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Co-pyrolysis of Sludge and Kaolin/Zeolite to Stabilize Heavy Metals

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Abstract : Sewage sludge, a typical solid waste, has inevitably been produced in enormous quantities in China. Still worse, the amount of sewage sludge produced has been increasing due to rapid economic development and urbanization. Compared to the conventional method to treat sewage sludge, pyrolysis has been considered an economic and ecological technology because it can significantly reduce the sludge volume, completely kill pathogens, and produce valuable solid, gas, and liquid products. However, the large-scale utilization of sludge biochar has been limited due to the considerable risk posed by heavy metals in the sludge. Heavy metals enriched in pyrolytic biochar could be divided into exchangeable, reducible, oxidizable, and residual forms. The residual form of heavy metals is the most stable and cannot be used by organisms. Kaolin and zeolite are environmentally friendly inorganic minerals with a high surface area and heat resistance characteristics. So, they exhibit the enormous potential to immobilize heavy metals. In order to reduce the risk of leaching heavy metals in the pyrolysis biochar, this study pyrolyzed sewage sludge mixed with kaolin/zeolite in a small rotary kiln. The influences of additives and pyrolysis temperature on the leaching concentration and morphological transformation of heavy metals in pyrolysis biochar were investigated. The potential mechanism of stabilizing heavy metals in the co-pyrolysis of sludge blended with kaolin/zeolite was explained by scanning electron microscopy, X-ray diffraction, and specific surface area and porosity analysis. The European Community Bureau of Reference sequential extraction procedure has been applied to analyze the forms of heavy metals in sludge and pyrolysis biochar. All the concentrations of heavy metals were examined by flame atomic absorption spectrophotometry. Compared with the proportions of heavy metals associated with the F4 fraction in pyrolytic carbon prepared without additional agents, those in carbon obtained by co-pyrolysis of sludge and kaolin/zeolite increased. Increasing the additive dosage could improve the proportions of the stable fraction of various heavy metals in biochar. Kaolin exhibited a better effect on stabilizing heavy metals than zeolite. Aluminosilicate additives with excellent adsorption performance could capture more released heavy metals during sludge pyrolysis. Then heavy metal ions would react with the oxygen ions of additives to form silicate and aluminate, causing the conversion of heavy metals from unstable fractions (sulfate, chloride, etc.) to stable fractions (silicate, aluminate, etc.). This study reveals that the efficiency of stabilizing heavy metals depends on the formation of stable mineral compounds containing heavy metals in pyrolysis biochar.

Keywords : co-pyrolysis, heavy metals, immobilization mechanism, sewage sludge
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