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Comparison of Back Propagation Network and Fuzzy Logic for Electrocoagulation Process to Treat Dye Waste Water

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Abstract : Wastewater discharged from textile industries becomes a major environmental problem because of the presence of high level of chemicals. Hence Wastewater treatment processes are introduced to achieve improvements in the quality of the wastewater. Though Conventional wastewater treatment methods provide good efficiency, they are time-consuming and utilize many chemicals. In the proposed work, Electrocoagulation process, an effective wastewater treatment method is used in treating dye waste water because of providing high efficiency, less consumption of time and chemicals. Soft computing techniques like Back Propagation Networkand Fuzzy logic are used to provide optimum current, optimum reaction time and color removal efficiency based on pH and conductivity measurements. The results obtained for test inputs are then compared to see their effectiveness in providing high color removal efficiency.
Keywords : Back Propagation Network; Electrocoagulation; Fuzzy logic; Wastewater.

1. Introduction

Wastewater generated from dyeing and finishing processes of textile industries should be given much care, due to the presence of strong color, a large amount of suspended solidsetc. The poisonous dye materials absorb the oxygen content of water and increase the problem for human life and environment [1-2].

Different wastewater treatment methods like adsorption, sedimentation, chemical analysis, chemical coagulation, biological etc., are used to treat wastewater discharged from textile mills. However these conventional methods are low in efficiency utilizes large amount of chemicals, high in cost and requires more time.

Electrocoagulation(EC), an emerging electrochemical process has been found as the best choice to treat textile wastewater due to the fact that the process provides high efficiency, consumes less amount of time and utilizes fewer amounts of chemicals. Electrocoagulation is a process where, electric current is allowed to pass through sacrificial metal electrodes to produce metal ions that remove pollutants by precipitation and coagulation mechanism[3-4].The main reactions that happen at the electrodes are as follows:

$Al \rightarrow Al^{3+} + 3e^-$ (Oxidation reaction at anode) (1)

$3H_2O + 3e^- \rightarrow 3/2\ H_2 + 3OH^-$ (Reduction reaction at cathode) (2)

Reactions happened in anode and cathode is shown in Equation 1 and Equation 2. Cathode may be chemically attacked by the OH- ions that are generated along with H_2 at high pH values. The generated Al_3+ and OH- react with each other to form metal hydroxide $Al(OH)_3$ shownin Equation 3.

$Al^{3+} + 3H_2O \rightarrow Al(OH)_3 + 3H^+$ (Hydrolysis reaction) (3)

The metal hydroxide (coagulant) obtained from hydrolysis reaction destabilizes and aggregates the suspended particles and absorb dissolved contaminants. Destabilization is achieved by means of two distinct mechanisms namely charge neutralization of negatively charged colloids by cationic hydrolysis products and sweep flocculation, where impurities are removed in the amorphous hydroxide precipitate formed. Hence pollutants from the wastewater are removed by means of coagulation and electrostatic attraction[5-8].

The proposed work provides optimum current, optimum reaction timeandcolor removal efficiency time based on the pH and conductivity measurements. For this, soft computing techniques like Back Propagation Network and Fuzzy Logic are used and their results are compared for better color removal efficiency.

2. Materials and Methods

2.1 General procedure

The Electro-coagulation system is composed of a DC power supply, a power control, measurement units, an electrochemical reactor and a stirrer for a batch study shown in Figure 1. The Electrochemical reactor is a 250mlbeaker with a set of one pair of bipolar electrodes made of titanium coated aluminum. Both electro desare in rectangular shape andc onnected vertically withadjustablegapof10-30mm betweenthem. The electrodes are connected to theDCpower supply.

