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Electrocoagulation for Treatment of Parboiled Rice Waste Water

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Abstract:
Rice is the staple food for 65% of the population in India. It is the largest consumed food grain in India. Our country is the second largest producer of rice in the world next to China. Rice needs to be process before human consumptions. The parboiled rice milling processes generates wastewaters which gives high BOD and COD it needs treatment before discharged into any water body. There are number of parboiled rice milling industries in Jharkhand which generates large amount of waste water. Such waste water discharged into nearby water body without any treatment. Presently very few parboiled rice mills have effluent treatment plant and the biological treatment method is being used to treat the wastewater. To overcome these problems electrocoagulation process has been adopted as an alternate stand alone treatment to reduce the area requirement and required time. The materials which are used for preparation of lab model were aluminium plate, wire, battery, rheostat, magnetic stirrer and multimeter.
Removal of Chemical Oxygen Demand, Total Solids, Total Suspended Solids, Total Dissolved Solids, Total Volatile Solids and Total Fixed Solids has been considered in the present study. The process variables are pH, time and current.

Key words: *Ampere, Coagulation, electrocoagulation, electrodes*

1. Introduction

Paddy in its raw form can't be consumed by human beings. It needs to be suitably processed for obtaining rice. Rice milling is the process which helps in removal of hulls and bran from paddy grains to produce polished rice. Rice forms the basic primary processed product obtained from paddy and this is further processed for obtaining various secondary and tertiary products. The basic rice milling processes consist of:

a) Pre Cleaning, b) De-stoning, c) Parboiling (optional), d) Husking, e) Husk aspiration, f) Paddy separation, g) Whitening, h) Polishing, i) Length grading, k) Weighing and Bagging: Preparing the milled rice for transport to the customer.

Large amount of waste water generated after parboiled rice milling processing, it cannot be harmful to human health but it contaminates the water resources. Mostly these are discharged into the nearby rivers or streams that are into the inland surface water bodies. This results in rapid depletion in the dissolved oxygen levels of the water bodies which hampers the aquatic life to a great extent.

Previous work done on [Treatment of rice mill effluent for pollution control by Electocoagulation], they studied on the parboiled rice mill waste water treatment by electrocoagulation and check the removal efficiency of COD, Oil and Grease, Turbidity and TSS.

Purpose of this study was to treat the parboiled rice waste water using electrocoagulation process at different pH, time and current variation and to check the removal efficiency of the equipment by the treatment and analysis of COD, TSS, TDS, TS, TFS and TVS.

2. Materials and Methods

2.1. Electrocoagulation

Coagulation and flocculation are traditional methods for the treatment of waste water. In these processes, Electrocoagulation is an alternative technology for wastewater treatment and for recovery of valuable chemicals from wastewater. Many studies have reported the potential of electrocoagulation in the treatment of a variety of wastewater. The method has been used for removing suspended solids, removing dyes, removing heavy metals, breaking oil emulsions in water, removing complex organics, and removing bacteria, viruses and cysts.

$$Al^{3+} + H_2O \longrightarrow AlOH^{2+} + H^+$$
$$AlOH^{2+} + H_2O \longrightarrow Al(OH)_2^{+} + H^+$$
$$Al(OH)_2^{+} + H_2O \longrightarrow Al(OH)^0_3 + H^+$$
$$Al(OH)^0_3 + H_2O \longrightarrow Al(OH)_4^{-} + H^+$$

(pH ↓)

(Peter Holt *et al.*, 2006)

2.2. Experiment Setup

The experiment set up consists of a cylindrical glass beaker of size 10.5 cm diameter and 15 cm height. Two aluminium electrode plates were used for electro-coagulation. Electrode plates were 3 mm thick, 1.8 cm wide and 15.5 cm long (Fig. 1). The current, pH and time variable done in entire process.

