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EDITORIAL

POLSOIL: research on soil pollution in China

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Soil is the foundation for terrestrial ecosystem and also a primary basis for agricultural production. On the other hand, soil is a primary sink in the environment for various contaminants due to its strong binding capacity. Sources for soil pollution include dry and wet precipitation from the atmosphere, discharge of wastewaters, sewage irrigation, use of pesticides and fertilizers, sludge amendment, mining, and stacking of solid wastes. When entering soil, the contaminants might have posed adverse effects not only to terrestrial ecosystem but also to human beings due to the transfer via food chain.

China has experienced increasing industrialization, heavy agricultural activities, and rapid urbanization during the past 30 years. Environment management has lagged behind the development of economy, and large amounts of anthropogenic chemicals have entered soil, threatening the safety of terrestrial ecosystem and agricultural production.

To control the hazardous effects of soil pollution, the following knowledge or technology are required; (1) pollution level, profiles, and source of contaminants in soil in a specific area; (2) transfer and transformation of a specific contaminant so as to elucidate its fate and bioavailability besides its toxicity; (3) remediation technology incorporating the removal of contaminants and protecting the soil functions.

Distribution and source apportionment of contaminants in soil A nationwide survey on soil pollution was conducted during 2005–2012 in China. The number of sites was sparse and the number of pollutants investigated was limited, and correspondingly, the results may underestimate the situation or mislead an overview evaluation. According to the bulletin of the survey, 16.1% of the investigated sites did not meet the standard for one or more indices and 82.8% of the above sites were caused by inorganic pollutants, mainly heavy metals. Generally, investigation on soil pollution level in China is lack and should be strengthened in future to give an accurate evaluation on soil pollution. To quantitatively analyze the contribution of different sources to a specific contaminant in soil is prerequisite for an accurate pollution control. To meet this demand, several models have been developed. In this special issue, Pan et al. (2017) has investigated the pollution level of organophosphate pesticides in agricultural soils from the Yangtze River Delta of China, and the results showed that pollution of this kind of pesticide is slight mainly due to their high degradability. Currently, the pollution level of organochlorine pesticides has generally decreased after a long period of prohibition, while the pollution of phthalate esters (PAEs) has increased due to the wide application of plastic film. High concentrations of PAEs were found in soils (109 to 5560 ng/g) and vegetables (60.1 to 2390 ng/g) in eastern China (Sun et al. 2017a). The application of biosolids was found to be the main reason for soil pollution of heavy metals and antibiotics in agricultural farmland (Yang et al. 2017).

Transfer and transformation The transfer and transformation of a contaminant in soil are crucial processes to determine the fate of the contaminant in soil environment. However, due to the complexity of soil constituents, the transfer and transformation of contaminants in soil are not well understood. Heavy metals exist in soil as various speciations due to the interaction with different components of soil particles. The speciation of heavy metals changes greatly with soil properties, e.g., pH, cation exchange capacity, (dissolve) organic carbon content, and clay content, which influences the bioavailability of heavy metals. As for organic contaminants, besides sorption-desorption, which determines their combination state and bioavailability, organic contaminants can be degraded by chemical and biological processes. In this research field, the recognition of metabolites is always with challenge and has become a research hotspot recently. Previously, plant uptake of organic contaminants has been seldom studied because most traditional organic contaminants are hydrophobic and their bioavailability to plant is low due to the strong sorption by soil particles. Recently, it was found that plants not only can absorb but also are able to metabolize organic contaminants, which have drawn much research interest. In this special issue, the uptake, translocation, and metabolism of hydroxylated and methoxylated polychlorinated biphenyls in various crop plants were studied (Sun et al. 2017b). It was found that both methylation and demethylation occurred mainly in the roots and the metabolites were translocated within the plants. Yang et al. (2017) examined the dissipation of antibiotics (tetracyclines, sulfonamides, fluoroquinolones, and macrolides) derived from the application of biosolids in agricultural field and found that the predicted half-lives of antibiotics were up to 3.69 years; hence, antibiotics can accumulate in farmland due to repeated application of biosolids. Heavy metals in

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biosolids prohibited the biodegradation of antibiotics due to their toxicity to microorganisms.