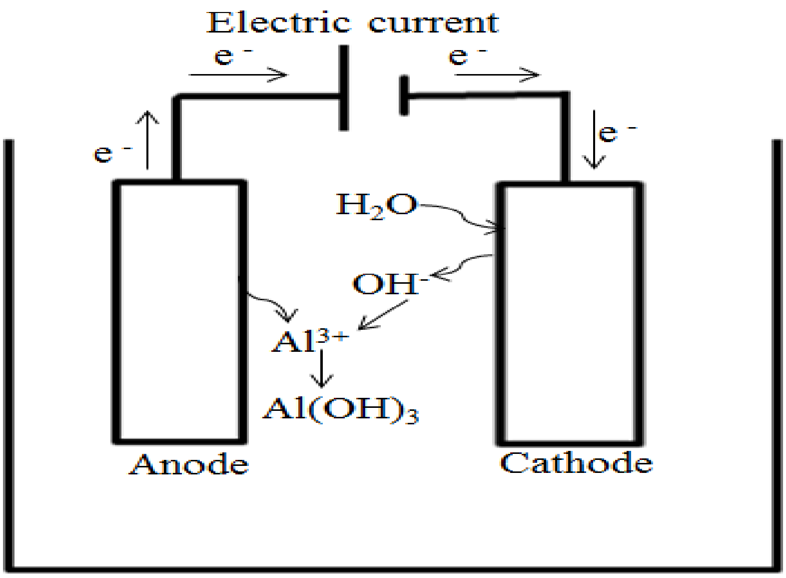

Figure 1: Electrocoagulation Reactor

The dye solution is prepared using two different dyes namely Congo red and Azure in 1:2 ratios for 1000ml to obtain the optimum conditions as well as to get the pH and Conductivity readings for the optimum conditions in electrocoagulation process under batch study. Typical runs are conducted at the room temperature. During the runs, the reactor unit is stirred by a magnetic stirrer with the speed of 200rpm.

Before and at the end of each run, electrodes are cleaned with a detergent then washed thoroughly with the help of distilled water. After washing, both electrodes are dried in an oven for 15min.After the performance analysis on EC process in batch study, optimal conditions of parameters in electrocoagulation are obtained. They are pH (7), conductivity (3mS/cm), NaCl (4%) and current (0.03A-0.3A).

The pH and conductivity measurements are obtained with the help of pH meter (Digital pH meter-DR314) and conductivity meter (Digital Conductivity meter with cell- Type 304). Also dye/color removal efficiency is noted at the end of each run with the help of UV spectrophotometer (UV Spectrophotometer-Model 752s). Data sets are obtained with the usage of optimum conditions in electrocoagulation process for soft computing techniques shown in Table 1.

Table 1: Experimental Data from electrocoagulation process in batch study

S.No.	Current (A)	pH	Conductivity (mS/cm)	Color Removal Efficiency (%)	Reaction time (min)
1.	0.3	9.394	9.619	98.91	15
2.	0.3	9.103	10.02	99.73	15
3.	0.3	8.181	10.63	99.71	15
4.	0.3	9.102	7.847	99.72	15
5.	0.1	8.785	8.129	99.63	5
6.	0.3	8.763	7.024	99.62	15
7.	0.2	8.573	8.855	97.08	5
8.	0.1	8.557	7.071	98.93	5
9.	0.3	7.967	6.245	97.21	15
10.	0.25	8.538	6.703	86.17	10
11.	0.25	8.567	6.016	72.17	10
12.	0.25	8.506	3.851	98.5	10
13.	0.25	8.475	5.02	95.69	7
14.	0.25	8.439	3.984	98.45	8
15.	0.25	8.281	3.195	97.80	5
16.	0.05	8.134	2.325	89.32	6
17.	0.03	8.322	1.073	96.15	9

By varying the current supply between the electrodes the corresponding pH and conductivity variations are measured for different trails in electrocoagulation process. Also, reaction time and color removal efficiency are obtained at the end of each trial in electrocoagulation process. Data sets obtained under optimum conditions are used for soft computing techniques like ANN and Fuzzy Logic.

2.2 Artificial Neural Network(ANN)

In this work, multilayer feed-forward ANN with one hidden layer is used. For all data sets sigmoid transfer function is used. The ANN is trained using Back Propagation algorithm. Both pH and conductivity readings are given as inputs. Current, Reaction time and Color removal efficiency are used as targets. To develop the architecture of the ANN, data collected from electrocoagulation process under batch study is taken and randomized into subgroups namely training (70%), validation (15%) and testing (15%)[9-10].

2.3 Fuzzy Logic

In this work, Mamdani method is used in fuzzy logic. Both pH and conductivity readings are given as inputs. Current, Reaction time and Color removal efficiency are used as outputs. For both inputs and outputs triangular membership function is used to create fuzzy sets. The number of rules that are utilized is nine. For Defuzzification, centroid method is used[11-12].

