CHAPTER-1
INTRODUCTION

Man’s need of water

Water is the elixir of life. Every living being requires good drinking water, but it is badly polluted today, because of population growth, speedy industrialization and rapid urbanization. Water is not only the basic need for human existence but also a vital input for all developmental activities. Its availability in sufficient quantity and of right quality is a necessary infrastructure for promoting better quality of life. In the economically poor nations, human and animal wastes are primarily responsible for the introduction of water pollutants into natural streams of water, whereas in affluent nations, such pollutants enter into the environment, mainly due to extravagant life styles and wide spread establishment of multifarious industries. However, only in recent years, there has been a growing awareness of health hazards caused by heavy metals, such as Cd, Cr, Cu, Pb and Hg due to their accumulation at various levels in the environment.

Although the waste waters or the effluents from the operations of the industries, such as mining, metal finishing, textile mills, tanneries, chemical industries and potteries are considered to be the primary sources of heavy metal pollutants in the environment, there is an added concern about the impact of fertilizers, pesticides, and petrochemical industries on the environmental load of heavy metals, which are harmful to man and animal and hence, the world is in search of some economical, but feasible and efficient methods for the removal of heavy metals from waters, waste waters or effluents. This
prompted the environmental scientists, chemists, biologists and engineers to search for some conventional or unconventional methods, capable of reducing the level of accumulation of each of the heavy metals in the environment to the acceptable or the permissible level.

1.1 HEAVY METALS

The term heavy metal includes metals with atomic number more than 20, having specific gravity at least five times greater than that of water, excluding alkali metals, alkaline earth metals, lanthanides and actinides. The seriousness of pollution associated with heavy metals has been recognized after the Minamata disaster in Japan due to mercury poisoning, caused by the consumption of the fish caught in Minamata bay which was the recipient of mercury, released from an industry, manufacturing vinyl chloride. Although, there was concern over the possibility of harmful health effects associated with water constituents such as lead, nitrate, fluoride and arsenic, anxiety about a much wider range of constituents developed ever since the harmful health effects arising due to the contamination of cadmium in relation to ‘Ouch-Ouch’ disease in the Toyoma region and Sevesco accident became apparent. The incidence of Itai-Itai Byo disease, among with age over forty in the same country, due to cadmium poisoning, underlines the adverse effects of heavy metals. In northern Brazil, fish from freshwaters are contaminated with mercury, as a result of ruthless, illegal gold extraction.

In the last three decades, national and international bodies responsible for public health have become increasingly anxious about trace constituents of food and water and their possible harmful effects on health. Although the discussion on long term health risks
associated with drinking water centers on organic micro pollutants, there are several inorganic constituents that have been the subject of concern. The possible relationship between fluoride levels and cancer has also been reported\(^6\). There has also been evidence of relationship between arsenic levels in water and incidence of skin cancer\(^7\). Similarly chromium is reported to produce systematic toxicity and cause cancer in human\(^8\).

In order that water is safe and acceptable to the consumer, it is subjected to treatment. In many supplies, if there is any treatment at all, it is limited to disinfection. Additional treatment, if required concerns with the removal of colour and suspended material by filtration often combined with coagulation and sedimentation. Occasionally, additional steps such as ozone or activated carbon treatment may be included for the control of toxic and odour causing organic contaminants. There inclusion however will have a substantial effect on the treatment cost. As it has become cognizant that man and technology are inseparable parts of modern civilization, in order that public can continue to receive a safe water supply at reasonable cost and to prevent unnecessary rejection of usable water resource in those parts where water is in short supply, it has become necessary to take adequate steps to cleanse the environment and check its further pollution through various control measures. The measures include containing the pollutants at the source itself, developing new technologies that would eliminate or minimize pollution and reprocessing of waste to recover useful materials. As a result, considerable growth of literature on treatment of wastes containing hazardous organic and inorganic substances has been witnessed during the past three decades.
1.2 TREATMENT METHODS

A variety of methods have been developed for the removal of toxic organic and inorganic constituents from water and waste water. The methods that find wide spread use are activated sludge process, precipitation, ion exchange, reverse osmosis, electro dialysis, ultra filtration, phytoremediation and adsorption.

1.2.1 Activated sludge process

Activated sludge process is a biological waste water treatment for the removal of biodegradable organics such as polychlorinated hydrocarbons, insecticides and herbicides. A mixture of waste water and microorganisms is agitated and aerated. The removals of biodegradable organics by activated sludge process were reviewed by several authors\textsuperscript{9-12}. This method, however works satisfactorily only when the wastewater to be treated is in large volume. In any case, the method can not produce effluent of sufficiently high quality to be suitable for direct reuse. The disposal of sludge can also pose problem.

1.2.2 Precipitation method

Precipitation method on the other hand, is used for the removal of inorganics from waste waters. Many reagents have been applied for precipitation purposes and these include caustic soda, hydrated lime, soda ash and sodium sulphide\textsuperscript{13} to precipitate the metal ions as insoluble hydroxides, carbonates and sulphides. Limes are generally favored for precipitation of heavy metals due to its low cost and ease of pH control. However problems can arise due to incomplete removal of the precipitated metal from
the treated effluent. As the sludge is to be disposed off as land fills, it could lead to contamination of ground water when conditions are favorable for their dissolution.

