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Baseline

Potential risk assessment of metals in edible fish species for human consumption from the Eastern Aegean Sea

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ABSTRACT

The levels of Hg, Cd, Pb, Cr, Cu and Zn were measured in the tissues of four edible fish species namely: *Diplodus annularis*, *Pagellus erythrinus*, *Merluccius merluccius* and *Mullus barbatus*, collected from the Turkish Coast of the Aegean Sea. Except for *D. annularis*, the levels of Cd and Pb in all fish tissues sampled in Aliaga Bay in 2009 were above the tolerable limits according to the Food and Agriculture Organization of the United Nations (FAO). Hg in *P. erythrinus* and *M. barbatus* were higher than the maximum permitted limits (FAO), while *D. annularis* and *M. merluccius* were lower than the limit for biota in the district of Aliaga. Although the Target Hazard Quotient (THQ) values for Cd, Pb, Cu, Cr, Zn in all fish samples were lower than 1.0, the THQ for Hg levels were higher than 1.0 for most of the samples. According to the THQ values, *M. merluccius* may be consumed in moderation from Aliaga Bay, while the consumption of *M. barbatus* and *P. erythrinus* collected from Aliaga Bay are potentially hazardous to human health due to the Hg concentrations. Fish collected from Izmir Bay can be consumed safely.

Metals have caused worldwide concern due to their toxicity, persistence, and non-degradability in the aquatic environment. Metal contamination increases due to industrial and urban activities in the marine environment and has influenced the coastal ecosystems. Fish can accumulate toxic trace metals both through the food chain and through water (Hadson, 1988) and they can also be considered one of the most significant indicators of toxicity. Hg is one of the most studied metals in relation to environmental and human health. Hg is a bioaccumulative toxic metal and biomagnified through the food chain causing a harmful impact on the environment and on human health (Manaham, 2003; USEPA, 2000). Cr is classified as one of the priority pollutants by the United States Environmental Protection Agency (USEPA) with a carcinogenic classification A (carcinogenic to humans), while Cd and Pb are classified in the same list with a carcinogenic classification B (probable human carcinogen) (USEPA, 1999).

The aim of this study is to compare the metal levels in different fish species in Aliaga Bay and Izmir Bay of the Eastern Aegean Sea. The impact of anthropogenic activities on the components of the aquatic system with respect to metal pollution has been assessed, and the potential risk for human consumption has been evaluated for four edible fish species in the study area.

Aliaga Bay is located in the central Eastern Aegean Sea (Fig. 1), and has been subjected to extensive industrial developments including a ship dismantling area. Izmir Bay has functioned as a major commercial port and has been an area of urbanization and industrialization for a long period. The Gediz River, which flows into the bay, is the second biggest river along the Eastern Aegean coast. The inner bay is heavily polluted by nutrients and organic material (UNEP, 1993).

Fish samples were collected in Aliaga Bay and Izmir Bay within the framework of two projects: (i) The determination of hazardous substances in coastal and transitional waters and ecological coastal dynamics projects (KIYITEMA, 2014) and (ii) Izmir Bay oceanographic monitoring project (DBTE-199, 2015). The study areas and sampling stations are shown in Fig. 1. Fish samples containing species such as *Diplodus annularis*, *Mullus barbatus*, *Merluccius merluccius* and *Pagellus erythrinus* were collected by bottom trawling. Muscle tissues were freeze dried, homogenized and then digested in a microwave digestion system (UNEP, 1984). All analyses were performed using Atomic Absorption Spectroscopy (AAS) with background correction (UNEP, 1982, 1985) by flame (for Cu, Zn, Mn and Fe), cold vapor (for Hg) and graphite furnace (for Cd, Pb and Cr) techniques. An intercalibration biota sample (IAEA 407; IAEA Laboratories) was used as a control for the analytical methods. The accuracy and detection limits of the AAS analysis are given in Table 1.

