CHAPTER-1

INTRODUCTION

In the past ten years there has been a growing concern about environment. Haphazard growth of population associated with rapid industrialization has led to environmental pollution. In particular, land, water and air pollution are faced by human beings. Among them water pollution is a major problem since water is essential to lead daily life. Since the water has become precious resource this year is notified as world’s water year by UN. But, on the other hand water is polluted in many ways particularly by textile industries.

Textile industries pollute water in a major way. They not only add organic pollutants, but they impart to water. A medium scale textile industry uses 2,00,000 liters of water daily. The effluent discharged by this industry contains chemicals, starch, dyestuffs, alkalis, acids, detergents, etc. Various approaches have been made to treat these effluents.

Textile processes are classified into two categories as,

1. Dry process
2. Wet process

Dry process includes opening, blending, mixing, carding, combing, spinning, weaving and knitting operations. The wetting process consists of sizing de-sizing, bleaching, dyeing and finishing operations.
Dyeing is an integral part of the textile process. The nature of dyeing process varies with the nature of fibre and colour. The large variety of chemicals used in the dyeing process makes the effluent as complex one to treat. Dyes used in textile industries are vat, sulphur, azoic and reactive dyes. Among them, azoic dyes are banned worldwide, since they are proven carcinogens.

Reactive dyes being economical, they are used in dyeing cotton fibres. They render wide variety of s. They can be easily applied to fibre. Only 70% of applied dyes are fixed with fibre. Remaining portion is discharged with water process where they get hydrolyzed and cause severe problem to treat.

The dye house effluent contains 30% of unused dye, chloride, carbonate, hydroxide, nitrite and sulphides of sodium. The discharged effluent is let into rivers, lakes, etc. Researches showed that these dyes are not getting adsorbed even after long distance. Because of this, the well water will become salty and coloured. These contents resist the self purification of rivers. Moreover dyes are known to be heavy metal carriers. They are also carcinogenic and cause skin allergy.

Many physico-chemical methods and biological methods are in practice at present. Some of them are capable of treating this effluent to certain level. But they often do not fulfill requirements of the standards set by the Government. Other major draw back of this process is that they need dilution of the effluent from 5-10 times of the total effluent volume. Though the Chemical method is found efficient, the chemicals used in the treatment are not consumed fully. Hence these again cause pollution. Biological treatments methods are often recommended for treating other industrial effluents. But as far as this effluent is concerned, biological methods are proved to be in effective because the complex nature of this effluent causes severe problem to this method.
Chemical coagulation/flocculation is often used in effluent treatment. But, this method consumes huge amount of chemicals and time. The other methods recommended for treating this effluent are activated carbon adsorption, Bio-sorption, Fenton oxidation and Foam floatation. An entirely different kind of treatment is electro chemical treatment. The electro chemical or combined techniques have been used to treat various types of industrial effluents such as pharmaceutical, dairy, distilleries, and petrochemical effluents.

**ELECTRO CHEMICAL METHODS AND THEIR PRINCIPLES**

Electro chemical methods of effluent treatment are based on the well known principles of electrochemistry viz.

1. Electro oxidation
2. Electro reduction
3. Electro deposition
4. Electro dialysis
5. Electro floatation
6. Electro coagulation
7. Electro filtration
8. Electro phoresis
9. Electro sterilization

Choice of the method has to be made. Often it may even be necessary to use more than one method in order to achieve satisfactory results. Among these techniques, first four methods are associated with the treatment of ionic impurities while next five methods are for the removal of suspended matters.
The electro chemical methods are based on the known principles of electrochemical reductions such as anodic oxidation, cathodic reduction and electro osmosis. Depending on nature of pollutants with due consideration for the toxicity of the reactants and products, an appropriate choice of the method has to be made. Based on the above principles, the following is the brief account of various electro chemical methods that can be used in treatment of effluents.

**Electro oxidation**

Effluents containing utilizable species as pollutants can be considered as the once amenable for treatment by electro oxidation. The reaction may either involve direct oxidation of the pollutants or through an intermediate oxidizing species generated in situ at the anode. The reaction during direct oxidation of CN effluent leads to the formation of C$_2$N$_2$ followed by hydrolysis. Use of brine as constituent in the electro oxidation destructive of CN is a well-known practice. In case of dye house effluent electro oxidation results in the conversion of organic pollutants to carbon dioxide and water. In this case it is preferable to use a supporting electrolyte in to the efficiency of operation.

**Electro Reduction**

Cathodic reduction of toxic pollutants can also be considered equally important for the treatment of easily reducible species. Electro reduction can be successfully used to convert Cr$^{6+}$ to Cr$^{3+}$, which can be more easily removed from waste streams.
Electro Deposition

The process of electro deposition from metal, non metal, the aqueous parts have been a very well known technology. But electro deposition of metals from wastewater has not gained much importance due to two reasons. Such as (i) The efficiency of such deposition will be very low owing to the low concentration of the corresponding metals present in the wastewater; (ii) In few industries, the effluent contains often more than one metal in solution, which will be in ppm levels. At such concentration, the prospects of getting a good electro deposit are a rare possibility. Even if the metal is deposited, the purity of the same is not good enough to make the recovered metal usable.

