Treatment Of Dairy Wastewater By Electro Coagulation Technique Using Combined Electrodes

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Abstract- *As the dairy industry generates strong wastewater which is characterized by high BOD, COD, Nutrients, inorganic, organic content and biodegradable materials that can disrupt aquatic and terrestrial ecosystems. Due to high pollution load of dairy w/w, the milk-processing industries discharging untreated/partially treated w/w cause serious environmental problems. The techniques used to treat the diary wastewater are conventional aerobic purification and anaerobic processes. However, other techniques have also been used, e.g. coagulation flocculation, Nanofiltration (NF), Reverse osmosis (RO) and use of membrane bioreactors. Biological processes require huge spaces and long time of treatment and generate great amount of sludge. The physico-chemical processes suffer the disadvantage that reagent costs are high and the soluble COD removal is low. Besides, chemical treatments could induce a secondary pollution due to the fact that chemical additives may contaminate the treated water. Among physico-chemical methods, electro coagulation technique is one of the processes which offer high removal efficiencies in compact reactors, with simple equipments for control and relatively moderate operating cost. In this study evaluation efficiency of electro coagulation technique using combined electrode to treat dairy waste water with optimization of parameters like effect of pH, electrolysis time (ET), applied voltage, shape & size of electrodes.*

Keywords- COD, Turbidity, electro coagulation, electrolysis time, dairy wastewater.)

I. INTRODUCTION

Milk may be defined as the whole, fresh, clean, lacteal secretion obtained by the healthy milk animals. It is generally defined by the three components as follows:(i)the fat or oil that is inside the emulsion droplets, (ii) the interfacial matter between the lipidic phase and the aqueous phase representing part (iii) of the emulsion. Each of these phases may be chemically complex. Milk consists also of three parts: (i) an oil-in-water emulsion in which the fat droplets are dispersed in the serum, (ii) a colloidal suspension of casein micelles, protein and lipoprotein particulates and the aqueous phase (iii) containing soluble proteins, mineral salts and vitamins. Large quantity of wastewater originates due to their different operations. The organic substances in the wastes comes either in the form in which they were present in milk, or in a degraded from due to their processing. As such, the dairy wastewater, though biodegradable, are very strong in nature. Dairy waste effluents are concentrated in nature, and the main contributors of organic charge to these effluents are carbohydrates, proteins and fats originating from milk. The liquid waste from dairies originates from different sections like receiving station, bottling plant, cheese plant, casein plant, condensed milk plant, dried milk plant and ice cream plant. The dairy wastes are very often discharged intermittently. The nature and composition of waste depends on the type of products produced and size of the plant.

The wastewater generated by the dairy industries includes:

1. Washing and cleaning operations in the tanks, trunks, pipes etc.
2. Spillage by leaks and overflow.
3. Processing loss include, sludge discharge from clarifiers, discharge from bottles and washer, evaporator entrainment, splashing and container breakage in automatic packing equipment.
4. Spoiled products, returned products or by products.
5. Detergent and other compound used in washing and sanitizing solution that are discharge as waste.
6. Entrainment of lubricants from conveyers, stackers and other equipment. Milk products are some time deliberately wasted sometime whey and butter milk.

II. OBJECTIVES

In these works following objectives have been set to study the dairy wastewater treatment by electro coagulation method with aluminium and iron electrodes.

1. To study waste water generation points in the dairy industry.

2. To study physico-chemical characteristics of dairy waste water.
3. To study efficiency of electrocoagulation treatment process to treat dairy waste water.
4. To study various optimum parameters which control efficiency of electro coagulation process

III. THEORY OF ELECTROCOAGULATION

The (EC) technology includes coagulation and precipitation of contaminants by a direct current electrolytic process followed by the separation of flocculent (settling or flotation) with or without the addition of coagulation-inducing chemicals. The water is pumped through a unit which consists of pairs of metal sheets called electrodes, that are arranged in pairs of two anodes and cathode electrodes made of iron or aluminum are installed. A direct current electric field is applied to the electrodes to induce the electrochemical reactions needed to achieve the coagulation. Treated water is discharged from the system for reuse or disposal. Concentrated contaminants in the form of bio solids are collected for disposal or reclamation.

