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**Effects of nanoparticles and modified clays on Cd, Cu, Ni and Zn release from sewage sludge-amended soil assessed through a kinetic study**

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**Abstract**

The objective of this study was to evaluate the kinetic release (0.5-88 h extraction) and fractionation of cadmium (Cd), copper (Cu), nickel (Ni) and zinc (Zn) in a soil amended with sewage sludge (SS) from Arak (SA), Rasht (SR) and Shiraz (SSh), in presence of zeolite and bentonite modified clays (MCs) and ZnO and MgO nanoparticles (NPs). The initial release of potentially toxic elements (PTEs) occurred rapidly during 1 to 4 h followed by a slower rate. The amount of Cd released in the soil+SA, soil+SR and soil+SSh was 2.44, 2.61 and 2.53 mg kg<sup>-1</sup>, respectively while when the adsorbents were added to this mixtures it was in the range of 1.33-2.07, 1.52-2.49 and 1.5-2.08 mg kg<sup>-1</sup>, respectively. The amount of Cu released decreased from 5.07, 6.06 and 5.11 mg kg<sup>-1</sup> in the soil+SA, soil+SR and soil+SSh to the ranges of 2.72-2.07, 3.51-5.06, 2.68-3.24 mg kg<sup>-1</sup> in presence of adsorbents. Also, the release of Ni and Zn was significantly affected by the presence of MCs and NPs. The release kinetics of Cd, Cu and Ni were described well by pseudo-second-order equation. Also, the exchangeable fraction of the PTEs in the SS-amended soil was reduced in presence of NPs and MCs as the MgO NP had the

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