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Drinking water treatment plant sludge as a potential adsorbent for the removal of Cadmium in wastewater

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Water pollution by heavy metals is a critical environmental issue that causes the deterioration of both human and ecosystem health. Cadmium (Cd^{2+}) is a heavy metal that is non-biodegradable and bioaccumulated through food chains. It also acts as a severe human carcinogen. Adsorption is an effective wastewater treatment method for removing heavy metals from wastewater which is limited due to the high cost of conventional adsorbents. In Sri Lanka, drinking water treatment plant sludge is being produced in large quantities and disposed on landfills without proper usage and exacerbating solid waste problems. The present study investigated the potential of using drinking water treatment plant sludge for the removal of Cd^{2+} by adsorption from wastewater. The effect of pH, initial Cd^{2+} concentration, and contact time on adsorption of Cd^{2+} onto drinking water treatment plant sludge was examined. Adsorption isotherm studies and kinetic studies were carried out to describe the adsorption mechanism of Cd^{2+} onto drinking water treatment plant sludge. The Langmuir and Freundlich isotherm models were used for isotherm studies. The pseudo first-order and pseudo second-order models were used in kinetic studies. The experiments on effect of pH on adsorption of Cd^{2+} in the range of pH 3 - 8 showed that adsorption is maximum when medium is basic (pH 7-8). The experiments on effect of initial Cd^{2+} concentration on adsorption showed that with the increase in initial Cd^{2+} concentration (2.5 – 100 mg L^{-1}), the adsorption capacity of drinking water treatment plant sludge increased reaching to a maximum adsorption capacity of 14.6 mg g^{-1}. Cd^{2+} was well fitted to the Langmuir isotherm model indicating monolayer adsorption on a homogeneous adsorbent surface with identical active sites. The experiments on effect of contact time on adsorption showed that adsorption of Cd^{2+} onto drinking water treatment plant sludge increased with the increase in contact time and then reached the equilibrium within 4 hours of contact time. The kinetic studies showed that adsorption of Cd^{2+} onto drinking water treatment plant sludge was well described by both pseudo first-order model (R^2= 0.9633) and pseudo second-order model (R^2=0.9334) indicating that both chemical and physical adsorption contribute to the adsorption of Cd^{2+} onto drinking water treatment plant sludge. Therefore, this study proves that drinking water treatment plant sludge is an effective, low-cost adsorbent for removing Cd^{2+} in wastewater. Therefore, future studies are required to be conducted on the field scale application of drinking water treatment plant sludge which will be beneficial for cost-effective wastewater treatment, especially in developing countries.

Keywords: Adsorption, Heavy metals, Isotherm models, Kinetic models, Wastewater treatment