Cod: 4.1033

SEISMIC EVENTS AS NATURAL FORCINGS OF ANTHROPOGENIC ENVIRONMENTAL IMPACTS: THE 1999 MW 7.4 IZMIT EARTHQUAKE ON THE MARMARA SEA AS A CASE STUDY FOR THE DEFINITION OF PCBS AND PAHS REDISTRIBUTION DYNAMICS.

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Introduction

The 1999 Izmit earthquake (Mw 7.4) caused over 20,000 casualties and huge damages to civil and industrial infrastructures not far from Istanbul (12 million inhabitants), in the most industrialized and populated region of Turkey, the Izmit Bay. Actually, more than 300 industries are located in the region, including an integrated oil refinery which supplies more than 30% of Turkish demand. It follows that, in addition to the human tragedy, an environmental disaster affecting the neighbouring Marmara Sea was observed, with the dispersal onto the sea surface of refined petroleum products and other chemicals, including combustion products from subsequent fires. The paleosismological study in the Marmara Sea has confirmed the presence of tectonic structures in the western boundary of the Izmit Gulf that are considered as good candidates for the next earthquake activity[1]. In addition, results from preliminary analyses of marine geological/geophysical data of the North Anatolian Fault in the Marmara Sea showed that the top 10 to 20 cm of the sedimentary sequence in the deep (~200 m) Karamursel and Darica basins are composed by a black, massive homogenite, marked at its base by an erosional surface and by a turbiditic layer of variable thickness from place to place[2]: this layer truthfully represents the sediment mass deposited over the sea bottom after the earthquake. Distribution of organic pollutants (PCBs and PAHs) within this layer is important to quantitatively estimate the effect of resuspension due to the shaking caused by the earthquake and subsequent tsunami in the Izmit Gulf.

The aim of this study is then to define levels and trends of PCBs and PAHs in sediments of the Izmit Bay that have been affected by the 1999 earthquake. Future developments will enable us to define contaminant sources and which pollutants can be re-introduced/redistributed in the environment as a consequence of a future seismic event.

Materials and methods

Sediment core IZ-112 was collected in 2005 with a SW-104 corer that preserves undisturbed sediment-water interfaces. The core was immediately extruded and sectioned into 1-2 cm intervals soon after collection. Samples were stored in glass containers first at 4°C and then at -20°C before the analysis, then freeze-dried. The chronological setting of the core was assessed through 210Pb and 137Cs measurements via alpha and gamma spectrometry. Details of the procedure can be retrieved in Bellucci et al., (2007)[3]. Aliquots of about 3 ± 0.01 g of dry sediment were spiked with known amounts of labelled compounds mixtures as internal standards. Samples were then extracted by means of Pressurized Liquid Extractor (PLE, FMS, Fluid Management System Inc., Watertown, MA) equipped with stainless steel cells, using dichloromethane/acetone (1:1 v/v) in presence of anhydrous sodium sulphate, diatomaceous earth and activated metallic copper. Extractions were performed at 100°C, 1500 psi with 2 static cycles of 7 min. Clean-up was carried out by injecting samples onto a disposable neutral silica column in an automated system (PowerPrep™, FMS) and by eluting with 30 ml of n-hexane and 30 ml of 1:1 n-hexane:dichloromethane, collected in a single fraction. Purified samples were reduced to 100 μL under a gentle nitrogen flow at 23 °C (Turbovap II®, Caliper Life Science, Hopkinton, MA, USA) and spiked with a known amount of the recovery standard solution. Determinations were made by HRGC-LRMS (7890A-5975C, Agilent Technologies). The gas chromatographic separation was carried out on a 60-m HP-5MS column (0.25 mm I.D., 0.25 μm; Agilent Technologies, Avondale, USA). Quantification was achieved using internal standards and isotopic dilution. 13C-labelled Acenaphthene, Phenanthrene, and Benzo(a)pyrene were used to quantify PAHs, while a mixture containing all indicators and dioxin-like 13C-labelled compounds was used for PCBs. Results were corrected by applying the instrumental response factors obtained from standard solution[4]. All concentrations and activities were calculated on a dry weight basis.