3. Results and Discussions

3.1 ANN modeling

The number of input neurons is defined by input variables, including pH and conductivity. The output variables are current and reaction time and color removal efficiency. The regression plots are obtained after ANN training, validation and testing shown in Figure 2(a), 2(b) and 2(c)

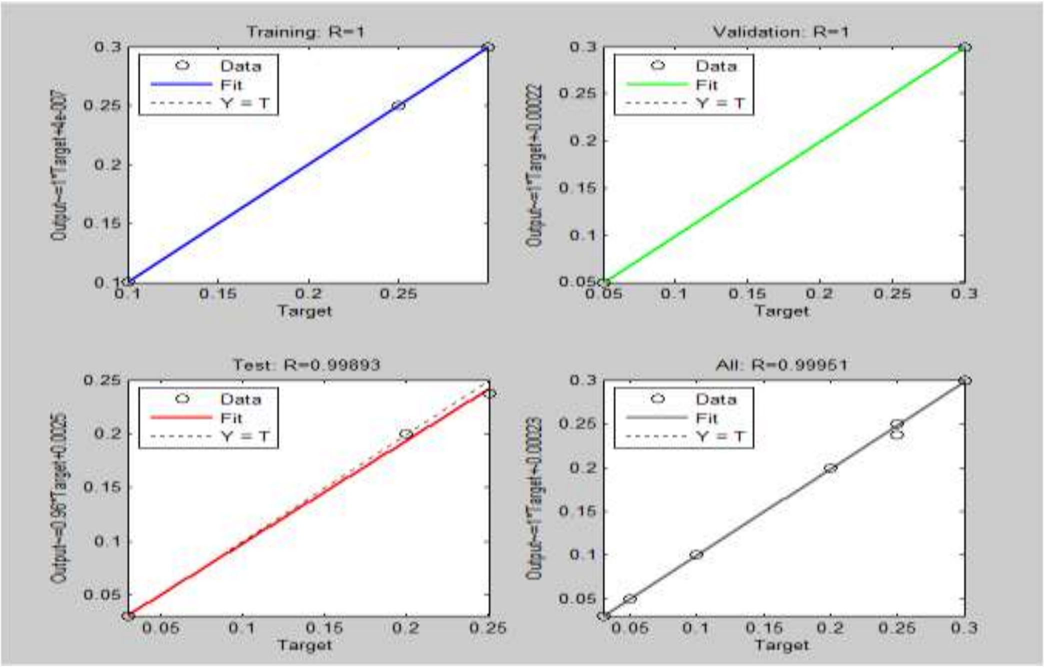

Figure 2(a): Regression plot for Current