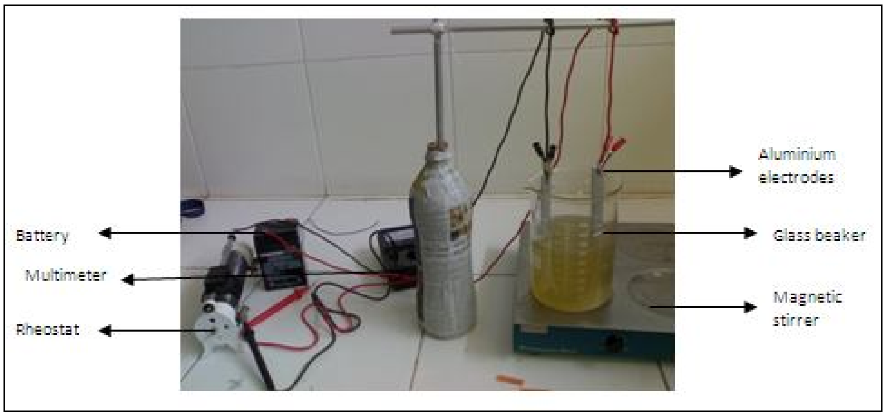


Figure 1: Showing experimental setup and equipments

2.3. Procedure

600 ml sample was taken for electrocoagulation treatment. The two aluminium plates were dipped into a 1000 ml capacity glass beaker containing wastewater samples of 600 ml. 6 cm distance was kept between electrodes. One aluminium plate was attached to the positive pole and other to the negative pole of the power supply unit with the help of electric wires.

pH of the waste water was adjusted between 5-8 using 0.1 N NaOH and 0.1 N H_2SO_4. Waste water was allowed to settle for 1-2 hrs, after that the supernatant waste water was collected for electro-coagulation. Electro-coagulation studies were carried out by using regulated DC power supply of current variation (50 A, 100 A, 150 A and 200 A) and time variable (20 min, 40 min, 60 min and 90 min) respectively. Current was maintained by rheostat. Throughout the process continuous mixing was done by magnetic stirrer at constant speed to distribute the ions thoroughly in the water. After that it allows to settle down the flocs.

2.4. Collection of Waste Water Sample

Samples were collected from household preparation of parboiled rice in the month of March from Ranchi (Jharkhand).
"Grab Sampling" technique was used for sampling.

2.5. Pretreatment Analysis

400 ml parboiled rice waste water was taken for initial measurement of pH, Chemical Oxygen Demand (COD), Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Volatile Solids (TVS) and Total Fixed Solids (TFS).

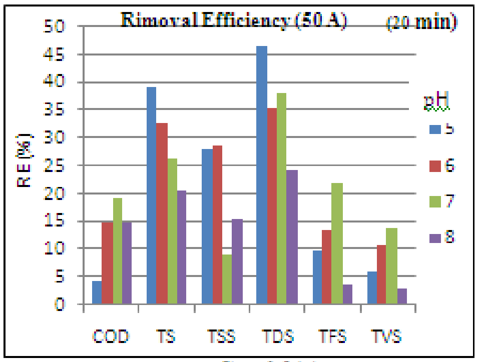
Parameters	Value
pH	5.32
COD	5644 mg/l
TS	4446 mg/l
TSS	1808 mg/l
TDS	2638 mg/l
TVS	1300 mg/l
TFS	1320 mg/l

Table 1

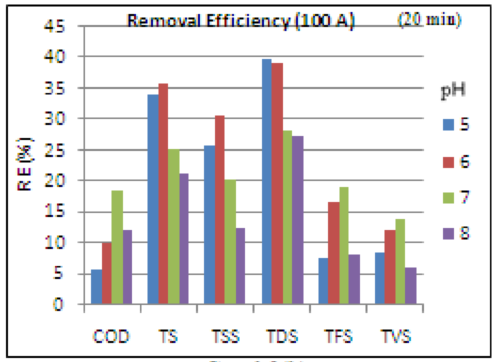
2.6. Post-Treatment Analysis
The same parameters which were analyzed before the treatment of waste water were analyzed after treatment of waste water. e.g. - Chemical Oxygen demand, Total suspended solids, Total dissolved solids, Total solids, Total fixed solids and Total volatile solids. The waste water samples were analysed as per STANDARD METHOD (20th Edition).

2.7. Determining the Efficiency
The results of pre and post treatment were analyzed and following equation was used to evaluate the efficiency of designed model.
Efficiency (%) = $(C_i\ C_f)/C_i * 100$
Where,
C_i= Initial concentration
C_f = Final concentration

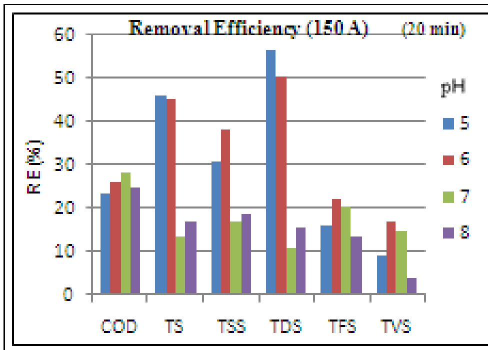
3. Results
Graph 1(a), 1(b), 1(c) and 1(d) showing the removal efficiency of pollutants which were observed after 20 min. treatment by electrocoagulation.