In an EC process the coagulated ions a produced in “in situ” and it involves three successive stages:-

1. Information of coagulants by electrolytic oxidation of the sacrificial electrodes.
2. Destabilization of the contaminants, particulates suspension and breaking of emulsions.
3. Aggregation of the destabilized phase to form flocs.

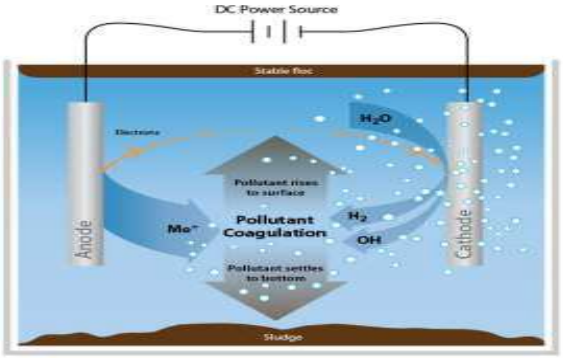

Fig. 1: Electrocoagulation process

IV. MATERIAL AND METHODS

The dairy waste water was collected from Sanjivani dairy industry, kopargaon. An attempt was made for the treatment of dairy wastewater using electro coagulation technique with Aluminium and iron electrodes in bipolar connection system. Initial characteristics of Sanjivani dairy plant effluent are given in table no.—

Parameters	Observed Value	unit
pH	8.92	-
Turbidity	210	NTU
Total Dissolved solids	1464	ppm
Electrical conductivity	6.417	$m\text{-}S^{-1}$
COD	3766	mg/lit

EXPERIMENTAL SET UP- EC reactor is used for the treatment of dairy effluents. The reactor is made up of glass with a total working volume of 1L. The DC source of 10-30V is used as a power supply. The EC units having a pair of two electrodes is connected in bipolar parallel system. Aluminum and iron electrodes having dimensions of 10 x05 x 0.1 cm will be immersed to a depth of 6-7cm in the reactor. The space between the electrodes is maintained at 2 cm. A magnetic stirrer is used for mixing to form homogeneous solution at 180 rpm. After the initial characterization of dairy effluent, the batch EC experiments is conducted to optimize the various parameters such as pH, applied voltage and ET(electrolysis time).During each run the voltage is varied to desired value(mostly 10V,20V,30V). pH of the solution is adjusted at 6,7 & 8 by adding either dilute HCL or NaOH as per the requirement. The electrodes is washed with HCl for the removal of impurities from the electrode surface. The EC experiments are performed with 0.5 L of effluent for 60 minutes. All the samples are allowed to settle for nearly 45 minutes before the determination of turbidity, COD,total dissolved solid and electrical conductivity of treated dairy effluent.

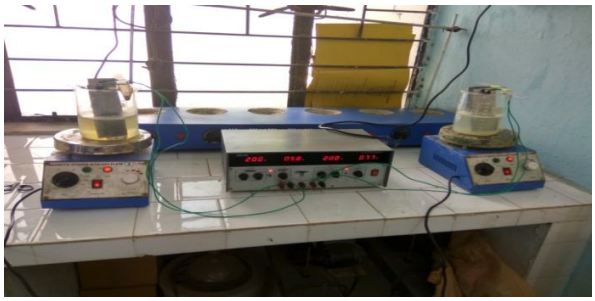

Fig. 2: Experimental set up.

V. RESULT AND DISCUSSION

The experimental work is carried out in batch mode, various parameters are controlled to optimise them for increasing efficiency of electrocoagulation process. The investigation was undertake to study the effect of pH, electrolysis time, applied voltage, electrode material, shape &

size of electrode on electro coagulation process to treat real dairy wastewater effluent.

