

SEDIMENTARY RECORD OF ANTHROPOGENIC METAL INPUTS IN THE TUZLA SHIPYARD (TURKEY)

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Introduction

The Tuzla shipbuilding region, is located on the south-eastern coast of the metropolis of Istanbul, the largest industrial zone in Turkey, with a population of nearly 13 million people. The Tuzla shipyard was built in 1969. The total shipbuilding area covers 1.3 million m² and consists of 44 shipyards in the Tuzla/Istanbul region. Both small sized and mid-sized chemical tankers and container ships up to 70,000 DWT bulk carriers, general cargo ships, tugs, ocean supply vessels and other types of ships are constructed at Turkish shipyards. The bottom topography in the Tuzla region is rather complex and shows a progressive deepening towards the outer part of the shipyard. A shipyard is a workplace contaminated with spilled petroleum, paints, solvents, PAHs, and processed metal slag in relation to shipbuilding and repair activities (Dugan et al., 1984; Mokhtar et al., 2002; Lee et al., 2003). There is no information available from the literature investigating metal contamination in the core sediments from the Tuzla shipbuilding region in the last 10 years. Therefore, the aim of this study was to contribute to a better understanding of the effects of metal pollution caused by shipyard activities on marine environment in the twentieth century

Recent metal pollution histories associated with shipyard activities have been examined via two cores (TZ-1 and TZ-2). Generally, Cd, Pb and Zn show an overall increasing trend from 40 cm to the top of the sediment cores, whereas Cr and Cu concentration in TZ-1 core increased in the first 25 cm. Based on the vertical distribution of trace metals and their EF and CF values, the Tuzla shipbuilding region sediments are moderately to heavily polluted with Cd, Cr, Cu, Pb and Zn, and unpolluted to moderately polluted with Al, As, Fe, Li and Ni. The EF, CF and PLI values indicated anthropogenic influence caused by shipyard activities. The results of the present study were obtained with the support of the TUBITAK project 111G153.

Methods

Two sediment cores from the seabed of the Tuzla area were collected using a stainless gravity corer sampler on board of the R. V. ALEMDAR of Istanbul University in 2014. The pollution level in the study area was determined by investigating grain size and heavy metals (Al, As, Cd, Cr, Cu, Fe, Li, Ni, Pb and Zn) distributions. Gravel and sand were determined in a presentative portion of each sample using sieving techniques (McManus 1988). Silt and clay distributions of core sediments were analyzed using Micromeritics Sedigraph 5100. The concentrations of Al, As, Cd, Cr, Cu, Fe, Li, Ni, Pb and Zn were measured using inductively coupled plasma-mass spectrometry ICP-MS (Agilent 7500ce) after a total digestion. The accuracy of analytical procedures for total metal determinations was checked using the reference material NIST-1944 Replicate analysis of reference materials showed good accuracy, with recovery rates for metals between 93% and 103%. The heavy metal data was evaluated using geo-statistical methods such as enrichment factor (EF), contamination factor (CF) and pollution load Index (PLI). For geo-statically calculations, average concentration values lower than the 70 cm in the core samples were used as the background values.

Results

TZ-1 and TZ-2 core sediments consist mainly of clay (30-75%) and silt (24-65%) with small amounts of sand (1-11%). Being located in the Tuzla shipbuilding area, the sediments in the TZ-1 and TZ-2 cores would be expected to have been affected by the shipyard activities, leaving some geochemical signatures. The average and range (in parentheses) concentrations measured in milligram per kilogram dry weight of sediment were 16347 (7322-34094) Al, 28625 (22213-33493) Fe, 17 (9-24) As, 0.4 (0.2-0.7) Cd, 164 (58-526) Cr, 128 (27-598) Cu, 44 (25-52) Ni, 82 (23-218) Pb and 135 (37-296) Zn. Metal profiles showed nearly constant concentrations below 50 cm, and were characterized by a drastic increase in the first 40 cm for Cd, Pb and Zn. Similarly, Cr and Cu concentrations of core sediments increased from 25 cm to top of the cores (Fig. 1).

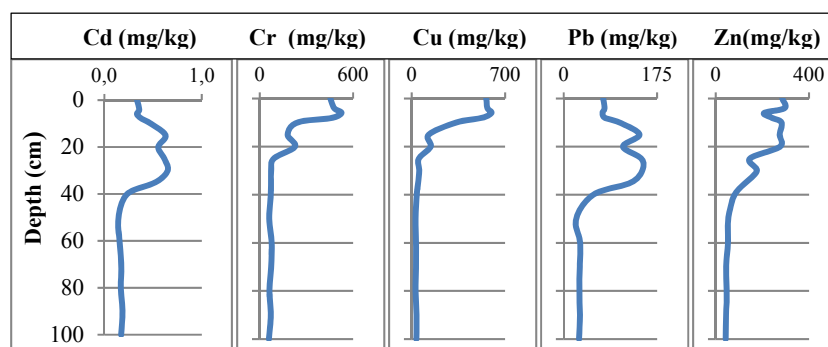


Figure 1. Variation of Cd, Cr, Cu, Pb and Zn with depth in the TZ-1 core.

In general, EF values below 40 cm of the cores ranging from 0.7 to 2 can be considered to be similar to that of the deeper or deficiency to minimal enrichment as implied by Sutherland's EF classification (Sutherland 2000). On the basis of the mean values of EFs and CFs in TZ1 and TZ-2 core sediments were enriched for metals in the following order: Cu > Zn > Pb > Cr > Cd > Ni > Al > Fe > As. According to the mean PLI value (1.86), the study area was moderately polluted. PLI of the first 40 cm of the cores was between 3 and 1.3 and must be classified as moderately to heavily polluted by investigated heavy metals.

Conclusion

The recent impacts of shipbuilding activities on sediment quality were studied by way of geochemical analysis and evaluated accordingly through EF, CF and PLI values reached through two cores collected from the area. Our findings imply that the core sediments below 40 cm were unaffected by any human influence, and shipyard activities and were derived predominantly from natural lithological sources. Analyzed data showed that the area has been polluted by Cd, Cr, Cu, Pb and Zn. The ongoing pollution also has been indicated by the EF, CF and PLI values. Seemingly, shipyard activities have played a significant role in the continuing pollution from 40 cm of the cores.

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