PREFACE

Water resources are of critical importance to both natural ecosystem and human developments. Increasing environmental pollution from industrial wastewater particularly in developing countries is of major concern. Heavy metal contamination exists in aqueous waste streams of many industries, such as metal plating facilities, mining operations, tanneries, etc. Some metals associated with these activities are cadmium, chromium, iron, nickel, lead and mercury. Heavy metals are not biodegradable and tend to accumulate in living organisms causing diseases and disorders. Many industries like dye industries, textile, paper and plastics use dyes in order to colour their products and also consume substantial volumes of water. As a result they generate a considerable amount of coloured wastewater. The presence of small amount of dyes (less than 1 ppm) is highly visible and undesirable. Many of these dyes are also toxic and even carcinogenic and pose a serious threat to living organisms. Hence, there is a need to treat the wastewaters containing toxic dyes and metals before they are discharged into the waterbodies.

Many physico-chemical methods like coagulation, flocculation, ion exchange, membrane separation, oxidation, etc are available for the treatment of heavy metals and dyes. Major drawbacks of these methods are high sludge production, handling and disposal problems, high cost, technical constraints, etc. This necessitates cost effective and environmentally sound techniques for treatment of wastewaters containing dyes and metals.

During the 1970s, the increasing awareness and concern about the environment motivated research for new efficient technologies that would be capable of treating inexpensively, waste waters polluted by metals and dyes. This search brought biosorption/adsorption to the foreground of scientific interest as a potential basis for the design of novel wastewater treatment processes. Several adsorbents are currently used which are by-products from agriculture and industries, which include seaweeds, molds, yeast, bacteria, crabshells, agricultural products such as wool, rice, straw, coconut husks, peat moss, exhausted coffee waste tea leaves, walnut skin, coconut fibre, etc
Adsorption/Biosorption using low cost adsorbents could be technically feasible and economically viable sustainable technology for the treatment of wastewater streams. Low cost adsorbents are nothing but materials that require little processing, are abundant in nature or is a byproduct or waste material from another industry.

The objective of the present thesis is to report the feasibility of using four agricultural by-products namely channa dal (*Cicer arientinum*) husk, tur dal (*Cajanus cajan*) husk, tamarind pod (*Tamarindus indica*) shells and coffee (*Coffee arabica*) husk in the removal of four metals namely chromium (VI), iron (III), mercury (II) and nickel (II) and dyes namely methylene blue, fast green, amaranth and rhodamine B. Batch-mode kinetic and equilibrium studies have been carried out. Regeneration of dyes and metals from the spent adsorbent to recover the adsorbent and adsorbate has been studied. The attractive features of the adsorbents used in the present study are that it is environmentally friendly and of low cost.

The results revealed that all the four husks were efficient in the biosorption of the four metals and dyes tested. The results showed that coffee husk was not efficient in the biosorption of dyes. Hence the results of biosorption of dyes by coffee husk are not presented here. The pH range at which the adsorption was optimal varied with the type of the metal and dye under investigation. Chromium was adsorbed optimally at pH 2, Iron (III) at 2.5; Mercury at 5.0 and Nickel at 6.0. The maximum adsorption of methylene blue by the four husks was at pH 8.0; fast green 3.0; amaranth at pH 2.0 and rhodamine B at 7.0. The percentage of adsorption increased with increase in time till equilibrium was achieved. The equilibrium time varied with the initial metal ion concentration and the type of the adsorbent. The amount of adsorbent required to reach equilibrium differed with the type of the dye and heavy metal. But in general, an increase in adsorption was seen with increase in adsorbent concentration. The adsorption capacity and intensity was calculated from Langmuir and Freundlich isotherm models and generally varied with the type of the adsorbent and heavy metal and dye under investigation. The Langregren equation was used to calculate the disassociation constant, which varied with type of adsorbent, heavy metal and dyes. The infrared spectra of the adsorbents before and after binding to the dye revealed
the presence of carboxylic, amine and hydroxyl groups which facilitated the biosorption of metals and dyes.

The agricultural byproducts used in the present investigation are attractive alternatives to the existing adsorbents. The adsorption capacity was comparable to activated carbon. The type of adsorption was mainly chemisorption showing that the adsorption was due to ion exchange or chemical bonding or both. The optimal conditions for adsorption varied on the basis of the charge carried by the individual metal or dye; i.e., whether the metal/dye under investigation was a cation or anion. Chemical reactions representing the adsorption mechanism have been worked out.

The analysis of the carbon, hydrogen and nitrogen content of the husks, showed relatively low percentage of nitrogen, revealing low content of protein in the adsorbents. This is advantageous over the protein rich algal and fungal biomass projected as metal/dye biosorbents, since proteinious materials are likely to putrefy under moist conditions. Further, most metal sorption reported in literature is based on algal and fungal biomass, which must be cultured, collected from their natural habitats and pre-processed, if available as discards and transported under special conditions, thus introducing the factor of additional costs. In contrast, BGH, TDH, TH and CH as agro-industrial wastes have negligible cost and have also proved to be an efficient biosorbent for the removal of metals/dyes. Furthermore, these adsorbed metal/dyes can be easily desorbed and the biomass be incinerated for final disposal. These biosorbents are of low cost, its utility will be economical and can be viewed as a part of a feasible waste management strategy.