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Editorial

Application of Ecohydrology Approach for Mitigation of Freshwater Ecosystems Contamination

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As a consequence of the rapid development of modern society during the 20th and 21st centuries, a significant number of pollutants have been dispersed into the environment. Consequently, the intensified emission and spread of pollutants within the catchment areas (e.g., agricultural lands, city spaces, industrial areas) presents a major environmental problem, as does the further transport and accumulation of these compounds and their metabolites in water ecosystems. The majority of these pollutants have been used in large scales as pesticides, pharmaceuticals, and industrial chemicals, or synthetized as undesirable byproducts. Increased levels of pollutants have been recorded not only in soil, but also in freshwater ecosystems worldwide [1–3]. Additionally, global climate change leads to disturbances of the hydrological cycle and water flow by affecting both the quantitative and qualitative properties of water resources. Since water is the primary medium responsible for the transport of matter, nutrients, and pollutants from the catchment, these processes will also influence the concentrations and loads of pollutants in freshwater ecosystems, such as rivers, lakes, and dam reservoirs [1,2]. All these changes have a profound impact not only on water, and the water-related environment, but also socioeconomic wellbeing [3].

It is crucial, therefore, to monitor and mitigate the degradation/pollution level of freshwater ecosystems. Such reductions will serve to protect against the degradation of the environment and the health of the population, and enable to achieve the goals of the European Union's strategy in the field of water policy.

According to the principles of ecohydrology [3], the first step toward reducing and/or reversing the degree of degradation of the water ecosystem is a thorough assessment of its condition. This assessment should include a broad spectrum of analyses of the pollution status of a given ecosystem in relation to the individual components of the environment (identification of threats), together with the interactions and processes that determine the pollution status (analysis of cause–effect relationships), and then using the knowledge of these links to improve the quality of the environment (developing methods and tools for reduction of identified threats).

In sight of this, the main goal of this Special Issue was to bring together studies looking into (1) the pollution of freshwater ecosystems, (2) the roles played by the factors and processes determining ecosystem pollution status, and (3) the nature-based solutions enabling safe remediation of the contaminated environmental matrices.

Seven articles are published in this Special Issue—five research articles and two reviews, covering a wide range of contaminants, monitoring and risk assessment approaches, cause–effect relationships, as well as solutions for the safe removal of identified pollutants from the water environment. What is more, diversified groups of contaminants have been included into this Special Issue, such as organic and inorganic compounds and pollutants subject to statutory monitoring (e.g., nutrients, persistent organic pollutants—POPs). The Special Issue also examines those compounds that are not commonly monitored in the environment, but have the potential to enter the environment and cause known or suspected adverse effects on the ecosystem and/or human health (e.g., compounds of emerging concern—CECs, antimicrobials, and antibiotic-resistant bacteria).

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Among the research articles, the papers by Dahmardeh Behrooz et al. [4,5] describe the levels and distribution patterns of legacy POPs, such as polychlorinated biphenyls and DDT, lindane and dieldrin, and organophosphorous pesticide—diazinon—in the surface water of the three major rivers flowing into the Caspian Sea (Iran). The authors not only report the presence of increased levels of the monitored compounds, especially in the downstream section of the rivers, but their data also indicates high ecotoxicological risk, reflected in the adverse effects of the studied pollutants observed on aquatic species. Through assessing the levels, spatial and temporal distributions, and risk related to the presence of the abovementioned toxic compounds in the freshwater ecosystems, these two papers reflect the identification of threats approach.

Kebedew et al. [6] in turn, present the distribution of another frequently-monitored pollutant, phosphorus, in the ecosystem of the Tana Lake (the largest freshwater lake in Ethiopia and the third largest in the Nile Basin) in relation to the lake morphometry. This paper, therefore, fits into a cause–effect relationship approach postulated by ecohydrology, as does the paper by Hart et al. [7] by demonstrating an insight into the processes regulating pollutant dispersion in a model beaver dam.

Finally, the article by Pietrini et al. [8] is a perfect illustration of the developing methods and tools for reduction of identified threats approach. The authors studied the capabilities of Chinese brake fern (*Pteris vittata* L.) to tolerate and accumulate As. Their results show that fern can be used as an efficient tool in the phytoremediation of As-contaminated water ecosystems, and thus may be useful in designing strategies for the rehabilitation of the water ecosystem.

The two review papers [9,10] provide an insight into a range of CECs (including antibiotics and antibiotic-resistant bacteria), the risk they may exert, as well as methods of their safe elimination from the environment. The paper by Serwcińska [9] describes the risk of antimicrobials and antibiotic-resistant bacteria to the environment and to public health. The author provides an insight into the problem of overuse and misuse of antibiotics, which substantially leads to increase in the levels of antibiotics and antibiotic resistance in the environment. As freshwater ecosystems (rivers, lakes, and reservoirs) are the final recipients of both raw and treated wastewater, the water-driven spread of antibiotic resistance is an important issue in modern environmental studies. In turn, the article by Mierzejewska and Urbaniak [10] provides a view of the role of molecular methods and novel -omics technologies in the ecohydrological approach to monitoring, protection, and rehabilitation (remediation) of CEC-contaminated freshwater ecosystems. By bringing together examples of the use of molecular tools in: (i) risk assessment, (ii) analysis of cause–effect relationships, and (iii) evaluation of the effects of applied remediation methods on CEC removal efficiency, the review covers all three steps toward reducing and/or reversing the degree of degradation of the water ecosystem, postulated by ecohydrology, i.e., identification of threats, analysis of cause–effect relationships, and developing methods and tools for reduction of identified threats.

To conclude, this Special Issue contains five research papers and two reviews dealing with the problems of contamination of freshwater ecosystems with nutrients, persistent organic pollutants, pesticides, heavy metals, compounds of emerging concern, and antibiotics and antibiotic resistance. The Issue presents also an ecohydrology approach to the monitoring and assessment of risks related to freshwater ecosystems pollution, analyses of factors, processes, and relationships affecting the observed pollutant levels, as well as methods for the safe removal of the identified threats from the environment. The research findings are novel and timely in informing the ecohydrology approach for mitigation of freshwater ecosystem contamination. The selected papers are important to progress the understanding of how anthropogenic and natural stresses alter freshwater ecosystems and to provide scientific methods for better assessment and protection of these unique ecosystems.

We trust that the collation of these papers contributes to piquing further interest in risks related to the pollution of freshwater ecosystems and environmentally safe but effective remediation methods.

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