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Baseline

Potential risk of mercury to human health in three species of fish from the southern Caspian Sea

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ABSTRACT

We aimed to investigate mercury level in three species of fish such as *Sander lucioperca*, *Liza aurata*, and *Rutilus frisii kutum*. Sampling was done in the southern coasts of the Caspian Sea. The ranges of mercury level in *S. lucioperca*, *L. aurata*, and *R. frisii kutum* were 104.67–675.33 ppb, 60.66–175.33 ppb, and 123.33–170.33 ppb, respectively. Results revealed that the mercury level in *S. lucioperca* was more than the allowable limit at several sites, while it was less than the allowable limit in *R. frisii kutum* and *L. aurata* at all sampling sites. Further, the target hazard quotient (THQ) index for *S. lucioperca* was > 1 at some sites and < 1 for other species at all sites. The maximum allowable consumption for each species at the study area was measured daily and monthly.

Nowadays, sea products play a considerable role in food supply for the people worldwide and are increasingly consumed because of their suitability and food priority compared to other proteins (FAO, 2009). Fish meat, which has several advantages, provides many elements required for the body, including phosphorous, calcium, minerals, and vitamins. In addition, fish meat is regarded as a rich source of polyunsaturated fatty acid (PUFA), also called as omega-3, which is beneficial to prevent coronary artery diseases.

Docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) are the most important omega-3 fatty acids that help in the treatment of atherosclerosis, cancer, arthritis, and aging disease such as Alzheimer's disease. Along with the increasing demand for marine products, serious increase in the rate of pollution in marine environments has intensified probable qualitative problems in these valuable food sources. Industrial development and overgrowth of population in cities and villages in addition to farming land extension and usage of fertilizers and pesticides cause increase in urban and industrial sewage, as well as agricultural runoff containing different chemical compounds such as heavy metals run toward aquatic ecosystems (Kojadinovic et al., 2006).

Mercury is considered as one of the most dangerous heavy metals found in organic and inorganic forms in the natural environment. Studies have indicated that the organic form of mercury (methyl mercury) is much more toxic and bioaccumulate along the food chain. Inorganic mercury is converted into the organic form (i.e., mercury methyl) through methylation and enzymatic process performed by bacteria and other aquatic microorganisms (Porcella, 1994; Adams and McMichael, 1999).

Mercury methyl can be absorbed by aquatic flora, algae, and primary organisms of the food chain, and then it can enter and accumulate in the fish food web. Fish consumption is the most substantial way of introducing mercury into the human body. Owing to the long-term biological half-life of mercury methyl, tremendous and undesirable effects have been observed on human health, particularly on the nervous system resulting in problems including psychopathy, hearing and vision loss, loss of control over the body, general weakness, anxiety attack, and the nervous system of the fetus (Dietz et al., 2000; Ruelas-Inzunza et al., 2008; Horvat et al., 2014).

White fish (*R. frisii kutum*) of the Caspian Sea is distributed in deep waters during autumn while prefers coastal areas (depth of about 30 m) and river estuaries during winter. When inhabiting the sea, they are found in areas with benthic organisms, especially the mollusks. They migrate when thermal changes and water currents occur. This species is found along the coastline of the southern Caspian Sea from the Atrak River to Kora River. In Iranian coasts, many white fish migrate for reproduction to the Shirood River, Havigh River, Lamir River, rivers reaching into Anzali wetland, Sefidrood, Tajan River, Babolrood, and Gorganrood (Shikhshabekov, 1979; Abdoli, 1999).

The Perch fish, *S. lucioperca* from the order Perciformes, inhabits freshwater and saltwater. They are mostly distributed throughout the northern hemisphere, although they are introduced to the southern hemisphere. Their individuals are commonly found in the southwest coast and are regarded as economically valuable fish in the Caspian Sea. In early life, they are zooplanktivorous, and after larval stages, they become predators. The perch feeds seldom on benthos, crustaceans, and

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insect larvae, except for other fish. However, according to the previous studies, its main foods in the Caspian Sea are Caspian roach, Kilka fish, gobies, and shrimp. Unfortunately, the population of this fish has decreased over the past few decades because of various reasons, and its fishing caused a sharp decline (Craig, 2000; Holčik and Oláh, 1992).

The golden mullet (*L. aurata*) was introduced during 1930–1934 into the Caspian Sea and was distributed at different parts. This species is mostly found in the southern coast of the Caspian Sea and can tolerate high temperature and changes in salinity. Often, they feed on mollusk, zooplankton and detritus. White fish, as the most dominant species in catch composition of teleosts throughout the southern Caspian Sea, form > 50% of fishery and > 60% of the fisherman's income. Next to white fish, mullet fish is of great economic importance and their catch provides > 30% of the fisherman's income.

Less information is available on the evaluation of risk associated with the consumption of aquatic organisms; specifically, previous studies are associated with the most edible fish in the Caspian Sea in terms of heavy metals such as mercury, with heavy metal measurements in various tissues of the fish, and the association between metal accumulations with biometric parameters. In the present research, risk evaluation of mercury consumption in three species of the most edible fish in the southern Caspian Sea was studied.

