

Editorial

Ecological and Health Risk of Soils, Sediments, and Water Contamination

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Abstract: Soils, sediments, and water require careful stewardship for the planet's security to achieve the Sustainable Development Goals (SDGs) set from the United Nations. However, the contamination of these natural resources can damage ecological and human health, and thus we need a comprehensive approach to provide a remediation reference for the SDGs. The aim of this Special Issue (SI) was to gather the papers emphasizing different aspects and findings of the contamination processes, remediation techniques, and risk assessment of soils, sediments, and water. The Guest-Editor of this SI collected seven papers dealing with biochar application for the reduction in soil nutrient leaching by Kuo et al. and for the immobilization of soil cadmium by Chen et al. Their works contributed to not only sustain soil functions but also to prevent sediments and water from contamination. Moreover, in situ stabilization by environmentally compatible approach is a green remediation of sediments such as thin-layer capping for freshwater and estuary sediments by Ou et al. and Ch'ng et al., respectively. Bioassays including microbiological response and enzyme activities were used to test water quality by Martín et al. and Aljahdali et al., in addition to the finding of antibiotic-degrading bacterial strains reported by Yang et al. in sewage sludge. These papers may aid to update and incorporate new views and discussion for the SDGs.

Keywords: bioaccessibility; biochar; biomarkers; green and sustainable remediation; heavy metal; SDGs; thin-layer capping

1. Introduction

There has long been concern about the issue of soils, sediments, and water pollution by various contaminants worldwide. Soil provides an interface between the lithosphere, atmosphere, hydrosphere, and biosphere, and thus improvement of soil function has recently become a major priority in ecosystems, particularly because of the growing awareness regarding the role of soil in controlling sediment and water quality crucial for human benefit [1]. For instance, the sustainable monitoring and management of contamination and remediation of soils, sediments, and water toward reaching the 17 Sustainable Development Goals (SDGs) set from the United Nations have been recognized as important in previous studies [2], which identified several targets with direct synergies with these natural resources across the goals.

Regarding soil and sediment remediation, conventional practices such as washing, landfilling, and excavation are commonly poor-feasible especially on a large scale because they are not environmentally compatible and are economically-prohibitive [3]. These concerns have prompted green and sustainable remediation (GSR) for the contamination of soils and sediments. Among GSRs, the in situ stabilization of contaminants using reactive or immobilizing materials has received increasing attention [4]. The aim of adding amendment is to sequester and stabilize contaminants in soils or sediments to reduce their ability to spread into water or biota, and thus to reduce their risk to human health. Aquatic ecosystems including sediments and water often play as the sinks of contaminants

transported from soil contamination and wastewater discharge. To identify the impact of contaminants in water by bioassays, it is necessary to test different representatives of biomarkers as indicators of substances that are harmful to living cells and tissues, useful even in the cases where physicochemical parameters fulfill the requirements of water quality. This identification approach may coincide with the GSR principles of soil and sediment contamination for ecological and human health.

2. Overview of This Special Issue

Seven original papers are published in this Special Issue: two are the topics of soil remediation by using biochar, two are heavy metal stabilization by iron sulfide-based amendments in sediments, two are evaluation of the biomarkers of heavy metal contamination in river water, and one is biodegradation of antibiotics by specific bacterial strains screened from sewage sludge.

Biochar acts as a liming amendment in soils, increasing the retention capacity of nutrient and heavy metal in the soil solids. Thus, the application of biochar has received growing interest as a sustainable technology in contaminated soils because it boosts the intrinsic sorption capacity of the soil [5]. Kuo et al. evaluated the effects of biochar on organic carbon (OC) and nutrient retention and leaching in a coarse-textured soil [6]. They conducted a 42-day column leaching experiment by the tested soil mixed with 2% of biochar pyrolyzed from the wood sawdust of Honduran mahogany (*Swietenia macrophylla*) at 300 °C (WB300) and 600 °C (WB600). The results indicated that biochar application increased the final soil pH and OC, concentrations of ammonium-N, nitrate-N, and available phosphorus (P) but not exchangeable potassium (K) concentrations. They concluded the ability to retain N, P, and K in the tested soil differed with pyrolysis temperatures of biochar, but WB300 and WB600 effectively contributed to the conservation of groundwater and river water in the catchment.

Biochar from rice husk was applied into a cadmium (Cd) contaminated soil by Chen et al. [7]. Lettuce (*Lactuca sativa*) and pak-choi (*Brassica chinensis*) were planted in the biochar-amended soil to observe the accumulation, translocation, and chemical forms of Cd in the leafy vegetables. In addition, the vegetable-induced hazard quotient was calculated via the chemical form and artificial digestant extractable concentration of Cd in the blanched edible parts to assess the risk from oral intake. The experimental results identified that the biochar increased the soil pH and decreased Cd concentration in the roots and shoots of tested vegetables compared with the control. As some chemical forms of Cd in the vegetables were leached out from tissues during cooking, using total Cd in the vegetables over-estimated the dose of Cd absorbed by the human body. Hence, the bioaccessibility of Cd through eating vegetables can be used to predict accurately the health risk of Cd intake, especially under the biochar-amended soil.

