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Editorial

Special Issue: Environmental Fate of Contaminants in the Aquatic Environment

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Citation: Barra Caracciolo, A. Special Issue: Environmental Fate of Contaminants in the Aquatic Environment. *Water* **2021**, *13*, 1350. https://doi.org/10.3390/w13101350

Received: 24 March 2021
Accepted: 12 May 2021
Published: 13 May 2021

Most of the Earth's surface (71%) is covered with water, and the oceans hold about 96.5% of all the planet's water. However, freshwater is only a small percentage (2.8%), most of it consists of ice, which is mainly trapped in glaciers and snowfield. Only 0.007% of the planet water is available from surface water (rivers and lakes) and groundwater, which are the main reserves. Consequently, freshwater is a precious resource for humans and survival of ecosystems. Moreover, the global availability of this water is constantly fluctuating due to climate change.

Currently, 20% of the world population uses 80% of the natural resources in a careless and improper way, causing a great deal of contamination, and compromising the use of drinkable water. Clean water is a common right as affirmed in the sixth Sustainable Development Goal by UN General Assembly in 2015.

Water scarcity is not the only limit for its use. Water quality is important and based on the intended uses of water for different purposes. Aquatic ecosystems are chronically subjected to a multiple contamination by various point and diffuse industrial, urban and agricultural sources. A cocktail of regulated hazardous chemicals (e.g., pesticides, hydrocarbons, heavy metals, surfactants), commercial products and emerging contaminants (e.g., nanoparticles, pharmaceuticals, antibiotics, personal care products, micro(nano)plastics) reach freshwater and can have detrimental effects on structure and functioning of ecosystems and on human health. The 'One Health' approach proposed by the World Health Organization recognizes that human health is connected to that of animals and the environment [1]. At the same time soil, water, and air compartments are strictly connected and this is particularly important for the transport and fate of contaminants.

Most organic and inorganic contaminants come from anthropogenic sources such as urban ecosystems, industrial sites, landfills, and agricultural practices and can reach water bodies from soil. Soil can be an effective filter in many cases, avoiding water contamination if pollutants are adsorbed or removed by abiotic processes and above all biodegradation. However, overall contaminant loads, type of pollution (e.g., acute or diffuse) and site-specific conditions (e.g., soil lithology, hydrology, hydrogeology) can significantly influence run-off and leaching of contaminants from soil to water. Beyond persistent organic compounds, such as polychlorobiphenyls (PCBs) and dichlorodiphenyltrichloroethane and its metabolites (DDTs), pseudo-persistent compounds (e.g., pharmaceuticals), and emerging micro-pollutants (e.g., perfluoroalkyl acid substances: PFASs, antibiotics) can also reach water ecosystems.

This special issue consists of 10 papers which cover a wide range of research topics, such as trophic magnification of pollutants, microbial diversity of contaminated areas, ecotoxicological effects, emerging contaminant detection and removal, sediment, soil and groundwater contamination. The pollutants include heavy metals [2], PCBs [3,4], DDTs and PFASs [4], insecticides (e.g., bifenthrin) [5], anionic surfactants [6,7], micropollutants [4,8–10], and nitrates [11].

Grosbois et al. [2] report a spatiotemporal distribution and leachability of some trace elements in sediments of the Xiangjiang River, tributary of the Yangtze River (China). Over the period reviewed, heavy metal (HM) contamination level displayed a spatial distribution. A 30-day leaching experimental protocol under aerobic and anaerobic conditions was carried out for evaluating HM mobility. Trace elements' fates depended mainly on the stability of bearing phases under specific physicochemical and microbial conditions and the sediments were an important sink.

A contribution for improving knowledge on bioremediation of PCBs from soil, preventing their diffusion to water compartments is reported in Di Lenola et al. [3]. The effectiveness of adding compost and the plant *Medicago sativa* in a soil historically contaminated by polychlorinated biphenyls (PCBs) was tested in greenhouse microcosms. At fixed times, PCBs were analyzed and the structure (cell abundance, phylogenetic characterization) and functioning (cell viability, dehydrogenase activity) of the natural microbial community were also measured. Compost and plant increased the microbial activity, cell viability, bacteria/fungi ratio, Proteobacteria abundance and decreased the amount of higher-chlorinated PCBs.

Mazzoni et al. [4] evaluated the biomagnification of mercury, PCBs, DDTs, and PFASs in the trophic web of Lake Mergozzo, a small and deep Italian subalpine lake. Carbon source and relative trophic levels were calculated by using ^{13}C and ^{15}N stable isotopes, respectively, and trophic magnification factors (TMFs) were derived. Zooplankton and 13 species of fish were collected and analyzed, and the results showed the elevated level of biota contamination from both legacy and emerging pollutants.

