Open Access

Epidemiology & Public Health

Article Type: Research Article

Volume 1 Issue 3 - 2023

Evaluation of Mercury Pollution and Risk Assessment of Human Health due to Consumption of Common Carp (Cyprinus Carpio) from the Caspian Sea

Hassan Malvandi*

Department of Environmental Sciences and Engineering, Faculty of Geography and Environmental Sciences, Hakim Sabzevari University, Sabzevar, Iran.

Abstract

Background: In the present study, the main goal was to measure the concentration of mercury in the muscle tissue of common carp and evaluate the health risk to consumers using different indices, and evaluate the possible difference between the values of the studied element in the sampling stations.

Methods: Samples of the studied species were collected from four different stations, Bandar torkaman, Faridunknar, Chalus, and Bandar Anzali, from the southern shores of the Caspian sea. Kruskal-wallis and Mann-whitney u tests were used to determine the difference in mercury concentration in fish muscle tissue at the stations.

Results: The average concentration of mercury in Bandar anzali, Chalus, Faridunknar and Bandar torkaman were 46.3, 35.8, 24.3 and 19.6 µg kg^{-1} DW, respectively. The results showed that there were significant differences between mercury concentrations in common carp muscle tissue in the studied stations ($p<0.05$). The results showed that there was a positive and significant correlation between mercury values and total weight ($p<0.05$), while no significant correlation was obtained between mercury values and total length ($p>0.05$).

Conclusions: The mercury values obtained in all the studied stations were lower than the standards recommended by NISO, WHO, FAO, SAC and JECFA. The obtained hazard quotient (HQ) values were less than 1 in all stations, which indicated the absence of potential risk for consumers' health. However, it is recommended to continuously monitor the amount of mercury in this and other fish species to maintain the health of consumers.

***Corresponding author:** Hassan Malvandi

Department of Environmental Sciences and Engineering, Faculty of Geography and Environmental Sciences, Hakim Sabzevari University, Sabzevar, Iran.

Received: Nov 01, 2023

Accepted: Dec 05, 2023

Published: Dec 12, 2023

Epidemiology & Public Health - www.jpublichealth.org

Citation: Malvandi H. Evaluation of Mercury Pollution and Risk Assessment of Human Health due to Consumption of Common Carp (Cyprinus Carpio) from the Caspian Sea. Epidemiol Public Health. 2023; 1(3): 1024.

Keywords: Mercury; Heavy metal; Fish; Caspian sea; Risk assessment.

Introduction

Today, the importance of fish consumption is not hidden to anyone, because these species are very important in terms of nutritional value, for reasons such as the high amount of omega-3 fatty acids, vitamins, fats and amino acids, and they also contain minerals such as FE, ZN, etc [1,2].

In recent decades, due to the increase in pollution in the aquatic ecosystem, a large amount of potentially toxic metals accumulate in various organs of fish and other aquatic animals. The remarkable thing about these pollutants is their biomagnification property, because in this way, their amount increases during the food chain and they can cause risks for the health of consumers. In most cases, these potentially toxic metals enter

the environment through the disposal of industrial and agricultural wastewater, industrial processes and factories, excessive use of fertilizers in the cultivation of agricultural products, etc [3,4].

Among toxic metals, mercury is of particular importance due to its relatively long half-life, high toxicity and carcinogenicity. In addition, this metal has the property of bioaccumulation and biomagnification and accumulates in various tissues, including muscles, bones, kidney and liver, and its concentration increases along the food chain. Its presence in the body of organisms causes harmful effects, including various neurological and blood diseases, genetic diseases and even death. A clear example is the minamata disaster in japan, which occurred due to the entry of factory sewage into the waters of this area, which caused the death of 600 people and the illness of 300 people [5-8].