5.1 Effect of electrode material

A series of experiments was performed at the room temperature with variation in pH .The voltage of 10, 20, 30V was allowed to pass through the sample. Different removal efficiencies where obtained at different conditions. Here different materials can be used as electrodes for electrocoagulation and electrode material has been known to be an important factor influencing the performance of the electrocoagulation process. Also Iron and Aluminum usually used as electrode in electrocoagulation process. But it was seen that the aluminium electrode was deteriorated more than the Iron electrode which shows more energy was consumed by aluminium electrode.

5.2 Effect of electrolysis time

The experiments were conducted upto the 100 min electrolysis time and during this process it was observed that when the ET is increased the percentage removal efficiency was also increased.

5.3 Effect of applied voltage

It has been observed that with the increasing voltage, the percentage removal removal efficiency is increased. The increase in voltage eventually causes the faster ionization and there by agile is the process of electrolysis. In this set of experiments the optimum results is obtained at 30 V.

5.4 Effect of pH

A set of experiments was performed at the room temperature with variation in pH .The voltage of 10, 20, 30V was allowed to pass through the sample. The experiments were carried out both in acidic and basic state but it is seen that at neutral state the best results are obtained.

5.5 Effect of size and shape

Throughout the experiments electrode plate were used instead of electrode rods as the plate has maximum contact with the sample than the rod which helps in improving the efficiency and also accerelates the process.

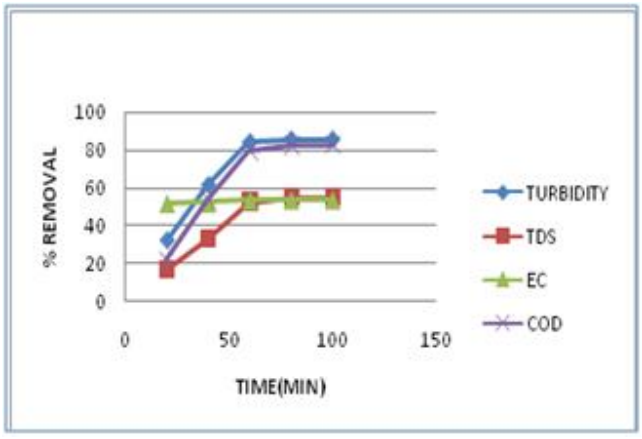

Fig.3: Effect of operational parameters on impurity removal in EC process at pH 7.0, voltage 10V.

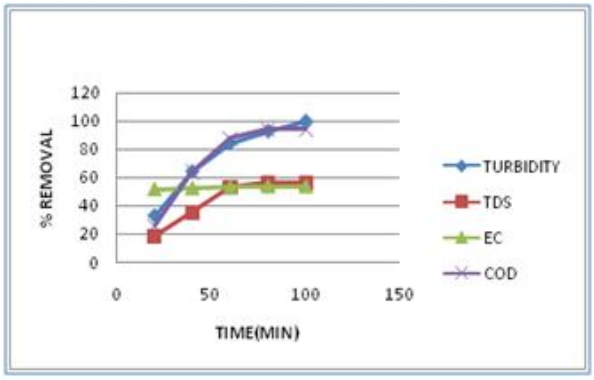

Fig.4: Effect of operational parameters on impurity removal in EC process at pH 7.0, voltage 20V.

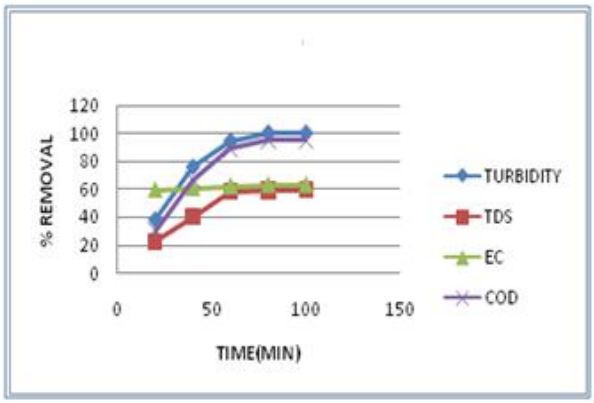

Fig.5: Effect of operational parameters on impurity removal in EC process at pH 7.0, voltage 30V.

