SYNOPSIS OF THESIS

Dyes producing industries and many other industries which uses dyes and pigments, generate wastewater, characteristically high in colour and organic content. Many heavy toxic metals are present in the effluents produced from the electroplating, leather tanning, cement, mining, dyeing, fertilizer industries and causes severe environmental and public health problems. A number of methods for the removal of metal ions from aqueous solutions have been reported, mainly reduction, ion exchange, electrodialysis, electrochemical precipitation, evaporation, solvent extraction, reverse osmosis, chemical precipitation and adsorption. The adsorption process is one of the effective methods for removal of dyes from the waste effluent. Most of these methods suffer from drawbacks such as high capital and operational costs or the disposal of the residual metal sludge. The process of adsorption has an edge over the other methods due to its sludge free, clean operation and almost completely removal of dyes and metals, even from the diluted solution.

Adsorption is surface phenomenon in which collection or accumulation of substance on the surface of the solid or liquid takes place. It is a physicochemical process in which dissolved molecules are attached to the surface of an adsorbent by physical or chemical forces. The substance which adsorbs another substance on its surface is called as adsorbent while the substance which itself get adsorbed on the surface of another substance is called adsorbate. Adsorption technology is currently used extensively for the removal of organic and inorganic micro-pollutants from aqueous solutions. On the basis of nature of forces acting between adsorbent and adsorbate molecules adsorption is classified into three types as (a) Physical adsorption which is due to physical attractive forces that is van der Wall’s forces of attraction between the adsorbent and adsorbate molecules. Physical adsorption usually observed at low temperature. Forces of attraction are weak and characterized by low heat of adsorption. (b) Chemical adsorption, in this
process chemical bond is formed between adsorbent and adsorbate molecules. It is due to unsatisfied valencies. It occurs at high temperature having high heat of adsorption (c) Electrostatic adsorption which involves electrostatic attachment of ionic species of opposite charge at the surface of adsorbent.

In industrial applications, the utility of activated carbon is based on adsorptive power, a relation quite apparent in traditional functions such as decolorization and in the removal of toxic vapors. Amongst the commercial adsorbents, activated carbon is the most commonly used adsorbent. Activated carbon, also called activated charcoal or activated coal is a form of carbon that has been processed to make it extremely porous and thus to have a very large surface area available for adsorption or chemical reactions. Due to its high degree of microporosity, just 1 gram of activated carbon has a surface area in excess of 500 m². Sufficient activation for useful applications may come solely from the high surface area, though further chemical treatment often enhances the adsorbing properties of the material. Activated carbon is carbon produced from carbonaceous source materials. It can be produced by one of the processes (a) Physical reactivation in which the precursor is developed into activated carbons using gases. This is generally done by using one or a combination of the processes such as Carbonization or Activation/Oxidation. (b) Chemical activation in which prior to carbonization, the raw material is impregnated with certain chemicals. The chemical is typically an acid, strong base, or a salt. Then, the raw material is carbonized at lower temperatures. It is believed that the carbonization/activation step proceeds simultaneously with the chemical activation. Chemical activation is preferred over physical activation owing to the lower temperatures and shorter time needed for activating material.

Adsorption processes provide a feasible treatment, if the adsorbent is reasonably priced and readily available but the commercially available activated carbon is expensive. So it needs to develop an economical adsorbent and we have
tried the same. These developed adsorbents were used to remove heavy metals and dyes from aqueous solution.

The thesis is divided into six chapters. At the beginning a brief introduction of adsorption phenomenon covering the theoretical aspects with special reference to principle and classification of adsorption system is given in Chapter 1. The actual experimental results obtained during phases of investigation are included in Chapters 2 to 6. Up to date literature survey of the adsorbate reported for the adsorption of respective metal and dye is given at the beginning of each chapter. The details about these are given below.

Chapter 1
Introduction

This chapter describes the water pollution concept including brief account of heavy metal and dye pollution. The need of removal of these respective pollutant and the various routes to remove them from aqueous solution is given in brief. The adsorption method is described including its advantages over other methods as well as its history, principle and classification including general applications.

Chapter 2
Efficient adsorption of Cr(VI) from aqueous solution on low cost adsorbent developed from Limonia acidissima (Wood apple) shell

