The development of the country depends on industrialization and agricultural production. To cater the need of the country, a number of industries have grown up. Any industries process releases some kind of pollutants, which increase the pollution load in all segments of environment, especially in water bodies. Heavy metals are found as pollutant in industrial wastewater streams. Mainly it is originating from chemical manufacturing, painting and coating, extractive metallurgy, mining, nuclear, and other industries. Heavy metals exert a deleterious effect on the flora and fauna of streams and lakes. So the role of chemist and technocrats become even important to reduce the load of pollution. One of the potential remedies to this problem is the use of adsorption technologies. Because of less initial cost, flexibility and simplicity of design ease of operation and insensitivity to toxic pollutants. Numerous conventional methods, such as chemical precipitation, coagulation, solvent extraction, ion-exchange, adsorption, and reverse osmosis, are available for the removal of heavy metal ions from wastewater. Adsorption is considered more effective and less expensive than other techniques.

The aim of the present research is to synthesize novel Polyamides bearing pyridyl and azomethine groups (PAP, PAT), Poly[2,5-1,3,4-(thiadiazole)benzalimine] TDIP and Polyurethane bearing phenylthiourea and azomethine groups PU through polycondensation technique. The synthesized polymers are characterized using Fourier Transform Infra-Red (FT-IR), X-ray Diffraction (XRD), Nuclear Magnetic Resonance (¹H-NMR and ¹³C-NMR).
Thermal stability of the synthesized polymers were determined using Thermogravimetric Analysis (TGA), surface morphology of the synthesized polymers are analysed using Brunauer Emmett Teller Spectroscopy (BET) and Scanning Electron Microscopy (SEM).

The synthesized Polymeric resins were then used as adsorbent for the removal of heavy metal ions such as Pb(II), Cu(II), Ni(II) and Cd(II) in aqueous medium using batch adsorption studies. Adsorption studies were performed in a rotary shaker to optimize parameters such as solution pH, adsorbent dose, contact time, initial metal ion concentration and temperature for the adsorption of heavy metal ions in aqueous media. The adsorption kinetics for the metal ions onto the polymeric adsorbents was studied using Pseudo first order, Pseudo second order, intraparticle diffusion and Elvolich kinetic models. The adsorption isotherm data were fitted to Langmuir and Freundlich and redlich-peterson isotherm models. The characteristic parameters for the isotherms and their coefficient of determination ($R^2$) values have been calculated.

The metal ion adsorption was initially found to be low due to the electrostatic repulsion with the occupied $H^+$ ions on the surface of the adsorbent. With increase in pH, the adsorbent surface becomes negatively charged, and hence the metal ion adsorption increases gradually and reaches equilibrium at pH 6.0. Beyond pH 6.0, adsorption capacity remains almost constant due to the formation of metal hydroxide rather metal adsorption. With increase in adsorbent dosage, a sharp increase in adsorption capacity of
the polymers was observed. This may be due to an increase in the active sites of the adsorbent.

Kinetic results shows that the metal ion-adsorbent system cannot be described by the pseudo-first order and the Elovich kinetic equations, since the $R^2$ values obtained for these equations are low, and the calculated $q_e$ values also considerably deviate from the experimental values. The pseudo-second order equation provides the best correlation with the experimental data. The adsorption of metal ions onto PAP, PAT, TDIP and PU is found to be controlled by surface diffusion in the earlier stages followed by pore diffusion in the later stages.

The effect of the initial metal ion concentration on metal ion removal was studied; it is observed that adsorption capacity increases with increase in the metal ion concentration. The applicability of the Freundlich, Langmuir and Redlich-peterson adsorption isotherm equations to the metal ion-adsorbent (PAP, PAT, TDIP and PU) system indicates that both physisorption and chemisorptions takes place on the heterogeneous surface conditions exist under the studied experimental conditions. The results observed from the adsorption isotherm studies indicates that the maximum adsorption capacity of the adsorbents are in the order of PU> TDIP> PAT> PAP with all four metal ions investigated.

An increase in the temperature shows a decrease in the removal of the heavy metal ions from the aqueous solution. This may be due to the decrease in surface activity of the adsorbent with the increase in temperature. This suggests that the adsorption between the metal ions and the polymeric
adsorbent is an exothermic process. The various thermodynamic parameters such as change in Gibbs free energy ($\Delta G^o$), enthalpy change ($\Delta H^o$), and entropy change ($\Delta S^o$), were evaluated, and the results show that the adsorption of metal ions onto the adsorbents (PAP, PAT, TDIP and PU) are feasible, spontaneous and exothermic in nature.

Desorption studies shows the possibility of regeneration and recovery of metal ions from the adsorbent. The synthesized polymeric resins are found to be stable in acidic condition without any characteristic change for even upto 6-10 weeks. Maximum metal recovery was observed with strong acids such as 0.1 N sulphuric acid, hydrochloric acid and poor metal recovery with acetic acid. This is presumably due to the weak acidic nature of the acetic acid. The physical adsorption mechanism plays a major role in the adsorption process, and it was assumed that the chemisorption or the ion-exchange process is predominant along with physisorption during the adsorption process. The stability of the polymers is observed to be stable even after five subsequent cycles and can be re-used without any serious performance decline. The overall results show that the newly synthesized chelating polymers bearing donor atoms are chemically resistant, thermally resistant which serves as a key contributory factor to exhibit high metal ion adsorption with all four metal ions studied.