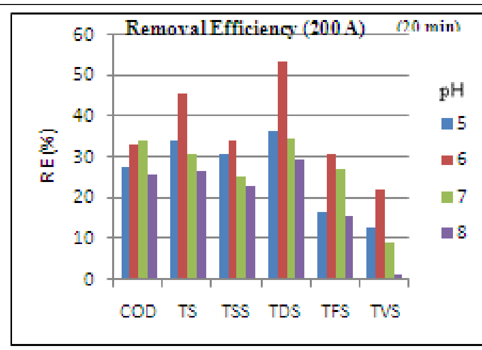
Graph 1(a)



Graph 1(b)

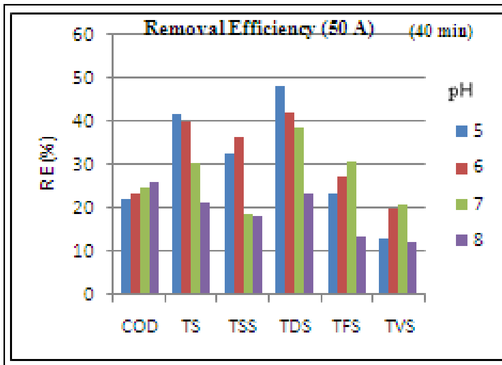


Graph 1(c)

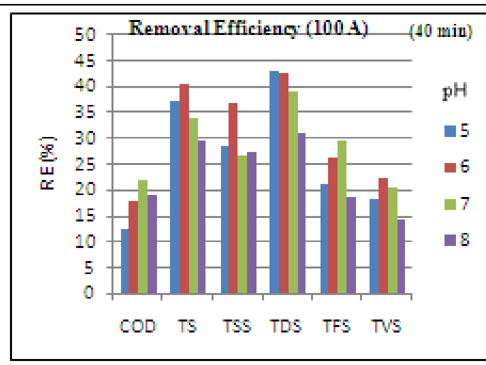


Graph 1(d)

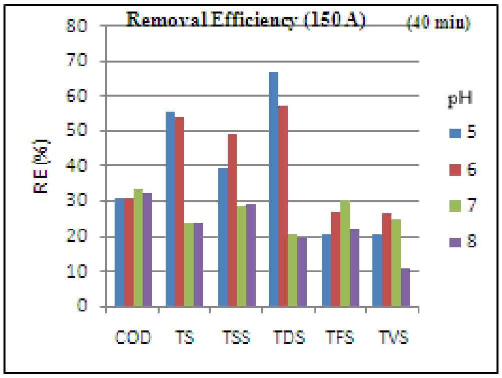
Graph 2(a), 2(b), 2(c) and 2(d) showing the removal efficiency of pollutants which were observed after 40 min. treatment by electrocoagulation.



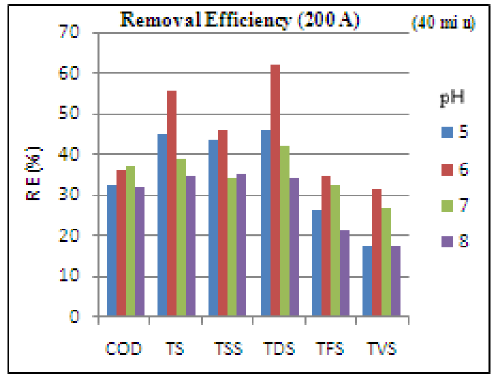
Graph 2(a)



Graph 2(b)

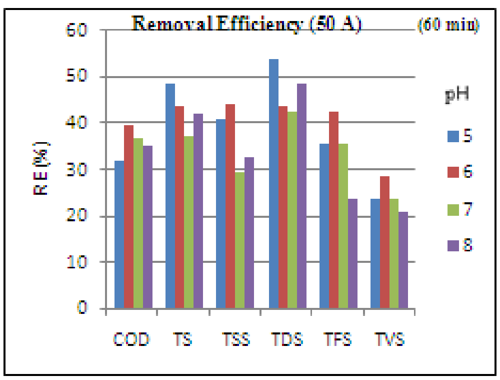


Graph 2(c)