Electro Dialysis

This method of treatment is based on the principle of ion transfer across the selective ion exchange membrane under the action of direct current has been made use of in this method of treatment. This process is very well used for desalination of seawater.

Electro Flotation

The basic principle involves in this method is to use the gases $\text{H}_2$ and $\text{O}_2$ generated at the electrodes, in the form of very fine bubbles, by electrolysis as the floatation agent. The cell consists of two electrodes with large surface area kept close to each other in order to minimize the voltage drop and allow the effluent to pass through. During electrolysis, the gasses generated at the electrodes in the form of bubbles get attached to the particles in the waste water thereby helping them to float. The suspended particles collected at the top of the column in the form of thick slurry, which can be
skimmed off and treated separately. This process can be successfully adopted whenever effluent consists of either finely divided suspended matter or immiscible oil components which can be easily floated. Example, the wastewater from engineering industries, dairy industries, etc.

**Electro Coagulation**

Electro coagulation is a modification of electro flotation in that the coagulation agent is produced in situ at the respective electrodes. The most commonly used electrodes are iron and aluminum, which results in the formation of coagulation which could not be successfully floated. In this method the pollutant is transformed into amorphous precipitates or adsorbed on hydroxides formed at the anodes.

**Electro Phoresis**

The process of migration of a particle under the influence of a high electrical field has also been adopted for wastewater purification. It is especially useful in case of treating mine waters that may contain colloidal particles, which cannot be separated using any other technique.

The particles in suspension under the influence of electric fields acquire a charge. This process could also be successfully adopted for treatment of wastewater from automobile industry, which contains various organic immiscible impurities like lacquer-paint.
Electro Filtration

Electro filters or electro precipitators are very well used in air pollution control. Though this involves electricity and electric field, the method does not directly correspond to electro chemical method. The particulate pollutants when subjected to a high voltage electric field leads to effective precipitation of the impurities from polluted air. The electrostatic precipitation of dust, mist smoke and fumes in an established process for cleaning fuses before they are let out.

Electro Sterilization

Sterilization is effectively brought by hypochlorite or free chloride generated by electrolysis of NaOCl. It appears from the current trend that these methods will have better prospects in the near future in the field of wastewater treatment.
as electron acceptor in the electron pathways. The products of the azo bond cleavage are lower molecular weight aromatic amines. Although they are colourless, they cannot be further degraded under anaerobic conditions. Therefore, various combined processes, such as anaerobic/aerobic [5], chemical/biological [7], and electro chemical/biological [8], processes have been under intensive study to completely mineralize organic dyes.

Though all the above methods have been found to be fairly satisfied, on considering the very stringent environmental regulations, there is a need for more effective alternatives. Anodic oxidation of some benzene derivatives (model organic pollutants) at platinum and DSA (dimensionally stable anode) anode elucidate the possibilities of the electro chemical method [9]. Dimensionally stable anode (DSA) with RuO₂-TiO₂ as a catalytically active layer coated on a titanium substrate by the thermal decomposition method has been successfully used and caused a technological revolution in the chloro-alkali industry since its invention in 1960s [10]. The first fundamental research on the properties of RuO₂, the main component of DSA, appeared in the open literature only in 1971 [11]. The Ti /RuO₂ electrode was prepared by thermal decomposition technique which consisted of the following steps: dissolution in isopropanol of RuCl₃, varnish application on the pretreated titanium base; drying at 80 °C; thermal decomposition at 500 °C; cooling and repeating the above operation 10 times, finally post heat treat for 2h at 500 °C [9]. Earlier work has proposed electro chemical treatment of xylenol orange dye and dye effluents on bench scale [12]. Electro chemical oxidation of textile dye wastewater using Pt / Ti electrode was studied in a pilot plant under batch recirculation process [13]. This leads to develop a pilot plant study of electro chemical technique using Ti /RuO₂ electrode for the treatment purposes under continuous single pass process. Hence this paper presents the treatment of Procion Black-5B by an electro chemical
ELECTRO-CHEMICAL TREATMENT HAS THE FOLLOWING ADVANTAGES

Applicability for various purpose like direct or indirect oxidation and reductions, phase separations, concentrations or dilutions, which deal with many pollutants that are in gaseous, liquid and solid state, which can be treated from micro liters to millions of liters.

Easy of automation of processing and controlling, as I and E are the variables.

No generation of secondary pollutants which help to keep the environment clean.

It is cost effective.

Simplicity of required equipments and operation.

Lower temperature requirements than that of non electro chemical process (eg. Thermal incineration)

Possibilities of minimizing the power losses due to poor current distribution, voltage drops and side reactions by controlling the potentials and designing the electrode and cells properly.

The capability of continuous operation with constant efficiency.