International Journal of Engineering Research and General Science Volume 4, Issue 3, May-June, 2016
ISSN 2091-2730

Treatments to Distillery Spent wash by Electro coagulation [EC] and Adsorption: A Review

Shubham P. Kulkarni[1], Vishwambhar R. Kakde[2], Krushna A. Mane[3]

Final year students of Civil Engineering, Padmashri Dr. Vithalrao Vikhe Patil College of Engineering, Ahmednagar, Maharashtra.

Email: kulkarni_sp@hotmail.com **Contact no:** 9049228758.

ABSTRACT- Distillery industries are one of the most polluting industries in world, generating very high strength wastewater which effect seriously on environment. The industry produces dark brown colored wastewater which have unpleasant odor known as spent wash. On production of alcohol, large amount of wastewater produced. Generally 8-15 lit of spent wash was generated on production of 1 lit of alcohol. The spent wash has high characteristics like COD, BOD, Color and TDS, which are difficult to remove easily. For supplementing existing waste treatment, there are number of studies carried out for removal of color and COD of spent wash. This review represent on overview of pollution caused by distillery spent wash and treatment technologies used such as Electro coagulation, adsorption and combination of different sand media as a filter.

Keywords: spent wash, melanoidin, decolourization, Electro coagulation, molasses, adsorption, activated charcoal.

INTRODUCTION

Distillery industries are one of 17 most polluting industries in India and generate large volumes of spent wash that effect on environment [Khandegar et al., 2014]. Sugarcane molasses is the raw material which used for production of alcohol. Molasses is the dark brown, viscous liquid, which is very common feed stock for industrial fermentation process, for effective fermentation process molasses diluted 1-3 fold [wagh et al., 2015].The dark brown color of spent wash affect the process of photosynthesis if disposed without any treatment and causes depletion of dissolved oxygen [Khandegar et al., 2014]. Spent wash released to environment is hazardous and introduces various toxic substances which result in change in physicochemical characteristics of soil and water [Eyob Kebede et al., 2015]. The odor of spent wash spread over the area and result into serious public hazard [Bharat kumar et al., 2015]. Economical and eco-friendly treatments are need of society also greatest challenge to environmentalist [wagh et al., 2015]. Spent wash contains 2% of melanoidins pigments that result of mailard type reactions of amino acids with reducing sugars [Wagh et al., 2015]. There are number of methods to treat distillery waste especially COD and color such as physical, chemical and biological [wagh et al., 2015]. Anaerobic treatment is an accepted practice for treatment of spent wash but however even after treated by anaerobic treatment pollutant level cannot meet effluent standards laid by CPCB [Kolte et al., 2014]. Bio-methanation of raw distillery spent wash followed by aerobic treatment is the common practice in India. Aerobic treatment can remove 50-70% of COD and Color but still 100% result yet to be achieving. [wagh et al., 2015].

General characteristics of spent wash generated during alcohol production are summarized as follows:

Table I Characteristics of spent wash [Khandegar et al., 2014; wagh et al., 2015**]**

Sr.No	Parameter	Range
1	Ph	3 – 4.5
2	BOD	50,000 – 60,000
3	COD	1,10,000 – 1,90,000
4	TS	1,10,000 – 1,90,000
5	TSS	13,000 – 15,000
6	TDS	90,000 – 1,50,000

7	Chlorides	8,000 – 8,500
8	Phenols	8,000 – 10,000
9	Sulphate	7,500 – 9,000
10	Phosphate	2,500 – 2,700

Distilleries Effluent Discharge Standards

Ministry of Environment and Forests (Government of India) has specified Standards for different industries taking into account the characteristics of the effluents the drainage water from the land after such treatment has to satisfy a limit of 30 mg/l of BOD.