The chapter 2 deals with the study of adsorption of Cr(VI) on the low cost wood apple shell activated carbon as an effective adsorbent from the aqueous solution. The adsorbent was prepared with H2SO4 as an impregnating reagent and then kept in muffle furnace for 1 h at 373 K to get porous material. The developed adsorbent has characterised with FTIR, SEM and elemental analyser as well as its other properties were also studied. The prepared adsorbent was applied to develop the method to adsorb Cr(VI). The various experimental conditions such as pH, agitation period, speed etc. were investigated to determine maximum adsorption of
Cr(VI). The removal of Cr(VI) ions with an initial concentration of 90 mg/g was found to be 98.05 % after shaking for 180 min at 140 rpm at 299 ± 2 K. The experimental data was applied to well known isotherm models amongst them, the Langmuir adsorption isotherm model fitted better than the Freundlich adsorption model. The Langmuir adsorption capacity was determined as 13.74 mg/g for Cr(VI) adsorption. The kinetic study has been done with pseudo-first and pseudo-second order. The temperature study reveals that, as the temperature increases, the adsorption capacity also increased which indicated that, the adsorption process was chemical in nature, being feasible, spontaneous, endothermic and confirmed by the evaluation of the relevant thermodynamic parameters such as, standard free energy change (ΔG°), standard enthalpy change (ΔH°) and standard entropy change (ΔS°). The comparison with other reported adsorbents shows this adsorbent is very effective.

Chapter 3

Kinetic and equilibrium studies of the adsorption of Cd(II) from aqueous solutions by wood apple shell activated carbon

In this chapter wood apple shell as a adsorbent was used to remove the Cd(II) ions from aqueous solution. The maximum 98.80 % Cd(II) was successfully removed with this adsorbent. The different operational parameters were studied during the process of investigations which are as, the contact time, initial concentration, adsorbent mass, pH, stirring speed etc. The adsorption isotherm study indicates that the Langmuir isotherm model was fitted better than Freundlich isotherm. The Langmuir isotherm model investigated that the 28.33 mg/g as maximum adsorption capacity. The temperature was varied from 303 to 323 K to study its effect on adsorption. The thermodynamic study has been done to evaluate standard enthalpy, standard entropy and Gibb’s free energy. Kinetic study of the adsorption was tested with help of pseudo first order and pseudo second order models. The comparison with other reported adsorbents showed that, this adsorbent has better results to adsorb Cd(II) from aqueous solution.
Chapter 4
Removal of Bi(III) with adsorption technique using coconut shell activated carbon as a low cost adsorbent

This chapter deals with the adsorption study of Bi(III) from aqueous solution using coconut shell activated carbon. The low cost activated carbon was prepared with H₂SO₄ as impregnating reagent and developed adsorbent was characterized with various techniques. This developed activated carbon was found to show the high capacity to adsorb Bi(III) ions from aqueous solution with amount adsorbed from 17.62 to 53.47 mg/g as per increase in the initial concentration up to 1000 mg/dm³ and the required period was 240 min. The isotherm models such as Langmuir and Freundlich were studied, amongst them Langmuir equation showed more applicability to the experimental data than Freundlich isotherm with 54.35 mg/g as a maximum adsorption capacity. The rate of adsorption was also investigated with kinetic study and it was found that the experimental data fits better in pseudo-second order than pseudo-first order model. The adsorption study was feasible, spontaneous and endothermic, which was confirmed by the evaluation of thermodynamic parameters viz. ΔH°, ΔG° and ΔS°.

Chapter 5
Mahogany fruit shell: A new low-cost adsorbent for removal of basic dye from aqueous solutions

We have introduced the new adsorbent Mahogany fruit shell and applied to the adsorption of methylene blue, a basic dye. The material was used without any treatment and characterized with techniques like, SEM, FTIR and elemental analysis. The various parameters such as pH, agitation speed, period etc. were investigated which showed that, the removal of dye was possible by Mahogany fruit shell up to 99.05 % when concentration of the dye was 100 mg/dm³. The study was evaluated with isotherm models amongst them, Langmuir adsorption was fitted better than Freundlich isotherm. The Langmuir maximum adsorption capacity was 51.81 mg/g as well as regression factor was 0.997. The kinetic study
has shown that the pseudo second order is more suitable for this study than pseudo first order. The temperature study concluded that, the process was endothermic and spontaneous. The thermodynamic parameters were evaluated such as, standard free energy change, standard enthalpy change and standard entropy change. The comparison with adsorbent from literature showed that, this adsorbent Mahogany fruit shell is more effective to remove methylene blue dye.

**Chapter 6**

**Malachite green dye biosorption onto surface of *Limonia acidissima* (Wood apple) shell: Isotherm and Kinetic Modeling**

Wood apple shell was characterized with modern techniques and successfully utilized as a low cost adsorbent without any treatment for the removal of hazardous malachite green dye which is given in this chapter. The removal of malachite green with initial concentration of 100 mg/dm³ at pH 8-10 was found to be 98.87 % in 210 min by agitating at 150 rpm. The adsorption equilibrium data is in good agreement with the Langmuir isotherm model with 35.84 mg/g as maximum adsorption capacity than Freundlich isotherm model. The kinetic study has done with pseudo-first and pseudo-second order models at 299 ± 2 K by keeping rest parameters constant. The thermodynamic study of adsorption of malachite green was also done. The comparison of wood apple shell with other adsorbents from literature showed that, the adsorption of malachite green dye with wood apple shell was more effective than other.

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