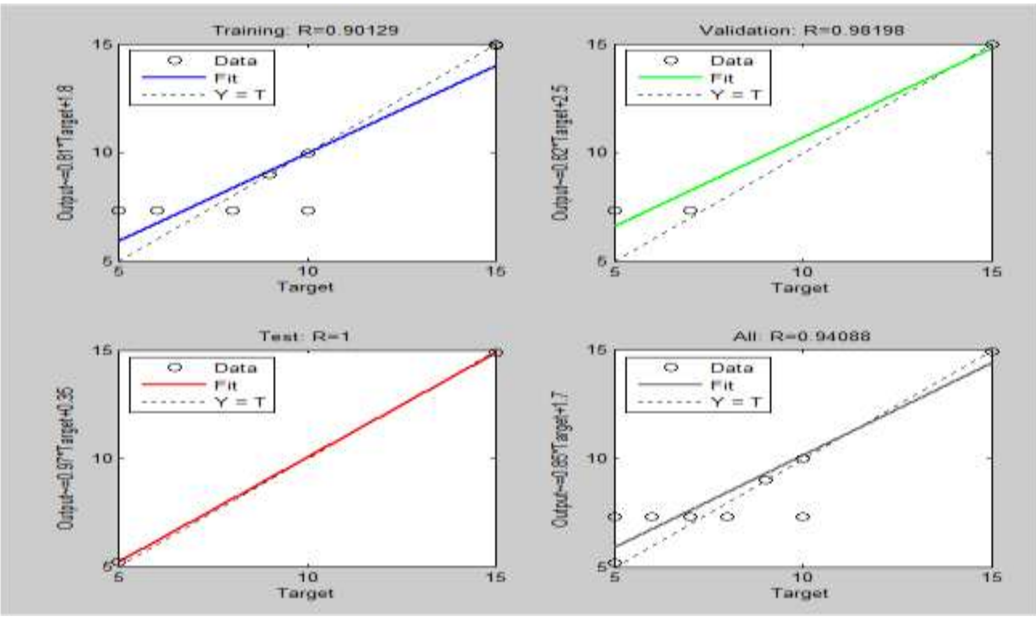

Figure 2(b): Regression plot for Reaction time

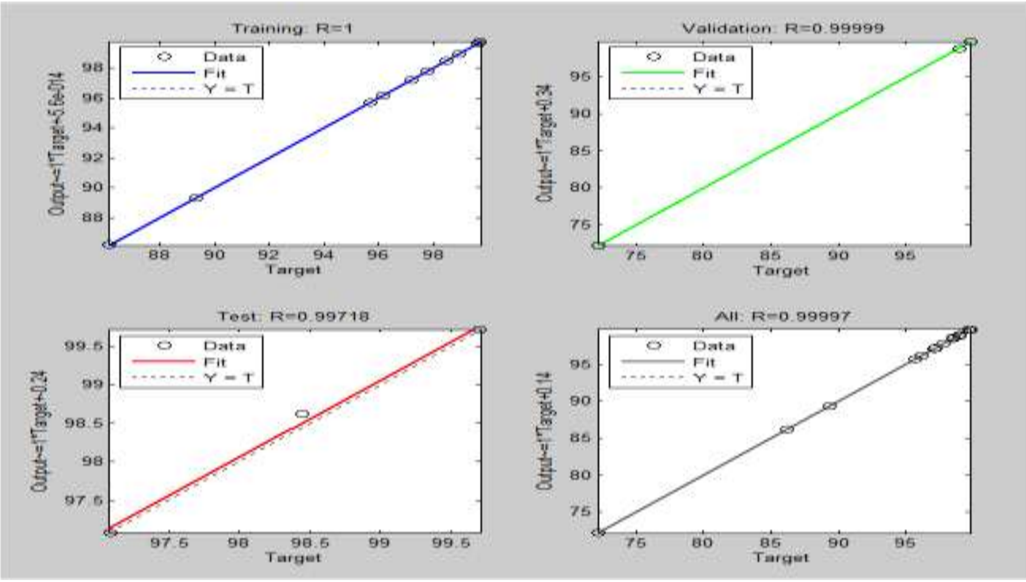

Figure 2(c): Regression plot for Color removal efficiency

3.2 Fuzzy modeling

For FIS, mamdani type inference system is used. pH and Conductivity are given as input variables whereas current, reaction time and color removal efficiency are used as output variables.

