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Temporal evolution of anthropogenic pollution and environmental changes in a marine inlet: the example of Gemlik Gulf, Marmara Sea

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Marginal marine basins are particularly prone to anthropogenic pollution because of restricted water circulation and commonly high population density in their drainage basin. Gemlik Gulf is such a semi-enclosed inlet with maximum depth of 113 m in the eastern part of the Sea of Marmara, which is separated from the rest of the Marmara shelf by a -50 m deep sill. It is under anthropogenic risk from different industrial and municipal pollution sources in its drainage basin. Moreover, Gemlik Gulf, located on the middle branch of the North Anatolian fault (NAF), is under a future earthquake risk with a high possibility of pollution from disruption to industrial plants and municipal infrastucture, similar to the the one that occurred in the İzmit Gulf during the 1999 Mw 7.4 İzmit earthquake.

In this study, we investigated the extent and temporal evolution of the heavy metal and organic pollution using a wide range of analyses of a 84 cm sediment/water interface long core from the central part of the basin, involving μ-XRF Core Scanner, Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), Total Organic (TOC) and Inorganic Carbon (TIC), and mass spectrometric stable C and N isotopic and C and N elemental analyses. The chronology of the core was determined using radionuclide (^{210}Pb and ^{137}Cs) and AMS radiocarbon analysis.

The core covers about last 800 years. The upper part of the core, representing the last 155 years, is gray mud grading into very dark grey mud in the top 84 cm. The 5-8 cm interval below sea floor (bsf) (AD 1985-1995) includes 3 white laminae consisting of coccolithophore *Emiliania huxleyi* and another carbonate rich layer deposited during AD 1855-1950. TOC values are commonly between 1.5 and 2.5 % below 12.5 cmbsf (AD 1965), but increases up to 4.25 % towards the core top. The core includes a mass flow unit, which is most probably triggered by the AD 1855 earthquake, and is characterized by high contents of Fe, Zr, low contents of Ca, Nb, La U, Th, Zn and Pb, Cu.

Enrichment factor (EF) of Mo, obtained with respect to the average metal values of uncontaminated substratum in the core and normalisation to Al, increase sharply upwards starting from 15 cmbsf (AD 1955) to a maximum EF of 23. Such a dramatic Mo increase, together with a Mn depletion, indicates the establishment of bottom water anoxia in the Gulf at least since AD 1970. At around the same time increases started to be observed in concentrations of most metals and semi-metals such as Cd, Zn, Cu, Pb, U, S, Sb, with a maximum EF of 5.7, 2.1, 1.6, 1.6, 1.3, 3.2, 2.2, respectively.

C/N ratio and δ^{13}C reveals the cylicity in origin of organic matter changing from bottom to top of the core respectively as: terrestrial, a mixture of marine and terrestrial, terrestrial in the mass flow unit, mixed, marine and terrestrial in most recent sediments of last about 15 years. The organic matter of terrestrial origin as well as pollutants were transported by Kocadere and Karsak Creeks and Kocasu river.

δ^{15}N values range between 4 and 4.5 ‰ during AD 1230-1540 and 2.5 and 3.1 ‰ during AD 1540-1740 and between 3.7 and 5.6 ‰ since AD 1855 to present. Assessment of δ^{15}N data together with the TOC and TIC data suggest that denitrification process has been effective especially during the last 150 years, and least effective during AD 1540-1740 which includes the Late Maunder Minimum cold period.