International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.03, April 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Treatment of Spent Wash Using Electrocoagulation Technology: A Review

L. S. Patil [1*], Dr. V. D. Salkar [2]

[1] M.Tech Student: Environment-Civil Engineering, Walchand College of Engineering, Sangli, (India)

[2] Associate Professor: Department of Civil Engineering,

Walchand College of Engineering, Sangli, (India)

ABSTRACT

Distillery industry is one of the major agro-based industry. In India molasses based industries are dominant. These industries are categorised into Red Category by CPCB. Distillery industry generates different types of liquid waste such as spent wash, spentleese and condensate. Out of these, spent wash produced per unit of alcohol is very large which is 8–15 L/L of alcohol. Spent wash treatment has many difficulties majorly due to its high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) with dark brown colour. As day by day effluent standards for the industries are becoming stringent, to achieve these effluent standards conventional treatments like anaerobic lagoons, biomethanation, composting proves to be insufficient. Their drawbacks include requirement of large area, huge quantity of sludge and high cost. Additionally, Using one of these tratment at a time doses not fullfill effuent standards hence series of treatment are employed to achieve desired effeunt quality. To overcome these difficulties faced in conventional treatments, recently Electrocoagulation, concentration and incineration in boiler are gaining importance. Out of this Electrocoagulation have many advantages like high treatment efficiency, easy operation, no additional chemicals, lower sludge volume and environmental compatibility. Literature review shows that performance and treatment efficiency of EC depend on various factors, such as electrode materials, Spacing between electrodes, operating current density, electrolysis time, pH of the solution, addition of electrolyte. The present study focuses on the use of EC process for pollutants removal in spent wash.

Keywords: Distillery, Electrocoagulation, Environmental compatibility, Spent wash.

I.INTRODUCTION

In today's world distilleries having their own significant contribution to the economy of the country. In the present scenario of the Indian economy, sugar mills and distilleries are the backbone of agro-industry. Distilleries are among top most polluting industries in India. Most of the distilleries co-exist with sugar mills and utilize the molasses from cane sugar manufacture as the starting material for alcohol production. In India, 285 distilleries use sugar cane molasses as a raw material for the production of ethanol. Usually, about 8–15 L of wastewater is generated for every litre of alcohol produced by the molasses-based distilleries called ''spent wash'' which amounts to more than 40 billion liter of spent wash annually [1].

The spent wash is characterized by extremely high chemical oxygen demand, biological oxygen demand, suspended solids, inorganic solids, colour content and acidic pH [2].spent wash contains intense quantities of recalcitrant pollutants in the form of dark coloured organic pollutants. The intense colour is due to the presence of a dark brown, acidic melanoidin pigment [3]. Apart from high organic content, distillery wastewater also contains nutrients in the form of nitrogen, phosphorus and potassium that can lead to eutrophication of water bodies. Primary treatment through bio-methanation and energy recovery – an economic process practised in Indian distilleries, however, does not meet the discharge standards [4]. It is much more hazardous when disposed of water bodies since it will lead to complete depletion of dissolved oxygen and destruction of aquatic life. If disposed of untreated on land, it reduces the alkalinity of the soil, and crops may be destroyed. In some parts of the country, colour problems in groundwater are very acute. These antioxidant and recalcitrant polymers cannot be easily degraded by conventional biological treatment methods, namely, anaerobic digestion (bio methanation), anaerobic lagoons, and activated sludge process. Since conventional methods can accomplish only low degradation of melanoidins, it is necessary to explore additional treatments to remove colour from molasses effluent. Melanoidins can be removed by physicochemical treatments, but these methods require high reagent dosages & generate a large amount of sludge.

During the last few years, environmental sector has shown a largely growing interest in the treatment of different types of wastewater by electrocoagulation (EC). It has recently attracted attention as a potential technique for treating industrial effluent due to its versatility, treatment efficiency, low cost, and environmental compatibility. EC has many applications, in which a can be used to remove variety of unwanted dissolved particles and suspended from the aqueous solution. However, very less work was done on EC. The main aim of this review is to present discussion of the fundamental of EC and also attempt has been made to brief review on treatment of spent wash by EC process.

