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Editorial

Advances in Remediation of Contaminated Sites

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With the development of the social economy, the population has increased sharply, and the land area involved in people's production and life is also gradually increasing [1,2]. To meet the production and development needs of society, land resources have been damaged and polluted synchronously to a certain extent due to human activity. Most site contaminations result from past and present anthropogenic activities. As land resources are non-renewable, developing efficient land restoration and improvement approaches is an important approach for achieving sustainable development of human society [3,4].

The remediation of contaminated sites has been one of the most rapidly developing environmental research subjects [5]. The remediation process of contaminated sites is a site-specific phased approach comprising site characterization, risk assessment, and remediation technology selection and application [6]. Site remediation technology has developed rapidly in recent years and has brought hope for environmental remediation. However, after this rapid development, site remediation technology has also encountered bottlenecks, and new breakthroughs are urgently required.

This Special Issue aims to provide scientific information on all areas of contaminated site remediation. This Special Issue contains 20 publications covering the full life cycle of contaminated site remediation. The research in the current Special Issue involves pollution investigation, environmental fate, pollution control and review, which, respectively, account for 30%, 40%, 20%, and 10%, which are shown in Figure 1a. The Special Issue addresses all aspects of contaminated site remediation, including heavy metal pollution, organic pollution, and combined pollution, and 75% of the articles investigate heavy metal, 20% focus on organic pollution, and the remaining 5% are concerned with combined pollution, which is shown in Figure 1b. As shown in Figure 2, Cd is the most frequent study item. PBDEs, PAHs, and MPs, which are widely concerned, are important investigated elements.

Pollution investigation articles mainly study the status of pollutants in different contaminated sites. Sun et al. investigated the chromium distribution, leachability, and speciation in a chrome plating site and found the chromium distribution was associated with the electroplating processes. A high level of Cr(VI) was found in soils from the sewage tank related to chrome-plating processes. Cr(VI) mainly accumulated in the loam layer and reached its maximum concentration. Except for the industrial pollution sites, agricultural pollution sites have also attracted much concern [7]. Shan et al. have collected surface soils from heavy metals, including Co, Ni, Cu, Zn, Cd, and Pb. The results indicated that the winter jujube planting soil was in healthy conditions and just slightly polluted by Co, Ni, Cu, and Cd, and they might be from some natural processes and the use of fertilizers [8]. Riverside, estuaries, and bays are seriously polluted due to developed industrial and agricultural production and intensive human activities. Three articles in this Special Issue have

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studied the heavy metal pollution in Coastal Pearl Bay of the South China Sea, Estuarine Bay of South China, and a Riverside Site of China, respectively. Yang et al. have detected the concentrations of As, Cd, Cu, Cr, Zn, and Pb in surface sediments (0–5 cm) from the twenty sites and found the coastal Pearl Bay was mainly polluted by Cd [9]. Likewise, Zhang et al. appealed that Cd pollution should receive more attention because they found that Cu, Pb, Zn, Ni, and Cr were at low levels, but Cd was high during the ecological risk assessment in the Estuarine Bay of South China. It is noteworthy that there was a great improvement in the sediment quality compared with previous research [10]. Luo et al. assessed the pollution health risk posed to humans and established a numerical model. The results showed that the soil and groundwater were all polluted and mainly concentrated in the production area of the site and the waste-residue stockpiles. The results indicated that the groundwater pollutants wholly migrate from south to north and will reach northern surface water bodies about 12 years later [11]. Machine learning is more and more widely used in environmental protection. Xia et al. successfully used machine learning to predict the heavy metal concentrations in contaminated sites from a portable X-ray fluorescence spectrometer [12]. More affirms the bright future of machine learning.