One of the main ways humans are exposed to this toxic metal is by consuming fish. There are various species of fish in iran, especially on the shores of the Caspian sea. One of the most consumed species of fish is the common carp (Cyprinus Caprio) belonging to the Cyprinidea family. This fish is native to the temperate regions of Asia and Europe, which over time has spread to most parts of the world and is considered one of the most important species economically and nutritionally. During the breeding season, this species migrates to the southern regions of the Caspian sea and enters the river estuaries to spawn. Due to its omnivorous diet, common carp has the ability to resist various pollutants and can be exposed to a wide range of environmental pollutants. But in recent years, this fish has been included among the species in need of protection due to the destruction of breeding places and overfishing [9-11]. Considering the importance of fish in the diet and their beneficial role in health, and on the other hand, the presence of pollutants in these species and their negative impact on the health of consumers, the main purpose of the present study was to determine the concentration of the toxic element mercury in the edible tissue of common carp caught from the southern shores of the Caspian sea. Also, other goals of this research were to determine the permissible amount of daily and weekly consumption, compare with international standards, evaluate the potential health risks of mercury for humans due to the consumption of this fish and evaluate the possible difference between the values of the studied element in the sampled stations.

Materials and methods

Sampling area Common carp fish were sampled from four stations along the southern coast of the Caspian sea (from west to east were Bandar Anzali, Chalus, Faridunknar, and Bandar torkaman). After recording the information of each sample, each fish was placed in plastic and kept at -22°c until the experiment. To measure the toxic element of mercury, first the muscle tissue samples were completely dried for 48 hours in an oven at a temperature of 105°c. After the sample was powdered, 1 gram of each sample was digested using a mixture of perchloric acid and nitric acid and finally diluted to a volume of 15 ml using deionized water [11,12]. The recovery rate was between 93% and 106% and also the detection limit was 3 µg kg^{-1} of dry weight.

Statistical analysis: The normal distribution of the data was checked with the Kolmogorov-smirnov test. Considering that the data were not normal, Kruskal-wallis and Mann-whitney u tests were used to determine the difference in mercury concentration in fish muscle tissue at the sampling stations. Also, spearman's test was used to determine the correlation between mercury concentration and parameters of total body length and total body weight.

Estimated daily intake (EDI)

The daily intake value depends on the contents of the metal studied in species and the values of fish consumed. The EDI was obtained based on the following formula [12].

$$EDI = \frac{(c \times ir_d)}{Bw},$$

In which c is the mercury value in the sample studied (µg g^{-1} in terms of wet weight); BW is the human weight (70 kg for adult human); and IR is the daily ingestion of fish (grams day^{-1}).

Estimated weekly intake (EWI)

The EWI values were calculated according to the following formula [13]:

$$EWI = \frac{(c \times ir_w)}{Bw}$$

In which c is the mercury value in the sample studied (µg g^{-1} in terms of wet weight); BW is mentioned above; and ir_w is the weekly ingestion rate of fish (grams $week^{-1}$) [12,14].

Hazard quotient (HQ)

The hq index was obtained based on the following equation

In which ed is the exposure period (70 years), EF is the frequency of exposure (365 days/year), FIR is ingestion rate by fao (36 g/person/day) and or food ingestion rate for the whole of Iran and the coastal provinces of northern Iran by the iranian fisheries organization (20.5 g/person/day and 38 g/person/day, respectively), c is the metal concentration in the sample studied (µg g^{-1}), BW is mentioned above, ta is the mean exposure time for non-carcinogens, and RFD is the reference dose of usepa (0.1 µg hg kg bw^{-1} day^{-1}) or acceptable daily intake of who (0.23 µg hg kg bw^{-1} day^{-1}) [14-16].

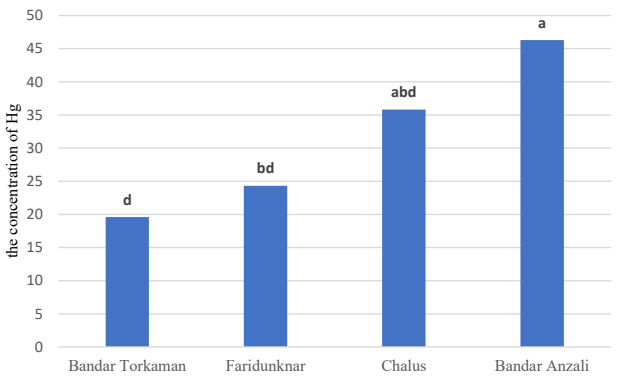

Figure 1: Values of mercury (µg kg^{-1} DW) in muscle tissue of common carp from the southern of the Caspian Sea (different letters indicate a significant difference between the values).

