Treatment of Paper and Pulp Industry Waste Water by Using Unified Electrocoagulation System

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Abstract— Electrocoagulation is an effective technique for treatment of pulp and paper industrial effluent. The effective performance of electrocoagulation technique in the treatment of pulp and paper mill waste water has been investigated using different combination of aluminium (Al) and iron (Fe) electrodes. The influence of electrolysis time, apply the current density, rotational speed, electrolyte PH, electrode distance and supporting electrolyte on electrocoagulation efficiency for treatment of pulp and paper industrial effluent has been attempted in present investigation.

Keywords: Electrocoagulation, Paper and Pulp Industry waste water, Iron and Aluminium Electrodes, pH, BOD and COD

I. INTRODUCTION

Paper industry is primarily dependent upon forest-based raw materials. The first paper mill in India was set up at Srirampur, West Bengal, in the year 1812. It was based on grasses and jute as raw material. Large scale mechanized technology of paper making was introduced in India in early 1905. Since then the raw material for the paper industry underwent a number of changes and over a period of time, besides wood and bamboo, other non-conventional raw materials have been developed for use in the papermaking. The Indian pulp and paper industry at present is very well developed and established. Now, the paper industry is categorized as forest-based, agro-based and others (waste paper, secondary fiber, bast fibers and market pulp). In 1951, there were 17 paper mills, and today there are about 515 units engaged in the manufacture of paper and paperboards and newsprint in India.

The pulp and paper making industry is water intensive industry; it is ranked third based on water consumption after metals and chemical industries. The Indian Pulp and paper industry consuming 100-250 M^3 fresh water/ ton of paper production depend on the process. The volume of wastewater generated by pulping and bleaching operation is approximately in the range of 75-225 M^3/ton product. The volume of effluent generated and its characteristics are normally dependent on process used for paper making and the effectiveness of the process. The discharge of highly colored wastewater into the ecosystem involves environmental problems like aesthetic pollution perturbation of aquatic life. The State Pollution Control Board of Tamil Nadu India, has directed the industries to implement zero discharge facilities. The continuous depletion of ground water shortage in rainfall and huge consumption of water by paper pulp industries necessitated the recycling and reuse of processed water. (R. Sridhar et.al,2011).

Indian pulp and paper scenario shows that it uses 39% of forest-based fiber, 31% Argo Residue based fiber and 30% fiber is derived from waste paper. The fibrous raw materials used by Indian paper industry for the production of different varieties of paper comes from different sources like wood, leaf of trees, shrubs, and grasses. The Indian paper industry produces mostly two types of virgin pulps from the fiber sources ie. Chemical pulps through either soda process or kraft process and semi-mechanical pulps. Each material has distinct morphological characteristics and chemical Composition. Morphological features of pulp fiber are the key factor controlling the Quality of products during papermaking. The fundamental properties of any pulp fiber are length, diameter/width, and cell wall thickness lumen diameter/width. The derived fiber factor as Runkel ratio, slenderness ratio and coarseness also indicate the fiber behavior in the papermaking process. The pulps have different types of cell types depending the source.

