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Treatment of Dairy Wastewater by Using Electro-Fenton Process by Adopting Aluminum and Iron Electrodes

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Abstract - *In this research, the treatment of dairy wastewater by Electro Fenton process adopting aluminum and iron electrodes for the removal of parameters such as Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS) is studied. The experimental design and optimization of independent variables such as Fenton Dosage, Electric Potential, Electrolysis Time and Distance between Electrodes are evaluated by means Box- Behnken Design(BBD) In Response Surface Methodology(RSM). The second order quadratic model was employed for the prediction of removal percentage of COD and TSS in several operations and conditions. The true impact of each independent variables and relationship of dependent and independent variables was analyzed by using analysis of variance(ANOVA). The treatment efficiency of Electro Fenton process for the removal of COD and TSS was studied by varying the independent variables such as Fenton Dosage (0.5-3.5) ml/L electrolysis time (10-60 Minutes), electric potential (3-12V) and distance between electrodes (2-6 cm), the optimal conditions of independent variables for maximum removal efficiency of responses are Fenton Dosage 3.5 ml/L, Electric Potential of 12 V, Electrolysis Time of 35 minutes and distance between electrodes of 4cm. the removals of COD and TSS at optimized conditions are found to be 84.26% and 90.47% respectively.*

Key Words: **Electro-Fenton, RSM, COD, TSS, Iron electrode, aluminum electrode, BBD.**

1. INTRODUCTION

In India, prompt growth of industrialization and urbanization with concurrently inhabitants lift has in tensed an irreversible destruction to the nature and caused reduction of fresh water pools, it created threat to the upcoming generation. Hence, supportability is dominant component to square up to the barrier of fresh water puddle and meet the accelerating clean water demand. Howbeit, wastewater mechanizations are reliable, yet there is required for efficient and low budget treatment process that can considerable huge and high established systems for advancing countries like India. Diurnal large amount of water is squandered as industrial dispense. The untreated and partly treated dispenses to waterbody fouling the fresh water bodies. All types of industrial dispense required a better treatment to reduce the water pollution and defend environment.

1.1 Electro-Fenton Process

This process involves the removal solid particles from the specified waste using a Fenton reagent and electricity applied to the electrodes. This method is segregation of electrical and chemical operations which is widely used to eliminate the particles in the effluent. In the Fenton reaction hydroxyl radicals are given raise from the depletion of hydrogen peroxide. Although this unconstrained reaction was only introduced 40 years after the submission of Fenton.

Fenton process is mainly depended on Fenton reagent which is comprised of hydrogen peroxide (H2O2) as oxidation agent and ferrous sulphate (FeSO4) as reduction agent. Fenton reagent is popularly known for its potential in the destruction of harmful pollution in wastewater and it is also help out in coagulation process. Hydrogen peroxide which has chemical symbol as H2O2 is a strong oxidant and its usage in operations of different pollutants are recommended. H2O2 is a strong oxidant but still it alone is not capable to eliminate the pollutants in the waste water due to its leisurely rate of reaction, so it required a reducing agent such as ferrous sulphate which makes the process efficient and better.

This technique is ideal at contexture temperature and pressure. This system comprised of ferrous salts added with hydrogen peroxide under acidic conditions. Ferrous ion reacts with hydrogen peroxide, creates hydroxyl; radicals OH written below in equation (1)

$$H_2O_2 + Fe^{2+} \rightarrow Fe^{3+} + OH^- + {}^{\circ}OH \quad \text{.....(1)}$$

The $^{\circ}$OH free radical, having a very large amount of oxidation, and it is potential of reducing with many organic particles by a chain of reactions.

$$Fe^{3+} + H_2O_2 \rightarrow + Fe^{2+} + HO_2 \cdot + H^+ \quad \text{.....(2)}$$

$$Fe^{3+} + HO_2 \cdot \rightarrow Fe^{2+} + O_2 + + H^+ \quad \text{.....(3)}$$

$$Fe^{3+} + R \cdot \rightarrow Fe^{2+} + R \cdot \quad \text{.....(4)}$$

Fe^{3+} generated can react with H2O2 and hydroxyl radical and this whole operation is called as Fenton like reaction.

In Fenton application, the lower pH is suggested to carry out the operation. It is recommended to keep pH in between of 2 to 4. By applying electric current to this operation COD can be removed to the greater amount from the dairy wastewater

1.2 Research Surface Methodology

RSM is a set of manners employed in numerical examining of realtionships.it is segregation of mathematical and statistical approaches for numerical models in which interest response is recommended by variety of variables and the objective is to optimize this response.

It is helpful in three approaches and those are,

(i) Statistical experimental design
(ii) Regression models
(iii) Optimization practice

The most common application of this software are in industrial, medical, social science, physical and engineering sciences. The major aspect of this RSM is to calculate the optimum responses. it is vital when more than one response to calculate the necessary optimum responses. RSM helps to the researcher to obtain optimum values of experiments by simply adjusting the lower and higher values of variables.