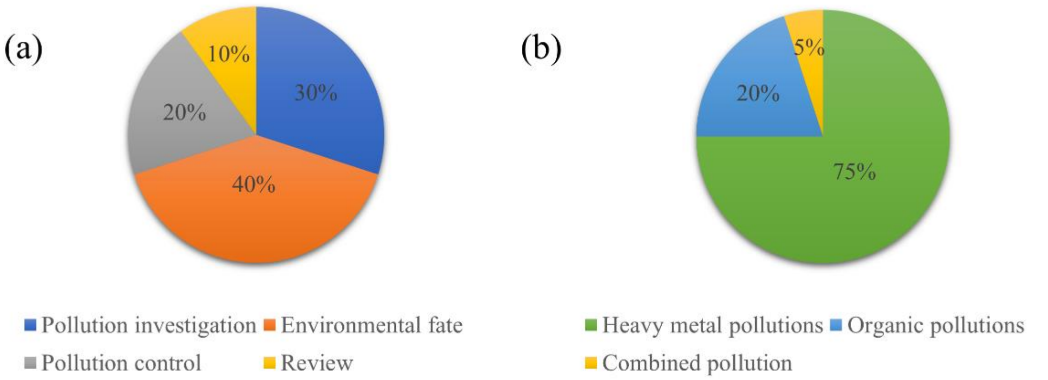

Figure 1. The classification of research in the Processes Special Issue: Advances in Remediation of Contaminated Sites. (**a**) the research fields, (**b**) the research object.

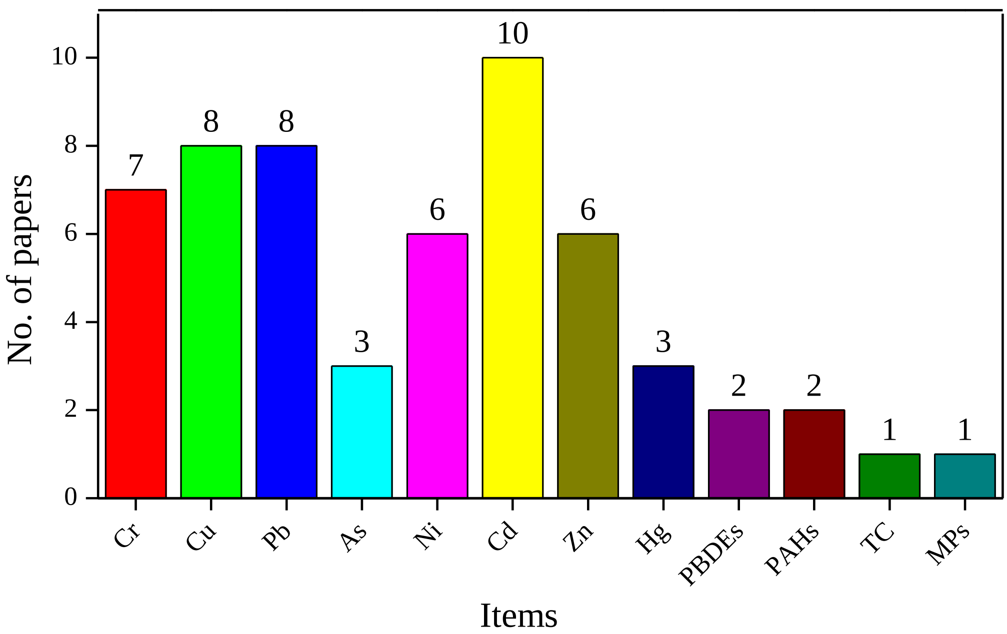

Figure 2. The investigated items of research in the Processes Special Issue: Advances in Remediation of Contaminated Sites.

