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Adsorptive Removal of Heavy Metals from Urban Storm Water Run-off

Master of Science Thesis

by

Devendra Yadav

Abstract

In recent years, increasing awareness of the environmental impact of the heavy metals has prompted a demand for the purification of urban storm water run-off prior to discharge into recipients mains natural water courses. Conventional methods of treatments such as coagulation- filtration, precipitation of metal hydroxides, ion exchange and reverse osmosis does not seem to be feasible owing to their high investment and operation and maintenance cost. Further these treatment methods produce large volume of toxic waste which needs further treatment. Adsorption has advantage over conventional treatment methods, being sludge free, its design is simple and involves lower capital and operation and investment cost as compared to other advance treatment technologies e.g. reverse osmosis.

This study investigated the adsorption of selected dissolved heavy metals like Cr (VI), Cr (III), cadmium and copper on iron oxide based adsorbents like Iron Oxide Coated Sand (IOCS) and commercially available products like Granular Ferric Hydroxide (GFH). Both batch adsorption and Rapid Small Scale Column Test were carried out in laboratory. Heavy metals removal efficiency with these iron oxide based adsorbents was carried out as a function of adsorbents dosage, contact time, initial heavy metals concentration and pH.

Batch adsorption results showed that Cr (III), Cr (VI) and Cu can be removed effectively with GFH. The Freundlich isotherms constant (K in mg/g) for Cr (III), Cr (VI) and Cu were found to 1.97, 6.52 and 26.86 respectively. IOCS can remove all studied heavy metals including Cd. The Freundlich isotherm constants (K) for Cr (III), Cr (VI), Cu and Cd were 67.25, 0.52, 24.49 and 2.01 respectively. It was found that GFH is more efficient for Cr (VI) removal than Cr (III). On contrary IOCS showed better removal of Cr (III) than Cr (VI). Removal of copper with GFH is more effective than with IOCS. There was no removal of cadmium with GFH where as cadmium can be removed with IOCS. Result obtained in batch adsorption experiments were fitted in Lagergren first order and pseudo second order kinetic models. The result obtained suggests that the adsorption kinetics seems to follow the pseudo second order kinetic model.

Experimental results of Rapid Small Scale Column Test showed the similarity with result obtained in batch adsorption experiments. The adsorption capacity of GFH for Cr (III), Cr (VI) and Cu were found to be 1.12, 25.68 and 17.86 mg/g at a breakthrough of 95%. Similarly adsorption capacity of IOCS Cr (III), Cr (VI), Cu and Cd were found to be 57.81, 6.49, 15.95 and 6.70 mg/g at a breakthrough of 95%.

Mechanism of removal of Cr (III) and Cu with GFH at pH of 6.0 could not be explained on the basis of electrostatic attraction. The removal of Cr (III), Cu and Cd with IOCS is supported by the electrostatic attraction. Removal of Cr (VI) with GFH is likely to be the electrostatic attraction and ligand exchange where as the removal of Cr (VI) with IOCS is likely to be the bridging effect of Ca^{2+} ions between negatively charged Cr (VI) species and the negatively charged surface of IOCS.

Based on the experimental results use of IOCS is advantageous for treatment of specifically cadmium containing urban storm water run-off.

Key words: Storm water, urban-runoff, adsorption, heavy metals, chromium (III), chromium (VI), cadmium and copper removal, GFH, IOCS, adsorption isotherm, Rapid small scale column test.