

Pollutants and Climate Change, Runoff, Behavior and Adverse Effects in Aquatic Ecosystems

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1. Introduction

This Special Issue addresses topics related to the sources of pollutants and their diffusion in ecosystems and aquatic organisms. Aspects of how to improve the monitoring of pollutants in the environment and within the food chain are also covered. The eleven research articles and two reviews included in this Special Issue improve the knowledge of the adverse effects on aquatic ecosystems induced by climate change, as well as the resilience potential of marine organisms within polluted environments.

The geographical areas of particular interest considered in this Special Issue are as follows:

- (i) The Adriatic Sea, a sea particularly conditioned by the supply of fresh water [1–3], shallower to the north and with greater bathymetry towards the south [4,5], where the waters encounter the rest of the Mediterranean Sea [6,7]. The circulation is characterized by hydrological processes typical of the northern hemisphere [8], where there are important bottom currents that transport suspended particles, including contaminants [9,10]. Various matrices from the Adriatic Sea were studied and treated, such as sediment, water, and organisms, coming from different areas: some with restricted circulation, such as in the inlets of Kotor [11–13], some along the coastal strip [2,14], and some in the open sea [15,16].
- (ii) The Gulf of Gabès, in the southeastern Mediterranean Sea: a shallow sea rich in nutrients [17] and biodiversity [18], strongly influenced by the main currents of the Mediterranean Sea coming from the west [19–21], that is of particular importance for fishing activity [22], albeit highly anthropized [23,24].
- (iii) The eastern boundary current, off the Chilean coast, flows along the west coast of South America and is one of the largest ocean current systems, known as upwelling, where cold, nutrient-rich water promotes high primary and secondary productivity [25]. For this reason, the water masses off the coast of Chile are among the best areas for fishing in the world [26,27]. The coastal waters in the South Pacific Ocean, especially along the Atacama Region of Northern Chile, are affected by intense anthropic activities. The rapid increase in industrial, agricultural, and fishing activities, together with the development of ports, desalination plants, and tourism, have strongly influenced the quality of the surrounding environment [28].

The mining sector has grown expeditiously in this geographical area, with the extraction of gold, silver, molybdenum, iron, and lithium, but above all, copper.

Furthermore, two drainage basins of important rivers, one in Spain and one in Brazil, were also studied to investigate metal/lloid contamination and the associated adverse



Citation: Marini, M.; DelValls, T.Á. Pollutants and Climate Change, Runoff, Behavior and Adverse Effects in Aquatic Ecosystems. *Appl. Sci.* **2024**, *14*, 2823. <https://doi.org/10.3390/app14072823>

Received: 14 March 2024
Revised: 24 March 2024
Accepted: 25 March 2024
Published: 27 March 2024



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effects on organisms. Finally, a novel and disruptive technology has been described in this Special Issue, demonstrating its validity for brine decontaminations and extrapolating it to a new paradigm related to the circular economy and its application to other sectors with contaminated waters or fluids. An overview of published articles is shown in the next paragraphs.

2. Environmental Contamination in Sediments of Aquatic Systems

Environmental contamination by different anthropogenic activities has been analyzed in sediments in different aquatic environments, such as river basins and marine sediment, both near shore and offshore. The tolerance level of some target benthic organisms was also evaluated. The areas surveyed in this research were: the Adriatic Sea, the southern Pacific Ocean, and two river basins: one in the southwest of Spain and one in Brazil. Mandić J. et al. (Contribution 1) showed the observed concentrations of polycyclic aromatic hydrocarbons (PAH) and their sources in the Central Adriatic Sea, both near the eastern coast and offshore. Pyrogenic sources were the main contributors to the total concentration of PAH in the coastal area. At the same time, in the mid-Adriatic offshore sediments, PAHs originated mainly from petrogenic sources. Bonnail E. et al. (Contribution 2) studied the state of ecological health in the northern coastal area (26° S) of the Atacama Region (Chile, Pacific Ocean), including a marine protected area, with sub-areas for tourism and benthic management, where there are many important industrial activities. Results of heavy metal pollution levels in sediments, including toxicity levels, measured on target organisms were presented. Riba et al. (Contribution 3) studied a segment of the Guadalquivir River (SW Spain), through an integrative assessment of sediment quality. The study was perfected in laboratory conditions with a biological test, using different organisms exposed to sediments to determine their toxicological risk. Additionally, Riba et al. (Contribution 4) presented a study on the São Francisco River (Brazil) with a weight-of-evidence approach to identify sources of pollution in the river and in the city of Três Marias (Minas Gerais, Brazil), based on the structure of the benthic community and the physicochemical characterization of the sediments. Three different sentinel species have been identified to improve sediment quality assessments in river areas.

3. Contaminant Accumulation in the Organisms

Aquatic organisms are excellent indicators of the presence of contaminating substances in the environment. In these studies, it was possible to see how consolidated knowledge of target organisms is useful for defining in-depth contamination evaluation criteria, as seen for heavy metals, as well as for new organisms, such as some invasive species. Martinovic et al. (Contribution 5) determined the content of trace metals in the soft tissues, shells, and shell demineralization products of the Mediterranean mussel *Mytilus galloprovincialis* L., in the Bay of Kotor (Adriatic Sea). The study aimed to investigate accumulation patterns of trace metals in the shell and soft tissues to assess pollution sources in coastal marine ecosystems. The study by Dghim et al. (Contribution 6) was based on demonstrating the accumulation capacity of the invasive blue crab species, *Portunus segnis*, by measuring the concentrations of heavy metals in the gills and hepatopancreas, together with its usefulness as a sentinel species for the Gulf of Gabès (southeastern Mediterranean Sea).

