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Do lagoon area sediments act as traps for polycyclic aromatic hydrocarbons?

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HIGHLIGHTS

- The effects of the coastal lagoon characteristics on PAH sorption have been evaluated.
- The transitional areas contribute to the increasing of the PAH accumulation.
- The lagoon area sediments turn into a trap for organic contaminants such as PAHs.

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ABSTRACT

The coastal lagoons are vulnerable systems, located between the land and the sea, enriched by both marine and continental inputs and are among the most productive aquatic ecosystems. The purpose of this work is to understand the influence of the lagoon area sediments on the behaviour of polycyclic aromatic hydrocarbons, through the adsorption coefficient determination. In fact, the sorption of polycyclic aromatic hydrocarbons is an important process because it governs the fate, transport, bioavailability and toxicity of these compounds in sediments. It has been observed that the adsorption of polycyclic aromatic hydrocarbons in a transitional system is the outcome of different factors, such as their sources and physicochemical properties, salinity and sediment composition, hydrology and environmental conditions. The results showed that transitional areas contribute to the polycyclic aromatic hydrocarbon accumulation in the sediment turning it into a trap.

1. Introduction

Several natural and anthropogenic processes can lead to the formation of polycyclic aromatic hydrocarbon compounds (Wakeham et al., 1980), whose main inputs are pyrolytic and petrogenic (Means et al., 1980; Lipiatou and Saliot, 1991). Each source generates a characteristic PAH distribution pattern due to the different chemical–physical behaviour of these compounds (Mitra et al., 1999). PAH behaviour in a marine system is the result of different factors, such as PAH sources and physicochemical properties, water and sediment movement, size fraction and environmental conditions (Baumard et al., 1999; Wang et al., 2001; King et al., 2004). Through the study of the probable source of these compounds, it is possible to identify PAH distribution in a certain area (Baumard et al., 1998; Mitra et al., 1999; Franco et al., 2006). Once PAHs appear in the marine environment, they are present in the water column then, due to their high hydrophobicity and molecular mass (Mackay, 1991), they tend to accumulate in sediment and biota. In the marine environment they can be studied mainly in three matrices: water column, marine organisms and sediments. Sedimentary hydrocarbons have received special attention because these compounds are readily sorbed onto particulate matter, in fact bottom sediments are considered as a reservoir of hydrophobic contaminants (Medeiros et al., 2005). The level of PAH in sediments varies, depending on the proximity of the sites to areas of human activity and on the PAH biodegradation (Bihari et al., 2007). The study of these compounds is needed because they have shown differences in their stability, transport mechanisms and fate, because of their physical–chemical properties, distribution constants, half-life times and origin (Bouloubassi and Saliot, 1993). Various studies have been carried out on PAHs in Mediterranean and Adriatic marine sediments (Baumard et al., 1998; Alebic-Juretic, 2011; Bouloubassi et al., 2012), in particular, this work is focused on the Italian Adriatic coast, since it is

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characterised by the presence of several rivers that discharge organic compounds (Tesi et al., 2007) in the sea and by transitional areas such as lagoons. Coastal lagoons are vulnerable systems, located between the land and the sea, enriched by both marine and continental inputs and are among the most productive aquatic ecosystems (Nixon, 1998). The coastal lagoon that has been examined in this study is the Lesina lagoon (Fig. 1). This area has been frequently investigated in the last few years (Roselli et al., 2009; Specchiulli et al., 2009; Specchiulli et al., 2010; Lugoli et al., 2012; D'errico et al., 2013). However, the effects of the coastal lagoon characteristics on PAH sorption in sediment have not been studied yet. Up to now, several studies on the different sorption properties of the sediments, the sorption kinetics and the various influencing factors have been performed (Karickhoff et al., 1979; Barret et al., 2010; Yang and Zheng, 2010). It has been demonstrated that the changes in salinity are significant for increase in equilibrium sorption constants (Means, 1995; Tremblay et al., 2005). Xia et al. (2006) have been focused on the PAH sorbed which increases with the sediment content. The purpose of this work is to understand the PAH behaviour in the lagoon areas through the determination of PAH distribution and PAH sorption. Specifically, how certain characteristics of the lagoon sediments such as particle-size, organic matter, salinity and vegetative sediments, may affect the PAH behaviour in the transitional areas compared to their behaviour in the open sea. For this reason two different areas have been compared: a closed transitional environment (Lesina lagoon) and a coastal marine environment (offshore Ravenna harbour) in order to see how PAHs behave before they reach the sea in crossing a transitional lagoon area.

