ABSTRACT

Metal pollution in the environment has been one of the most current world-wide interest, which poses a large danger for environment and threats serious disease for human beings due to their bioaccumulation and toxicity. Therefore, many treatment methods have been developed to remove these pollutants. Adsorption methods, where a wide range of mineral and organic sorbents are the most popular. One of the alternative metal sorbent might be groundwater treatment residuals (GWTRs) that are by-product generated during drinking water treatments. Currently, GWTRs after dewatering and drying are deposited in landfills located at water treatment plants, however there is crucial to find an achievable management option for GWTRs which might prove to be beneficial both in terms of environmental safety and economy.

The aim of the research conducted as part of the doctoral thesis was to analyze the phase, chemical composition, and physicochemical properties of GWTRs and determine sorption properties toward selected metals. To analyze the GWTRs following methods were used: X-Ray diffraction (XRD), X-ray fluorescence (XRF), Fourier transform infrared spectroscopy (FTIR), thermogravimetric, differential thermogravimetric, and differential thermal analysis (TG, DTG, and DTA, respectively), scanning electron microscopy (SEM) with energy dispersion spectroscopy (EDS), inductively coupled plasma optical emission spectrometry (ICP-OEP), photoelectron spectroscopy(XPS) specific surface area (BET) measurement, and determination of isoelectric point (pH_{IEP}). Furthermore author prepared a study that is a critical review of the literature, where WTRs have been described as heavy metals sorbents. Another objectives of the doctoral thesis was to determination of the sorption capacity of GWTRs toward following metals: Cd(II), Cu(II), Pb(II), Zn(II), and Cr(III), determining the effect of contact time, initial metal concentration, temperature and pH on metal sorption efficiency. The other goal was , modeling of adsorption equilibrium data, determination of sorption kinetic and thermodynamic of sorption parameters. To determine the sorption mechanisms, the characteristic of GWTRs after sorption were performed using following instrumental methods: XRD, FITR, SEM-EDS and XPS.

According to the results, GWTRs demonstrate amorphous character that are predominantly composed of ferrihydrite with minor quartz and calcite admixtures. They are mainly composed from iron (32-55% Fe_2O_3), silicon (4-28% SiO_2) and calcium compounds (4-17% CaO). The GWTRs particles have irregular shape and variable size and tend to form aggregates, that are a few micrometers in size. The contribution of trace elements such as As, Ba, Sr, Zn, Cr, or Sr are relatively low and similar to those in soils, and most metals and

metalloids occur in stable forms. GWTRs found to be mesoporous material (adsorption isotherm type II and type IV with a hysteresis loop type H3) with a relatively large specific surface area (49 – 246 m^2/g). Isoelectric point values range from pH 4.0 to 4.5.

GWTRs demonstrate good adsorption properties toward heavy metals comparable with commercially used sorbents.

. GWTRs are sorbing from tens to up to 230 g of metal by kg of sorbent. The optimal sorption conditions are pH 5-8, reaction time 4-5 hours, and temperature 25°C. Pseudo-second-order model best describes the results of kinetic data, suggesting that chemisorption is the dominant mechanism of metal immobilization. The Langmuir isotherm illustrate the equilibrium data of the meal-sorbent much better than the Freundlich, Temkin and Dubinin-Radushkevich isotherm models. Thermodynamic data suggested that sorption is random, feasible, and endothermic. Metals were removed from the solution through the process of inner-sphere adsorption on the surface of the precipitate, coprecipitation with iron compounds and incorporation into the ferrihydrite structure or precipitation in the form of their own mineral phases, such as carbonates, metal oxides or hydroxides.

The research revealed the nature of GWTRs and also proved that they can be effectively used in sorption processes. The results of these studies can be applied in environmental protection, both in the possible option management of waste and water treatment.

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