International Journal of Modern Trends in Engineering and Research
www.ijmter.com

e-ISSN No.:2349-9745, Date: 2-4 July, 2015

Treatment of Distillery wastewater by Electro coagulation using Aluminum electrodes

Kaustubh S Sasane[1], Sandip R Korke[2]

[1]Student, Department of Civil Engineering, SRES, Collage of Engineering, Kopargaon,
[2]Assistant Professor Department of Civil Engineering, SRES, Collage of Engineering, Kopargaon

Abstract-The persent exprimental work elaborates the treatment method for distillery wastewaterusing aluminium plate electrodes.the electrocoagulation process governing diffrent key the parametrs such as pH,Current density ,hydrulic retention time and number of aluminium plates between the anode and cathod were investigated and analysed.

I. INTRODUCTION

The production of by product from sugarcane includes white crystalline sugar, Ethanol, Potable liquor, Industrial alcohol etc. India produced a total of 8.6 million MT of molasses in year 2006, which is used to produce ethanol and potable liquor. During the production of such potable liquor wastewater is generated in various manufacturing processes like fermentation, distillation column and rectification column etc.

The byproduct of sugar cane molasses like potable liquor and industrial alcohol are derived from the fractional distillation of residual part of sugarcane juice after extraction of crystalline juice and hence it contains the major polluting parameter like Chemical oxygen demand, Biological oxygen demand, total solids, Chlorides and Sulphate. Due to presence of such parameters the hazardous effect takes place into soil and water .therefore most efficient treatment for such wastewater is required so as to reduce the concentration of the parameter up to the limits specified by the central pollution control board.

The conventional physio chemical treatment used by the distillery units for treatment of wastewater may be Chemical coagulation, flocculation, Adsorption, Oxidation, anaerobic lagoon, membrane filtration etc. but as these treatment having limitations like limited removal efficiency, high operating cost, maintenance and requires a high detention time which ultimately increases the overall treatment process time.

To overcome the limitation and disadvantage of the conventional treatment unit; the new sustainable treatment can be used to archive maximum removal efficiency. Nowadays a new sustainable technology is replacing the conventional treatment unit which is based on the electrochemistry and hence the process is known as electrocoagulation. The major advantage of this technology is that; it generates approximately 83% less sludge volume as compared to classical chemical coagulation.

An implementation of electrocoagulation technology gave better results for Tannery wastewater, Dye removal, Dairy wastewater, heavy metal removal and petrochemical wastewater. Also this technology proves effective from Economy and electrical energy consumption point of view. Hence lot of research work is going on for application of electrocoagulation technology to treat various type of wastewater. In this work the investigation carried out for analyzing the effect of electrode arrangement on the removal efficiency will make any significant change in the removal efficiency for COD, total solids and turbidity.

II. EXPERIMENT

Treatment of Distillery wastewater by Electrocoagulation using different electrode arrangements

2.1. Material and methods

The electrolyte cell (20cm x 10cm x 15cm) is made up from the of Plexiglas acrylic material having 1.5lit net capacity to treat the electrolyte, the electrode, pH meter , thermometer and the magnetic stirrer with hot plate is utilized to perform the experimental work. The anode and cathode with surface area of 0.2cm² were made up from the aluminum alloy with Zinc (2-5%).the inter electrode distance between plate electrode is kept constant for all the arrangements. The electrolyte was mixed thoroughly by using a motor less magnetic stirrer model 30 MAG 11(Labline, India) which is having maximum speed of 400rpm,a regulated direct current supplied by using Virupaux model VP17310SF (10 A,0-30V),and pH is measured by using digital pH meter.

The Plate electrodes of aluminum are made up from locally perched aluminum sheet of 3mm thickness and having dimension of 20cm x 7.5 cmx2 mm. The inter electrode distance is maintained between 15 mm-30mm. The distillery wastewater sample is collected from GSSK, Pune in a plastic bottle. The physio-chemical parameters of treated sample were analyzed with respect to factors like time and current density for different electrode arrangement.

2.2 Samples

In current experimental setup, sample of distillery wastewater is located in GSSK, Pune. The collected sample was diluted before electrocoagulation process by 75% dilution factor. The composition of collected wastewater is tabulated in table 1

Table 1. The water quality parameters (WQPs) of distillery wastewater without and with dilution.

2.3 Mechanism of electrocoagulation

Electrodes which produce coagulants into water are made from either iron or aluminum. In addition, there can be inert electrodes, typically cathodes, which are sometimes used as counter-electrodes in the system.

