The Adsorption Behavior of Cu^{2+} and Cd^{2+} in Soils and Soils Amended with Different Organic Agricultural Waste Substances

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Introduction

Heavy metal such as cadmium and copper contamination of soils is a result of industrial and agricultural activities activities. These substances are characterized by high toxicity (carcinogenic properties) and non-biodegradability, which leads to their bio-accumulation and concentration throughout the food chain. Sorption is a major process responsible for the fate of heavy metals in soils, since the mobility of heavy metals is directly related to their partitioning between the soil solid phase and soil solution. The sorption behavior of Cd, and Cu in soils varies from soil to soil and is influenced by soil properties, such as pH, organic matter, cation exchange capacity (CEC), and clay content.

Objectives

- Study the adsorption behavior of cadmium and copper in soils of varying physical and chemical properties using batch technique
- Study the impact of adding different organic agricultural amendments (pomegranate peel, and palm leaves) on the adsorption of the heavy metals in soils

Materials and Methods

- Three bulk soil samples were collected from different regions of Jordan (Karak and Ajlun Governorates) to cover a range of variability of physical and chemical
- Batch sorption experiments were carried out to study the adsorption behavior of cadmium and copper by three soils and by the same soils amended with pomegranate peel and date-palm stems and leaves
- The effect of initial concentration, effect of sorbate concentration, and effect of organic amendments content were investigated

Results and Discussion

Soils Characterization

Soil	pH	EC (dS/m)	OC (%)	$CaCO_3$ (%)	Fe oxides (g/kg)	CEC($cmol_{(+)}$/kg)	Clay %
Karak1	8.12	0.259	0.53	33	10.7	38.5	56
Karak2	8.25	0.234	0.53	28	7.6	28.8	44
Ajlun	7.63	0.209	1.79	3.5	32.3	52.7	69

Isotherms of Cadmium and Copper Adsorption onto Soils

Cadmium and copper adsorption on K1, K2, and Aj soils increased with the increasing initial concentration (Figure 1). Cd^{2+} adsorption by K1, and K2 soils was higher than that by Aj soil from 5 to 150 mg/L. Cadmium removal percentage was in the range of 49- 59.5% at the highest concentration This is despite that Aj soil has a higher organic matter, CEC, iron oxides, and clay content than K1, and K2 soils. Copper adsorption on K1, K2, and Aj soils increased with the increase in the initial concentration of Cu^{2+} from 1 to 175 mg/L. The values of maximum qe were approximately the same for three soils (4.36 mg/g) with a removal percentage more than 99 % at the highest concentration for all soils.

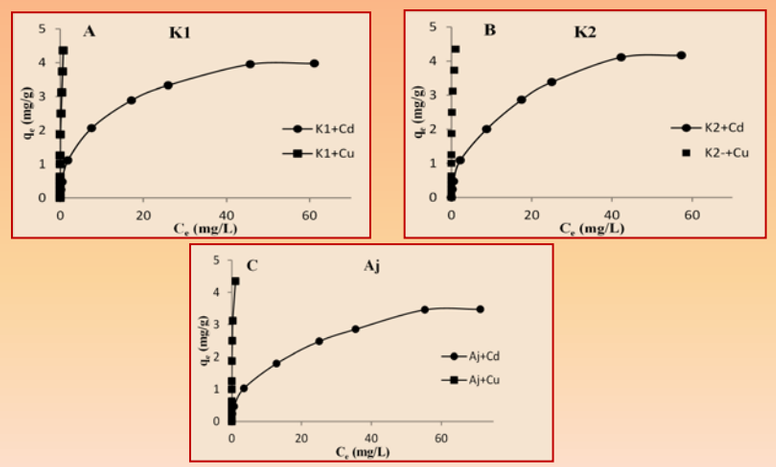


Figure 1. Adsorption isotherms of Cd^{2+} and Cu^{2+} on: A: Karak1 soil; B: Karak2 soil; C: Ajlun soil at different initial concentrations