1.2.3 Ion exchange method

Ion exchange is a reversible process which facilitates the removal of anionic and cationic constituents present in water by exchange with the ions of the resin. A variety of synthetic organic resins, inorganic gels and liquid ion exchangers have been examined for the removal of heavy metal ions from dilute aqueous solutions\textsuperscript{14}. When the resin bed becomes saturated, it is regenerated using acid or alkali. The economic limitation of the process comes from the initial exchange process. In addition, fouling of resin bed with wetting agents and organic brighteners used in plating, clogging due to precipitated water hardness and oxidation of resin by oxidizing agents, if present, are some of the frequent problems associated with treatment by ion-exchange method.

1.2.4 Reverse osmosis

It is a process in which heavy metals are separated by a semi-permeable membrane at a pressure greater than osmotic pressure caused by the dissolved solids in waste water. The disadvantage of this method is that the operation cost is high\textsuperscript{15}.

1.2.5 Electro dialysis

In this process, the ionic compounds (heavy metals) are separated through the use of semi-permeable ion selective membranes. Application of an electrical potential between the two electrodes causes a migration of cat ions and anions towards respective electrodes. Because of alternate spacing of cations and anions permeable membranes, cells of concentrated and dilute salts are formed. The disadvantage is the formation of metal hydroxides, which clog the membrane\textsuperscript{15}. 

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1.2.6 Ultra filtration

They are pressure driven membrane operations that use porous membranes for the removal of heavy metals. The main disadvantage includes high cost and partial removal of certain ions$^{15}$.

1.2.7 Phytoremediation

Phytoremediation is the use of certain plants to cleanup soil, sediment and water contaminated with metals. The disadvantages include that it takes a long time for the removal of metals and the regeneration of the plant for further biosorption is difficult. Hence the disadvantages like incomplete metal removal, high reagent and energy requirements, generation of toxic sludge or other waste products that require careful disposal has made it imperative for a cost-effective treatment method that is capable of removing heavy metals from aqueous effluents$^{15}$.

1.2.8 Adsorption method

Adsorption is a unique process useful for the removal of both organics and inorganics from water and waste water. It is a process by which the concentration of solute is enriched at the surface or interface between two phases. Among the various methods described, adsorption is generally preferred for the treatment of polluted water due to its high efficiency, easy handling, availability of different adsorbents and cost effectiveness. In addition, it is capable of producing effluent free of suspended solids. Adsorbents such as fly ash and clay minerals have been found useful to remove organic and inorganic constituents from waste water. Fly ash which contains 12-30% carbon is apparently responsible for its adsorption property$^{16}$. It has been reported$^{17}$ that it is
effective for the removal of phenol, dyes and metal ions from waste waters. Naturally occurring minerals like fuller’s earth and kaolinite have also been examined for the treatment of waste water containing organic and inorganic pollutants.

Adsorbents used for the removal of some toxic metals from water and waste waters include, cocoa growing soils, commercial green tea, rice husk ash, soils, natural zeolite, calcareous soils, phosphorylated wood, bottom ash, illicit soils, colloidal iron(III) hydroxide, china clay, burnt clay and soils (C-black), titanium dioxide, granules consisting foamed clay, Fe and lime, bismuth trioxide, granular peat, waste Fe(III)/Cr(III) hydroxide, sawdust, hydroxyl apatite, blast furnace flue dust, sphagnum moss peat, chromate waste, banana pith, coconut fibre compost, corncob, polyacrylamide grafted tin(IV) oxide gel, unicellular green algae and waste biomass.

Among the various clean up methods, adsorption using activated carbon appears to have the least adverse effects. It includes a broad range of carbonaceous materials that exhibit a high degree of porosity and large surface area which find use for the removal of toxic biodegradable and non-biodegradable substances from waste waters. It is attractive as it can treat wastewater to the acceptable quality suitable for reuse. Most commercial activated carbons are derived from coal based materials. The use of such carbon for the removal of broad spectrum of organic compounds is well documented. The application of activated carbon for the removal of inorganics from aqueous solution is of recent origin. Filtrasorb 400 (derived from bituminous coal) has been examined for the treatment of chromium plating waste water. The use of various agricultural products and bye products has been described by numerous authors. Hande et al., have explained
the use of bark to remove heavy metal ions from waste water. The use of adsorbents such as, peat mass\textsuperscript{50,51}, straw\textsuperscript{52} and saw dust\textsuperscript{53} has also been reported.

Bansal \textit{et al}\textsuperscript{46} reviewed the criteria to be considered while selecting a potential carbonaceous precursor for the preparation of activated carbon. They include storage life of the material, volume and cost of the material, workability of the material and minimum presence of inorganics. Other desirable characteristics include density, carbon content, porosity and availability of the raw material. Although a few materials satisfy all these requirements, selections are often made primarily on the basis of the availability of the raw material.

\textit{T. grandis} L.f. is a well known for its high grade timber. Although it is known less for its medicinal properties and uses but in India, its different plant parts are in use as medicine since generations. The present study deals with the preparation of adsorbents from teak leaves such as Raw Teak Leaves powder (TLR), Carbonized Teak Leaves (TLC), Teak Leaves Activated Carbon TLAC [i.e. TLAC1 (H\textsubscript{2}SO\textsubscript{4} Treated), TLAC2 (Na\textsubscript{2}CO\textsubscript{3} Treated), TLAC3 (ZnCl\textsubscript{2} Treated), TLAC4 (ZnSO\textsubscript{4} Treated)], and also a Commercially available Ash Powder (CAP), followed by the usage of these adsorbents for the adsorption of Cr(VI) from aqueous solutions.