Table II [Wagh et al., 2015, CPCB &M$_O$EF 2002]

Sr.No.	Parameter	Standards
1	pH	5.5-9
2	Color and Odor	Absent
3	BOD 3 at 27 0C mg / l Max 1. Disposal into land surface water/ rivers/ streams 2. Disposal on land or for irrigation 3. Suspended Solids mg/l Max	 30 100 100

II. Process Description

Alcohol Manufacturing Process

Alcohol manufacturing process consists of different steps such as feed preparation, fermentation process, distillation process and packing shown in figure

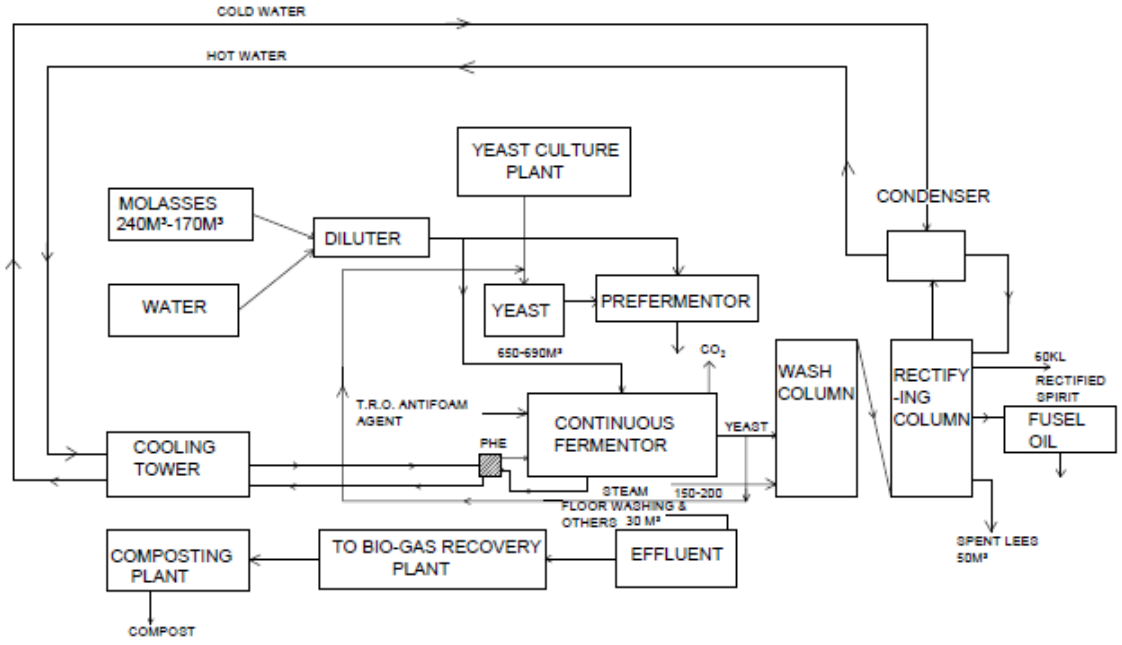

Figure 1. Alcohol manufacturing process flow diagram [wagh et al., 2015]

Electro coagulation:

Electro coagulation is an emerging technology that combines the advantages of conventional floatation, coagulation and electrochemistry in water and wastewater treatment [Kuokkanen et al 2013]. Then requirement for quality drinking water expanded all around, and profluent principles of wastewater get to be stringent, thusly it important to create compelling conservative and eco friendly treatment. This prompted enthusiasm for electro coagulation as exploration for researchers [Kuokken et al., 2013]. Electro coagulation is a straightforward and successful treatment strategy for wastewater [Khandegar et al., 2014]. Wagh et al., (2015) uncovered that most extreme 99.78% shading expulsion was gotten by utilizing Fe-Fe anodes at 25 Volts for pH 8 and ideal COD evacuation of 85.71% for pH 3 at EC time of 150 minutes. Shading expulsion productivity of electro coagulation is reductions with expansion in convergence of melanoidin he additionally specified that cathodes utilization increments with increment in centralization of melanoidin [kobya et al., 2012]. Proficiency of the Chemical oxygen demand (COD) expulsion hindered with expansion in pH, separating between anodes assumes critical part in decolourization of melanoidin , COD evacuation productivity quicken with expansion out yonder between electrodes[Khandegar et al., 2014]. Acidic condition is more positive for treatment of refinery spent wash because of diminished creation of chlorine or hypochlorite at higher pH[Krishna B.M. et al., 2010]. Al-Al cathodes are more compelling to evacuate shade of distiller spent wash when contrasted with al-fe and Fe-Fe anodes because of Fe iron produced amid the EC proclaim from iron terminals has high dissolvability at acidic condition and are effectively oxidized into Fe, since Fe is hard to settle [kobya et al., 2003, 2012]. Aluminum anodes are evacuate most extreme shading up to 96.09% aluminum cathodes are more powerful than iron terminals. By utilizing graphite – graphite electrodes 85.2 % COD evacuation at pH 6.9-7.2 and span is 180 minutes, by utilizing Al-Al terminal 72.3% COD expelled in 2 hours when pH 3[Krishna B.M et al., 2010, Khandegar et al., 2014; kobya at al., 2003]. Electro coagulation strategy can be effectively utilized for the treatment of refinery spent wash [Khandegar et al., 2014]. The upsides of EC over traditional coagulation incorporate financial viewpoints (moderately low speculation, maintaince, vitality and treatment costs), altogether bring down volume of muck produce, better slop quality, comparative or marginally better effectiveness, shirking of compound increments, simplicity of robotization ,straightforward equipment and conservative size of EC frameworks, more noteworthy practical pH extent and pH balance impact and the nearness of electro floatation [Kuokkanen et al., 2013].