TABLE 1: - Effect of operational parameters on impurity removal in EC process at pH 6.0, voltage 10V.

Electrolysis Time (min)	Turbidity (NTU)	% removal	TDS (ppm)	% removal	EC ($m\text{-}S^{-1}$)	% removal	COD (mg/lit)	% removal
20	160	23.80	1203	17.82	2.83	55.89	3047	19.09
40	108	51.42	1091	25.47	2.83	55.89	1890	49.01
60	70	66.66	812	44.53	2.81	56.21	817	78.30
80	41	80.47	810	44.67	2.80	56.28	735	80.48
100	41	80.47	810	44.67	2.80	56.28	710	81.14

TABLE 2:- Effect of operational parameters on impurity removal in EC process at pH 6.0, voltage 20V.

Electrolysis Time (min)	Turbidity (NTU)	% removal	TDS (ppm)	% removal	EC ($m\text{-}S^{-1}$)	% removal	COD (mg/lit)	% removal
20	147	30.00	1200	18.03	2.76	56.98	2710	28.04
40	96	54.28	1055	27.93	2.72	57.61	1366	63.72
60	48	77.14	808	44.80	2.63	59.01	364	90.33
80	18	91.42	808	44.80	2.60	59.48	250	93.36
100	00	100	808	44.80	2.60	59.48	250	93.36

TABLE 3:- Effect of operational parameters on impurity removal in EC process at pH 6.0, voltage 30V.

Electrolysis Time (min)	Turbidity (NTU)	% removal	TDS (ppm)	% removal	EC ($m\text{-}S^{-1}$)	% removal	COD (mg/lit)	% removal
20	125	40.47	1205	17.69	2.70	57.92	2653	29.55
40	59	71.90	1016	30.60	2.65	58.70	1251	66.78
60	20	90.47	795	45.69	2.46	61.66	300	92.03
80	00	100	790	46.03	2.45	61.82	190	94.95
100	00	100	790	46.03	2.45	61.82	190	94.95

TABLE 4:- Effect of operational parameters on impurity removal in EC process at pH 8.0, voltage 10V.

Electrolysis Time (min)	Turbidity (NTU)	% removal	TDS (ppm)	% removal	EC ($m\text{-}S^{-1}$)	% removal	COD (mg/lit)	% removal
20	162	22.85	1210	17.34	2.73	57.45	3027	19.62
40	90	57.14	949	35.17	2.70	57.92	1873	50.26
60	50	76.19	786	46.31	2.65	58.70	829	77.98
80	38	81.90	762	47.95	2.65	58.70	705	81.27
100	38	81.90	761	48.01	2.65	58.70	697	81.49

TABLE 5:- Effect of operational parameters on impurity removal in EC process at pH 8.0, voltage 20V.

Electrolysis Time (min)	Turbidity (NTU)	% removal	TDS (ppm)	% removal	EC ($m\text{-}S^{-1}$)	% removal	COD (mg/lit)	% removal
20	135	35.71	1184	19.12	2.59	59.63	2656	29.47
40	63	70.00	915	37.50	2.54	60.41	1309	65.24
60	30	85.71	766	47.67	2.44	61.97	390	89.64

80	12	94.28	745	49.11	2.43	62.13	268	92.88
100	00	100	745	49.11	2.43	62.13	260	93.09

TABLE 6:- Effect of operational parameters on impurity removal in EC process at pH 8.0, voltage 30V.

Electrolysis Time (min)	Turbidity (NTU)	% removal	TDS (ppm)	% removal	EC (m-S^{-1})	% removal	COD (mg/lit)	% removal
20	131	37.61	1180	19.39	2.59	59.63	2698	28.35
40	52	75.23	865	40.91	2.56	60.10	1370	63.62
60	18	91.42	656	55.19	2.49	61.19	316	91.60
80	00	100	648	55.73	2.46	61.66	225	94.02
100	00	100	648	55.73	2.45	61.82	222	94.10