1. Principal of electrocoagulation

The main principle of electrocoagulation (EC) technique is based on "electrolysis". Electrolysis is a process in which oxidation and reduction reaction occurs when electric current is applied to an electrolytic solution. EC system consists of an anode and cathode electrode which is connected to external DC power supply. These electrodes are submerged in aqueous solution which is being treated. EC is a process in which the anode material undergoes oxidation while cathode material undergoes reduction. When anode material undergoes oxidation, there is production of various polymeric metal hydrolyzed species. In an EC process the coagulating ions are produced 'in situ' involves following successive stages: (i) Formation of destabilization agents such as Al and Fe ions by electrolytic oxidation of the 'sacrificial electrode' that neutralize the electric charge present on colloidal particles. (ii) Destabilization of the contaminants, particulate suspension, and breaking of emulsions. (iii) Accumulation of the destabilized phases to form flocs. (iv) Formation of OH^- ions, Formation of H_2 and O_2 gas at cathode and anode respectively. (v) Removal of colloids by sedimentation or floatation.

II.LITERATURE SURVEY

2.1 Raw spent wash

In the current study, Electro-coagulation technique is used for the treatment of distillery wastewater with and without the presence of activated Areca catechu nut carbon (AAC)). He used aluminium plate as anode and stainless steel plate as cathode electrode. They have used EC process to remove suspended (fine) solids and dissolved molecules. In order to remove of pollutants from distillery effluents, EC is more effective in the presence of AAC than in the absence of AAC. Further they also found that efficiency for COD removal was 75.5% and 80.1% with and without AAC respectively [5].

An experimental study were conducted to optimize the parameters such as electrolysis time (ET), voltage, pH and type of electrode In this experimental study of electrocoagulation, Iron and aluminium electrodes were used as electrodes in lab scale batch study EC reactor of capacity of 2 liter. These two electrodes were placed having fixed gap of 3cm and electrode dimension were used are 150mm x 50mm x 5mm. In this study, initial characteristic of effluent such as COD (134000 mg/L), BOD (59072 mg/L), TDS (12300mg/L), colour (316000 Pt-Co) and turbidity (15880 mg/L) were observed. Result obtained for aluminum electrodes removal efficiencies for COD, BOD, TDS, colour and turbidity were found 98.39%, 97.57%, 83.91%, 97.64% and 98.85% respectively. Efficiency of aluminum electrodes was found good compare to iron electrodes at optimal conditions pH 9, voltage 15V, and electrolysis time of 90 min. [6]

In further study, investigation was done on the feasibility of Electrocoagulation remove the colour and COD of distillery spent wash by comparing Electrocoagulation and chemical coagulation treatment. A combination of the different electrode was used such as Al-Al, Fe-Fe in batch mode experiment which was performed by taking 1000 ml of distillery spent wash in a beaker. The 110 x 25 mm^2 area of electrodes was dipped out of 135 x 25 mm^2. A DC power supply in the range from 20V to 30V was applied. The experiments were conducted at different pH like 3,5,6,8 and for each 20 min. interval COD and colour were observed. From these experiments, they found that maximum COD removal was 85.7% for Al-Al electrode and for Fe-Fe 73.71% at pH 3 which concludes that acidic condition is more favorable. Whereas in case of chemical coagulation the maximum colour removal efficiency 96.09% was achieved at pH 8 using Al-Al electrodes. The efficiencies were obtained from chemical coagulants for alum and lime was 66.27% and 51.43% respectively which was found at pH 5. EC process was found better than chemical coagulation through the comparison of above results. [7]

"Concentration and incineration in boiler" technique for spent wash was shown drawbacks due to the presence of calcium and magnesium and silica in another study. Spent wash has $CaCO_3$ which forms amorphous sludge of chalk, $CaSO_4$ forms scale and Silica is insoluble in the water this results in lowering the efficiency of the boiler. The purpose of this study was to remove removal of calcium magnesium and silica. Batch mode experiments were done by taking 500 ml sample and pH of sample was changed to alkaline range using the lime. They found that maximum calcium removal efficiency was 55% obtained at 1.5A current in 45 minutes electrocoagulation. They concluded that before incineration of spent wash in boiler electrocoagulation technique can be used. Use of electrocoagulation technique helps in reducing salinity and corrosion which reduces the maintenance cost. [8]

2.2Diluted Spent Wash

Some of the researchers were worked on treatment of diluted spent wash using EC. Dilution was done with deionized water for experimental purpose.

