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Title of the Thesis: Physico-chemical and toxicological studies of ground water samples and water bodies in rural areas of Delhi and removal of toxic elements using different adsorbents.

Abstract

This thesis contains mainly eight chapters, **the first and second chapter** describes introduction about ground water, groundwater pollution, heavy metals, its toxicity, removal of heavy metals from aqueous solutions and its literature review. **In third chapter,** the hydrogeology and sampling locations in rural areas of Delhi are described. Various physico-chemical parameters for drinking purpose have been explained briefly. The ground water quality for irrigation purposes like Salinity, SAR, Percent sodium, Kelly's Index (KI), Residual sodium carbonate (RSC), Chloroalkaline indices and Permeability Index (PI) had also been presented. Preparation of biosorbent for the removal of toxic metals through batch mode with their equilibrium and kinetic studies are also given. The objective of this work is to evaluate the contamination of groundwater and water bodies in rural areas of Delhi and the removal of heavy metal using different adsorbents.

In fourth chapter, "Hydrochemical investigation and quality assessment of ground water in rural areas of Delhi, India", the suitability of groundwater quality for drinking and agricultural purposes was assessed based on various water quality parameters. A total of 50 ground water samples were collected randomly from different sources viz. hand pump, tube well, boring and analyzed for major ion chemistry to understand the operating mechanism of geochemical processes for ground water quality. The quality analysis is performed through the estimation of pH, EC,TDS, total hardness, total alkalinity, sodium, potassium, chloride, nitrate, sulphate, DO, BOD, Cu, Cr, Cd, Ni, Zn and Pb. Hydrochemical facies were identified using Piper, Durov and Chadha diagram. Chemical data were also used for mathematical calculations (SAR, %Na, RSC, PI, KI, and chloroalkaline indices) for better understanding the suitability of ground water for irrigation purposes. The results of saturation index shows that all the water samples were supersaturated to undersaturated with respect to carbonate minerals and undersaturated with respect to sulphate and chloride minerals. According to USSL diagram, most of the samples fall in the field of C_3S_1, indicating medium salinity and low sodium water which can be used for almost all types of soil with little danger of exchangeable sodium. Assessment of water samples from various methods indicated that majority of the ground water in the study area is chemically suitable for drinking and agricultural uses.

In fifth chapter, for the **"Role of Azadirachta indica (Neem) Biomass in the Removal of Ni(II) from Aqueous Solution",** neem leaves fresh(NLF), neem leaves activated(NLA), leaves ash(LA), neem bark fresh(NBF) and neem bark activated(NBA) were used for adsorption studies. Neem leaves and neem bark were activated by giving heat treatment and with the use of concentrated sulphuric acid. Batch adsorption technique was carried out as a function of contact time, pH of the solution, biosorbent dose, and metal concentration. The adsorption efficiencies were found to be pH dependent, which increase by increasing the pH of the solution in the range from 2 to 7. The equilibrium time was attained after 2 h and maximum removal was achieved at an adsorbent loading weight of 2 g. The decrease in the removal was attained by increasing metal concentration. Maximum biosorption capacity for Ni(II) was 95% at the pH of 7. FTIR spectroscopy confirmed neem biomass interaction responsible for Ni(II) adsorption. The equilibrium adsorption data were interpreted by using both langmuir and freundlich isotherms. The isotherm values fitted well with correlation coefficient (R^2) values.

The sixth chapter "Adsorption of Zinc (II) and Nickel (II) from aqueous solution using Syzygium aromaticum (cloves): Kinetic and isotherm studies", deals with the adsorption of Zn(II) and Ni(II) onto cloves (*Syzygium aromaticum*) from aqueous solution under different process conditions. The adsorption was carried out in a batch process taking different concentrations of the metal ion in aqueous solution with variation in adsorbent dose, pH and agitation time. The solution initial pH values affected metal sorption. Over the pH range of 6 - 9, pH-related effects were significant. Meanwhile, at lower pH values the percentage of metal removal decreased. The sorption was found to decrease with increase in initial concentration and increases with increasing adsorbent dose. The equilibrium nature of Zn (II) and Ni (II) adsorption at different metal ion concentration were described by Langmuir, Tempkin and Freundlich Isotherm. The equilibrium data indicates the following order to fit the isotherms: Freundlich > Tempkin > Langmuir. In order to evaluate kinetic parameters Lagergren's first-order, pseudo-second-order, Elovich kinetic model and intra-particle diffusion models were explored. Among the kinetic models studied, the pseudo-second-order equation was the best applicable model to describe the sorption process. FTIR spectra of the adsorbent were recorded to explore the number and position of functional groups available for the binding of Zn (II) and Ni (II) ions of the studied adsorbent.

In the seventh chapter, "Removal of Pb(II) form aqueous solution by adsorption onto Ashwagandha (Withania Somnifera) Biomass: Equilibrium and Kinetic Studies", the ability of Adulsa leaves powder (ALP) to adsorb Hg(II) from aqueous solutions has been investigated through batch experiments. The parameters are investigated in this study included pH, adsorbent dosage and effect of contact time along with initial Hg(II) concentration. The adsorption process was relatively fast and equilibrium was achieved after 40 min of contact time. The maximum removal of Hg(II) was observed at pH 7. The amount of metal sorbed decreases with an increase of sorbent dosage. On changing the initial concentration from 25 – 100 mg/l the amount of mercury adsorbed increased. The correlation coefficient values obtained from the Langmuir, Freundlich and Tempkin isotherms indicate that the adsorption pattern for Hg(II) on ALP followed the Langmuir > Tempkin > Freundlich isotherm at all experimental concentrations. The kinetic process of Hg(II) adsorption onto ALP was tested by applying pseudo-first-order, pseudo-second-order, Elovich and Intra particle diffusion. The results indicate that Adulsa leaves powder may be a cost effective alternative for the removal of mercury.

In the eighth chapter, "Adsorption of Hg(II) from aqueous solution using Adulsa (*Justicia Adhatoda) leaves: Kinetic and equilibrium studies",* Ashwagandha leaves Biomass (ASLB) has been prepared for the removal of Lead from aqueous solution. Biosorption of Pb(II) on ASLB was investigated in batch mode and optimum conditions were determined. The adsorption continuously increased in the pH range of 3–5, beyond which the adsorption could not be carried out due to precipitation of metal. The biosorption capacity of the metals ions decreases with increasing adsorbent loading dose and increases by increasing initial metal ion concentration. The uptake of metal was very fast and equilibrium was attained within 60 minutes. It was found that the overall adsorption process was best described by pseudo second-order kinetics. Langmuir, Freundlich and Tempkin isotherms were tested, and it was found that the Langmuir had a better fit with the data.