Electrolysis is a procedure in which oxidation and decrease responses happen when electric current is connected to an electrolytic arrangement. At it least difficult, an electro coagulation framework comprises of an anode and a cathode made of metal plates, both submerged in watery arrangement being dealt with [Emamjomeh et al., 2009]. An Electro coagulation framework may contain it is possible that one or various anode-cathode combines and might be associated in either bipolar mode [Emamjomeh et al., 2009]. The most imperative variable affecting the productivity of EC procedure are the anode materials utilized , connected current thickness, treatment time, and arrangement science, including beginning pH and the concoction creation of the aqueous arrangement being expelled. The arrangement temperature , kind of salt used to raise conductivity, nearness of chlorides, cathode hole, passivation of anode, water stream rate additionally affect the evacuation efficiency and financial sturdiness of a given EC application [Kuokkanen et al., 2013]. Krishna Prasad et al., (2008) found that 95% shading expulsion was acquired with 31 mA / cm^2, weakening of 17.5%, and 4 hour electrolysis plan. Körbahti et al., (2008) presumed that 100% contamination load, 61.6% COD, 99.6% color removal, and 66.4% turbidity were expert by an electrochemical reactor, where ideal conditions for leading the investigation were at temperature of 30 degrees Celsius, 25 g/L electrolyte focus, 8 V electrical potential, with a 35.5 mA / cm^2 current thickness.

Having considered current thickness, pH, and electrolysis outline, the creators were fit for concentrating on the impacts of COD, turbidity, TS evacuation, and ooze settling with aluminum cathodes. Vasudevan et al., (2010) considered utilizing mellow steel as

anode and cathode, expelling 98.6% arsenate at a present thickness of 0.2 A/dm2, and a pH of 7. Energy established that the evacuation was inside 15 minutes, taking after a second request rate retention. At long last, Langmuir adsorption isotherm portrays fittingly this condition. Balasubramanian et al., (2010) displayed adsorption isotherm energy for arsenic expulsion from watery arrangements by method for electro coagulation through reaction surface philosophy.

Thakur et al., (2009) presumed that COD and shading evacuation of 61.6% and 98.4%, individually, were equipped for treating bio-digester gushing inside an electro coagulator. This was a consequence of a bio-digester plant took after by two-stage oxygen consuming treatment. While considering a second-arrange relapse model for this wonders—pH, current thickness, between cathode separation, and electrolysis time as parameters, the model closed a r2 estimation of 0.9144 for COD and 0.7650 for shading.

Gadd et al., (2010) presumed that treatment productivity was identified with the anode region, alongside coagulant and air pockets, elements of terminal zone, current thickness, and effectiveness. This operation was finished utilizing a vertical plate electro coagulation treating molasses process wastewater. M. Kobya et al., (2007) uncovered that Acidic medium is best for a high COD expulsion for both terminal materials; iron cathode performs obviously better with BP-S mode, while the execution of aluminum is not unequivocally subject to association mode. For a high turbidity expulsion, the ideal pH relies on upon the terminal material; aluminum anode associated in BP-S mode performs better in acidic medium, while the poor filterability of the flocs manages pH 7 to be more appropriate for the iron cathode associated in MP-S mode.