VI. CONCLUSIONS

The batch EC studies were performed to investigate the influence of various experimental operating parameters on the removal of impurities from dairy effluents. The EC technique can be efficiently used for treatment of dairy wastewater using aluminum & iron electrodes in bipolar connection. It is a simple method using minimum electricity and an economic method applicable to industries for the treatment of wastewater, which is fast, easy and can be operated using minimum equipment and limited space. The removal efficiencies of turbidity, COD, total dissolved solids, electrical conductivity were observed to be dependent on initial pH, applied voltage and operating time. The electrocoagulation setup described in this study is simple in design and operation and can be used as a convenient tool in the removal of related industrial wastewaters. The optimum condition for treating dairy waste water was observed at pH 7 voltage 30v and electrolysis time 100 minutes.

REFERENCES

[1] C. B. Shivayogimath and Praveen Meti, "Electrochemical treatment of dairy effluents using aluminum electrodes," 14th IRF International Conference, Bengaluru, India, 2015.

[2] K. Dermentzis, A.Christoforidis, E.Valsamidou, A.Lazaridou and N.Kokkinos, "Removal of hexavalent chromium from electroplating wastewater by electrocoagulation with iron electrodes," Global nest journal, vol. 13, No 4,2011, pp. 412-418.

[3] Ahmed Samir Naje and Saad A.Abbas, "Electrocoagulation Technology in wastewater Treatment: Review of Methods and Applications," Civil and Environmental Research, Vol.3, No.11, 2013, pp.29-43.

[4] Ana L. Torres, Sandra J.Lopez and Catalina de la Rosa "Electrocoagulation Process Coupled with Advance Oxidation Techniques to Treatment of Dairy Industry Wastewater," Int. J. Electrochem. Sci., 9 (2014),pp.6103 – 6112.

[5] Bhushan Lohar and Anand D. Kulkarni, "Performance of Electrocoagulation Technique for the treatment of Dairy Wastewater in a Batch Process," International Journal of Science and Research (IJSR),pp.2574-2578.

[6] Deepak Sharma,"Treatment of dairy waste water by electro coagulation using aluminum electrodes and settling, filtration studies,"International Journal of ChemTech Research, Vol.6, No.1, pp. 591-599

[7] Gouri Mirji and Dr.P.B.Kalburgi, "Study of Electrocoagulation mechanism on dairy wastewater for COD and Turbidity removal," International Journal of Advance Engineer ing and Research Development,Volume 1, 2014,pp.1-10.

[8] Chethan Marol, Siddaling Talawar, Dattatreya Narale, Gurappagoud Biradar and Rajeshwari Nagaral, "Removal of Cod and Turbidity by Electrocoagulation (EC) Technique," International Journal for Scientific Research & Development, Vol. 4, 2016, pp.836-839.

[9] Mostafa Mohammadizaroun and Mohd Suffian Yusoff "Treatment of Leachate by Electrocoagulation Technique Using Iron And Hybrid Electrodes,"International Journal of Scientific Research in Knowledge,2014, pp. 497-508.

[10] Dr. C.B. Shivayogimath and Vinayak Rao S R, "Treatment of Dairy Effluent by Electrocoagulation-Fenton Oxidation,"vol 5,2016,pp.15047-15053.

[11] Bhise R.M. and Patil A.A., "Removal of Colour of Spent Wash by Activated Charcoal Adsorption and Electrocoagulation," Research Journal of Recent Sciences,Vol. 1(6),2012,pp.66-69.

[12] Nilesh A. Fagnekar and Prof. Sachin Mane, "Removal Of Turbidity Using Electrocoagulation," international Journal of Advance Foundation And Research In Science & Engineering,vol 1,2015,pp.253-262.

[13] Madhusudhan C. and Nagarajappa D.P., "Performance Evaluation of Electrocoagulation Process in Treating

Dairy Wastewater using Mono-polar Electrodes,"vol 1,2015,4104-4110.

[14] Dr. Bassam Al Aji, "Electrocoagulation of chromium containing synthetic wastewater using monopolar iron electrodes," Damascus University Journal Vol. (28) - No. (2) 2012, pp.79-90.