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The role of particle-size soil fractions in the adsorption of heavy metals

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Ion-exchange adsorption phenomena are important in the immobilization of heavy metals (HMs) by soils. Numerous works are devoted to the study of this problem. However, the interaction features of different particle-size soil fractions and their role in the immobilization of HMs studied insufficiently. Therefore, the assessment of the effect of the particle-size distribution on the adsorption properties of soils is a vital task. The parameters of Cu^{2+}, Pb^{2+} and Zn^{2+} adsorption by chernozems of the south of Russia and their particle-size fractions were studied. In the particle-size fractions separated from the soils, the concentrations of Cu^{2+}, Pb^{2+}, and Zn^{2} decreased with the decreasing particle size. The parameters of the adsorption values of k (the constant of the affinity)and C_{max}.(the maximum adsorption of the HMs) characterizing the adsorption of HMs by the southern chernozem and its particle-size fractions formed the following sequence: silt > clay > entire soil. The adsorption capacity of chernozems for Cu^{2+}, Pb^{2+}, and Zn^{2+} depending on the particle-size distribution decreased in the following sequence: clay loamy ordinary chernozem clay loamy southern chernozem> loamy southern chernozem> loamy sandy southern chernozem. According to the parameters of the adsorption by the different particle-size fractions, the heavy metal cations form a sequence analogous to that obtained for the entire soils: $Cu^{2+} \geq Pb^{2+} > Zn^{2+}$. The parameters of the heavy metal adsorption by similar particle-size fractions separated from different soils decreased in the following order: clay loamy chernozem> loamy chernozem> loamy sandy chernozem. The analysis of the changes in the parameters of the Cu^{2+}, Pb^{2+}, and Zn^{2+} adsorption by the studied soils and their particle-size fractions showed that the extensive adsorption characteristic – the maximum adsorption (C_{max}.) – is a less sensitive parameter characterizing the adsorption capacity of the soils than the intensive characteristic of the process – the adsorption equilibrium constant (k).The ratio between the content of exchangeable cations displaced from the soil adsorbing complex (SAC) into the solution and the content of adsorbed HMs decreased with the increasing concentration of adsorbed HMs. These values could be higher (for Cu^{2+} and Pb^{2+}), equal, or lower than 1 (for Zn^{2+}) and depend on the properties of HMs. At the first case, this was due to the dissolution of readily soluble salts at low HM concentrations in the SAC. In the latter case, this was related to the adsorption of associated forms HMs and the formation of new phases localized on the surface of soil particles at high HM concentrations in the SAC. Soil solution equilibrium (SSE) accords to the soil fine fraction composition. SSE thermodynamics causes the ratio of free and associated forms of ions and ion's activity in soil solution influencing composition, concentration and adsorption of HMs salts by SAC.

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