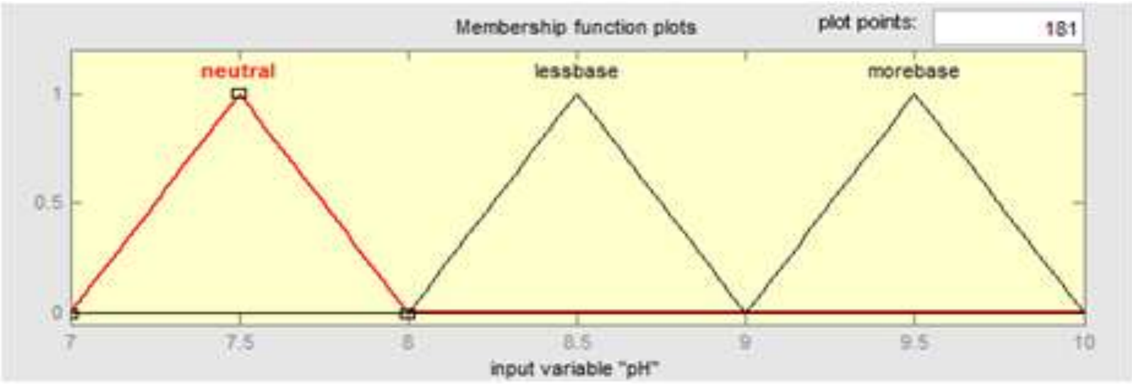

Figure 3(a): pH membership function

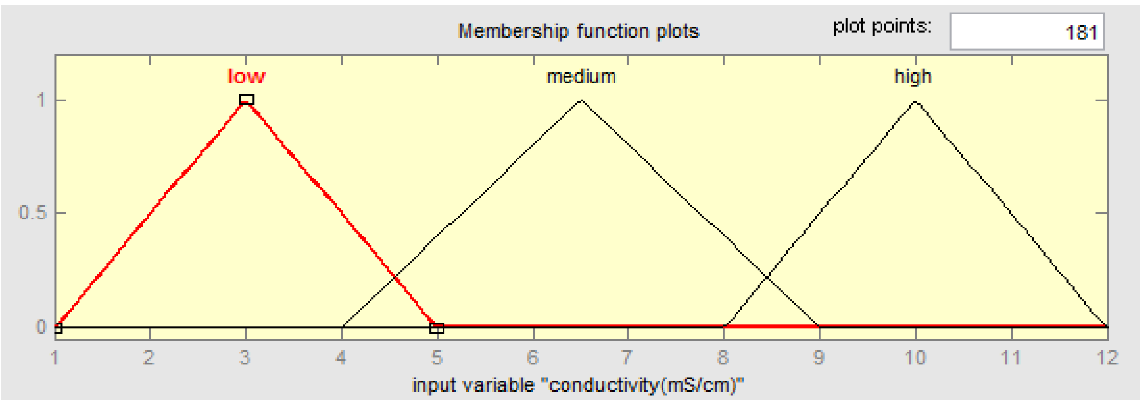

Figure 3(b): Conductivity membership function

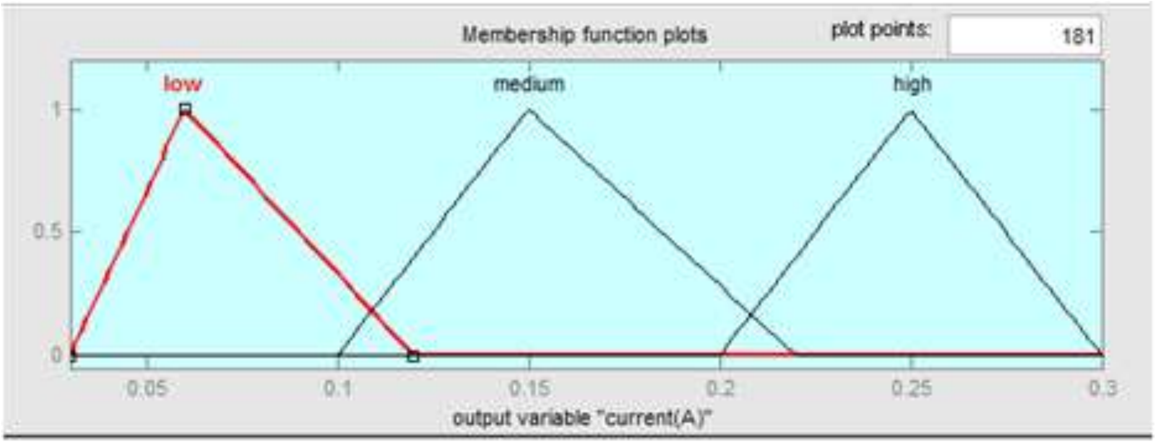

Figure 3(c): Current membership function

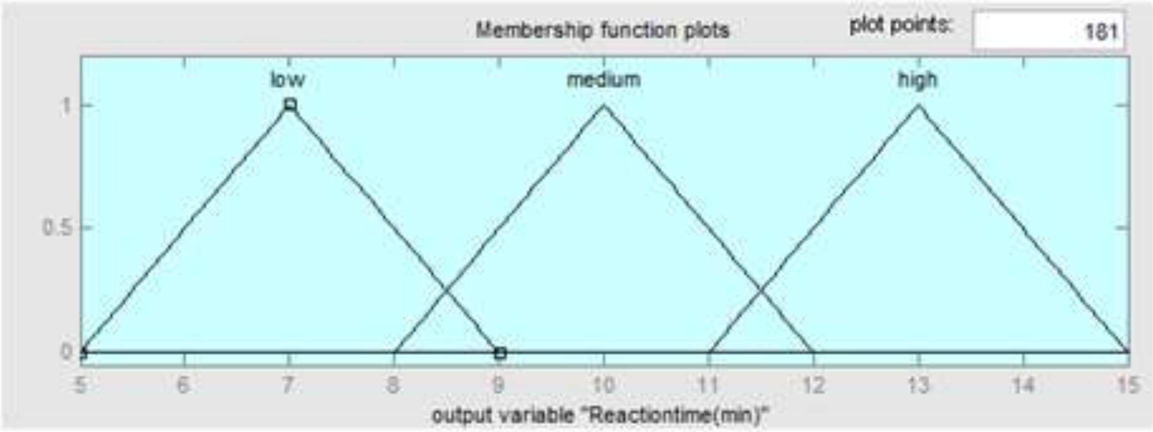