In the present study experiments were done on spent wash having dilution factor of 10. This diluted spent wash was used for electrocoagulation experiment using PbO2- Ti, RuO2-Ti and graphite as an anode and Stainless Steel (SS) used as the cathode. Main objective of study was to remove COD and colour. They found that maximum 56.3 and 62.0% COD reductions were observed as maximum with PbO2–Ti and RuO2–Ti anodes without addition of electrolyte but with addition of 3gm/lit. NaCl gives 92% of chemical oxygen demand (COD) reduction, 98.1% of biological oxygen demand (BOD) reduction and 99.5% of absorbance reduction were obtained in case RuO2–Ti as anode and stainless steel as cathode were used which is higher than that of graphite electrode used as anode and stainless steel as cathode. From these results it found that use of catalytic anode gives better efficiency than graphite electrode [9]

In another study they used electrocoagulation to treat spent wash with Iron as anode electrode and stainless steel plate as cathode electrode. This study was mainly focused on decolorization of spent wash. The factors which affects on EC process such as current density, dilution factor and time of electrolysis were optimized using Box-Benhnken design of response surface methodology. They found that the maximum 93.5% decolonization can achieved at current density 31 mA/cm^2, dilution 17.53% and 4 hrs. EC process at pH 7 **[**10].

2.3Bio-digested effluent

Another study was done on bio digester effluent as feed for electrocoagulation. A batch mode process was used for COD removal using aluminium electrodes. Here using RSM method, COD removal was taken as the response of the system and namely current density, pH, the gap between electrodes and time for electrolysis taken as input parameters. The quadratic model was found suitable for analysis. The results reveal that at pH nearly 6, COD removal efficiency of 52% as maximum efficiency. Mechanism At low pH is Al^{+3} generated at anode and neutralizes this charge on pollution which increases their insolubility while at higher pH greater than 6 involved absorptions of organic substances on metal hydroxide. The study concluded that effect of pH has significant effect on removal efficiency and maximum removal efficiency was observed at pH equal to 6 maximum COD removal efficiency 52.2% at current density 120 A/m^2, the gap between electrodes 1 cm and electrolysis time in 150 minutes [11].

In this study, they investigated the applicability of EC treatment for COD removal and to improve the BOD_5/COD ratio of distillery wastewater collected from the anaerobic lagoon of existing distillery wastewater treatment plant using aluminium electrode. They also studied the effect of operating parameters such as electrolysis duration, pH and current density on COD. removal for experiment lab scale batch reactor having volume 1.5 L and the aluminium electrode of size 5cm*5cm with spacing 2 cm. The maximum COD removal 72.3% was found to be and BOD_5/COD ratio increases from 0.15 to 0.68 for 120 min EC duration at current density 0.03 A/cm^2 and pH 3.[12]

Another study, the effectiveness of two-stage EC process using multi-parameter optimization for treating bio-digested distillery spent wash by SS and Al electrodes was evaluated.in stage one they used SS electrode and in next stage they used Al electrodes. They also compared the separate efficiency of SS electrodes and Al electrodes. Three response parameters such as COD, color and TOC were selected for optimizing the operating parameters namely initial pH (pH_o), current density (j), electrode spacing (g) and electrolysis time (t). They used aluminium as anode and SS as cathode in both stages. The experiments were design by varying the operating parameters in the range such as in case of pH it is varied from 2 to 10 for SS electrodes and 4 -10 for aluminium electrodes, current density 30.86 to154.32A/m^2 , gap between electrodes 0.5 to 2.5 cm and EC time 30 to 150 min. From the results they found that SS electrode was more effective as compared to Al electrode for the removal of COD, color and TOC. To increase removal efficiency a two-stage EC process was also conducted and the results shows that SS followed by Al electrode gives total COD, color and TOC removal efficiency of 81%, 94% and 78%, respectively whereas Al followed by SS electrode combination gives total COD, color and TOC removal efficiency of 78%, 89% and 76%, respectively). This shows that SS followed by Al electrode more effective than Al followed by SS electrode [13].

2.4RO reject

Researchers also worked on Electrocoagulation in treatment of spent wash as tertiary treatment.

In this study, the reverse osmosis reject was treated by Electrocoagulation to reduce COD. For a batch mode experiments were conducted in 500 ml glass beaker by using aluminium electrode and iron electrodes. The study revealed that as pH increases the COD removal efficiency decreases because at low pH protons reduce to H_2 thus OH^- protons are less and which reduces the COD removal efficiency. They also found that use of Al-Al electrodes gives a better result than that of Fe-Fe electrodes. In the same study they also observed that iron electrodes have a high solubility in the acidic condition as compared to aluminium electrodes. The maximum COD removal efficiency 98% was discovered at optimum value of current density 17.9 mA/cm^2 and at pH equal to 7.2 (initial pH solution) [2]

2.5Synthetic melanoidin

In treatment of spent wash colour is the major problem which is due to presence of melanoidin polymer. Melanoidin polymer formed during Millard reaction between amino compounds and carbohydrates . The presence of melanoidins in water causes a dark brown colour. To remove melanoidin researchers use electrocoagulation treatment.

