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Polycyclic aromatic hydrocarbons and effects on marine organisms in the Istanbul Strait

B. Karacık [a], O.S. Okay [a,*], B. Henkelmann [b], S. Bernhöft [b], K.-W. Schramm [b,c]

[a] Istanbul Technical University, Faculty of Naval Architecture and Ocean Engineering, 34469, Maslak, İstanbul, Turkey
[b] Helmholtz Zentrum München, Research Center for Environmental Health, Institute of Ecological Chemistry, Ingolstädter Landstrasse 1, 85764 Neuherberg, Germany
[c] TUM, Wissenschaftszentrum Weihenstephan für Ernährung und Landnutzung, Department für Biowissenschaften, Weihenstephaner Steig 23, 85350 Freising, Germany

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ABSTRACT

Surficial sediments and mussels (*Mytilus galloprovincialis*) from the Istanbul Strait and Marmara Sea were analysed for sixteen parent polycyclic aromatic hydrocarbon (PAH) contents by gas chromatography-mass spectrometry (GC-MS) employing isotope dilution technique. Microalgae toxicity testing was applied to sediment elutriates and biological responses in terms of filtration rate and lysosomal stability were measured in mussels. Total PAH concentrations ranged from 2.1 to 3152 ng g^{-1} dry wt in sediments and from 43–601 ng g^{-1} wet weight in mussels. Molecular indices of phenanthrene/ anthracene, fluoranthene/pyrene and benzo (a)anthracene/chrysene were used to differentiate between pyrolytic and petroleum origin. Results showed that most of the contamination originates from high temperature pyrolytic inputs with some slight contribution of petrogenic PAH. PAH in sediments were frequently lower than the National Oceanic and Atmospheric Administration (NOAA)–ERM (Effects Range Medium) index. Results of sediment elutriate toxicity testing and biomarkers indicate that the cause of negative effects in sediments may result from different classes of pollutants and does not only relate with PAH contamination. Mussels from most of the stations showed both reduced lysosomal membrane stability and filtration rate indicating disturbed health although the two biomarker results did not always complement each other. The effect studies showed that the pollutants in the strait ecosystem have more pronounced effects in the middle parts than those at the Black Sea entrance.

1. Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a large group of organic compounds with two or more fused aromatic rings. PAHs have been known to affect a variety of biological processes and can be potent cell mutagens and carcinogens (Pelkonen and Nebert, 1982). PAHs are usually introduced into the environment as a result of anthropogenic activities which increased dramatically in the last two decades. PAHs are generally produced as a result of pyrolytic processes, especially the incomplete combustion of organic materials during industrial and other human activities as well as in natural processes such as forest fires. PAHs are also released into the aquatic environment through wastewaters, from coke and petroleum industries, vehicle traffic, and oil spills. Most lipophilic anthropogenic organics tend to be associated to the suspended particles in the water column due to their low solubility and accumulate in the sediments. Sediments frequently contain higher concentrations of pollutants than those found in the water column. Lipophilic PAH levels in sediments are generally several orders of magnitude higher compared to their water phase concentrations. PAHs also accumulate in fish and shell fish especially in mussels and may lead to serious human health hazards (Takatsuki et al., 1985; Heintz et al., 2000; Carls et al., 1999; Okay et al., 2003).

In this study, the concentrations of PAHs in sediments and mussels of the Istanbul Strait (Marmara Sea, Turkey) were measured. Algal toxicity tests were applied to the sediment elutriates and biological responses of mussels were measured to evaluate the effects of the pollutants in the strait ecosystem. The Turkish Strait System (TSS) including the Istanbul strait, Marmara Sea and Çanakkale strait (Dardanelles) connects the Black Sea and the Marmara Sea. Istanbul Strait has been affected by urbanization, by harbour activities, by ship traffic, by commercial fishing and by the pollutants entering from the Black Sea basin. Therefore, the PAH sediment data obtained from the Istanbul Strait were compared to Sediment Quality Guidelines (SQGs) in order to assess ecotoxicological risk. Although the oceanographic characteristics of Istanbul Strait have been studied extensively (Özsoy et al., 2001; Oğuz et al., 1990), the levels of individual PAHs were not well documented in the strait. The objectives of the study can be summarised as follows: (i) analysis of the degree of contamination by PAHs of the surface sediments and mussels in the Istanbul strait (ii) comparison of the results obtained with the previous studies in Turkey and worldwide (iii) assessment of the

* Corresponding author. Tel.: +90 212 285 64 07; fax: +90 212 285 64 54.
E-mail address: oya.okay@itu.edu.tr (O.S. Okay).

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sources of PAHs, (iv) comparison of sediment data with SQGs (v) evaluation of the potential toxic effects by using biomarker studies and toxicity tests applied to mussels and sediment elutriates respectively.