Figure 3(d): Reaction time membership function

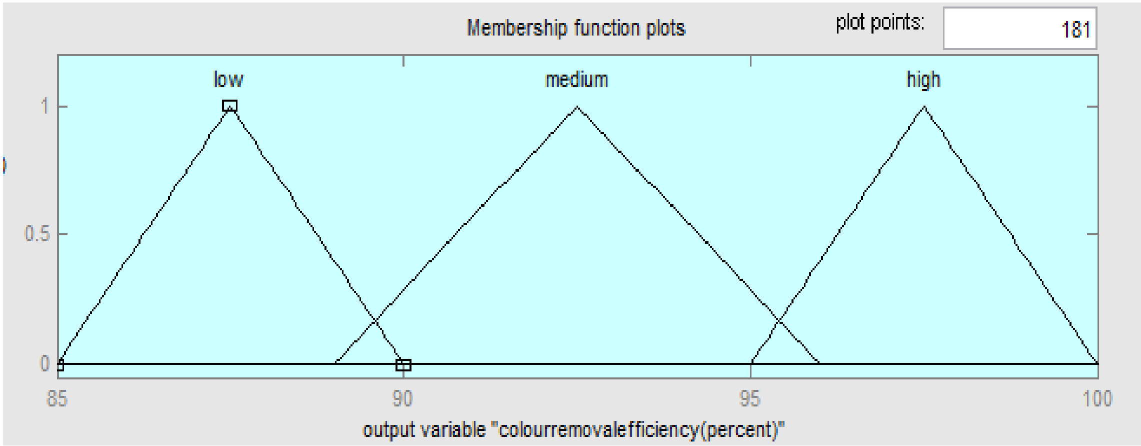

Figure 3(e): Color removal efficiency membership function

Triangular membership function is used for both inputs and outputs to create fuzzy sets for fuzzy modeling shown in Figure 3(a), 3(b), 3(c), 3(d) and 3(e).

