Name of Scholar: **Saif Ali**
Name of Supervisor: **Prof. Tabrez Alam Khan**
Name of Co-supervisor: **Prof. Imran Ali**
Department: **Chemistry, Jamia Millia Islamia**
Title of the thesis: **Removal of Toxic Heavy Metal Ions by using Low-Cost Adsorbents**

ABSTRACT

Groundwater contamination due to heavy metals is posing a threat to human beings and other aquatic organisms. Arsenic is one such element which contaminates groundwater and is a serious problem especially in Bangladesh having one of the highest infant mortality rates in the world. Drinking water containing high concentrations of naturally occurring arsenic for long time could cause chronic health affects including the development of various skin lesions, such as hyper pigmentation (dark spots), hypo pigmentations (white spots), and keratosis of hands and feet, skin and internal cancers. Weathering process contributes a significant flux of arsenic to the ground and surface waters and a study has found that over 137 million people in more than 70 countries are probably affected by arsenic poisoning. Other toxic metals are added to surface water by mining, metallurgy, electroplating, oil refineries, textile, tannery and battery manufacturing units. Once inhaled heavy metals cannot be metabolized and therefore, get accumulated in soft and hard tissues causing chronic and acute ailments including damage of central nervous system, blood composition and cancer of lungs, kidneys, liver and other organs. There is no antidote available to save human being from toxicity of these metals; therefore, their removal from water wastewater effluents before disposal is need of the present era. Various techniques are available for their removal and adsorption is one such which can be used economically; in the developing countries like India. The objectives of this research work were to prepare adsorbents using riverine sand and red mud by impregnating with different metal oxides and testing them for the adsorptive removal of arsenic, chromium, cadmium, lead, zinc and nickel ions.

The thesis has been divided into following six chapters: C**hapter 1** gives a brief account of water pollutants and diseases associated with contamination and methods of remediation. **Chapter 2** deals with the materials and methods used for carrying out the research work. The fundamental backgrounds of the characterization techniques: XRD, FT-IR, SEM and EDX, adsorption isotherms, and kinetics and thermodynamics of adsorption processes have been discussed. **Chapter 3** describes the removal of As(III) and As(V) by adsorption onto zirconium oxide coated marine sand (ZrOCMS). Langmuir adsorption capacities, Q_o, for As(III) were 111.11, 129.87 and 136.98 and that for As(V) were 250, 270 and 250 µg/g at 30, 35 and 40ºC, respectively.

Regression coefficients of Freundlich isotherm plots for both As(III) and As(V) indicated fitting of isotherm. Temkin isotherm and Dubinin-Radushkevich isotherms indicated physical adsorption for As(III) and border line between physical and ion exchange for As(V). Gibb's free energies indicated adsorption as feasible for both arsenic species. **Chapter 4** contains the removal of Cr(VI) and Cr(III) by adsorption onto manganese oxide coated sand (MOCS). Q_o for Cr(VI) were found to be 227.27, 196.08 and 166.67µg/g at 25, 30 and 35°C, respectively. Regression coefficients for Freundlich isotherm plot indicated good fitting of isotherm. Temkin isotherm indicated that bonding was strong and more feasible at 35°C. D-Radushkevich isotherm indicates physical nature of adsorption. Gibb's free energy and enthalpy indicated spontaneous endothermic nature of adsorption. Pseudo-second order reaction rate was followed by Cr(VI) adsorption. **Chapter 5** discusses the removal of Pb(II) and Zn(II) by adsorption onto MOCS. Q_o for Pb(II) were 135.13, 140.84 and 147.06 µg/g and that for Zn(II) were 116.28, 114.94 and 113.63 µg/g at 27, 35 and 40ºC, respectively. Freundlich constant, *n*, for Pb(II) and Zn(II) indicated good adsorption intensities at these temperatures. Temkin constants, A_T suggested stronger bonding between MOCS and Pb(II) and Zn(II) at higher temperature. The average energies from Dubinin-Radushkevich isotherm indicated ion exchange for Pb(II) and physical adsorption for Zn(II). Enthalpies of adsorption, indicated ion exchange mechanism for Pb(II) and physical adsorption for Zn(II). **Chapter 6** deals with the adsorption of Cd(II) and Ni(II) onto IOARM. Q_o for Cd(II) were 117.64, 116.28 & 107.53 and that for Ni(II) were 89.285, 86.956 & 82.644 µg/g at 20, 25 and 35ºC, respectively. Freundlich constant, *n* for both ions were higher than unity, suggesting feasibility of adsorption process. Temkin isotherm constant (A_T) indicated weak interaction for Cd(II) and Ni(II) and IOARM i.e. physical adsorption. D-R isotherm, Gibb's free energy and enthalpy for Cd(II) and Ni(II) suggested physical adsorption. Pseudo-second-order model described the adsorption kinetics and Elovich kinetic constants, α and β indicated that rate of adsorption was much higher than desorption. The adsorption of Cd(II) and Ni(II) on IOARM involved both intraparticle diffusion as well as liquid film diffusion.

Briefly, the results presented in this thesis are interesting as most of the experiments were performed and worked at natural conditions. Besides, the adsorption capacities of the developed adsorbents were quite high. Moreover, the contact time was quite short or processes of adsorptions were quick. All these results indicated that the reported methods may be used to remove heavy metal ions from any water body. Moreover, the cost associated with the preparation of reported adsorbents was low and therefore, technique is economical and can be used in under developing countries. Millions of people from West Bengal (India) and Bangladesh can be saved from arsenic poisoning using adsorption processes and the adsorbents reported in this thesis.