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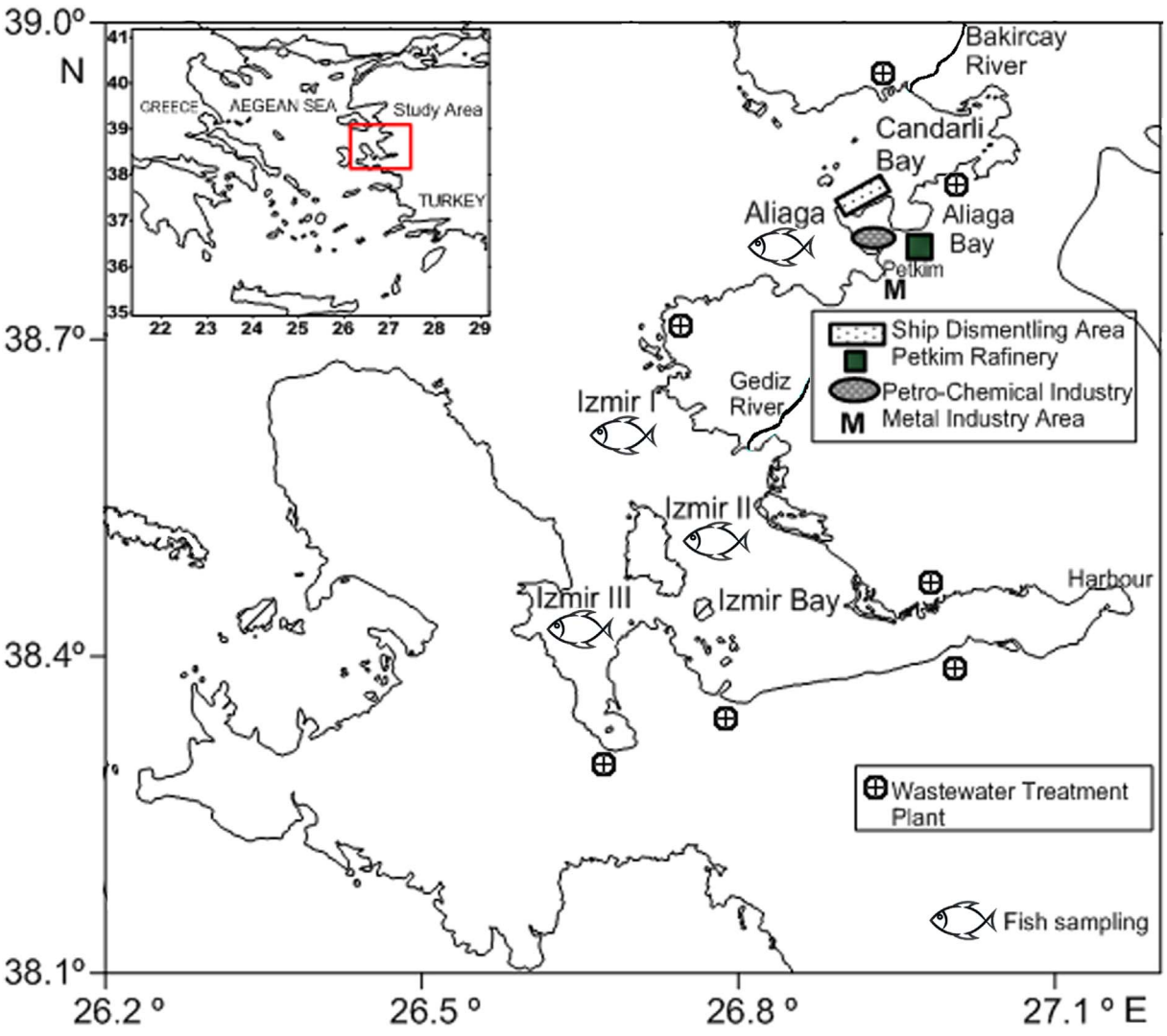

Fig. 1. Location of fish sampling stations.

Table 1
Observed and certified values of reference material (IAEA-407) as mg kg^{-1} dry weight.

Element	Measured value	Certified value	Detection limits
Hg	0.222	0.228	$0.05 * 10^{-3}$
Cd	0.176	0.189	$0.10 * 10^{-3}$
Pb	0.137	0.12	$0.10 * 10^{-3}$
Cr	0.75	0.73	0.06
Cu	3.52	3.28	0.03
Zn	65.5	67.1	0.01

Table 2
Oral reference doses of metals (USEPA, 2009).

Metal	Hg	Cd	Pb	Cr	Cu	Zn
RfDo/(mg/kg-day)	1.6×10^{-4}	1×10^{-3}	4×10^{-3}	1.5	4×10^{-2}	3×10^{-1}

The health risks to humans via dietary intake of fish were assessed according to the THQ values. The THQ, which is the ratio between the exposure and a reference dose (RfD), is used to express the risk of non-carcinogenic effects (Table 2). If the ratio is less than 1, there will not be any obvious risk. Conversely, if the dose is equal to, or greater than, the RfD (Yi et al., 2011), an exposed population will experience health risks. The method for determining the THQ value is provided in the United States EPA Region III risk-based concentration table (USEPA, 2000). The dose calculations were carried out using standard assumptions from an integrated United States EPA risk analysis. The models for estimating THQ have been calculated according to Chien et al., 2002.

The results for the metal concentrations in the muscles of different fish taken from Aliaga Bay and Izmir Bay (three sampling locations; Izmir I, II and III) were summarized in Table 3. The mean metal concentrations in fish samples in Aliaga Bay increased following the sequence Zn > Hg > Pb > Cu > Cr > Cd. The maximum value of Hg detected in this study was 0.83 mg kg^{-1} ww (wet weight) for *P. erythrinus*. The highest Zn concentrations were found in *D. annularis*; the maximum concentrations of Cd, Pb and Cu were found in *M. barbatus* and the highest concentration of Cr was observed in *M. merluccius* in Aliaga Bay. In Aliaga Bay, Cd, Pb, Cu and Zn concentrations in *D. annularis* were higher than *M. barbatus* during 2014. High levels of Cd, Pb and Cr were measured in the Izmir I location due to the Gediz River, which is a densely populated region with numerous industries by comparison to the other sampling locations in Izmir Bay. Cr, Cu and Zn concentrations were similar to each other for the two bays. However, the highest concentration of Cu (1.6 mg kg^{-1} ww) was measured in Aliaga Bay.

In this study, factor analysis was performed to analyze the data. The first step in the multivariate statistical analysis was the application of factor analysis aimed at grouping the sampling areas for *D. annularis*