Chapter II

Aim and Scope

Synthetic dyes are used in large quantities by many industries including textile, leather, cosmetics, paper, printing, plastic, pharmaceuticals, food etc., to colour their products. The textile industry alone accounts for two third of the total dye stuff production, which generates considerable amounts of coloured effluents, subjective to the presence of azo bonds and its associated chromophores. The biological reduction of this bond is responsible for the appearance of dangerous aromatic amines in liquid effluents, such as aniline and sulphanilic acid. These chemicals are carcinogenic to humans causing allergic dermatitis, skin irritation, cancer etc. Dye molecules are difficult to be removed from effluents due to their higher water solubility and consistently persistent nature. Heavy metals such as cadmium, copper, lead and mercury are added to certain dyes and pigments to improvise their fasting property, apart from these metals being incorporated in structures of certain dye molecules. These toxic metals also being a pollutant in dye effluents, bioaccumulate over time and cause damages to nervous system. In this context, there is an increasing demand for efficient methods to remove dyes and heavy metal ions from textile effluents. Amongst all the treatment techniques available, adsorption has been recognized as a promising technique due to its ease of operation, simplicity of design, high efficiency and comparable low cost application.

The commercially available activated carbon is expensive apart from other disposal problems and thence not viable for treatment of industrial effluents effectively on certain aspects. The prime phase is focused on the development, characterization and evaluation of novel low-cost materials such as agricultural products, forest and animal wastes, aquatic plants which can be utilized as preferred adsorbents. Ample availability, great efficacy, renewability, economical and ecofriendly nature cause the plant/animal waste materials as feasible option for dyes/metal ion remediation. They affirm a potential alternative to commercially activated carbon.

The present study aims at the exploration of such raw materials from plant/animal wastes origin. Two materials viz., tree bark of *Prosopis juliflora* (PJB) and Goat Dung (GD), an animal waste have been identified being inexpensive/abundantly available bioorganic debris. The sorption characteristics of chosen materials are enhanced through modifications into activated carbons employing phosphoric acid (PJB) and sulphuric acid (GD). Direct Brown 2 dye (DB2), Reactive Red 152 dye (RR152) and Cu(II) metal ion have been chosen

as the sorbate species, since their prevalence is observed to be vivid in dye wastewaters. The prepared activated carbons PJBAC/GDAC are modified into nano magnetic and photocatalytic composites using cobalt ferrite and titanium dioxide respectively.

Physico - chemical and surface characteristics of the prepared carbons are analyzed using standard methods and BET /BJH, SEM/EDAX, FT-IR, EDAX, TGA-DSC techniques respectively, to study the nature of the materials prior to adsorption studies. The derived nanocomposites are subjected to BET/BJH, SEM/EDAX, XRD, AFM and VSM techniques, to confirm the appropriate properties. Batch equilibration experiments (pilot) are performed for the dyes/metal – modified materials systems under influential parameters viz., initial concentration, contact time, sorbent doses, solution pH and temperature, in order to investigate the maximum uptake of the respective species. The effects of various ions viz., cations, anions and co-ions in Cu(II) systems are studied to record the performance of the identified materials, as the presence of aforesaid ions in the dye effluent is inevitable. Dye removal efficiencies of magnetic nanocomposites are analyzed and is compared with their corresponding carbons. Degradation of DB2 using nano photocatalytic composites are studied by varying doses under different agitation time frames at optimized parametric values. Desorption and regeneration studies are conducted to the explore possibilities of the adsorbent reuse. Statistical responses of sorbent materials in sequestering dyes/metal ion are verified with SPSS software. Column experiments are performed to quantify and assess the sorbents' efficiencies.

Langmuir, Freundlich, Tempkin, Dubinin-Kaganer-Radushkevich (DKR) isothermal graphs are plotted and on the basis of adsorption equilibrium data, the best suited isotherm model is arrived at. Pseudo-first order, Pseudo-second order, Elovich and intraparticle diffusion models are employed to evaluate the mechanism of sorption kinetics, since these models furnish the nature of adsorption process. Thermodynamic parameters are calculated to assess the feasibility/spontaneity and exothermicity/endothermicity of the sorption reactions. Decolorizing efficiencies of adsorbents are extended to textile industry effluents to emphasize their maximum capacity. Based on the results, a judicious comparison on the efficacies of the two sorbent materials, their modified nano magnetic counterparts are made in the process of trapping the dye molecules and metal ion of interest. Also, an order of preferential adsorption amidst the chosen adsorbate species is ensured.