Hall and Anderson [5] conducted a long-term (2001–2019) temporal trend analysis of bifenthrin in sediment of California waterbodies. Twenty of the 126 sites showed a statistically significant downward trend in bifenthrin concentrations, while nine sites showed a statistically significant upward trend. Declining bifenthrin sediment concentrations were more evident in urban waterbodies than in agricultural dominated waterbodies. An analysis of bifenthrin long-term sediment trends by waterbody with at least three sites showed a significant trend for only one residential/urban stream and this trend was declining.

Barra Caracciolo et al. [6] performed mesocosm experiments at a real construction site for evaluating the possible effects and fate of the anionic surfactant sodium lauryl ether sulphate (SLES) contained in soil conditioned with foaming agents used for tunnel excavation. The soil mesocosms were set up with two different lithologies, which contained four different foaming agent products at the highest amounts used for excavation. The decrease in SLES concentrations and five ecotoxicological tests (including terrestrial and aquatic species) were performed in soil and its water extract (elutriate) at different times (0, 7, 14, 28 d). The results showed a decrease in SLES over time and different ecotoxicological responses depending not only on the initial amount and kind of commercial product, but also on the soil lithology and organism tested.

Patrolecco et al. [7] performed microcosm experiments for evaluating the environmental fate and effects of a foaming agent used for conditioning soils collected from a real tunnel excavation, in the presence/absence of an anti-clogging polymer, both containing SLES. Soil microcosm experiments were set-up and incubated for 28 days. Over time, soils and their elutriates were collected to perform both ecotoxicological tests (*Vibrio fischeri*, *Lepidium sativum*, *Eisenia foetida*, *Hetereocypris incongruens*, *Danio rerio*) and SLES analysis. The results showed that, just after conditioning, SLES did not exert any hazardous effect on the organisms tested except for the bacterium *V. fischeri*, which was the most sensitive to its presence. However, from day seven the toxic effect on the bacterium was never observed thanks to the SLES decrease in elutriates (<2 mg/L). SLES degraded in soils (half-lives from 9 to 25 days) with higher disappearance rates corresponding to higher values of microbial abundances. This study highlights the importance of site-specific studies for assessing the environmental reuse of spoil materials.

Rutere et al. [8] showed in river sediment microcosms how different concentrations in total organic carbon (TOC) drives multiple biogeochemical reactions, including attenuation of organic micro-pollutants (MP). The higher removal efficiencies of MP, such as pharmaceuticals and personal care products in the high than the low-TOC sediments were associated with a more abundant microbiome and higher sorption. Although the stressor effect of MP, the bacterial community in the high-TOC sediment samples remained relatively stable if compared to the low-TOC sediment community. The latter decreased in the relative abundance of most phyla, except Proteobacteria. Bacterial genera associated with biodegradation of MPs such as *Xanthobacter, Hyphomicrobium*, *Novosphingobium*, *Reyranella*, and *Terrimonas*, were identified.

A review on emerging pollutants (EPs), sources for aquatic environment (e.g., wastewater treatment plants) and major impacts on biota and human health is reported by Vasilachi and co-authors [9]. The paper raises some relevant problems related to water environment pollution with EPs (e.g., UV filters), the risks they can generate for aquatic life and humans and opportunities to reduce the effects of pollution by their removal. The removal of EPs from the environment as a solution to risk mitigation is addressed, with emphasis on several non-conventional processes involving biological removal of EPs.

Rauseo et al. [10] studied the effect of the antibiotic sulfamethoxazole (SMX) on growth and antibiotic resistance genes of a microbial community collected from an anaerobic digestion plant. Concentration-dependent experiments, using SMX at various concentrations, were performed. The antibiotic concentrations affecting the mixed microbial community in terms of growth and spread of resistant genes (*sul1*, *sul2*) together with SMX biodegradation were investigated. SMX amounts in the range of those found in environments did not affect the microbial community growth and did not select for antibiotic-resistant gene maintenance or spread. Furthermore, the microorganisms tested were able to degrade SMX in only 24 h. This study confirms the complexity of antibiotic resistance spread in real matrices where different microorganisms coexist and suggests that antibiotic biodegradation needs to be included for fully understanding the resistance phenomena among bacteria.