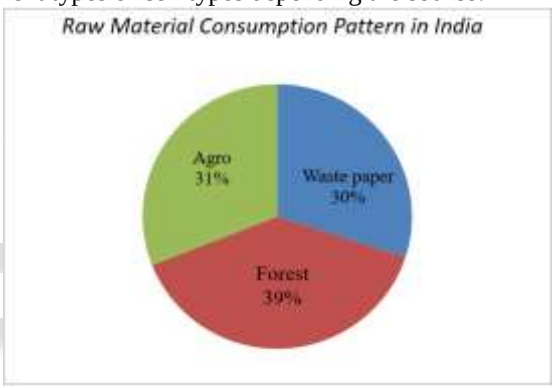

Fig. 1: Raw Material Consumption Pattern in India

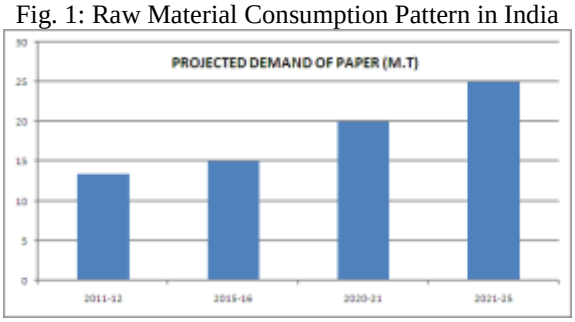

Fig. 1: Paper production 25 million MT by the year 2020.

A. Wastewater Characteristics

Paper mill wastewater was collected from Chobo khaghaz Sari (paper mill Factory, Sari). The main characteristics of the paper mill wastewater used in this work are presented in Table-1. A digital calibrated pH-meter (Radiometer PHM 210) and a conductivity-meter (Radiometer CDM 230) were used to measure the pH and the conductivity of the paper mill wastewater sample.

Sl no	Characteristics	Value
1	pH	6.4
2	Conductivity (ms cm^{-1})	12.7
3	Color (absorbance at 600 nm)	0.34
4	COD (mg/l)	1700

5	Phenol (mg/l)	34
6	Total dissolved solids (mg/l)	8741
7	Total suspended solids (mg/l)	1060
8	Total solids (mg/l)	9801
9	BOD (mg/l)	850
10	TOC (mg/l)	910

Table 1: Characteristics of paper mill waste water

Total solids (TS), suspended solids (SS), total dissolved solids (TDS), biochemical oxygen demand (BOD), and chemical oxygen demand (COD) (the open reflux method has been used) were analyzed in triplicate based on Standard Method. The analytical determination of phenol was carried out using UV- spectrophotometer (Shimadzu, Model UV - 160) by analyzing the color resulting from the reaction of phenol with 4-aminoantipyrine at maximum wave length =500nm. Decolorization of the textile effluent was analyzed using a UV-Vis spectrophotometer (Hitachi U 2800, Tokyo, Japan) at 600 nm. TOC determination was carried out with TOC -5000A Shimadzu Total Organic Carbon Analyzer. (Reza Katal, Hassan Pahlavanzadesh).

B. Paper Industry Wastewater Treatment

The treatment of the waste may consist of all or combination of some of some of following.

1) Recovery
2) Chemical treatment
3) Activated carbon
4) Physical treatment

1) Recovery:

The recovery of the process chemicals the fibers reduces the pollution load to a great extent. Where the economy permits the color bearing 'Black liquor' is treated for the chemical recovery. The process of recovery described earlier.

2) Chemical Treatment for color removal:

The chemical coagulation for the removal of color is found to be uneconomical. Attempts have been made to remove color from the waste using the Lime sludge; the results are not at all encouraging (Sastery et.al, 1974). "Massive Lime Treatment" process, developed by the National Council for Stream Improvement in USA is said to be capable of removing 90% of color and 40% to 60% of BOD from the waste (Subrahmanyam).

3) Activated Carbon for color removal:

In a study conducted by NEERI, it has been observed that Acidic Activated Carbon can remove 94 % color from the Pulp mill waste. However, pH of the waste required to be reduced to 3.0 before this activated carbon treatment.

4) Physical Treatment for clarification:

Mechanically cleaned circular clarifiers alone are found to be capable of 70-80% removal of the suspended solids from the combined mill effluent. About 95-99% removal of settleable solids can be accomplished in the clarifiers (Gillespie).

II. ELECTROCOAGULATION PROCESS

In its simplest form, an electro coagulating reactor may be made up of an electrolytic cell with one anode and one cathode. When connected to an external power source, the anode material will electrochemically corrode due to oxidation, while the cathode will be subjected to passivation. But this arrangement is not suitable for wastewater treatment, because for a workable rate of metal dissolution, the use of electrodes with large surface area is required. This has been achieved by using cells with monopolar electrodes either in parallel or series connections.

