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The adsorption mechanisms of heavy metal ions by meadow soil

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Soil is one of the key elements for all terrestric ecosystems. The ability of soils to adsorb metal ions from aqueous solution is of special interest and has consequences for agricultural issues as remediation of polluted soils. The aim of this work was to study the mechanisms of copper and zinc adsorption by meadow soil in the Rostov region (Russia). To study the ion-exchange adsorption of the Cu^{2+} and Zn^{2+} cations, the soil in the natural ionic form was disaggregated using a pestle with a rubber head and sieved through a 1mm sieve. The soil samples were treated with solutions of Cu^{2+} and Zn^{2+} nitrates at the separate presence of metals. The concentrations of the initial solutions were 0.05, 0.08, 0.1, 0.3, 0.5, 0.8 and 1.0 mM L^{-1}. The soil:solution ratio was 1:10. The suspensions were shaken for 1 h, left to stand for 24 h, and then filtered. The contents of the metals in the filtrates were determined by atomic absorption spectrometry. The contents of adsorbed cations were calculated from the difference between the metal concentrations in the initial and equilibrium solutions. The isotherm of Cu^{2+} and Zn^{2+} adsorption by meadow soil from nitrate solutions is described by the Langmuir equation:

$$C_{ad} = C_{\infty}K_lC_e / (1 + K_lC_e), \quad (1)$$

where Cad is the amount of adsorbed cations, C_{∞} is the maximum adsorption, mM kg^{-1}, C_e is the concentration of the metal in the equilibrium solution, mM L^{-1} and K_l is the Langmuir constant, L mM^{-1}.

According to the binding strength (constant value Ðš$_l$) to the meadow soil, the studied cations form the series Cu^{2+} (103.7±6.3) >> Zn^{2+} (3.9±0.4). The specific interaction with the soil exchangeable complex could be more typical for the adsorption of Cu^{2+} by the soil than for the adsorption of Zn^{2+}. The obtained regularity also coincides with the order of the change in the electronegativity of the metals. The higher the electronegativity of a metal, the stronger its interaction with the surface of the soil particles, which results in the formation of stronger bonds with the surface functional groups. The values of the maximum adsorption (Ð$_{i\infty}$) for Cu^{2+} and Zn^{2+} decrease in the same order as the constants, but not so significantly: Cu^{2+} (13.2±0.4) > Zn^{2+} (3.9±0.4). Thus, the maximum adsorption, an extensive characteristic of the adsorption, is a less sensitive parameter than the equilibrium constant of adsorption K_l, an intensive characteristic of the process.

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