At the anode: $M_{(s)} \rightarrow M_{(aq)}n^{+} + ne^{-}$

$2H_2O_{(l)} \rightarrow 4H^{+}_{(aq)} + O_{2(g)} + 4e^{-}$

At the cathode: $M_{(aq)}n^{+} + ne^{-} \rightarrow M_{(s)}$

$2H_2O_{(l)} + 2e^{-} \rightarrow H_{2(g)} + 2OH^{-}$

Where M denotes Metal of electrode

Reactions with aluminum metal electrode

Anode: $Al_{(S)} \rightarrow Al^{3}_{(aq)} + 3e^{-}$

At the cathode: $2H_2\,O + 2e^{-} \rightarrow H + 2OH^{-}_{(aq)}$

Overall cell: $Al + 2H_2O \rightarrow Al^{2+} + H_{2(g)} + 2OH^{-}$

III. RESULT AND DISCUSSION

3.1 Effect of pH on the performance of the electrocoagulation process

A key factor which governs the overall performance of the electrocoagulation process is the initial ph of the electrolyte, the variation in the pH value alters the solubility of the solid aluminum metal into gelatinous form of aluminum hydroxide and thus the coagulant dose varies depending on the ph of the electrolyte. To analyze the effect of the pH on the electrocoagulation process the initial ph of the sample solution was adjusted using diluted sodium hydroxide or sulfuric acid. Hence (fig 1) elaborates the removal efficiency of COD, turbidity, sulphate, chlorides and total hardness as a function of the influent pH with the optimum pH range about 3.5-5. However ,the suddenly at the pH value <6.similery in case of COD the results shows that the electrocoagulation treatment proves better for acidic pH value than natural and alkaline pH. In case of distillery wastewater electrocoagulation process favors the formation of an anodize aluminium surface and adsorption is adequate at lower ph values.

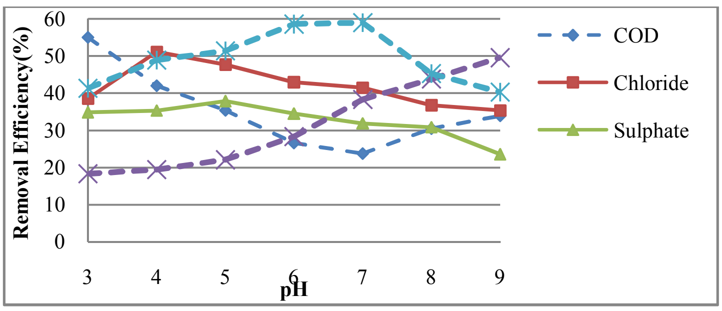

Figure 1 Removal efficiencies of COD, Chloride, Sulphate, Total hardness and Turbidity as a function of intial pH(HRT:15 min, inter electrode distance:15mm)

3.2 Effect of HRT on pH change

The basic theory of electrochemistry says that, the reason behind change in pH is the production of OH- from wastewater due to H2 and O2 bubbles generated, which ultimately imparts increased pH value. Moreover, chemical dissolution of Al will consume H+ and increased pH value in treated wastewater. Electrolysis time is an important parameter which influences the treatment efficiency of electrocoagulation process .it is noticed during the run of experimental set up that, an increased electrolysis time results into increased COD removal efficiency. The COD removal efficiency directly depends on the concentration of hydroxyl ion generated on the electrode and time of reaction for such ions with pollutant species and partials suspended in the electrolyte.

3.3 Effect of HRT on removal of COD, Chlorides,Sulphates,total hardness,Colour and turbidity

In the experimental setup two Al electrodes and two Al plate placed between electrodes at a fixed potential of 30 v, 15 mm distance between plates and at different electrolysis time. The figure 2 shows that COD removal increased during first 15 min at relatively high rate, then slows, reaching a plateau after 40 min reaction time. as the distillery waste water contains high organic matter synthesized during fractional distillation and fermentation of molasses which causes high COD value of such water which can be removed successfully within very short duration of treatment process. The other possible mechanism based on electrochemistry such as electro flotation, direct anodic oxidation and indirect oxidation by chloride ions could be used for removal of COD in combination of electrocoagulation process.

The distillery wastewater contains elements like sulphate which is removed by adsorption on metal hydroxides produced from respective coagulant. The major limitation of this technology is that presence of anion like chlorides and sulphate reduces removal efficiency and increases the total dissolved solids (TDS) in the treated waste water. So to resolve this difficulty in current experimental work, aluminium plates are placed for anode and cathode. The other parameters such as Chlorides, Sulphates, total hardness, Colour and turbidity totally dependent on optimum electrolysis time, as the constant current density produced offers the constant amount of coagulant dose disseverment in the electrolyte the saturation stage come after the optimum dosage of coagulant. Another most important feature of this process is that a very lesser amount of residual material is left behind after the process and it is fact that the 40-50 % of the total cost is consumed in the sludge management thus this technology the limitation in the conventional treatment