Modified Table Electro coagulation used for treatment of distillery spent wash (Wagh et al., 2015).

Current density in A/cm^2	Time (Min)	pH	% Colour Removal	% COD Removal	Anode –Cathode	Reference
0.817	120	3	-	81.3,71.8,52.4	Al-Al, Al-Fe, Fe-Fe	Khandegar et al., 2014
0.01	140	3	-	56	Al-Al	Krishna B.M.et al., 2010
0.143	180	5	-	37	RuO2-Ti – SS	Prasad et al., 2009
1.467	150	6.75	-	61.6	SS-SS	Thakur et al., 2009
0.06	180	6.9-7.2	-	85.2	Graphite-Graphite	Manishankar et al., 2004
0.03	180		-	84	Mixed metal oxide (MMO) electrode	Asaithambi et al., 2012
0.71 0.718	60 60	7.5 7.2	-	60,50 99.88	Al-Al, Fe-Fe Al-Al, Fe-Fe	Khandegar et al., 2014
0.03	140	7	94	-	Al-Al	Shruti et al., 2013
0.03	140	7	97.76	-	Al-Al with Fenton reagent	Shruti et al., 2013

0.03	240	6	100 89 7	83 60 7	Ozone assisted EC Al-Al electrodes Ozonation	Asaithambi et al., 2012
- -	150 150	8 3	99.78 -	- 85.71	Fe-Fe electrode Al-Al electrode	Wagh et al., 2015
0.04	120	3	96.09	85.7	Al-Al electrode	Wagh et al., 2015

Adsorption techniques

Bharat kumar et al., (2015) revealed that adsorbent technique is one of best method for removal of pollutants from distillery spent wash and we can reuse the effluent characteristics so it could be used for irrigation to reduce pressure over normal irrigation water. It is beneficiary to use diluted effluent for better growth of plants. Activated charcoal is an ideal adsorbent for removal of color of wastewater and 99.7% discoloration was found and maximum COD removal of 58.15% by using activated charcoal [Bharat Kumar et al., 2015]. Carbon has been utilized as an adsorbent for a considerable length of time. Enacted carbon capacity to expel mixes from wastewater expanded its utilization from most recent 30 years. Adsorption is normal procedure by which atoms of a broke up compound gather on and hold fast to surface of an adsorbent solid[Bhise et al., 2012]. It is ideal to go for adsorption by utilizing enacted carbon before treating refinery spent wash by electro coagulation. When all is said in done the most extreme rate decrease in every parameter has been found in filtration bed containing sand, dirt and charcoal [Eyob kebede et al., 2015]. The most extreme shading expulsion with adsorption process with was discovered 0.550 [Bhise et al., 2012].

Primary treatment through biomethanation and energy recovery – an economic process practiced in Indian distilleries is however, does not meet the discharge standards (CPCB, 2002). In absence of acceptable and efficient methods for further treatment of digested spent wash, many a times it is discharged into water bodies or on the land directly. It is much more hazardous when disposed into water bodies, since it will lead to complete depletion of dissolved oxygen and destruction of aquatic life. If disposed untreated on land, it reduces alkalinity of the soil, and crops may be destroyed. In some parts of the country, color problems in groundwater are very acute (Chauhan and Dikshit et al., 2007).

Shivayogimath et al., (2014) concluded that maximum removal of COD,TDS and color of 95.2%, 89.8% and 62.83% respectively & obtained at parameter 6 hours of contact when treated with a activated carbon dose of 10g/ml at pH 2.& also activated carbon could be a feasible alternative for the treatment of biomethanated distillery spent wash. Conventional methods can accomplish only low degradation of melanoidins it is necessary to explore additional treatments to remove color from molasses effluent. Melanoidins can be removed by physicochemical treatments, but these methods require high reagent dosages & generate large amount of sludge (Chine and Korake et al., 2012). Adsorption is one of the set up unit operations utilized for the treatment of wastewater. Enacted carbon is the most utilized adsorbent. As business enacted carbons are exorbitant; subsequently elective ease adsorbent has been the centered. Also, the preparing and change of farming deposits into enacted carbon with great adsorption properties would mitigate issues of transfer and administration of these waste by-items, while giving an astounding finished item for water and wastewater treatment [Shivayogimath et al., 2014]. It was prescribed that the waste slime from this industry be used as a substitute for ordinary coagulants. Adsorption happens when the attractive strengths at the carbon surface defeat the appealing powers of the fluid. Granular enacted