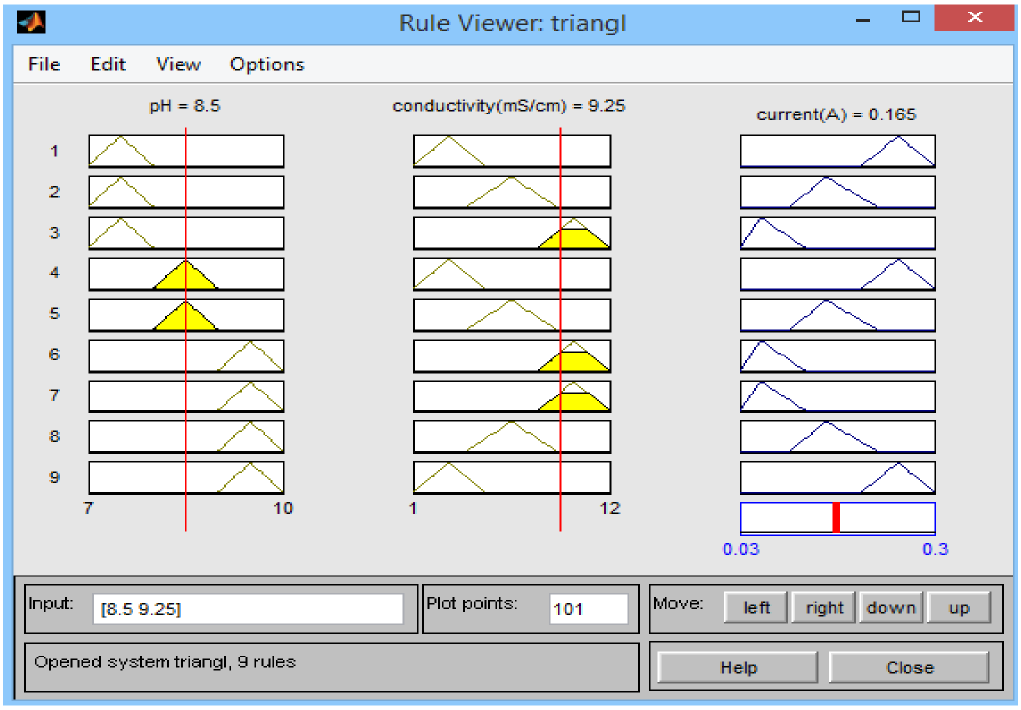

Figure 4: Rule viewer

In rule viewer, each row of plots corresponds to one rule, and each column of plots corresponds to either an input variable or an output variable shown in Figure 4.It is used to know output for change in inputs.

3.3Performance Evaluation for Back Propagation Network and Fuzzy Logic

The results obtained from both fuzzy logic and Back Propagation Network for different test inputs to get the optimum current output, optimum reaction time and color removal efficiency are compared in terms of accuracy for electrocoagulation process under batch study shown in Table 2(a), 2(b) and 2(c).

Table 2(a): Comparison of results obtained from Fuzzy Logic and Back Propagation Network to get optimum Current

S.No.	Inputs		Fuzzy Logic output	Back Propagation Network output
	pH	Conductivity (mS/cm)	Optimum Current (A)	Optimum Current (A)
1.	7.6	9	0.0717	0.3
2.	7.8	5.2	0.1582	0.29999
3.	8.488	7.192	0.1571	0.28058
4.	8.8	8.093	0.1589	0.28711
5.	9.211	8.371	0.1286	0.3

Results showed that the Back Propagation network provides better optimum current than Fuzzy logic for different test inputs in terms of accuracy.

Table 2(b):Comparison of results obtained from Fuzzy Logic and Back Propagation Network to get optimum reaction time

S.No.	Inputs		Fuzzy Logic output	Back Propagation Network output
	pH	Conductivity (mS/cm)	Optimum Reaction time (min)	Optimum Reaction time(min)
1.	7.6	9	6.983	5.0039
2.	7.8	5.2	10	11.3887
3.	8.488	7.192	10	5.0148
4.	8.8	8.093	10	14.4141
5.	9.211	8.371	8.7167	14.9099

Results showed that the Back Propagation network provides better optimum reaction time than Fuzzy logic for different test inputs in terms of accuracy.

Table 2(c): Comparison of results obtained from Fuzzy Logic and Back Propagation Network to get color removal efficiency

S.No.	Inputs		Fuzzy Logic output	Back Propagation Network output
	pH	Conductivity (mS/cm)	Color removal Efficiency(%)	Color removal Efficiency(%)
1.	7.6	9	97.499	99.73
2.	7.8	5.2	92.5	96.6625
3.	8.488	7.192	93.0532	99.6682
4.	8.8	8.093	97.4974	99.6033
5.	9.211	8.371	97.4992	99.7124

Results showed that the Back Propagation network provides better color removal efficiency than Fuzzy logic for different test inputs in terms of accuracy.

4. Conclusion

In this work, electrocoagulation process is used for removing dye from wastewater. Soft computing techniques likeBack Propagation Network and Fuzzy Logic are applied for data obtained from batch study. After modeling both Back Propagation Network and Fuzzy Logic, the results are obtained for different test inputs. The results show that Back Propagation Network provides 99% color removal efficiency with better optimum current and optimum reaction time whereas fuzzy logic provides 97% color removal efficiency with good optimum current and optimum reaction time. Hence BPN can be preferred for electrocoagulation process in batch study to get better color removal efficiency by providing optimum current and optimum reaction time based on pH and conductivity of the effluent in real time.

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