Isotherms of Cadmium and Copper Adsorption on soil amended with Pomegranate Peel (PP)

Cadmium and copper adsorption on soils amended with 10 percent pomegranate peel (PP) is shown in Figure 3. The initial concentration used for adsorption of Cd^{2+} on all amended soils (K1, K2, and Aj) was in the range 0-200 mg/L. However, for the adsorption of Cu^{2+} on the amended soils, the initial concentration used for K1, and K2 soils was 0-300 mg/L, while it was 0-500 mg/L for Aj soil. The values of maximum q_e for the adsorption of Cd^{2+} on the three amended soils were: 5.05, 4.24, and 4.15 mg/g for Aj-PP, K1-PP, and K2-PP, respectively. The maximum q_e values for the adsorption of Cu^{2+} on the three amended soils were: 8.58, 7.28, and 7.23 mg/g for Aj-PP, K1-PP, and K2-PP, respectively.

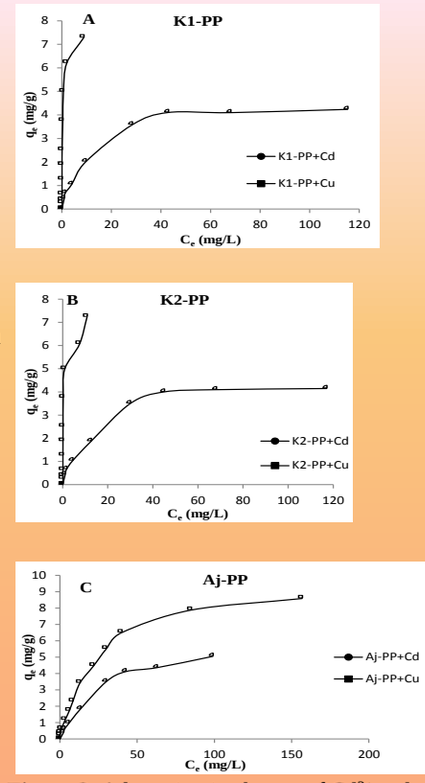
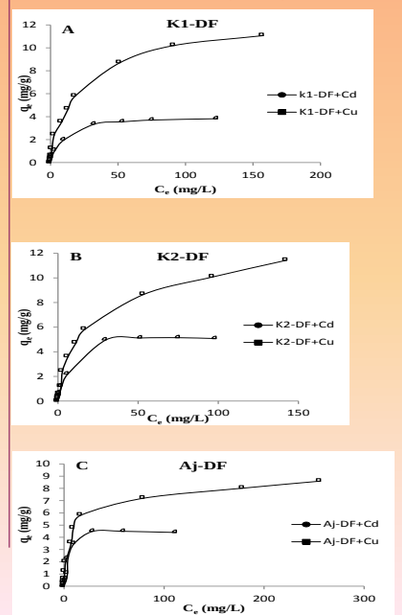


Figure 3. Adsorption isotherms of Cd^{2+} and Cu^{2+} on soils amended with PP.

Isotherms of Cadmium and Copper Adsorption on Soils Amended wit Date Fronds (DF)



Cadmium and copper adsorption on soils amended with 10 percent date fronds is shown in Figure 4. The values of maximum q_e for the adsorption of Cd^{2+} were 3.82, 5.07, and 4.39 mg/g for K1-DF, K2-DF, and Aj–DF soils, respectively. The maximum q_e values for the adsorption of Cu^{2+} were: 11.06, 11.43, and 8.60 mg/g . There was an increased 5 to 6 times after mixing the soil with DF . The adsorption after mixing the soils with date fronds was variable; it decreased slightly for K1-DF (3.82 mg/g), but increased for K2, and Aj amended soils to be 5.07, and 4.39 mg/g, respectively.

Figure 4. Adsorption isotherms of Cd^{2+} and Cu^{2+} on soils amended with DF .