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Short Communication

Trace Metal Concentration and Sea Water Quality of Tuzla Shipyard Area, Istanbul, Turkey Using Mediterranean Mussels (*Mytilus galloprovincialis*) for Monitoring Aquatic Pollution

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ABSTRACT

The mussels of the genus *Mytilus* have been proposed for routine biomonitoring programs to evaluate pollutants such as heavy metals in coastal environments. The concentrations of Pb and Cd were determined in *Mytilus galloprovincialis* (n=200) caught from the Tuzla area of Istanbul, Turkey between May 2013 and April 2014. The Cd level was found to be low whereas concentrations of Pb in mussels collected from 4 stations exceeded acceptable levels for human consumption according to the legal standards of Turkish Food Codex and United Nations Environment Programme.

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Authors' Contributions

FEK, NB and AA conceived and designed the project. FEK and NB performed the exepriments. NDYE and CS analyzed the data and helped in article writing.

Key words

Cadmium, lead, *Mytilus galloprovincialis*, shipyard, harbour.

Coastal ecosystems are affected from industrial and anthropogenic activities such as wastes from iron and steel factories, shipyards, shipbuilding/breaking etc. Tuzla Shipyard is located in the Marmara Sea area on the Southeast coasts of Istanbul and it is the receptor of multiple industrial activities such as metal works, port activities and urban wastewaters (Okay *et al.*, 2014; Kayhan *et al.*, 2015; Balkıs *et al.*, 2012; Taskın *et al.*, 2011). There is currently no monitoring of Pb and Cd in the Tuzla coastal region. Accumulation of heavy metals such as Pb and Cd in living organisms leads to concentrations several orders of magnitude higher than those of the surrounding water and metals accumulate throughout the trophic chain (Bellas *et al.*, 2014; Besada *et al.*, 2011; Siddique *et al.*, 2014; Batool and Javed, 2015).

When people consume sea food which have been exposed to high amounts of Pb such as lead sulphate, lead nitrate and lead acetate they are likely to inflict DNA damage in human lymphocytes (Vidal-Linan *et al.*, 2013; Casas *et al.*, 2008). *Mytilus* is commonly used in biological studies for determination of heavy metal uptake and biological effects of metals. Mussels are generally termed "bioindicator organisms" because they accumulate heavy metals in their soft tissue (Thebault *et al.*, 2008; Serpe *et al.*, 2010; Joksimovic *et al.*, 2012). For this reason, *Mytilus galloprovincialis* was selected as bioindicator in this study. The aim of this study was to determine cadmium and lead concentrations in the soft tissue of mussels caught from the Tuzla shipyard area of Istanbul, Turkey.

Materials and methods

A total of 200 samples of the mussels (3-5 cm in length) were collected monthly from four different locations along the coastline of the Tuzla including shipyard region between May 2013 and April 2014. The mussels were manually collected and packed in ice cold plastic bags and transferred same day to the Marmara University, Hydrobiology Laboratory where they were stored at -20°C until analysis. Glass equipment cleaned with 10% nitric acid and plastic tools were used to separate the soft tissue of mussels from their shell. The soft tissue was then rinsed with tap water and Milli-Q water to remove sand and any other particles. After rinsing, the soft tissues were weighed before acid digestion (UNEP, 1991, 1993).

Atomic Absorption Spectrophotometer (AAS) was used to determine the concentrations of Pb and Cd in soft tissues of the mussels using accredited methods (Loring and Rantala, 1992). The samples were homogenized and digested in teflon bombs with 2 ml H_2O and 5 ml HNO_3 in a closed microwave system at 180°C (MARSX5). Samples were heated with pressure at 1.103 MPa for 60

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min. After cooling, samples were diluted with MilliQ water up to the 25 ml mark in a volumetric flask and stored at the room temperature until analysis. Pb and Cd levels in samples were measured by flame AAS (SHIMADZU-6701F). Mussel samples were evaluated by analysis of variance (ANOVA). Metal concentrations were expressed as mg/kg^{-1} wet tissue weight. The detection limit expressed in ppm dry weight were Pb:1.5 and Cd: 1.00 (UNEP,1993; Loring and Rantala, 1992; Turkish Food Codex, 2002).