Thin-layer capping is an environment-compatible technique for in situ sediment remediation, reducing contaminants released from the solid phases to overlying water. The main approach is to allow the sediment left in place but decreasing further contamination from resuspension of contaminants by the capping layer [8]. Ch'ng investigated mercury (Hg) removal efficiency of iron sulfide (FeS), sulfurized activated carbon (SAC), and raw activated carbon (AC) sorbents influenced by salinity and dissolved organic matter (DOM), and the efficiency of these sorbents as thin layer caps on the remediation of Hg-contaminated estuary sediment to decrease the risk of release [9]. They elucidated that FeS on Hg removal was not significantly affected by salinity levels and maintained with high removal efficiency. The Hg removal efficiency of AC and SAC increased as salinity increased. However, the Hg removal by sorbents decreased with the addition of DOM at different salinity levels. To cope with highly complex conditions in sediment, mixed capping with multiple materials was further performed by Ou et al. [10]. They selected kaolinite, carbon black (CB), iron sulfide (FeS), hydroxyapatite (HAP), and oyster shell powder (OSP) as mixed active caps to retain nickel (Ni), chromium (Cr), copper (Cu), zinc (Zn), and Hg released from freshwater sediment by column experiments. The HAP and OSP showed the highest removal efficiencies towards Ni, Cr, Cu, and Zn, with CB taking the third place. However, the FeS and CB played a more significant role in Hg removal, corresponding to the findings by Ch'ng et al. [9].

The mobility of heavy metals in aquatic environments by desorption from sediments into the surface water is controlled by many biological and chemical factors, making the surface water a major intermediate source of toxic metals in benthic sediments. Aljahdali et al. determined concentrations of heavy metals in sediments and the freshwater mollusc *Bellamya unicolor*, pollution indices, and antioxidant enzyme activities in *Bellamya unicolor* across the five sites in the River Kaduna, Nigeria to further evaluate the risk assessment of heavy metals [11]. They found that a significantly positive correlation between metal concentration and antioxidants catalase and superoxide dismutase was established, supporting the potential ecological risk as a result of heavy metals pollution in the River Kaduna. Martín et al. evaluated the water quality of Boque River in Colombia contaminated by gold mining drainage by bioassays (*Lactuca sativa*, *Hydra attenuata*, and *Daphnia magna*), mutagenicity (Ames test), and microbiological assays, in addition to physiochemical parameters such as pH, heavy metals, Hg, and cyanide [12]. They found Hg, Cd, and cyanide exceeded the permitted concentrations in Colombia and *D. magna* showed sensitivity and *L. sativa* showed inhibition and excessive growth in the analyzed water. The presence of bacteria and coliphages in the water indicated a health risk to inhabitants. The mutagenic index showed the possibility of mutations in the population consuming this type of water. Additionally, bioassays played as an alert system when concentrations of contaminants cannot be analytically detected. In addition to conventional contaminants, emerging contaminants such as antibiotics have received great concerns in the environment worldwide. Yang et al. examined the degradation of antibiotics in the sewage sludge from a wastewater treatment plant by antibiotic-degrading bacteria under aerobic and anaerobic conditions [13]. Four antibiotic-degrading bacterial strains, SF1 (*Pseudomonas* sp.), A12 (*Pseudomonas* sp.), strains B (*Bacillus* sp.), and SANA (*Clostridium* sp.), were isolated, identified, and tested in their study. The experiments indicated the addition of SF1 and A12 under aerobic conditions and the addition of B and SANA under anaerobic conditions increased the biodegradation of antibiotics in the sludge. Moreover, twenty-four reported antibiotics-degrading bacterial genera were identified to have the possible potential for the removal of antibiotics including oxytetracycline (OTC), tetracycline (TC), chlortetracycline (CTC), amoxicillin (AMO), sulfamethazine (SMZ), sulfamethoxazole (SMX), and sulfadimethoxine (SDM) in the sludge.

3. Conclusions

The seven papers in this SI provide valuable results in the topics of soils, sediments, and water contamination according to the consideration of ecological and health risk. They also point out open questions and possible research in the future. Biochar application can benefit both soil conservation and contamination, but further research should be conducted to investigate whether these positive effects can be extended to the field scale. Similar to biochar, scale-up design will be helpful for thin-layer capping in situ sediment by using mixed active amendments. Both physiochemical analysis and bioassays mutually supported the evaluation results of river water quality. However, we need better approaches and policies of management to prevent further contamination from the discharge of untreated industrial and domestic waste into this aquatic ecosystem. The use of microorganisms to eliminate antibiotics is a promising strategy, but the future work should verify the biodegradation ability of antibiotic-degradation bacteria in the wastewater treatment plant.

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