive	> 1	Hyperaccumulation	> 1	Can accumulation
1-0.1	Medium	< 1	Excluder	< 1	Not accumulation
0.1-0.01	Weak				
0.01-0.001	Non accumulation				

Table (A) showed variances, calculation F and correlation coefficient for water, sediment and study parts of two kind of fish.

Anova: Two-Factor Without Replication						
SUMMARY	**Count**	**Sum**	**Average**	**Variance**		
cr	6	8.932	1.488667	1.107899		
cu	6	13923	2320.5	631596.4		
zn	6	100047.9	16674.65	96847412		
pb	6	17.286	2.881	1.340601		
Cd	6	7.864	1.310667	0.313292		
water	5	26591.02	5318.203	1.13E+08		
sediments	5	35465.69	7093.139	1.97E+08		
Muscles sha.	5	9250.69	1850.138	11354954		
Gills sha.	5	18157.39	3631.478	43819648		
Muscles carp	5	7871.721	1574.344	7991702		
Gills carp	5	16668.44	3333.688	38087032		
ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Rows	1.27E+09	4	3.17E+08	16.82421	3.47E-06	2.866081
Columns	1.11E+08	5	22151055	1.176246	0.355366	2.71089

Error	3.77E+08	20	18831989			
Total	1.75E+09	29				
Correlation	**water**	**sediments**	**Muscles shanik**	**Gills shanik**	**Muscles carp**	**Gills carp**
water	1					
sediments	0.999964	1				
Muscles shanik	0.995514	0.996285	1			
Gills shanik	0.99559	0.996354	0.998976	1		
Muscles carp	0.993832	0.994742	0.999866	0.999853	1	
Gills carp	0.997068	0.997684	0.999835	0.999849	0.999404	1

Table (B) showed correlations factors of BAF values of muscles and gills with heavy metal concentration in aquatic environment.

	aquatic environment	BAF gills shanik	BAF gills Carp	BAF muscles shanik	BAF muscles Carp	BAF all shanik	BAF all Carp
aquatic environment	1						
BAF gills shanik	0.999993254	1					
BAF gills Carp	0.999993254	0.9999996	1				
BAF muscles shanik	0.999993254	0.9999989	0.999985	1			
BAF muscles Carp	0.999993254	0.9999975	0.999976	0.999956	1		
All shanik	0.99979264	0.9998607	0.999861	0.999861	0.999861	1	
all Carp	0.999782494	0.9998524	0.999852	0.999852	0.999852	0.999996	1

Table (C) showed correlation factors of BCF values of muscles and gills with heavy metal concentration in water.

	water	BCF muscles shanik	BCF gills shanik	BCF muscles Carp	BCF gills carp
water	1				
BCF muscles shanik	-0.97401	1			
BCF gills shanik	-0.65716	0.619413	1		
BCF muscles Carp	-0.89526	0.9226201	0.83619	1	
BCF gills carp	-0.76609	0.7384093	0.922473	0.922862	1

Table (D) showed correlation factors of BSAF values of muscles and gills with heavy metal concentration in sediment.

	sediments	muscle shanik	gills shanik	muscle carp	gills carp
sediments	1				
BSAF Muscle shanik	-0.60484	1			
BSAF Gills shanik	-0.17911	0.868441	1		
BSAF Muscle carp	-0.57129	0.945963	0.896927	1	
BSAF Gill carp	-0.32882	0.875376	0.938457	0.942505	1

4- Conclusions

1- Depending on BCF values the concentration of separating organs can be medium in risk
2- The concentration of heavy metal in muscles and gills depending on availability of heavy metals in water
3- According to BAF values, the heavy metals have less accumulation to study heavy metal with some exception
4- The BSAF values showed less accumulation of heavy metals in muscles and gills from sources of sediments
5- All the results from BCF, BAF and BSAF pointed to the dangerous of consuming gills with muscles of fish
6- The fish in current study can be dangerous to human healthy

5- Recommendations

1- More study about heavy metals in water and fish
2- More attention about decreasing of water level in rivers that considered a primary source to many artificial fish lakes
3- Detected every week on concentration of heavy metals in water lakes and tissues of fish before sending to market

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