Remediation Several soil remediation technologies have been developed during the past 30 years. Thermo-desorption is the most frequently used physical technology for a polluted site with multiple organic contaminants in China. Degradation of organic pollutants by microorganisms has drawn much research interest due to its friendliness to soil ecosystem and low cost. However, the efficiency of biodegradation is usually prohibited by low bioavailability of the target contaminant and formidable environment either lacking nutrients or being toxic for the growth of active species. Addition of surfactants has been proven to be an efficient way to enhance the bioavailability of the sorbed contaminants. Chemical oxidations, especially advanced chemical oxidation using oxidants such as Fenton reagent, ozone, permanganate, and persulfonate, have stronger capacity to destroy organic contaminants compared to biotechnology. The main drawback of chemical oxidation is the adverse effects to soil ecosystem and hence is not recommended to be used on a large scale. As for heavy metals, fixation by different types of adsorbents is the primary approach adopted for the remediation of heavy metal pollution in farmland in China. To elevate the cleanup efficiency of heavy metals from farmland soil, plants with high accumulation capacity, i.e., hyperaccumulators are sometimes inter-planted (Wu et al. 2017). Other available remediation approaches include electro-dynamics and reduction by (nano) zero-valent iron, etc. Biochar, which is obtained by pyrolyzing biomass residue under limited or zero oxygen, is recognized as a promising soil amendment of multiple functions, e.g., fixation of carbon, improvement of soil fertility, inhabiting of microorganisms, and adsorption of contaminants. More recently, biochar was found to be able to catalyze hydrolysis of pesticides and promote oxidation or reduction of contaminants by accelerating electron transfer (Jia et al. 2017). In this special issue, a novel immobilizing agent, hydrozyapatite nanoparticles, was developed to promote the growth of plants and inhibit the plant uptake of heavy metals by forming solid amorphous phosphate (Sun et al. 2017c). Biosurfactants (saponin and alkyl polyglycoside) showed greater efficiency to enhance the removal of dichlorobenzene than chemical surfactant Tween 80 (Pei et al. 2017). Ma et al. (2017) found that the addition of modified peanut shell powder could favor both amended microorganism and native biodiversity, hence promoting the removal of polycyclic aromatic hydrocarbons in a field macrocosm experiment. Biochar goes through series of changes after it is incubated with soil, which depends much on the structure of the original biochar (Lin et al. 2017). Ren et al. (2017) found that the structure and sorption capacity of biochar changed due to the interaction with soil constituents and the sorption capacity for organic chemicals changed dynamically with the aging time. The results provide important information on the proper use of biochar technology.

In order to improve soil pollution control, Chinese State Council issued Action Plan of Soil Pollution Control in May 2016. The plan includes ten aspects concerning soil pollution control, which is commonly named as “Soil Ten Items” in China. The research concerning soil pollution control in China will be emphasized more in the future.

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In the recent decade, he has achieved a series of innovative outcomes in the field of multimedia interfacial behavior and regulation technologies for organic pollutants, with mitigation and restoration of soil organic pollution. The molecular mechanisms of non-linear behavior at the multimedia interface of organic pollutants and the associated principles of regulation and control technologies have been illuminated. His group has developed a new method for surfactant-enhanced sorption and fixation of organic pollutants in soil, while preventing their uptake and accumulation. Additionally, his group has developed the surfactant-enhanced bioremediation (SEBR) techniques for soils/sites contaminated with organic pollutants.

Professor Zhu has published four books and more than 360 papers in Chinese or international journals, 215 of which are indexed by SCI. He was awarded a second class prize of the State Scientific and Technological Progress Award and a second class prize of the State Natural Science Award.

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