2. METHODOLOGY

The sample adopted for the study of this work is dairy wastewater which was taken from the milk processing unit of wastewater treating unit section of KMF (Karnataka Milk Federation Ltd.) dairy situated at Doddabathi near Davanagere. This dairy is also popular as Davanagere dairy which is little far from the Davanagere city. This dairy unit generates wastewater which is made after the milk products like curd, cheese and desserts. The dairy wastewater from the KMF dairy Davanagere was collected in a polyethene can having capacity of thirty liters and maintained this in the refrigerator for about $4^{\circ}C$ in order to make it free from the activity of microbes.

The electro Fenton operation has been performed in a 2000 ml beaker which is made up of borosilicate material along with two electrodes of different materials were employed one was iron electrode as anode and other one was aluminum electrode as cathode, both electrodes having same size as 15 cm in height, 5 cm in width and 0.3 cm in thickness. The overall surface area of the electrodes were measured as 324 cm^2. Exactly 1000 ml of dairy wastewater is added in the beaker of borosilicate container. Electrodes were placed inside the beaker following the different distance between them depending on the trials. The beaker is kept above the magnetic stirrer; this does the better mixing of the reaction. The electrodes distances were adjusted between 2 cm to 6 cm and a proper dosage was added in the beaker based on the trails and this operation was conducted following a proper electric current and electrolysis.

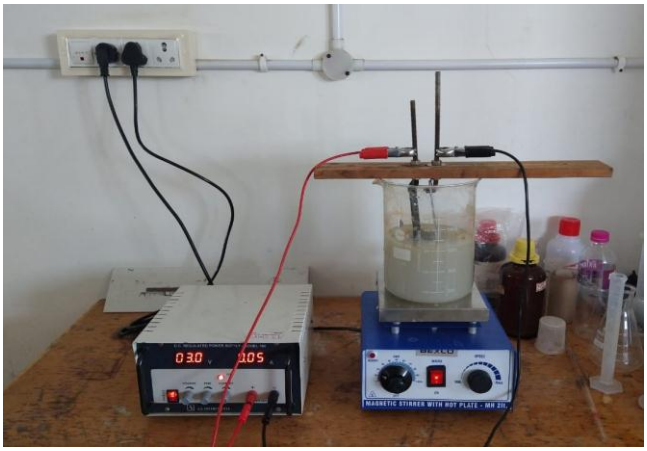

Fig-1: Experimental Setup

3. RESULTS

Primary aim of the research was to find the efficiency of removal for COD and TSS using four different paramters like Fenton Dosage, Electric Potential, Electrolysis Time and Distance between Electrodes and efficiency was measured based on the results found in initial characteristics of raw dairy wastewater.

Table -1: Initial Characteristics Dairy Wastewater

SL. NO.	CHARACTERISTICS	QUALITY
1	pH	5.1
2	Color	White
3	TDS	840 mg/l
4	TSS	1030mg/l
5	Electric Conductivity	1466 µs/cm
6	BOD	980 mg/l
7	COD	1780 mg/l

There were 27 experimental trials adopted for knowing the efficiency of removal of COD and TSS by using RSM software. For all the trails obtained from the software electro fenton treatment operation conducted with respect to trails attributes. Among 27 trials many of the significant results found efficient and highest efficiency was obtained as 84.26% and 90.47% respectively for COD and TSS. it is clearly closer to the values of predicted values of COD and TSS as 84.70% and 94.43% respectively.it says the

experimental data is convinced with the predicted results. In ANOVA test, it represents the ideal by showing R^2 as 91.53% and R^2(adj) as 91.19% for COD and R^2 as 86.92% and R^2(adj) as 86.39% for TSS.

The plot of fitted line in Chart -1 represents the points of data for actual COD destruction efficiency level in percentage which are closer to the straight line and straight line represents the predicted results. This clearly says that there is good relationship up to 95 % between the experimental COD destruction percentage with predicted results.

The plot of fitted line in Chart-2 represents the points of data for actual TSS destruction efficiency level in percentage which are closer to the straight line and straight line represents the predicted results. This clearly says that there is good relationship up to 94 % between the experimental TSS destruction percentage with predicted results