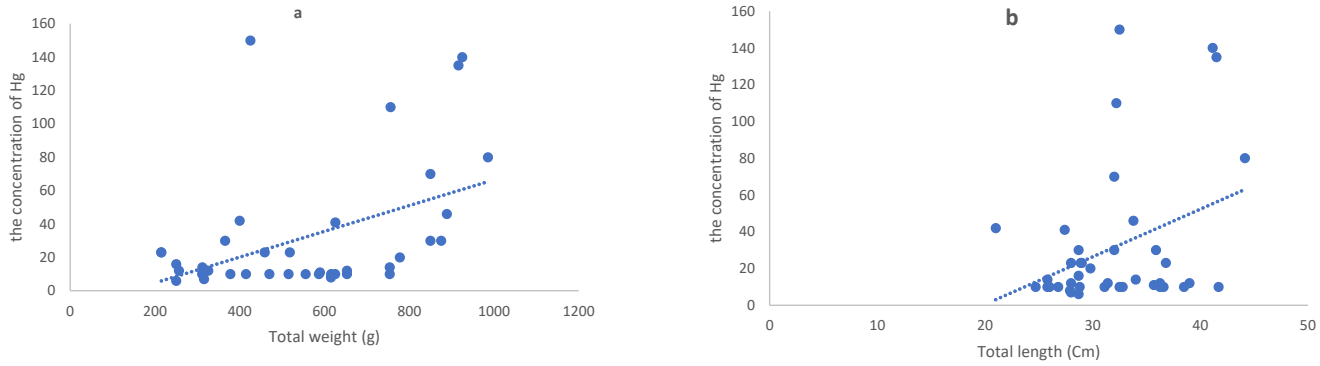

Figure 2: Correlation between mercury concentration and parameters of body length and total body weight.

Table 1: Orphological information of common carp from the Caspian Sea.

Parameters	Bandar torkaman		Faridunknar		Chalus		Bandar anzali	
	Total length (cm)	Total weight (g)	Total length (cm)	Total weight (g)	Total length (cm)	Total weight (g)	Total length (cm)	Total weight (g)
Mean	35.1	542.1	27.3	529.8	32.9	613.1	32.6	502.5
Std. Deviation	5.3	269.9	3.2	128.7	4.6	243.0	5.0	266.6
Minimum	28.0	215.0	21.0	312.0	27.4	256.8	25.8	215.0
Maximum	44.2	985.5	32.2	755.8	41.5	915.8	41.2	925.0

Table 2: Mean, standard deviation, minimum and maximum values of mercury (µg kg-1 dw) from muscle tissue of common carp.

Parameters	Bandar torkaman	Faridunknar	Chalus	Bandar anzali	Total
Mean	19.6	24.3	35.8	46.3	31.5
Std. Deviation	22.5	31.9	37.0	54.9	38.4
Minimum	6.0	8.0	10.0	12.0	6.0
Maximum	80.0	110.0	135.0	150.0	150.0

Table 3: Comparison of average HG values of the common carp with hg values found by other authors.

Sampling location	Country	Concentrations	Reference
Southern caspian sea	Iran	31.5[a] (5.5[b])	Present study
Anzali wetland	Iran	190[a]	[18]
Anzali wetland	Iran	179[a]	[19]
Southern caspian sea	Iran	500[a]	[20]
Southern caspian sea	Iran	302[a]	[21]
Shadegan wetland	Iran	563[a]	[5]
Hamon wetland	Iran	280[a]	[22]
Taham dam	Iran	26[b]	[23]
Jinsha and tuo rivers	China	39[b]	[24]
Velky kocelovicky pond	Czech	31.6[b]	[17]
Mysliv pond	Czech	22.9[b]	[17]
Zehunsky pond	Czech	3.6[b]	[17]

[A] µg kg^{-1} dw; µg kg^{-1} ww

Results and discussion

In Table 1, the sample morphometric data, i.e. Total length and total weight for common carp from each sampling station. The average values of total length were 35.1 cm, 27.3 cm, 32.9 cm and 32.6 cm from the Bandar Torkaman, Faridoonkanar, Chalus and Bandar Anzali stations, respectively. The average values of total weight were 542.1 g, 529.8 g, 613.1 g, and 502.5 g from the Bandar Torkaman, Faridunknar, Chalus, and Bandar Anzali stations, respectively.

