Chapter 9

CONCLUSIONS AND SCOPE FOR FUTURE WORK

9.1. Conclusions

On the basis of observations and analysis, following conclusions may be drawn:

i. The two nanoadsorbents: nanocrystalline zirconia and nano crystalline oxide/ hydroxide were synthesized in laboratory. The crystallite size of nano crystallite zirconia increased with increase of temperature.

ii. The materials were synthesized by precipitation method.

iii. The synthesized materials were characterized for XRD, FTIR, SEM, TEM, and surface area analysis. The nano crystalline oxide/hydroxide was characterized for Raman, magnetization and XPS analysis. The nano crystalline zirconia was also characterized for DTA/TGA analysis.

iv. The nanoadsorbents were used for adsorption of chromium and cadmium from aqueous solutions. The optimization of the adsorption process parameters was done by response surface methodology.

v. Nano crystalline zirconia can be effectively used to remove chromium and cadmium from aqueous solutions. The pH was most dominating factor for removal of chromium using nano crystalline zirconia. The initial concentration and adsorbent dose were found to be most dominant factor after pH. However, temperature did not significantly affect the removal of chromium from aqueous solutions.

vi. Optimum values for initial concentration, pH, adsorbent dose and Temperature were 16.72 mg L^{-1}, 2, 4.22 g L^{-1}, 305.8 K for removal of chromium using nano crystalline zirconia. The adsorbent was regenerated with ammonium hydroxide.

vii. The XRD suggested the presence of Fe_3O_4 or Fe_2O_3 within the sample of nano crystalline iron oxide/hydroxide. The Raman analysis confirmed the presence of FeO(OH) in the sample.

viii. The pH was also most dominating factor for removal of chromium using nano crystalline iron oxide/hydroxide. The initial concentration and adsorbent dose followed the most dominant factor respectively for removal of chromium respectively using nano crystalline iron oxide/hydroxide. Temperature was also non significant factor for removal of chromium using nano crystalline iron oxide/hydroxide.

ix. The optimum condition found were at initial concentration 20 mg L^{-1}, pH = 2-2.5 and adsorbent dose of 11 g L^{-1} and 303 K for removal of chromium using nano crystalline iron oxide/hydroxide. Regeneration of adsorbent was achieved with sodium hydroxide.

x. The removal of chromium increased with decrease in pH by nano crystalline zirconia and nano crystalline iron oxide/hydroxide. The removal of chromium decrease with rise of initial concentration and increase with rise of adsorbent dose by nano crystalline zirconia and nano crystalline iron oxide/ hydroxide.

xi. Nano crystalline zirconia is also used for abatement of cadmium from aqueous solutions. The initial pH was the most dominating factor followed by initial concentration and adsorbent dose. The optimum conditions for removal found were initial concentration = 1 mg L^{-1}, pH = 7 and adsorbent dose of 4 g L^{-1} for removal of chromium using nano crystalline zirconia.

xii. Nano crystalline iron oxide/hydroxide is also applied for abatement of cadmium from aqueous solution. The optimum condition for removal of cadmium by nano iron oxide/hydroxide were found to be as initial concentration 27 mg L^{-1}, pH = 7 and adsorbent dose of 4 g L^{-1}. Regeneration of adsorbent was also achieved with Hydrochloric acid.

xiii. The removal (%) of cadmium increased with increase in pH by nano crystalline zirconia and nano crystalline iron oxide/hydroxide. The removal of chromium decrease with rise of initial concentration and increase with rise of adsorbent dose by nano crystalline zirconia and nano crystalline iron oxide/hydroxide.

xiv. The isotherm and kinetics was explained by the linear analysis due to non uniform results by nonlinear curve fitting analysis. All system follows Langmuir isotherm and pseudo-second order model.

xv. The thermodynamic parameters estimated by linear analysis of Langmuir constant method are taken in consideration. All processes were spontaneous in nature as indicated by negative sign afore to coefficient of free energy change. The removal of cadmium using nanocrystalline zirconia is exothermic in nature and rest of the systems studies were endothermic in nature. All adsorption systems studied showed increase in entropy during the adsorption process.

xvi. The adsorption processes were governed by boundary layer diffusion model.

xvii. The values of Arrhenius energy were calculated for all adsorbate and adsorbent systems. The activation energies for nanocrystalline zirconia-chromium and nanocrystalline zirconia-cadmium systems were 10.39 and -15.09 kJ mol^{-1} respectively. The activation energies for nanocrystalline iron oxide/hydroxide-chromium and nanocrystalline iron oxide/hydroxide-cadmium systems were 9.39 kJ mol^{-1} and 32.32 kJ mol^{-1}. The activation energy for adsorption of cadmium using nano crystalline zirconia is negative and for rest adsorption system it is positive in nature. The negative value of activation energy suggests that the adsorption of cadmium nano crystalline zirconia requires energy to proceed.

9.2. Scope for future work

Water scarcity is a serious concern and contamination of drinking water further aggravates the problem. The contamination of water leads to health problems to humans. The current study is a step to deal with this problem. The contaminants chromium and cadmium were selected due to their widespread contamination across the world. The objective of the current study is to find optimum parameter for removal of chromium and cadmium from aqueous solutions using nanocrystalline zirconia and nanocrystalline iron oxide/hydroxide. The isotherm, kinetic and thermodynamic parameters were also determined using various methods.

In view of the future work, better regression models of wide range of varying conditions to predict the removal (%) chromium and cadmium is needed. The better strategy can be developed for prediction of isotherm kinetic models. Another important aspect is calculation of cost effectiveness of the process to be adopted in treatment systems. Cost of treatment will also prove it to be a key parameter for any strategy.