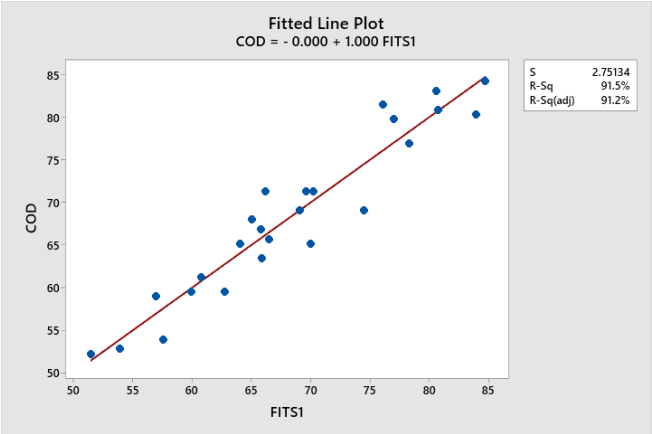

Chart -1: Comparison of actual and predicted values of COD

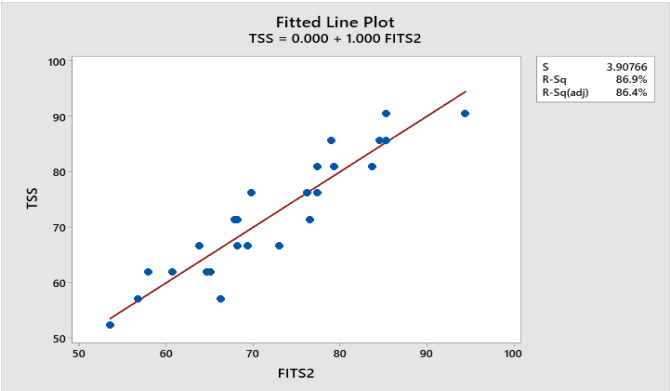

Chart -2: Comparison of actual and predicted values of TSS

Pareto chart represents the importance of individual variables such as Fenton dosage, current, time and electrode distance which are considered as individual variables in this work. It helps in comparison of individual variables presence in the experiments From figure 15 it clears that COD destruction mainly depended on the dosage, higher value of Fenton dosage gives the better efficiency. Fenton dosage is considered as prime independent variables compared to other variables. After the dosage, potential plays vital role in the destruction of COD. Greater potential eliminates the higher value of COD. Other than dosage and potential next prime variable considered in destruction of COD is distance between electrodes, electrode distance have major influence on the destruction of COD. As the distance between electrode reduced it gives the greater efficiency for COD destruction. Increasing in time it provides better efficiency for COD destruction. Among four variables Fenton dosage plays have major role in treatment of dairy wastewater. From the above figure it says that more number of trials got good results in destruction of COD employing the dosage in treatment.

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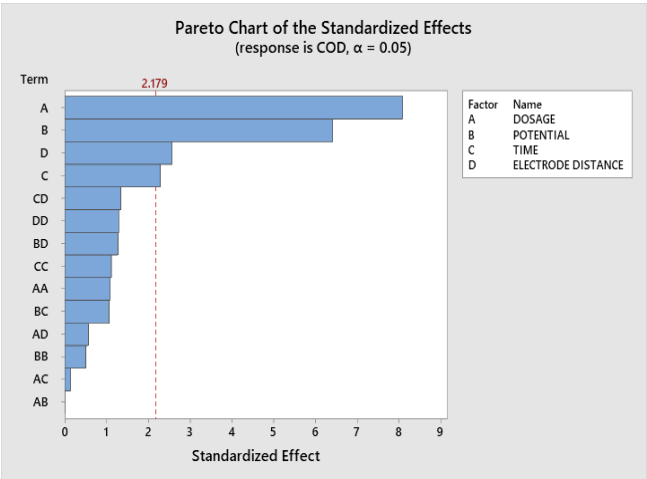

Chart -3: Pareto Chart for COD Removal

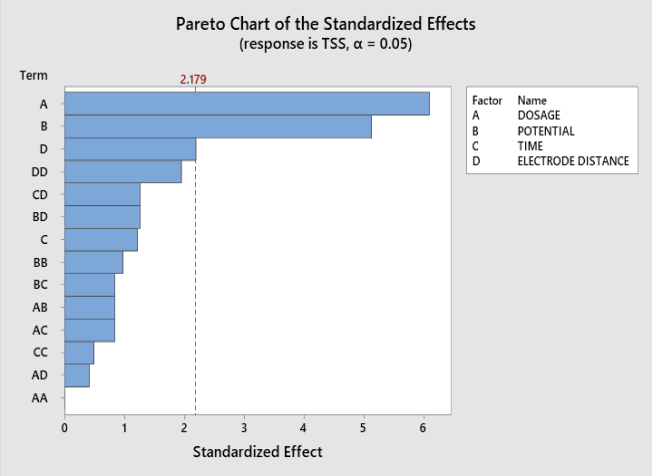

Chart -4: **Chart -3**: Pareto Chart for TSS Removal

4. CONCLUSIONS

The efficiency of destruction of COD and TSS are greatly dependent on the effective values of independent variables like Fenton dosage, electric current, time and electrode distance. The perfect constraint for getting higher value of efficiency for destruction of COD and TSS is found at 3.5 ml/L of Fenton dosage, 12.0 V of electric current, 35 minutes of electrolysis and 4 cm of electrode distance maintained and employing of Aluminum and Iron electrodes.

The actual COD and TSS destructions are found as 84.26% and 90.47% respectively, it is clearly closer to the values of predicted values of COD and TSS as 84.70% and 94.43% respectively.it says the experimental data is convinced with the predicted results. In ANOVA test, it represents the ideal by showing R^2 as 91.53% and R^2(adj) as 91.19% for COD and R^2 as 86.92% and R^2(adj) as 86.39% for TSS. It clears that obtained results from experimental data are closer to the predicted results and found significant.

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