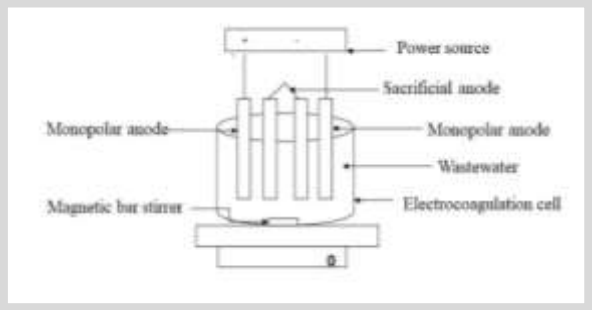

Fig. 2: EC reactor with bipolar electrodes in parallel connection

The sacrificial electrodes are placed between the two parallel electrodes without any electrical connection as shown in Fig-2. Only the two monopolar electrodes are connected to the electric power source with no interconnections between the sacrificial electrodes. This cell arrangement provides a simple set-up, which facilitates easy maintenance during use. When an electric current is passed through the two electrodes, the neutral sides of the conductive plate will transformed to charged sides, which have opposite charge compare to the parallel side beside it. The sacrificial electrodes in this case are also known as bipolar electrodes.

A. Significance of the Present Research

Various treatment options available for the Paper and pulp industry wastewater, each of them have their own advantages and limitations. The aerobic and anaerobic treatment processes have capability to reduce COD and BOD to higher extent. The efficiency of the process decreases when the wastewater contains significant amount of oil and grease material. Hence there is need of a technique which can remove COD, BOD, turbidity along with oil and grease from wastewater.

B. Objectives of Proposed Work

The objectives of proposed work are listed below:

1) Design and fabrication of the electro coagulation unit, for paper and pulp wastewater treatment.
2) To investigate the treatment efficiency of the electro coagulation for pollutants removal from paper and pulp wastewater in batch /continues process.
3) To study the effect of the pH, Current density, Voltage time, Conductivity, electrolysis duration.
4) Optimized parameters will be studied to find feasibility of electrocoagultion technology.
5) Experiment results were analyzed by design expert software RSM (Response Surface Methodology)

III. MATERIAL AND METHODS

Various materials to be used and the methodology to be adopted will be discussed in this chapter.

For the batch electrocoagulation's studies, the reactor will be made up of acrylic material with a total working volume of 1 L and with the dimensions of 15cmx10cmx15cm. The electrocoagulation unit will be

consisting of two electrodes in the reactor and DC power supply. The DC source of 0-30 V and 0-2 A will be used as power supply to the system. Iron and aluminium will be used as electrodes having dimensions of 5cmx5cmx1cm.

IV. BRIEF MYTHOLOGY

The initial characteristics of the wastewater will be analyzed. The batch experimental studies will be conducted to optimize various parameters such as pH, electrolysis duration and voltage. The experiments will be performed with two electrodes connected to the DC power supply. The space between the electrodes will be maintained 1cm in all the experiments. In each run the voltage will be varied to a desired value. The volume of solution in each batch experiment will be 1L. To maintain homogenous mixing of the reactor content, magnetic stirring will be used. All the analyses of the wastewater will be conducted as per standard analytical techniques.

V. EXPECTED OUTCOMES OF PROJECT

1) Electrocoagulation assessed as a possible technique for the reduction of color, phenol and COD concentration in paper industry wastewater.
2) The influence of variable such as Current density type of electrode material, electrolysis time and wastewater pH.
3) The advantage of electrocoagulation by solar energy, it helpful for such places where electricity is not available easily.
4) Electrocoagulation can be considered as a suitable alternative to existing methods or applied as pretreatment step of biological process used for treatment for black liquor.
5) Electrocoagulation technique could be successfully used for, the recovery of water from pulp and paper industries bleaching effluent for reuse.

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