carbon is great retentive medium because of its high surface range to volume proportion. Likewise other material is utilized to evacuate the metal, for example, peat, fleece and silk.[Sohail Ayub, Nusrat Ali et al., 2016]

Sand filtration technique

There are several technologies that have been explored for treatment of waste water; this can be generally classified as physical, chemical and biological methods. The aim of present study is to develop a simple and economical method of wastewater treatment disposed from distillery industry. Maximum percentage reduction in COD and color was in filter containing sand, clay and charcoal. The proficiency of filtration bed can be requested as sand: dirt, sand: clay: ash, sand: clay: charcoal mix. There are different propelled strategies for wastewater treatment yet most are uneconomical yet sand filtration procedures can be considered as an option and prudent strategy to treat waste water [Eyobe kebede et al., 2015].

Prasad G. et al., (2007) concluded that maximum COD removal of 78.96% was recorded at 2 feet sand depth of sand soil ratio of 3:1. The distillery effluent was passed through filter bed with various ratios. There is significant reduction in removal of COD, BOD and color without any labour and energy cost except filtration bed. Optimization of sand size, depth of filter and with mathematical modeling is required to increase filtration rate.

Conclusions

Electro coagulation with Adsorbent and sand filtration can be prove efficient technology to treat highly polluted wastewaters, from above literature we conclude that

- It is possible to reduce the pollution from waste water by using locally available material by application of sand and soil as an alternative and economical method to treat wastewater.
- Adsorption using activated carbon is better choice before treating distillery spent wash before Electro coagulation.
- The distillery wastewater after adsorbent treatment is suitable for irrigation purpose.
- On increasing of contact time and adsorbent dose after the limit there is not much effect on removal of pollutants.
- Electro coagulation is an economical method for treatment of distillery spent wash but only problem is about secondary sludge developed during EC process.

Acknowledgement

The authors would like to express sincere thanks to Dr. H. N. Kudal Principal, Padmashri Dr.Vithalrao Vikhe Patil College of Engineering, Ahmednagar. We are also thankful to our project guide Prof. M. P. Wagh, Department of Civil Engineering, Padmashri Dr.Vithalrao Vikhe Patil College of Engineering, Ahmednagar for their Guidance.

REFERENCES:

1. V. Khandegar and Anil K. Saroh "Treatment of distillery spent wash by electro coagulation" *journal of clean energy technology* pp.244-247 July 2014.

2. Ville Kuokkanen, Toivo Kuokkanen, Jaakko Rämö, Ulla Lassi " Recent Applications of Electro coagulation in Treatment of Water and Wastewater—A Review *"green and sustainable chemistry* scientific Research pp.89-121 May 2013
3. Manoj P. Wagh and P.D.Nemade " Colour and COD removal of Distillery Spent wash by using Electro- Coagulation" *International journal of Engg research and general science* pp.1159-1173 May-June 2015

4. Eyob Mulugeta Kebede and Terefe Tafese Bezuneh "Sand Filtration as an Alternative Technique for the Treatment of Distillery Effluent" *Journal of Environment and Earth Science* pp.28-32 2015
5. Manoj P.Wagh and P.D.Nemade "Treatment processes and Technologies for decolourization and COD removal of Distillery Spent wash: A Review" *International Journal of innovative research in Advanced Engineering* pp.30-40 July 2015.