The average, standard deviation, minimum and maximum amount of mercury in the samples are shown in Table 2. The highest values of mercury was 46.3 µg g^{-1} DW in Bandar anzali samples and the lowest values was 19.6 µg g^{-1} DW in Bandar torkaman samples (Table 2). The mercury concentration obtained in the muscle tissue of the studied fish was compared with international standards. The results showed that the concentrations of mercury in all the samples were less than the amount of 0.5 µg g^{-1} WW set by the National Iranian Standards Organization (NISO), food and agriculture organization (FAO), the Standardization Administration of China (SAC), the joint FAO/WHO expert committee on food additives (JECFA) and Food And Agriculture Organization (FAO) and 0.3 µg g^{-1} WW set by environmental protection agency (EPA). This indicates that the mercury values of common carp does not pose a risk to the health of consumers.

Determining the difference in mercury concentration among the samples obtained from four stations is also shown in figure 1. The results showed that there were significant differences between mercury concentrations in common carp muscle tissue in the studied stations ($p<0.05$). The value of mercury in the samples caught from Bandar Anzali station was significantly different from Faridunknar and Bandar Torkaman stations. A significant difference was also observed between the mercury values in the samples caught from Chalus station and Bandar Torkaman, while no significant difference was found in the mercury values in other stations (Figure 1). The results also showed

Table 4: Hazard quotient (HQ) to common carp consumers from mercury.

Station	Index of hq					
	Hq_{fe} [a]	Hq_{fw} [b]	Hq_{ime} [c]	Hq_{imw} [d]	Hq_{ine} [e]	Hq_{inwk} [f]
Bandar torkaman	0.000021	0.000009	0.000012	0.000005	0.000022	0.000009
Faridunknar	0.000026	0.000011	0.000015	0.000006	0.000027	0.000012
Chalus	0.000041	0.000018	0.000023	0.000010	0.000043	0.000019
Bandar anzali	0.000047	0.000020	0.000027	0.000012	0.000049	0.000021
Total	0.000035	0.000015	0.000020	0.000009	0.000037	0.000016

A. HQ index based on FAO's food ingestion rate and USEPA's reference dose.
B. HQ index based on FAO's food ingestion rate and WHO's reference dose.
C. HQ index based on the food ingestion rate in the whole of Iran and USEPA's reference dose.
D. HQ index based on the food ingestion rate in the whole of Iran and who's reference dose.
E. HQ index based on the food ingestion rate in the coastal provinces of northern Iran and USEPA's reference dose.
F. HQ index based on the food ingestion rate in the coastal provinces of northern Iran and who's reference dose.

Table 5: Estimated daily intake (edi) and estimated weekly intake (ewi) values for mercury in common carp.

Station		Index			Index	
	Edi_{f} [a]	Edi_{im} [b]	Edi_{in} [c]	Ewi_{f} [a]	Ewi_{im} [b]	Ewi_{in} [c]
Bandar torkaman	0.0021	0.0012	0.0022	0.0144	0.0082	0.0152
Faridunknar	0.0026	0.0015	0.0027	0.0180	0.0103	0.0190
Chalus	0.0041	0.0023	0.0043	0.0288	0.0164	0.0304
Bandar anzali	0.0047	0.0027	0.0049	0.0328	0.0187	0.0346
Total	0.0035	0.0020	0.0037	0.0245	0.0139	0.0258

A. Food ingestion rate by fao (36 g/person/day).
B. Food ingestion rate in the whole of Iran (20.5 g/person/day).
C. Food ingestion rate in the coastal provinces of northern Iran (38 g/person/day).

that the concentration of mercury in the studied fish samples increased from east to west and this difference was also significant. These results indicate that the fish samples located in the western stations are exposed to higher amounts of pollution.

