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Editorial

Transport, Persistence, and Toxicity of Pollutants in the Sea

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1. Introduction

Eight research articles and two reviews are included in this Special Issue focused on the transport, persistence, and toxicity of pollutants in different seas: the Western and Central Mediterranean Sea, the Adriatic Sea, the Tyrrhenian Sea, the Baltic Sea, and the South China Sea.

The results, specifically described below, highlight different aspects of the main topic of the Special Issue, including:

- The implications of anthropogenic effects on the coastal environment and seabed;
- How climate change modifies surface water regimes and whether it affects the runoff of contaminants in the sea;
- Pollutants in sediments and marine organisms;
- Seasonal variations in pollutants in the sea;
- Estuarine pollution and the influence on seawater contamination.

The results provided in this Special Issue are grouped into three different topics that thoroughly cover the themes reported in all the papers.

2. Effects of Contamination on Marine Organisms

Coastal marine areas receive significant anthropogenic input, mainly derived from metropolitan areas, industries, and activities related to tourism. Many studies have been conducted on heavy metal accumulation and on its possible effects on different edible marine species; in particular, the most-studied sessile organisms are bivalves. Roveta et al. [1] conducted a review of heavy metals, focusing on other sessile taxa (sponges, cnidarians, bryozoans, polychaetes, barnacles, and tunicates), proposed to be bioindicators in shallow coastal waters. In a second paper, Roveta et al. [2] showed the concentrations of mercury in the tissues of different sponges collected in Montecristo and Giglio, two islands of the Tuscany Archipelago National Park in the Tirrenian Sea (Mediterranean Sea). These results underline the species-specificity of metal concentrations for Porifera and provide additional data to address the main input of the Marine Strategy guidelines in order to protect coasts, seas, and oceans.

De Giovanni et al. [3] summarized the results of epidemiological investigations on the genetic component of individual susceptibility in exposure to methylmercury and polycyclic aromatic hydrocarbons in the coastal population, and on the effects of these two pollutants on human epigenetic profiles (DNA methylation). The potential impact of methylmercury and polycyclic aromatic hydrocarbons on the human genome and Mediterranean epigenome was investigated, as this population is characterized by a traditionally high consumption of local fish; this influences the characteristics that, consequently, render the Mediterranean Sea particularly polluted [4,5].

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In a second paper, De Giovanni et al. [6] collected and harmonized the results of several studies published over the years (1981–2019) in order to obtain a database [7] of georeferenced observations on polycyclic aromatic hydrocarbons (PAHs) in Western and Central Mediterranean seafood. For each observation, some information on the taxonomy and the ecology of the sampled species was reported, as well as details on the investigated hydrocarbon, and spatial and temporal information on the sampling. Moreover, two health risk indexes were calculated for each record and included in the database. The analysis of the data showed that, at a consumption rate typical of the Italian population, seafood caught from the area considered in the present work seems to pose minimal risk to health.

Rivoira et al. [8] studied the presence of 16 polycyclic aromatic hydrocarbons (PAHs) and 14 dioxin- and non-dioxin-like polychlorinated biphenyls (PCBs) in the neritic protected marine area of the Southern Ligurian Sea (Mediterranean Sea), affected by the impact of human activities. The study was focused on the possible partition of micropollutants within seawater, sediment, and zooplankton. The results showed that both seasonal and anthropogenic causes strongly affect contaminants' transfer behaviors, with summer being most impacted by PAH and PCB contamination.

To better understand the occurrence of preferential bioaccumulation pathways in zooplankton, partition studies were also performed in several taxa (hyperbenthic Isopoda, holoplanktonic crustacean copepods, and ichthyoplankton), through the calculation of bioaccumulation factor values. They observed that both living and feeding habits could influence the bioaccumulation process.

3. River Runoff into the Sea

Barra et al. [9] focused on the geochemical and sedimentological characterization of recent sediments from two marine sites located in the North Adriatic Sea, between the Po River prodelta and the Rimini coast. Major and trace metal concentrations reflect the drainage area of the Po River and its tributaries, considered one of the most polluted areas in Europe [4].

High values of Cr, Ni, Pb, and Zn were detected in sediments collected from the Po River prodelta. This suggests a Po River supply. Meanwhile, lower levels of these elements in sediments collected in front of the Rimini coast were measured, indicating the Apennines provenance of these.

The historical trends of Pb and Zn reconstructed from the sedimentary record around the Rimini coast document several changes that can be correlated with the industrialization prior to World War II.

Giglio et al. [10] examined the transport of sediments and their surficial pathways from the mouth of Neretva River toward the Eastern Adriatic Sea. Sediment dynamics were evaluated using several proxies such as organic matter, radiochemical isotopes, selected metal concentrations, and physical parameters. The data analysis showed that the influence of the river on particle distribution decreases northward, with an estimated sediment accumulation rate ranging from 1.9 to 8.5 mm/yr. We speculate that either the dispersion or accumulation of sediments is driven by an eddy in the waters of the Neretva River, triggered or intensified seasonally by the interaction of karstic springs, river input, and Eastern Adriatic Sea waters.

The Huangmao Island dumping area is adjacent to the Pearl River Estuary in the South China Sea. From its first dumping activity in 1986 to 2017, $6750 \times 104\ m^3$ dredged materials were dumped in this dumping area. The evaluation results reported by Tao et al. [11] for the heavy metals revealed that the dumping area with a large dumping amount was more severely polluted. The dumping of dredged materials seemed to have a negative impact on the benthic community in the dumping area.

4. Dynamics of the Sediments

Karlonienė et al. [12] assessed trace heavy metals' temporal and spatial distribution in the sandy beach sediments along the south-eastern Baltic Sea coast (Lithuania). They

studied how geochemical analysis can provide valuable information about the local and regional patterns of sediment transport, distribution, provenance, and coasts condition. The spatial analysis of trace elements indicated that the trace metal content depends on the coastal processes, showing a difference in the mainland and spit sea-coast.

Sediments represent a critical component of coastal marine ecosystems due to the toxic and long-lasting effects of the contaminants buried therein. Spagnoli et al. [13] studied the properties of the superficial sediments off the coast of the Southern Marche Region (Western Adriatic Sea); it is characterized by numerous minor rivers [14] and a bottom current that flows southwards, carrying out suspended and dissolved contaminants [15–17]. Some pollution indicators, such as the enrichment factor, the geoaccumulation index, and the pollution load index were calculated to assess the deviation from the natural background levels. The results showed pollution by As and Ba due to human activity in the 20th century.

5. Perspectives on Future of Research

The work presented in this Special Issue offers concrete advances and new insights for the study of anthropogenic chemical contaminants in marine ecosystems yet in-depth research will still be required for a complete understanding of the traces of these in the sea.

Over the next few years, water scarcity is expected to increase in light of global climate change and increased urbanization, particularly near coastal zones; moreover, extreme weather events, which have occurred more frequently in recent decades, could lead to increasing surface runoff via the collection of pollutants, including emerging ones, discharging them into the sea. Effective means of risk-based prioritization of contaminants, particularly in seafood and bathing water, are needed within this context. Ultimately, much additional work is needed to identify affordable and effective means of evaluating and determining these contaminants and sensitizing people to rational and conscious use, according to green deal priorities.

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