The hydraulic retention time (HRT) goes on increasing up to 45 min the poly-nuclear hydroxyl aluminum complexes such as $Al2(OH)_2^{4+}$, $Al_7(OH)_{17}^{4+}$, $Al_{13}(OH)_{34}^{5+}$, $Al_3(OH)_4^{5+}$, $Al(OH)_6^{3-}$,$Al(OH)_7^{4-}$ and AlO^{2-},take place as the coagulate dose and the phase comes when the charge density of these ions get saturated, at this stage the destabilized element which are suspended, dissolved in the effluent are lose its suspended nature, as the free electron of the aluminum collides the suspended and dissolved particulate matter which is responsible to break the stabilized stage and at same time the hydrogen bubble from cathode lift these impurities in the form of floc. Since HRT is an important factor which favors chemical and physical adsorption of distillery wastewater the optimum HTR gives us the maximum removal efficiency thus if we control the HTR, Current density then proper dosing of aluminum can be maintained during the process.

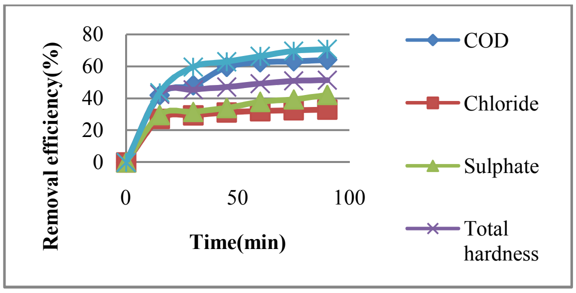

Figure 2: Removal efficiencies of COD, Chloride, Sulphate, Total hardness and Turbidity with time(Voltage 30v, inter electrode distance:15mm)

3.4 Effect of Voltage on removal of COD, Chlorides,Sulphates,total hardness,Colour and turbidity

As the HRT is important factor but the factors associated with the HRT for the maximum removal efficiency are operating voltage and the electric current in batch mode electrocoagulation set up. The aluminum electrode metal dissolved is directly proportional to the charge loading which follows Farday's law. The passage of 1 F (26.8 Ah) of current evolves 0.0224 Nm3 hydrogen gas, which is much greater than the volume of gas released in traditional dissolved air flotation. Consequently, increasing current density will increase the charge loading leading to increased removal of pollutants. Furthermore, better collection efficiencies can be obtained during electro flotation by generation of smaller bubbles with increasing current density.1

The directly controlled parameter in the electrocoagulation process is the voltage, because the current will change with time and same time due to build up of sediments like carbonate salts on the aluminum plate can affect the electrical current. In this system electrode spacing is fixed and voltage is a continuous supply. The voltage directly determines both the coagulant dose and bubble generation rate, as well as strongly influencing both mixing of solution and mass transfer at the electrodes.

Thus experimental run carried out to analyze the effect of varying operating voltage on the removal efficiency and the overall performance.

Table 2. Removal efficiencies of COD,Chlorides,Sulphates,Total hardness and Turbidity as a function of voltage

Time(min)	COD Removal (%)			Chloride Removal (%)			Sulphate Removal (%)			Total Hardness Removal (%)			Turbidity Removal (%)		
	10v	20v	30v	10v	20v	30v	10v	20v	30v	10v	20v	30v	10v	20v	30v

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	34.11	35.01	41.92	24.98	25.69	27.14	22.35	23.77	29.64	26.05	29.7	31.25	31.94	33.41	35.17
30	37.98	38.55	46.26	25.75	26.85	29.38	25.16	27.11	31.52	28.75	30.51	34.83	34.82	36.89	37.43
45	42.36	44.96	53.47	27.04	28.33	31.17	27.98	30.79	33.96	31.98	32.83	36.1	38.64	41.08	43.87
60	48.75	51.17	58.11	28.69	30.19	32.05	32.22	33.47	37.86	35.78	34.93	38.06	42.09	44.32	48.31
75	52.85	57.65	64.04	30.01	32.53	34.84	36.87	38.16	39.36	38.63	39.11	41.93	45.57	47.85	50.87
90	56.21	63.64	68.66	34.86	36.85	37.28	39.76	41.39	42.13	41.87	42.08	44.92	48.63	50.02	53.51

IV. CONCLUSION

In the experimental study of batch mode electrocoagulation process for treatment of distillery wastewater it is observed that; process yields significant result as compared to the conventional treatment process by using aluminum electrodes. The effect different of pH, voltage and hydraulic retention time were studied clearly.

From the experimental work it is clear that, the COD,Chlorides,Sulphates,Total hardness and Turbidity removal efficiency were increased by maintain the optimum voltage supplied to the electrode,HRT and the maintaining optimum charge density within the volume of electrolyte. The removal efficiency shows that the electrocoagulation proves a sustainable treatment process for treatment of Distillery wastewater.

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