The average mercury values obtained in common carp are compared with the average concentrations obtained from other studies conducted on this fish (Table 3). Comparison of mercury values in this fish showed that the average concentration obtained in this study was higher than the values obtained from Zehunsky pond (czech) [17], and lower than the reported values from other studies. In Table 3, the highest average mercury value was from Shadegan wetland (Iran) [5] and the lowest value was Zehunsky pond (czech) [17].

Correlation between the values of mercury in the studied fish with the morphological parameters of total length and total weight was analyzed. The results showed that there was a positive and significant correlation between mercury values and total weight ($p<0.05$), while no significant correlation was obtained between mercury values and total length ($p>0.05$) (Figure 2). In other studies, the relationship between mercury levels in common carp and morphological parameters has been investigated. For example, a positive and significant correlation has been obtained between mercury values with total weight and total length in common carp species from Anzali wetland (Iran) [19]. Similar results were obtained in the study conducted in Shadgan wetland (Iran) [5]. On the other hand, in another study conducted on the coast of the caspian sea, no correlation between mercury concentration and the considered parameters was reported [20].

The hazard quotient (HQ) values for the samples were in the range of 0.000005 and 0.000049 (Table 4). If the HQ value is greater than one, the consumption of fish is dangerous for health. Therefore, the results showed this important fact that the risk of consuming fish species for people's health is small and insignificant. Similar results have been obtained in other studies conducted on this species.

In Table 5, estimated daily intake (EDI) and estimated weekly intake (EWI) values were used based on the per capita fish consumption stated by FAO, as well as the average per capita fish consumption values in the northern coasts of Iran and the average of the country of Iran. Based on different per capita amounts of fish consumption, the amount of mercury intake by the body through the consumption of common carp varied in the range of 0.0012 to 0.0049 $\mu g/g^{-1}$ per day and in the range of 0.0082 to 0.0304 $\mu g/g^{-1}$ per week.

The obtained results showed that the concentrations of mercury in the muscle tissue of common carp were lower than the permissible limits provided by organizations such as Iran national standard, FAO, US EPA, WHO, FDA and EC. The value of the HQ index obtained was less than one, so the consumption of this species is fortunately healthy and safe for the health of consumers. However, it is worth mentioning that due to the negative effects of this metal on the health of species and humans and its bioaccumulation and biomagnification property, it is necessary to carry out additional research to investigate the decreasing or increasing trend of the concentration of this metal over time in different species.

Declarations

Conflict of interest: The author has no conflicts of interest to declare for this study.

Funding: The author(s) received no financial support for the research, authorship, and/or publication of this article.

Acknowledgements: The author is also thankful to Mr. Ali kashi, fishermen and fish sellers, for their assistance in collecting fish samples.