Results and discussion

The concentration-depth profile of PAHs in the sediment core retrieved in the Izmit Basin accounts for an increasing trend from the 1950s to the 1980s, in accordance with the beginning of industrialization within the area (Fig. 1). The 1999 earthquake caused the erosion, mixing and subsequent ri-deposition of the sediment layer deposited between 1980 and 1999. The PAH concentration profile within the 1999 seismo-turbidite presents a maximum value in the sample at 20-21 cm depth, while the uppermost two samples display lower concentration. The reason for this trend has to be clarified.
Excluding the seismo-turbidite, PAH concentration in the surficial value is the highest measured in the core and fits well with a continuous increasing trend following uncontrolled inputs originating from industrial activities and urban development;

The diagnostic ratio that compares the abundance of low and high weight PAHs (LMW/ Fig. 2) accounts for the predominance of pyrogenic sources (LMW/HMW < 1) all along the sediment core. However, an increase of petrogenic PAH sources is observed at the onset of industrialization (33-34 cm depth), with respect to older sediments and those within the seismo-turbidite. Comparison with values in surficial sediments collected before 1999 in the most polluted areas of the Marmara Sea would be extremely important to better discriminate the origin and behaviour of these contaminants during the seismic event.

As for PAHs, the concentration-depth profile of PCBs in the sediment core retrieved in the Izmit Basin is in accordance with the beginning of industrialization within the area, showing an increasing trend from the 1950s to the 1980s (Fig. 3). The surface value is similar to that present in sediments deposited in 1980. The profile within the 1999 seismo-turbidite presents a maximum value at 20-21 cm depth, then a decreasing trend is evidenced in its immediately upper part. A relevant high value of 29.34 μg kg-1 is recorded at 1-2 cm depth.

Acknowledgments: The research was carried out in the framework of a bilateral programme between the Italian CNR and the Turkish TUBITAK.

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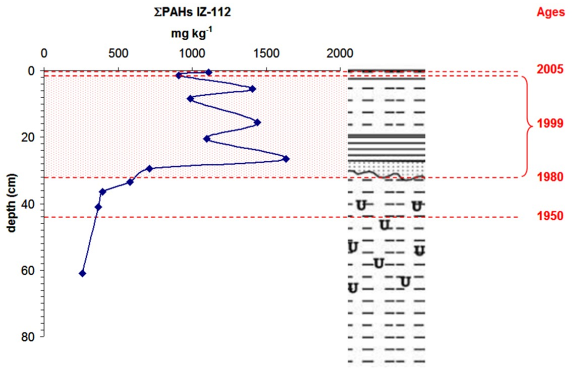

Fig. 1. Concentration-depth profile of PAHs in core IZ-112. Indicative years of deposition (red) are shown by dotted red lines. Sediment stratigraphy and the vertical extension of the turbidite deposit is also reported.

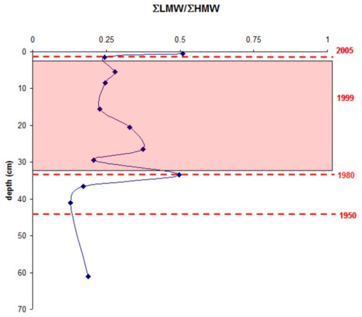

Fig. 2. Depth profile of LMW/HMW diagnostic ratio in core IZ-112. Indicative years of deposition (red) are shown by dotted red lines. The vertical extension of the turbidite deposit is also reported.

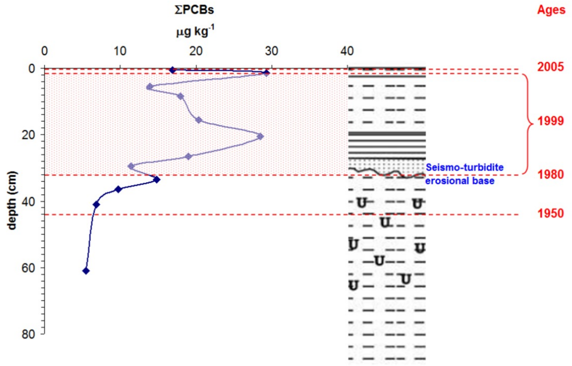

Fig. 3. Total PCB concentration depth profile in core IZ-112. Indicative years of deposition (red) are shown by dotted red lines. Sediment stratigraphy and the vertical extension of the turbidite deposit is also reported.