The publications related to environmental fate mainly focus on migration, transformation, accumulation, and ecological risks. Qin et al. found the main heavy metals speciation and distributions in the rhizosphere and non-rhizosphere soils are similar, which means mineral-source heavy metals are the main and the exchange content is low. In addition, they found the pH value, organic matter content, and plant growth can affect the heavy metal morphological distribution in rhizosphere soil [13]. Meanwhile, they have also investigated Pb(II) accumulation and transport in different Miscanthus Floridulus from the Dabaoshan Mining Area and the non-mining area, respectively. The mining area ecotype showed stronger tolerance [14]. Wu et al. successfully established a model of Cr(VI) migration in the slag–soil groundwater system by the column experiments, and the maximum and minimum difference of measured and simulated values are 1.158 and 0.001 mg/L, respectively. Moreover, the results indicated that the chrome slag treatment improved the surrounding groundwater quality [15]. Pollution accumulation and transfer in organisms are key aspects of environmental fate. The improved ecological risk index (RI) was used by Fang et al. to investigate the effects of electroplating factories released heavy metals. They found the closure of the electroplating plant is not the end of pollution, and the heavy metals continuously spread horizontally and vertically, leading to high ecological risk [16]. This Special Issue also includes some articles on typical organic pollution sites. Chen et al. gathered soil from three typical oilfields to simulate the vertical migration of PAHs and found that pH has no discernible effect on the migration of PAHs. The migration of PAHs was closely linked with IS and soil particle size [17]. PBDEs and MPs, as emerging contaminants, receive more concern. Huang et al. have conducted BDE-209 photodegradation on a soil suspension and found that it can lead to debrominated degradation, and the soil particle, humic acid, Cu(II), and Fe(III) all inhibit its degradation [18]. Liu et al. investigated the changes in the soil properties, bacterial communities, and enzyme activities in relation to polyethylene microplastics and phenanthrene. The results indicated that the soil chemical properties, bacterial community diversity/composition, and enzymatic activities were influenced. The existence of PE has a significantly positive effect on the nitrogen cycle, and the metabolic function might lead to conspicuous alterations in urease/FDAse activities and SOM/AN contents [19]. Tao et al. studied the combined effects of tetracycline (TC) and copper pollution on a soil bacterial community and water spinach growth. The results indicated that Cu had a greater influence than TC. There was a synergistic effect at low TC concentrations and an antagonistic effect at high when the Cu concentration was fixed [20].

Pollution control and remediation, as the ultimate means of site pollution, need to be vigorously developed. This Special Issue includes four articles on pollution remediation. They all use carbon materials to remove pollutants. Zhou et al. prepared a soil passivator of iron-based biochar (T-BC) with iron tailings and urea. The volatilization of toxic metals and the formation of stable metal compounds during the co-pyrolysis process make the T-BC more safe. The results proved that the T-BC soil passivator has promising potential in the stabilization of Cd and Pb in contaminated soils [21]. Guo et al. pretreated bone char with hydrogen peroxide and then with traditional pyrolysis. They found using hydrogen peroxide-treated pyrolytic bone char to immobilize Cd(II) is feasible [22]. Ma et al. used coconut shell granular-activated carbon (GAC) to remove PBDEs from Triton X-100 (TX-100) soil-washing solution. They found GAC can effectively remove PBDEs and recover surfactants from the TX-100 solution. The π-π interaction and van der Waals interaction dominant force of GCA attract PBDEs, which were proved by Density functional theory (DFT) and FTIR [23]. Except for coconut shell biochar material, our Special Issue also received the article on biochar materials produced by rice-straw (RSB) and sugarcane bagasse (SBB). They were treated at different pyrolysis temperatures (300–600 C) for the passivation of pyrite. They found RSB is better than SBB because the Fe-O bonds formed through C=O bonding with pyrite. In addition, RSB created a reducing environment in the mixture system because of its strong electron-donation capacity (EDC) and altered the energy-band structure of pyrite, which promoted the transfer of electrons from biochar to pyrite [24].

In addition to the research articles, this Special Issue also includes two reviews. They are all publications about contamination remediation. Water pollution induced by tetracycline (TC) has received increasing global attention owing to its extensive use, environmental persistence, and potential harm to human health. Fan et al. concluded the application of magnetic composites in the removal of TC through adsorption and advanced oxidation processes (AOPs). They discussed magnetic composites (MCs) synthesis methods and the mechanisms of TC adsorption and removal. In addition, they further discussed the challenge and future perspectives in MCs-based adsorption and AOPs in removing TC [25]. Functionalized biochar, as a promising remediation material, was widely applied for cadmium pollution soil control in the last decade. Lu et al. summarized the functionalized biochar preparation technology, the heavy metal existing forms in soil, the soil cadmium contamination remediating mechanism, and the influence factors during the remediation. Finally, they discussed the latest research advances in functionalized biochar remediating cadmium contamination soil and summarized the challenges of biochar used for remediating Cd soil contamination [26].

The overview of this Special Issue highlights important knowledge gaps in the field of the remediation of contaminated sites. More extensive regions, more typical pollution, and more complex pollution should be considered in the next Special Issue, "Advances in Remediation of Contaminated Sites: Volume II". We thank all the contributors and the Editor-in-chief for their enthusiastic support of the Special Issue and the editorial staff of Processes for their effort.

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