2. Materials and methods

2.1. Study area

TSS has a two layer water system. The salinity of the top layer is 18–25 ppt and bottom layer is 33–38 ppt originating from the Black Sea and Mediterranean Sea, respectively. Fig. 1 shows the location of the Strait. The length of the Strait is approximately 31 km and its width varies from 0.7 km to 3.5 km. Water depths vary around a mean of 33 m with a maximum depth of 110 m. The Istanbul strait is one of the most important shipping route handling annually 50 000 ships, in addition to fishing boats and local traffic; over one-half million people cross the waterway daily (Köse et al., 2003). Around one-tenth of the ships is oil or liquefied natural gas tankers. The strait receives domestic and relatively small industrial discharges carried by small rivers. Surface currents from the Black Sea also add pollutants to the system. Additional to those, a heavy vehicle traffic on the coastline and surface runoff from the residential and agricultural areas on both sides contribute to the pollution level of the strait.

Sampling stations and descriptions about the sites on the strait coastline are shown in Fig. 1 and Table 1, respectively. There are four main freshwater tributaries connected to the strait which are close to stations 4, 6, 7 and 18. Station 9 is a tourist site occupied with restaurants, cafes among others. Depending on the season, the coastal waters of that station are exposed to the runoff water carrying some domestic wastes from the watershed area. Station 23 is a sandy beach on Büyükada island (Marmara Sea). Stations of 4, 5, 17 and 20 have been affected by strong water current since they are located on the sharp turn

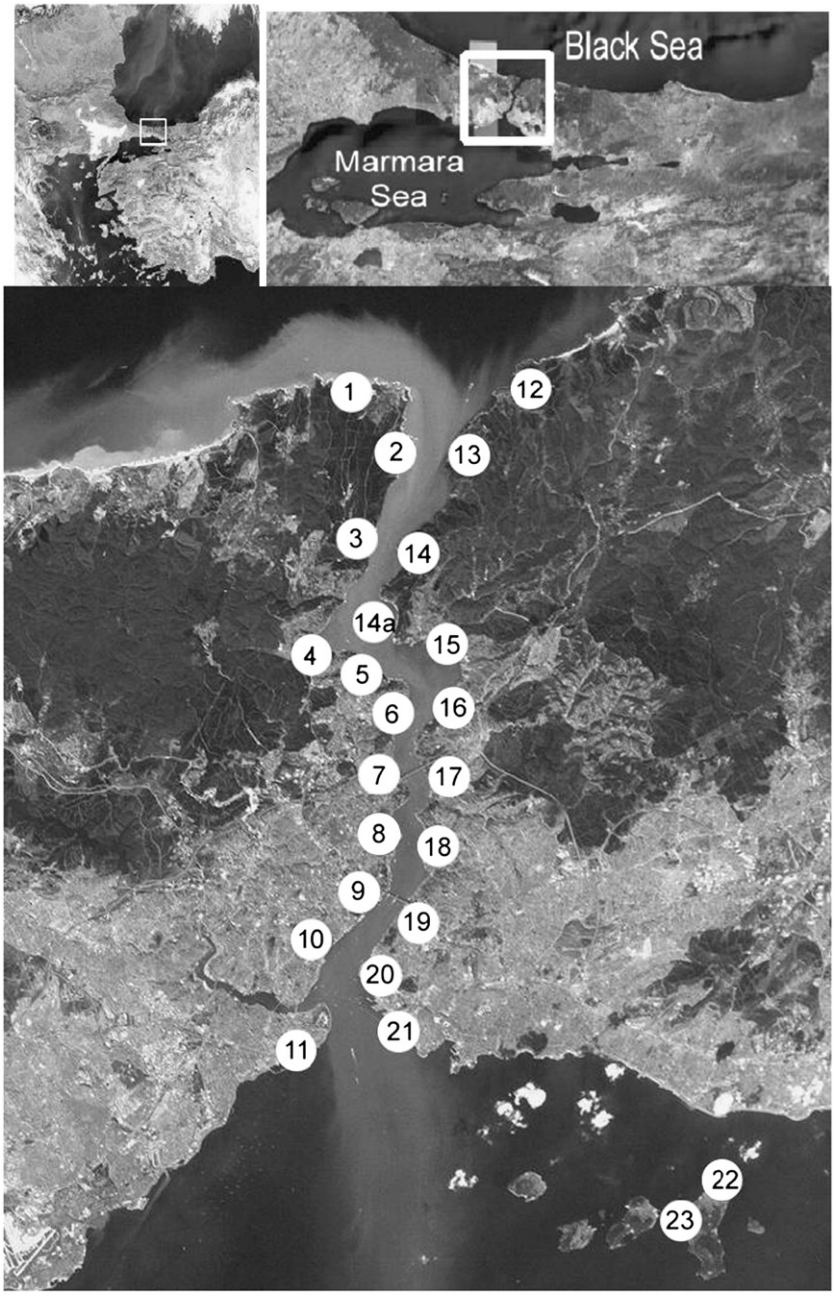

Fig. 1. Location of İstanbul Strait and sampling stations.