In one of the study a batch mode electrocoagulation treatment was done to remove colour due to melanoidin. The experiments were conducted on synthetic melanoidin which was prepared in laboratory. Experiments were conducted at different pH within range of 4.2–8.2 at *current density* $5A/m^2$; they found that the pH values affected the removal of melanoidins. The results indicated that the decolourization performance was dependent on pH values, because the lower pH values led to faster reactions and higher decolourization efficiency. The decolourization or melanoidin removal mechanisms are precipitation and charge neutralization between pH of 4.2 - 6.5. They observed that increase in current density increase the decolourization efficiency and as EC time goes on increasing the decolourization efficiency also increases but with the increase in melanoidin concentration decolourization efficiency decreases. The optimal operating parameters for greater than 98% decolourization of melanoidins were pH = 4.2, current density $5A/m^2$ and at 10 min. EC time [3].

III.CONCLUSION

In this view, electrocoagulation (EC) process is one of the alternatives available in the treatment of spent wash at different stages of treatment process. Many of researchers were worked diluted spent wash which is not feasible on actual field but many distillery industries are along with sugar industry so the dilution can be done with sugar industry waste water.

It is also found that most of the researchers have done their EC study in batch mode (lab scale) and very few researchers worked on continuous-flow EC systems study. Continuous flow EC system should be applied more in future studies in order to apply EC process on field scale.

Use of solar power to supply the energy to EC system can make this process more green.

REFERENCES

[1.] Annual report on "Opportunities for Green Chemistry Initiatives: Molasses Based Distilleries.", 2014, *Office of Principal Scientific Adviser to The GOI,* New Delhi, India.

[2.] Khandegar V. and Saroha A. K., (2014), "Treatment of Distillery Spent Wash by Electrochemical." *Journal of Clean Energy Technologies,* 2(3), 244-247.

[3.] Kobya M. and Gengec E. (2012), "Decolourization of melanoidin by electrocoagulation process using aluminium electrodes." *Environmental Technology,* (33)21, 2429-2438.

[4.] Central Pollution Control Board (2002), "Management of distillery wastewater. Resource recycling series:RERES/4/2001-2002",*CPCB:NewDelhi,India.http://cpcbenvis.nic.in/cpcb_newsletter/AGRO.pdf*

[5.] Kannan N., Karthikeyan G., Tamilselvan N. (2006), "Comparison of treatment potential of electrocoagulation of distillery effluent with and without activated Areca catechu nut carbon." *Journal of hazardous material,* (137), 1803-1809.

[6.] H. Santosh, N. Shanmukha and B. Lokeshappa , "Comparative assessment of iron and aluminum electrode for treatment of distillery spent wash by electrocoagulation method," International Conference on Emerging Trends in Engineering, Technology, Science and Management. pp. 317-322, July 2017.

[7.] Wagh M. P., Nemade P. D., (2015). "Treatment of Distillery Spent wash by using chemical coagulation and electrocoagulation." *American journal of environmental protection,* (3)5, 159-163.

[8.] Patwardhan A. and Dharnaik A.S., "Treatment Of Raw Spent Wash Using Electrocoagulation.", *International Journal of Innovative Research In Technology,* 4(2), 340-343.

[9.] Manisankar P., Viswanathan S. and Rani C., (2003), "Electrochemical treatment of distillery effluent using catalytic anodes." *Green Chemistry,* 5, 270–274.

[10.] Krishna Prasad R., Kumar R. Ram, and Srivastava S. N., (2008), "Design of Optimum Response Surface Experiments for Electro-Coagulation of Distillery Spent Wash." *Water Air Soil Pollution,* 191, 5–13.

[11.] Ponselvan F. I., Kumar M., Malvia J. R., Shrivastava V. C., Mall I. D., (2009), "Electrocoagulation studies on treatment of Biodigester effluent using Aluminium electrodes." *Water air Soil Pollution,* 199,371-379.

[12.] Krishna B. M., Murthy U. N., Kumar B.M., Lokesh K.S., (2009), "Electrochemical pretreatment of distillery wastewater using aluminium electrode.", *J Appl. Electrochem,* (40), 663-673.

[13.] Sharma P., Joshi H. Srivastava V. C., (2015) "Two- stage electrochemical treatment of bio-digested distillery spent wash using stainless steel and aluminium electrodes." *Journal of Environmental science and Health, Part A* 50,617-630.