Results

Table I shows the water quality parameters of the Maramara Sea, whereas Table II shows Pb and Cd concentration in soft tissues of mussel from Tuzla Shipyard area. In addition the accuracy of the total analyses was checked by analyzing the IAEA 405 and 433 reference materials are showed in Table III.

In this study, generally Cd levels in the soft tissues of our samples were found to be in acceptable concentrations according to legal standards of Turkish and United Nations Environment Programme. In general, the levels of Pb in this study were found to be higher than Cd levels. The highest Pb concentrations found in soft tissue of mussels at the stations respectively were S4: 9.0 ppm Pb (May, 2013) and S1: 9.0 ppm (January, 2014). These stations showed extremely high values in Pb when compared to the other samples.

The Pb concentrations in mussel samples was high all the year round at all stations posing health risk for mussel consumers. Environmental fluctuation such as rain and high temperature affect concentrations of heavy metals in the sea water. *M. galloprovincialis* grows on rocks, piers and stones and hence are affected by high levels of heavy metals in aquatic environment.

Dıscussıon

When our results were compared with those of previous studies it was clearly seen that Pb levels in mussels from the Tuzla stations were higher than those of the Marmara Sea (Aksu *et.al.,* 2011). Moloukhia and Sleem (2011) determined Cr and Cd accumulation in soft tissue and shells of two aquatic molluscs collected from industrial waste areas in coastal waters. They found that both molluscs could accumulate Cr and Cd metals to large amounts were absorbed by their shells. In this study we found low Cd concentrations at all stations (Moloukhia and Sleem, 2011). According to Besada *et al.* (2011) metals do not degrade in general, they accumulate throughout the food chain. They determined Hg, Cd, Pb, Zn and Cu levels in mussels collected at 41 stations on the Spanish coastal Atlantic and northern coastal waters. Especially, they found that the levels of Cr and Cd generally higher for their study areas. Cd concentrations were generaly found to be low in our study (Besada *et al.,* 2011).

According to Duarte *et al.* (2011) physiological changes in organisms can be related to the effects of heavy metals in water that are accumulated in tissues of these filter-feedings mussels such as *Mytilus* genus. They investigated the oxidative stress biomarkers of heavy metal pollution in mussels from the Beagle Channel. Duarte *et al.* (2011) reported relatively moderate levels of pollution in their study area as a result of urban influences. Rank (2009) investigated the level of environmental pollutants at two sites in a highly contaminated harbour area in Denmark. They investigated the effect of heavy metals, PCB congeneres, butyltin (BT) and PAH compounds in snails (*Littorina littorea*) and DNA damage in blue mussels (*Mytilus edulis*). Rank found the analysis of the chemical compounds clearly showed that anthropogenic activities related to the building/breaking ships contribute significantly to the contamination of harbour water environments and biota (Rank, 2009). According to Aksu *et al.* (2011) people are at potential risks of heavy metals by trophic chain in seawater. While increasing anthropogenic activities in the Marmara Sea which significantly effects its coastal areas (Aksu *et al.,* 2011). Balkıs *et al.* (2012) and Kayhan *et al.* (2007) reported the high Pb, Cd and Hg concentrations in mussels (*M. galloprovincialis*) and nearshore surface sediment at the same area from the both sides of Bosphorus, European and Anatolian side (Balkıs *et al.,* 2012; Kayhan *et al.,* 2007). Kut *et al.* (2000) also reported high Pb and Cd levels in marine algaes from the North of Bosphorus (Kut *et al.,* 2000). Catsiki *et al.* (2003) investigated heavy metal levels in mussels and surface sediments collected from Thermaikos Gulf, Greece in 1999. They found that in all cases the heavy metal concentrations in mussels were below the permissible limits for consuming seafood (Catsiki *et al.,* 2003).