Specimens of white fish (15 fish at each site), mullet (15 fish at each site), and perch (15 fish at each site) were caught from six sampling sites of the Caspian Sea (from Astatara to Gorgan coasts) in winter 2017 by beach seine (Fig. 1) and then transported to the laboratories in ice boxes. The fishes were rinsed with distilled water and weighed using a digital balance. Then, other biometric measurements including standard, fork, and total lengths were analyzed using a digital ruler (with an accuracy of 1 mm). In the laboratory, the mussel between the anterior part of the dorsal fin and lateral line was separated and kept in a freezer at −80 °C until analysis. For mercury analysis, 0.5 g of each homogenized sample from different sites was separately weighed and poured into a 50-ml Teflon-capped container. Then, 5 ml of a mixture of perchloric acid ($HCLO_4$) and nitric acid (HNO) (with the ratio of 1:3) was added and shaken well while the container was capped (AOAC, 1995). For completion of the digestion, the solution was heated from 100 to 150 °C for 45 min in an oven and then sieved through a Whatman paper until a transparent solution was achieved. Afterwards, drying of the solution was carried out at room temperature, and 0.5 ml of 0.1 M SnCl and double distilled water was added to make up the volume to 50 ml. After preparation, samples were measured by the cold vapor technique and using the atomic absorption device. Data were analyzed using statistical package of SPSS (Ver. 16). First, data normality was performed by the Kolmogorov-Smirnov test when $\alpha = 0.05$. Normality test indicated a normal distribution for all data. Thereafter, mean comparisons were done by one-way ANOVA and Duncan's multiple range test. Pearson correlation was applied to assess the association between all measured factors.

Results of biometric data and mercury content in the studied fish are shown in Tables 1 and 2. The range of mercury content in *S. lucioperca* was from 104.67 ppb to 675.33 ppb, with the highest level at site 1 and the lowest level at site 5. Moreover, the highest and lowest content of mercury in *R. frisii kutum* was obtained at sites 4 and 2, respectively. The mean level of mercury in this species was 141.44 ± 28.28 ppb. In *L. aurata*, the highest level of mercury (175.33 ± 6.02 ppb) was detected at site 1, while its lowest level (60.66 ± 7.57 ppb) was observed at site 4.

In the study area, mercury level in *S. lucioperca* showed a decline from west to east. The highest and lowest levels of mercury in *R. frisii kutum* were measured in eastern and western sites, respectively. By contrast, in *L. aurata*, the highest level of mercury was seen in the western site, while the lowest level was obtained in the eastern site.

Difference in heavy metal accumulation in various fish species is pertained to their life, habitat, feeding habit, capability in bioaccumulation, age, and size. In other words, metal bioavailability can be affected by biotic and abiotic factors controlling a specific metal and its bioaccumulation (Spry and Wiener, 1991; Storelli et al., 2005; Kelly et al., 2008). Comparison of mean mercury contents in the three studied species discovered that mercury level in *S. lucioperca* was higher than that in the other two species ($p < 0.05$), while no significant difference was observed in the mercury levels of *R. frisii kutum* and L. *aurata* ($p > 0.05$) (Fig. 2). The higher level of mercury in *S. lucioperca* might be attributed to its carnivorous feeding habit, and this species

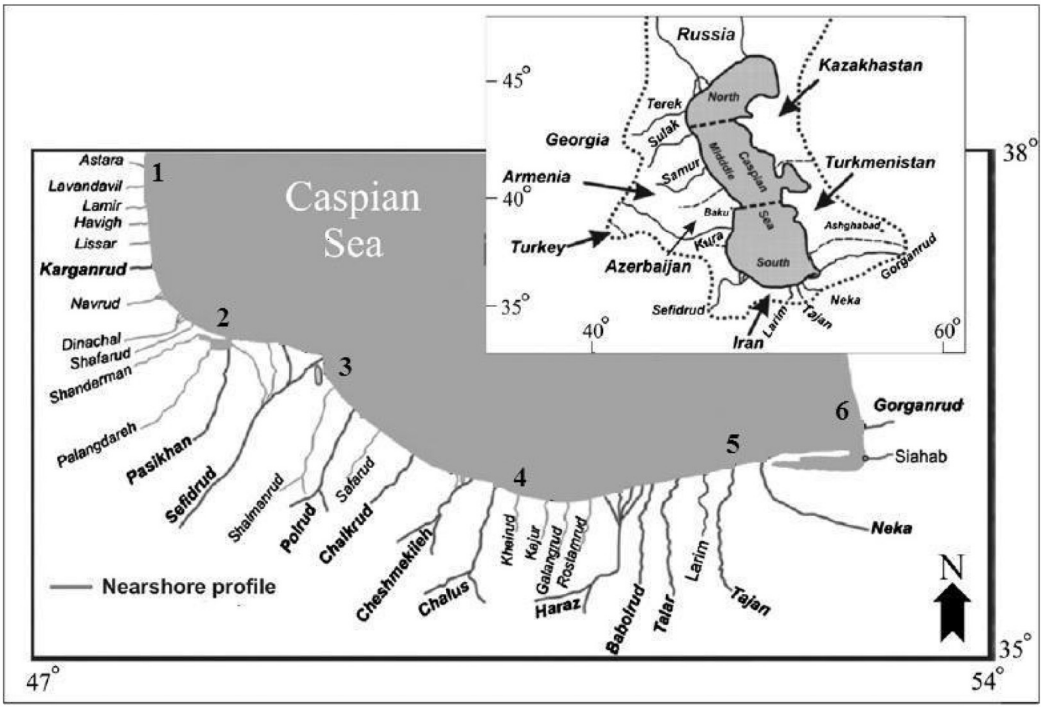

Fig. 1. The locations of the sampling sites at the coastline of the southern Caspian Sea.