References

1. Asiabar zm, taghavi l, valinassab t, pourgholam r measuring concentration of heavy metals (pb , cd , hg) in tissue of liza saliens and risk sssessment associated with its use (case study : coastal w of the caspian sea). Int j environ sci technol 18. 2016.
2. Amirjanati a, norouzi m, nazemi a investigation of genetic structure of common carp (cyprinus carpio linnaeus 1758) in anzali lagoon and gorganroud mangrove by microsatellite molecular method. Journalof aquac dev. 2013; 7: 1-10.
3. Banagar g, alipour h, hassanpour m, golmohammadi s estimation of daily intake and potential risk of chromium, lead and cadmium in consumers of common carp and zander from gorgan gulf. Zanko j med sci. 2015; 19: 22-31.
4. Malvandi h assessing the potential health risk from mercury through consumption of the most popular and preferable fish species, rutilus frisii kutum, on the northern coast of iran. Biol trace elem res. 2020; 1-7.
5. Khoshnamvand m, mojodi f, khosravi rmeasurement and comparison of mercury concentration in different length groups of common carp muscle tissue from the shadegan wetland. J heal dev. 2016; 5: 45-57.
6. Khani pour aa, ahmadi m, zare gashti g, zolfi nejad kevaluation of bioaccumulation of heavy metals (cadmium, lead and zinc) in edible muscle tissue of crucian carp (carassiu sauratus) from international wetland of anzali. Food sci technol. 2015; 13: 155-163.
7. Malvandi h, shamabadi mh, berglund åmm measurement of metal concentrations in feathers of bird-vehicle collisions, sabzevar, iran. Environ sci pollut res. 2021; 28: 57686-57694. Https://doi.org/10.1007/s11356-021-14576-0.
8. Malvandi hpreliminary evaluation of heavy metal contamination in the zarrin-gol river sediments, iran. Mar pollut bull. 2017; 117: 547-553. Https://doi.org/10.1016/j.marpolbul.2017.02.035.
9. Fazli h, kor d, tavakoli m, et al spatial-temporal distribution of common carp (cyprinus carpio) in iranian waters of the caspian sea. Renew nat resour res. 2013; 3: 29-37.
10. Farhangi m, hajimoradloo am, rostami charati f determination of lethal concentration 50, 96h of zinc (lc5096h, znso4) on common carp (cyprinus carpio) under experimental condition. J anim res. 2014; 27: 119-125.
11. Malvandi h, alahabadi a evaluation of potential human health risk due to the exposure to mercury via fish consumption of alosa spp. From the southern caspian sea. Mar pollut bull. 2019; 143: 66-71. Https://doi.org/10.1016/j.marpolbul.2019.04.042.
12. Malvandi h, sarvary korojdeh m, azimi s assessment of mercury contamination in perch species in the southern caspian sea. Arch environ contam toxicol. 2020. Https://doi.org/10.1007/s00244-020-00730-1.
13. Barone g, storelli a, garofalo r, et al assessment of mercury and cadmium via seafood consumption in italy: estimated dietary intake (ewi) and target hazard quotient (thq). Food addit contam - part a chem anal control expo risk assess. 2015; 32: 1277-1286. Https://doi.org/10.1080/19440049.2015.1055594.
14. Malvandi h, esmaili-sari a, aliabadian m mercury contamination in khramulia (capoeta capoeta) from the cheshme kile and zarrin gol rivers in iran and human health risk assessment. Bull environ contam toxicol. 2014; 93: 472-477. Https://doi.org/10.1007/s00128-014-1335-1.
15. Liu f, ge j, hu x, et al risk to humans of consuming metals in anchovy (coilia sp.) From the yangtze river delta. Environ geochem health. 2009; 31: 727-740. Https://doi.org/10.1007/s10653-009-9258-1.
16. Bonsignore m, manta ds, oliveri e, et al mercury in fishes from augusta bay (southern italy): risk assessment and health implication. Food chem toxicol. 2013; 56: 184-194. Https://doi.org/10.1016/j.fct.2013.02.025.
17. Pavla s, danka h, premysl m, et al do the total mercury concentrations detected in fish from czech ponds represent a risk for consumers? Sci rep. 2022; 12: 553.
18. Sadeghi rad m heavy metal determination in fish species of anzali lagoon. J iran sci fish. 1997; 5: 1-16.
19. Astani e, vahedpour m, babaei h organic and total mercury concentration in fish muscle and thermodynamic study of organic mercury extraction in fish protein. Ecopersia. 2016; 4: 1517-1526. Https://doi.org/10.18869/modares.ecopersia.4.3.1517.
20. Nasrollahzadeh saravi h, pourgholam r, pourang n, et al heavy metal concentrations in edible tissue of cyprinus carpio and its target hazard quotients in the southern iranian caspian sea coast. J maz univ med sci. 2013; 23: 33-44.
21. Elsagh a determination of some heavy metals in rutilus frisii kutum and cyprinus carpio fillet from south caspian sea. Vet j. 2011; 4: 33-44.
22. Zolfaghari g risk assessment of mercury and lead in fish species from iranian international wetlands. Methodsx. 2018; 5: 438-447. Https://doi.org/10.1016/j.mex.2018.05.002.
23. Sobhanardakani s, jafari sm investigation of as, hg, zn, pb, cd and cu concentrations in muscle tissue of cyprinus carpio. J maz univ med sci. 2014; 24: 184-195.
24. Li j, yan y, yue n, et al (2018) comparative study of metal accumulation in three fish species (silurus asotus, cyprinus carpio, and carassius auratus auratus) from the jinsha and tuo rivers located upstream of the yangtze river, china. Bull environ contam toxicol. 101: 26–32.