Bellas *et al.* (2014) investigated that chemical, biochemical and physiological variables in *M. galloprovincialis* samples for evaluationing marine pollution. In their study high level of pollutants found in mussel populations located close to major cities and industrialized areas (Bellas *et al.,* 2014). Kljakovic-Gaspic *et al.* (2007) investigated 6 trace metals (Cd, Cr, Cu, Hg, Pb and Zn) in the coastal waters of the eastern Adriatic in 2006 using *M. galloprovincialis* as bioindicator species. They found that there is no health risks for mussel consumers in their study area. According to Farmaki and Thomaidis (2008) marine environment close to big cities was found reasonably polluted. When our results were compared with those of previous studies

Table I.- General physical and chemical characteristics of water of Marmara Sea.

Season	Year	pH	Temperature (°C)	Dissolved O_2 mg/L)	Salinity (g/L)	Phoshate (µM)	Nitrate (µM)	Nitrite (µM)
Spring	2013	7.9	11	6.90	20.90	7.14	1.22	1.17
Summer	2013	8.0	23	6.85	21.54	2.57	5.50	0.10
Autumn	2014	8.0	17	6.90	20.95	2.05	4.00	1.55
Winter	2014	8.0	9	7.10	20.15	1.77	9.07	2.20

Table II.- Concentrations of Pb and Cd (µg/g^{-1} dry wt.) in soft tissues of mussel *Mytilus galloprovincialis* caught from Tuzla shipyard area, Istanbul, Turkey.

Stations*/	S-1		S-2		S-3		S-4	
Months	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd
May-2013	0.85	0.02	1.35	0.12	2.07	0.11	9.00	0.11
June-2013	0.27	0.08	0.40	0.03	0.40	0.13	0.24	0.13
July-2013	0.55	0.07	0.01	0.02	1.70	0.21	0.60	0.18
Aug-2013	0.40	0.05	5.00	0.02	0.30	0.12	0.02	0.09
Sept-2013	0.55	0.08	2.03	0.05	0.50	0.16	0.10	0.11
Oct-2013	0.67	0.01	1.20	0.08	0.40	0.12	0.11	0.13
Nov-2013	0.41	0.04	0.62	0.03	0.30	0.13	0.12	0.12
Dec-2013	0.43	0.02	0.41	0.04	0.85	0.16	2.40	0.11
Jan-2014	9.00	0.11	0.78	0.02	0.51	0.18	1.23	0.09
Feb-2014	0.90	0.11	2.01	0.16	6.40	0.13	1.25	0.09
Mar-2014	0.30	0.04	0.55	0.08	6.55	0.11	0.12	0.09
April-2014	0.25	0.08	4.40	0.06	0.13	0.07	0.60	0.13

*S1, S2, S3 and S4 are stations of Tuzla shipyard area.

it was found that Pb concentration levels in our samples from Tuzla coast were generally higher.

Table III. Accuracy of AAS analyses used in this study as determined by analysis of reference materials (the RSD of measurred values were ≤7%).

Reference material	Element	Measured value (this study) ppm (µg/g)	Certified value or range ppm (µg/g)
*IAEA 405[a]	Pb	76.9	72.6-77
*IAEA 433[b]	Cd	0.153	0.145-0.161

[a,b]*IAEA-MEL Reference samples for laboratory.

Conclusions

In our study all stations are affected by anthropogenic activities such as industrial and agricultural from the Tuzla shipyard area. Heavy metal toxicity, in aquatic organisms is related with instant contamination in aquatic environment and this situation poses risk for human. Anthropogenic and industrial activities in harbours, shipyard and shipbreaking areas and traffic, painting and repairing of ships and boats cause heavy metal contamination of seawater, sediments and biota.

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