The paper by Chotpantarat et al. [11] deals with groundwater (GW) in western Thailand, where water overuse and agrochemical contamination has compromised its quality. The authors evaluated hydrochemical characteristics of groundwater using multivariate statistical analysis. They performed principal component analysis (PCA) and hierarchical cluster analysis (HCA), and integrated stable isotopes ^{18}O and ^{2}H with hydrochemical data for evaluating the origin of the GW and indirectly identifying the nitrate pollution sources. They evaluated 60 wells with different hydrogeological characteristics and land use types in the rainy and summer seasons. The PCA results revealed the influence of seawater intrusion. Furthermore, multivariate statistical analysis revealed that the NO_3^- mainly released from potassium nitrate (KNO_3), for example, during pineapple cultivation, directly contaminating the groundwater system.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data sharing not applicable.

Conflicts of Interest: The author declares no conflict of interest.

References

1. World Health Organization Food and Agriculture Organization of the United Nations & World Organization for Animal Health. *Antimicrobial Resistance: A Manual for Developing National Action Plans*; Version 1; World Health Organization: Geneva, Switzerland, 2016; ISBN 9789241549530.
2. Grosbois, C.; Desmet, M.; Zhang, M.; Gassama, N.; Peng, Q.; Zhang, J.; Luo, L.; Zhang, F.; Battaglia, F. Trace Element Contamination in One of the Yangtze Tributaries (Hunan, China)—Source Review and Potential Release from Sediments. *Water* **2021**, *13*, 271. [CrossRef]
3. Di Lenola, M.; Barra Caracciolo, A.; Ancona, V.; Laudicina, V.A.; Garbini, G.L.; Mascolo, G.; Grenni, P. Combined Effects of Compost and Medicago Sativa in Recovery a PCB Contaminated Soil. *Water* **2020**, *12*, 860. [CrossRef]
4. Mazzoni, M.; Ferrario, C.; Bettinetti, R.; Piscia, R.; Cicala, D.; Volta, P.; Borgå, K.; Valsecchi, S.; Polesello, S. Trophic Magnification of Legacy (PCB, DDT and Hg) and Emerging Pollutants (PFAS) in the Fish Community of a Small Protected Southern Alpine Lake (Lake Mergozzo, Northern Italy). *Water* **2020**, *12*, 1591. [CrossRef]
5. Hall, L.W.; Anderson, R.D. An Eighteen Year Temporal Trends Analysis of Bifenthrin Sediment Concentrations in California Waterbodies. *Water* **2020**, *12*, 2402. [CrossRef]

6. Barra Caracciolo, A.; Grenni, P.; Mariani, L.; Rauseo, J.; Di Lenola, M.; Muzzini, V.G.; Donati, E.; Lacchetti, I.; Gucci, P.M.B.; Finizio, A.; et al. Mesocosm Experiments at a Tunnelling Construction Site for Assessing Re-Use of Spoil Material as a By-Product. *Water* **2021**, *13*, 161. [CrossRef]
7. Patrolecco, L.; Pescatore, T.; Mariani, L.; Rolando, L.; Grenni, P.; Finizio, A.; Spataro, F.; Rauseo, J.; Ademollo, N.; Muzzini, V.G.; et al. Environmental Fate and Effects of Foaming Agents Containing Sodium Lauryl Ether Sulphate in Soil Debris from Mechanized Tunneling. *Water* **2020**, *12*, 2074. [CrossRef]
8. Rutere, C.; Posselt, M.; Horn, M.A. Fate of Trace Organic Compounds in Hyporheic Zone Sediments of Contrasting Organic Carbon Content and Impact on the Microbiome. *Water* **2020**, *12*, 3518. [CrossRef]
9. Vasilachi, I.C.; Asiminicesei, D.M.; Fertu, D.I.; Gavrilescu, M. Occurrence and Fate of Emerging Pollutants in Water Environment and Options for Their Removal. *Water* **2021**, *13*, 181. [CrossRef]
10. Rauseo, J.; Barra Caracciolo, A.; Spataro, F.; Visca, A.; Ademollo, N.; Pescatore, T.; Grenni, P.; Patrolecco, L. Effects of Sulfamethoxazole on Growth and Antibiotic Resistance of A Natural Microbial Community. *Water* **2021**, *13*, 1262. [CrossRef]
11. Chotpantarat, S.; Parkchai, T.; Wisitthammasri, W. Multivariate Statistical Analysis of Hydrochemical Data and Stable Isotopes of Groundwater Contaminated with Nitrate at Huay Sai Royal Development Study Center and Adjacent Areas in Phetchaburi Province, Thailand. *Water* **2020**, *12*, 1127. [CrossRef]