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In situ Immobilization of Mercury in a Contaminated Calcareous Soil Using Water Treatment Residual Nanoparticles

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Abstract : Mercury (Hg) is one of the most toxic and bio-accumulative heavy metal in the environment. However, cheap and effective in situ remediation technology is lacking. In this study, the effects of water treatment residuals nanoparticles (nWTR) on mobility, fractionation and speciation of mercury in an arid zone soil from Egypt were evaluated. Water treatment residual nanoparticles with high surface area (129 m 2 g-1) were prepared using Fritsch planetary mono mill. Scanning and transmission electron microscopy revealed that the nanoparticles of WTR nanoparticles are spherical in shape, and single particle sizes are in the range of 45 to 96 nm. The x-ray diffraction (XRD) results ascertained that amorphous iron, aluminum (hydr)oxides and silicon oxide dominating all nWTR, with no apparent crystalline iron–Al (hydr)oxides. Addition of nWTR, greatly increased the Hg sorption capacities of studied soils and greatly reduced the cumulative Hg released from the soils. Application of nWTR at 0.10 and 0.30 % rates reduced the released Hg from the soil by 50 and 85 % respectively. The power function and first order kinetics models well described the desorption process from soils and nWTR amended soils as evidenced by high coefficient of determination (R2) and low SE values. Application of nWTR greatly increased the association of Hg with the residual fraction. Meanwhile, application of nWTR at a rate of 0.3% greatly increased the association of Hg with the residual fraction (>93%) and significantly increased the most stable Hg species (Hg(OH)2 amor) which in turn enhanced Hg immobilization in the studied soils. Fourier transmission infrared spectroscopy analysis indicated the involvement of nWTR in the retention of Hg (II) through OH groups which suggest inner-sphere adsorption of Hg ions to surface functional groups on nWTR. These results demonstrated the feasibility of using a low-cost nWTR as best management practice to immobilize excess Hg in contaminated soils.

Keywords : release kinetics, Fourier transmission infrared spectroscopy, Hg fractionation, Hg species
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