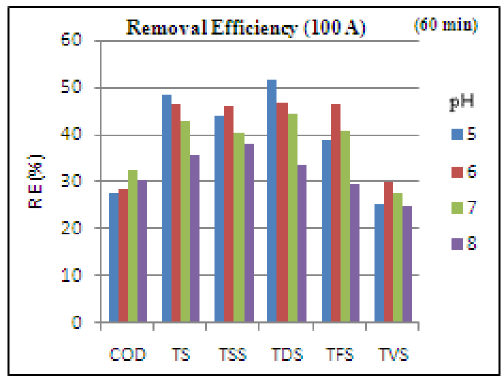


Graph 2(d)

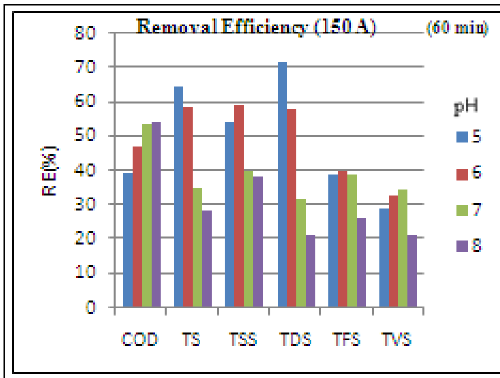
Graph 3(a), 3(b), 3(c) and 3(d) showing the removal efficiency of pollutants which were observed after 60 min. treatment by electrocoagulation.



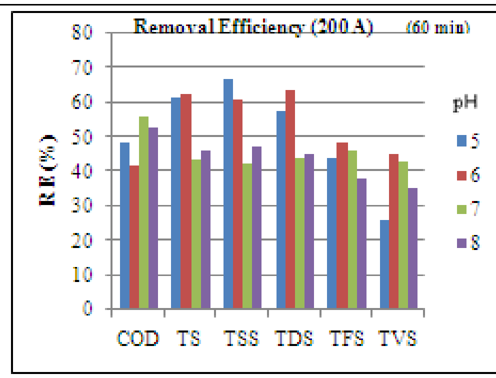
Graph 3(a)



Graph 3(b)

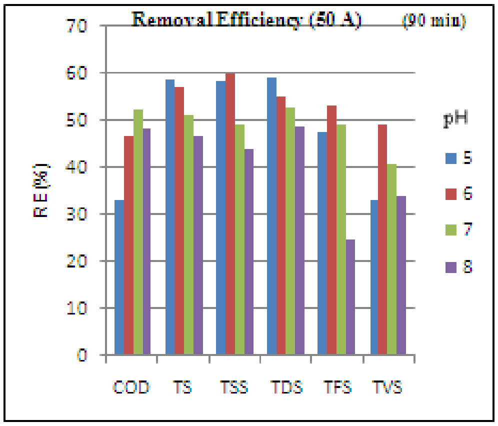


Graph 3(c)

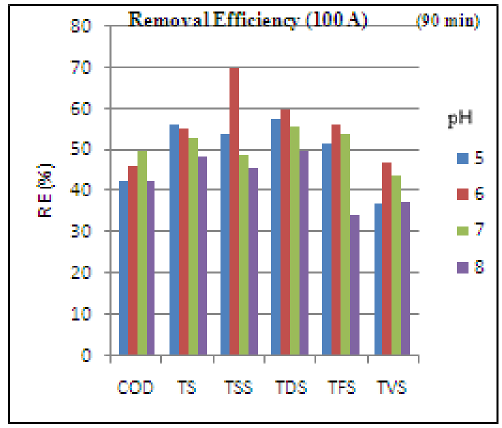


Graph 3(d)