4. Effect of Climate Change

Even studies on the effects of climate change, such as ocean acidification, can compromise the vitality of some organisms, such as bivalves, which are widely used for monitoring studies in coastal areas as useful bioindicators of persistent pollutants. These results should be taken into consideration when environmental monitoring approaches are carried out, particularly in areas most affected by these changes, like in tropical marine areas where recorded pH variations interfere with the health status of organisms and their metabolic functions, as described in the papers by da Silva Souza et al. (Contribution 7) and Cunha Passarelli et al. (Contribution 8). Over the past three decades, the ecology of benthic

foraminifera has been intensively studied to improve the potential application of these marine organisms as a proxy for the effects of climate change and other global change phenomena, as well as the ability to retain persistent pollutants. An interesting study was made by Rostami et al. (Contribution 9) in a large stretch of the Adriatic Sea, where climatic variations were also observed, further verifying how the fluvial water regime has changed in the last century, carrying higher loads of nutrients that contribute to eutrophication, making the Adriatic Sea one of the most productive areas of the Mediterranean Sea (study presented by Marini and Grilli, Contribution 10).

5. Other Topics: Applications and Technology

Desalination of aquifers and marine water represents a viable choice to meet global domestic and industrial water needs. With the rise in sea levels and saltwater intrusion into groundwater, desalination becomes increasingly necessary. Removing dissolved salts from seawater to obtain fresh water of sufficient quality for many purposes generates highly concentrated salt waste, known as brine. Bonnail et al. (Contribution 11) described a clean, low-impact technology for producing drinking water without producing pollution. Rampazzo et al. (Contribution 12) used very advanced technologies to define the decomposition of plastic materials in the marine environment, in particular bioplastics, such as starch-based compostable shopping bags. This leads to useful considerations for defining the use of increasingly rapidly degrading materials in the marine environment. Bellucci and Giuliani (Contribution 13) consider coupling scientific evidence from sediment cores with historical information as an effective way to reconstruct and quantify anthropogenic impacts in transitional and marine-coastal areas and thus establish the responsibilities for pollution that may also be used in the legal field. Good practices for selecting sampling sites and specific investigation techniques are key to understanding pollution histories and dynamics, along with reliable dating methods and analytical procedures. Examples are shown of how the results have been used in preliminary investigations or judicial debates to attribute responsibility for environmental pollution to past or present industrial management.

6. Conclusions and Perspectives on the Future of Research

The work presented in this Special Issue contains concrete progress and new insights into the study of coastal and river waters in different geographical areas.

The presented studies offer innovative ideas for the correct monitoring and evaluation of the negative effects of pollutants on aquatic ecosystems. From monitoring itself to remediation technologies, it has been demonstrated that this type of study could potentially help to improve our knowledge and applications in different contexts, such as in the legal field. It was thus highlighted that the evaluation of the effects of pollution requires interdisciplinary and multidisciplinary efforts, as well as the application of new investigative methodologies.

Author Contributions: M.M. and T.Á.D. both conceived the idea and wrote the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflicts of interest.

List of Contributions

1. Application of Positive Matrix Factorization for Source Apportionment of Polycyclic Aromatic Hydrocarbons (PAH) in the Adriatic Sea, and the Evaluation of PAH-Related Carcinogenic Risks
2. An Integrated Approach for the Environmental Characterization of a Coastal Area in the Southern Atacama Desert
3. Sediment Contamination and Toxicity in the Guadalquivir River (Southwest, Spain)
4. Integrative Assessment of Sediment Quality in the São Francisco River (Mina Gerais, Brazil)
5. Shell Organic Matrix (Conchix) of the Mediterranean Mussel *Mytilus galloprovincialis* L. as the Medium for Assessment of Trace Metals in the Boka Kotorska Bay
6. Assessment of the Accumulation of Trace Metals and Oxidative Stress Response Biomarkers in the Portunid *Portunus segnis*
7. Integrated Assessment of CO₂-Induced Acidification Lethal and Sub-Lethal Effects on Tropical Mussels *Perna perna*
8. Risk Assessment of a Coastal Ecosystem from SW Spain Exposed to CO₂ Enrichment Conditions
9. Understanding the Distributions of Benthic Foraminifera in the Adriatic Sea with Gradient Forest and Structural Equation Models
10. The Role of Nitrogen and Phosphorus in Eutrophication of the Northern Adriatic Sea: History and Future Scenarios
11. A new disruptive technology for zero brine discharge: towards the paradigm shift
12. An FTIR and EA-IRMS Application to the Degradation Study of Compostable Plastic Bags in the Natural Marine Environment
13. The Role of Sediment Records in Environmental Forensic Studies: Two Examples from Italy of Research Approaches Developed to Address Responsibilities and Management Options

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