6. Prasad G. Rajput, Chopra A.K. "Alternative economic technology for treatment of distillery effluent to prevent surface and ground water pollution" *Journal of Applied science and Environmental Management* pp.35-39 September 2007
7. Sohail Ayyub and Shoebuddin Usman "Treatment of distillery and breweries spent wash wastewater" *International journal of Reasearch in Engineering and Technology* pp.204-214 February 2014

8. Bhise R.M.,Patil A.A., Raskar A.R.,Patil P.G., Deshpande D.P. " Removal of colour of spent wash by activated charcoal adsorption and electro coagulation" *Research journal of Recent science* pp.66-69 June 2012

9. Bharat Kumar "Treatment of distillery effluent using activated charcoal, fly ash, wood ash for irrigation purpose" *International Journal of novel research in life science* pp.27-30 March-April 2015.

10. M.S. Chauhan and A.K. Dikshit., 2007. Decolourisation of Distillery Wastewater in India: Current Status and Future Trends, Proceedings of the 10th International Conference on Environmental Science and Technology Kos island, Greece.

11. Chine S.S. and Korake S.R., 2012. "Physico-chemical Methods for Colour Removal of Waste Water in molasses based alcohol distilleries: A Review, DCSI, 07: 150-155.

12. Sohail Ayub, Nusrat Ali, Hassan Haleem, Impact of Distillery Effluent on ground water: A review. International Conference "*Emerging trends in Engineering and Technology*" held at TMU, Muradabad, April 6-7 2012.

13. Krishna Prasad, R.; Ram Kumar, R.; Srivastava, S. Design of optimum response surface experiments for electro-coagulation of distillery spent wash. *Water Air Soil Polllut.* **2008**, *191*.

14. Körbahti, B.K.; Tanyolaç, A. Electrochemical treatment of simulated textile wastewater with industrial components and Levafix Blue CA reactive dye: Optimization through response surface methodology. *J. Hazard. Material* 2008, *151*, 422-431.

15. Vasudevan, S.; Lakshmi, J.; Sozhan, G. Studies relating to removal of arsenate by electrochemical coagulation: Optimization, kinetics, coagulant characterization. *Separ. Sci. Tech*. 2010, *45*, 1313-1325.

16. Balasubramanian, N.; Kojima, T.; Srinivasakannan, C. Arsenic removal through electro coagulation: Kinetic and statistical modeling. *Chem. Eng. J*. 2009, *155*, 76-82.

17. Thakur, C.; Srivastava, V.C.; Mall, I.D. Electrochemical treatment of a distillery wastewater: Parametric and residue disposal study. *Chem. Eng. J*. 2009, *148*, 496-505.

18. Shivayogimath C.B, Shreya Inani" Treatment of biomethanated distillery spent wash by adsorption process on bagasse activated carbon*" Sci.& Eng. Journal* 2014,1068

19. Mehmet Kobya, Mahmut Bayramoglu ,Murat Eyvaz "Techno-economical evaluation of electro coagulation for the textile wastewater using different electrode connections" *Journal of Hazardous Materials* (2007) 311–318.

20. Hemangi Kolte, Apeksha Walke, Deepali Nimbakar, Vikram Ghole " Evaluation of Fenton reagent treatment to anaerobic ally digested spent wash in combination with biological treatment*" International Journal of innovative research in Science, Engineering and Technology* Nov 2014, pp17460-17466.

21. Asaithambi.P. Lakshminarayana Garlanka., Anantharaman.N. Manickam. Matheswaran (2012):- Influence of Experimental Parameters in the treatment of distillery effluent by Electrochemical Oxidation, "*Separation Science and Technology*", 47. 470- 481.

22. Shruti.M.Krishna.B.M.and Usha.N.Murthy "Colour removal from bio-digester effluent by electrochemical treatment with and without Fenton reagent*" International Journal of current Engineering and Technology* 2013 pp.115-117.

23. Emamjomeh and M.Sivakumar, "Review of Pollutants removed by Electro coagulation /Floatation Processes" *Journal of Environmental Management* 2009 pp1663-1679.

24. Gadd, A.S.; Ryan, D.R.; Kavanagh, J.M.; Barton, G.W. Design development of an electro coagulation reactor for molasses process wastewater treatment. *Water Sci. Technol.* 2010, *61*, 3221-3227.

25. Manoj Wagh, P. D. Nemade, Treatment of Distillery Spent Wash by Using Chemical Coagulation (CC) and Electro - coagulation [EC], American Journal of Environmental Protection, (2015), Vol. 3, No. 5, 159-163