2. Material and methods

2.1. Study areas

The lagoon of Lesina (Fig. 1), situated on the Southern Adriatic coast of Italy (41.88°N and 15.45°E), is characterised by shallow water (0.7–1.5 m) and limited exchanges with the sea. Due to its shallow depth, the Lesina lagoon is strongly influenced by meteorological and climatic conditions, continental inputs and low tidal exchange. The lagoon is connected to the sea by two tidal channels: one to the west (about 2 km long) and the other to the east (about 1 km long) (Roselli et al., 2009). It receives freshwater inputs from urban wastewaters, intensive aquaculture and agricultural activities, determining a very important input of organic and inorganic contaminants, which cause eutrophication events, characteristic in the coastal lagoon (Specchiulli et al., 2009). To find out which characteristics of the lagoon affect the PAH accumulation in the sediment, the Lesina lagoon has been divided into two basins: a western and an eastern one, showing well known different hydrological and physical–chemical characteristics. Indeed, about 80% of the annual freshwater budget is discharged into the eastern part of the lagoon, consequently, a trophic and salinity gradient from the western to the eastern part of the basin was established (Roselli et al., 2009). For a better understanding of PAH behaviour in transitional environment such as the Lesina lagoon, also the accumulation, distribution of the PAHs in a coastal sea area sediment, offshore Ravenna harbour in the Northern Adriatic Sea, (Fig. 1) have been evaluated. This area has been chosen since it is strongly influenced by the contribution of fresh water that flows

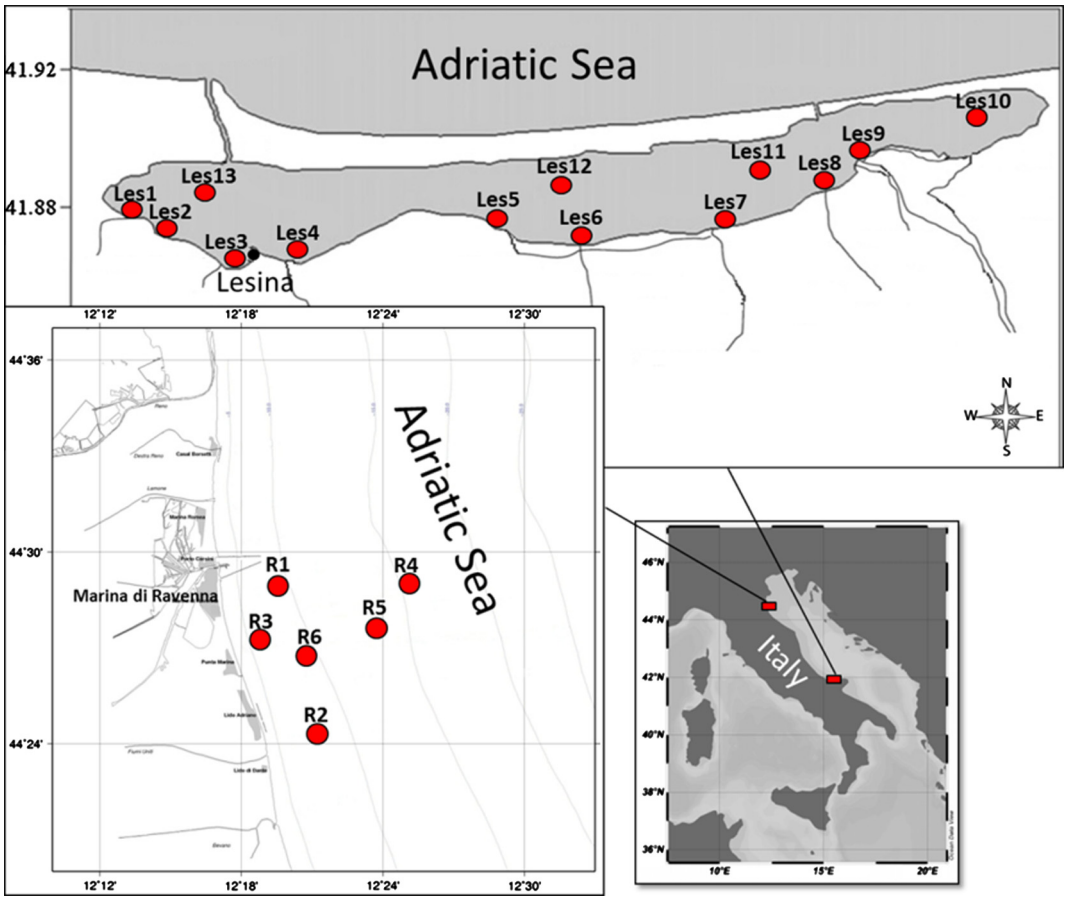

Fig. 1. Locations of Lesina lagoon study sites and off Ravenna harbour study sites.