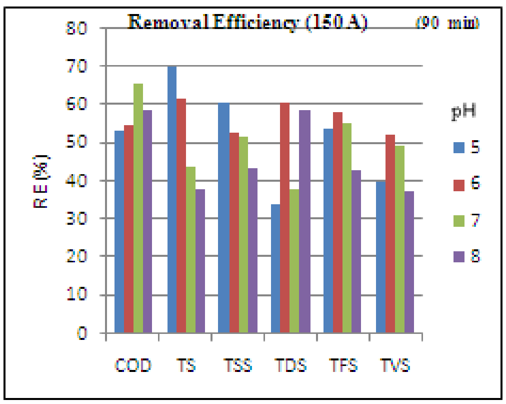
Graph 4(a), 4(b), 4(c) and 4(d) showing the removal efficiency of pollutants which were observed after 90 min. treatment by electrocoagulation



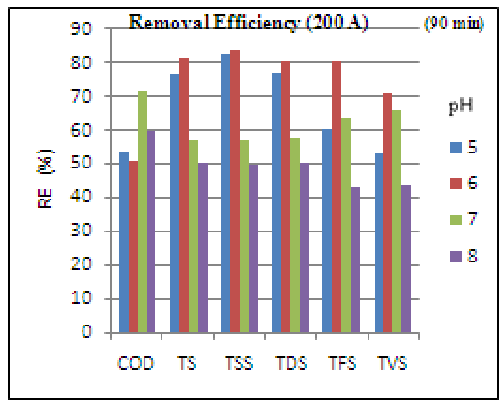
Graph 4(a)



Graph 4(b)



Graph 4(c)



Graph 4(d)

The waste water generated from boiler in parboiled rice mills waste water having high COD, TDS, TSS, TS, TFS and TVS. The waste water was yellow in colour. Aluminium consumed for treatment of 1 litre of wastewater is 0.0935 gm and current consumed 1.2 kwh during the treatment for 1 litre of parboiled rice waste water. Above graphs showed the removal efficiency of pollutant. Maximum Removal efficiency of COD was observed 71.65 % at pH 7 after 90 mins treatment by electrocoagulation at current 200 A as shown in graph 4(d). Removal efficiency of Total Suspended Solids (TSS) was obtained as 83.96 % at pH 5-6 (graph 4d), Total Dissolve Solids (TDS) was obtained as 80.29 % at pH 5-6 (graph 4d), Total Solids (TS) 81.78 % at pH 5-6 (graph 4d), Total Fixed Solids (TFS) was obtained as 80.3 % at pH 5-6 and Total Volatile Solids (TVS) was obtained as 70.77 % at pH 5-6 (graph 4d). The removal efficiency of TS, TDS, TSS, TFS and TVS was observed after 90 mins treatment by electrocoagulation at current 200 A.

4. Discussion

4.1. Effect of pH

The effect of pH on coagulants depends on the produced reactions on different conditions

In neutral conditions:

$3Al + 8H_2O \longrightarrow Al(OH)_2 + 2Al(OH)_3 + 4H_2$

In acid conditions:

$2Al + 6H_2O \longrightarrow O_2 + 4H_2 + Al(OH)_2$

In alkali condition:

$2Al + 6H_2O \longrightarrow 2Al(OH)_3 + 3H_2O$

Here, Al $(OH)_3$ and Al $(OH)_2$ settle while, H_2 moves upward and causes flotation. As reactions show, in acidity condition Al $(OH)_2$ and in alkali condition Al $(OH)_3$ are produced. Since Al $(OH)_3$ has higher weight and density, it settles faster and has higher efficiency (M. Malakootian *et al.*2009).

4.2. Effect of Current

Removal efficiency of pollutant increases with increase in current. Removal of pollutant is less at current 50 A and high at 200 A. The greatest pollutants removal efficiency was obtained at 200 A shown in graphs 1(d), 2(d), 3(d), 4(d).

4.3. Effect of Time

Removal efficiency of pollutants also increases with increase in time. Removal of pollutant was less at 20 minutes but high at 90 minutes.

5. Conclusion

At high current, size and growth rate of produced flocs increases which affects the efficiency of the process. The maximum removal of COD was observed at pH 7; the maximum removal of TS, TDS, TSS, TFS and TVS was observed between pH 5-6. Aluminium consumed for treatment of 1 litre of wastewater is 0.0935 gm and current consumed during the treatment for 1 litre of wastewater for 1 hr. is 1.2 kwh. The treated waste water cannot meet the permissible limits by treating electrocoagulation treatment method; it requires further treatment to improve the effluent quality which will add to the cost. So the electrocoagulation method is costly method for treatment for parboiled rice waste water.

6. References

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