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Predicting the Amount of Chemical Dosage in Effluent Treatment Plant Using Artificial Neural Network

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Abstract: The wastewater is treated to dispose the water safely to the environment that can be acceptable for the end-use, which can be for drinking, domestic and industrial use. Wastewater treatment is the complex and dynamic process of removing pollutants from outlets of industries, agricultural farms or municipal organizations. The main features of the pollutants are randomly distributed, non-Linear, time-varying and uncertain. The concept of the treatment is based on controlling the effluent parameters like pH values and dissolved oxygen (COD, BOD) so that the condensate coming out will meet the fresh water quality. The main objective of this paper is to predict the amount of dosage (acid or alkali) to be added at the primary clarifier to control the pH value. To predict the correct amount of acid or alkaline, an Artificial Neural Network (ANN) has been used. The sensors read the pH value, COD, BOD, TSS etc., from the polluted water collection tank. The sensor inputs are fed to the ANN along with the target values for training. Backpropagation training algorithm has been used along with Gradient descent training algorithm for training the neural network. Using the trained ANN model the amount of acid or alkaline is added to restore the pH value to the desired level (Ph value = 7). It is observed that the ANN model developed is able to predict the amount of acid or alkaline correctly for a set of input sensor values.

Keywords: Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), pH, Effluent, Artificial Neural Network (ANN), Radial Basis Function (RBF).

1. INTRODUCTION

The polluted water sources before it is given to the end user the waste water must be treated to remove the effluent parameters. There are various sources of waste water from industries, agricultural, domestic etc. Some waste water is more difficult to treat. Industries pay heavily to use the water from rivers or lakes and hence it is necessary to implement wastewater treatment plant to reduce the cost and conserve them. The main aim of this plant is to convert the entire effluent to zero level by separating water and salt using evaporation and separation technologies

In the waste water treatment system there are various components and technologies used such as Sensors, instrumentation systems, control system etc. Sensors are the key components for monitoring and control of the process environment. The sensor is just one element in a process control loop and is at the lowest level of the plant monitoring system. On-line sensors for waste water treatment contribute to reducing the accuracy of the data sensed [2]. Treatment processes are regarded as the weakest part of the control loop and the most unreliable component of a monitoring system. This is because the sensor is subject to significant level of extraneous noise that corrupt the output signal from the sensors. Wastewater treatment systems are nonlinear with many contributing disturbances

To overcome the limitations of the usage of sensors Artificial Neural Network (ANN) technique is used. ANN has great potential in solving the problem of modeling systems with strong nonlinearity and heavy uncertainty. Hence ANN is regarded as a kind of ideal approach to solve the nonlinearity problems

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existing in wastewater treatment plants of soft measurement in complex system, including prediction of wastewater treatment plant performance. This system learns from the historical data of the process. The major parameters to be monitored are Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Total Suspended Solids (TSS).

To improve the efficiency, to cut the operational cost, and to decrease the risk of unwanted odor, the process of monitoring dissolved oxygen (DO) is necessary. One of the most important parameter is pH value to access the. To produce the fresh water quality standards, the control of the pH value plays a vital role and ANN is used to precisely adjust the pH value to the neutral state by adding acid or alkaline appropriately to the treatment process.

2. METHODOLOGY

A. Structure of an ANN Model

ANN model can solve problems which are non-linear and with complex data even if the data are imprecise and noisy. The ANN consists of three layers namely input,output and hidden. Input into a node is a weighted sum of outputs from nodes connected to it.

The input function is normally given by equation $\text{Net}_i = \Sigma w_{ij} x_j + \mu_i$

Where $\text{Net}_i \rightarrow$ Result of all the inputs x_i weighted by w_{ij} and the threshold value μ_i.

The inputs are applied to the input layer and they are transferred to the middle layer after multiplying by the respective weights. The middle layer neurons apply the activation function and transfer the data to the output layer after multiplying by the respective hidden layer weights.

Sigmoidal activation functions, which are continuously differentiable have been used have been used for the middle and the output layer neurons which are continuously differentiable [3].

B. Architecture of the whole System

The main scope of this paper is to measure the effluents in waste water in order to improve its quality by adding the requisite dosages of acid/alkaline to the primary clarifier for controlling the pH value and monitor the oxygen demand. An ANN model is developed for the water quality system as indicated in Figure 1. The neural network consists of 3 neurons in the input layer and 1 neuron in the output layer and the middle layer neurons are tentatively chosen to be sixteen. The three inputs to the network are pH value, TDS and TSS along with the target pH values which are the desired values of amount of acid / alkaline to be added. The output value represents the amount of acid/alkaline to be added to make the pH value normal. There are various parameters that have to be diagnosed from the effluent of a textile industry but in this paper the value of pH, TSS, TDS are considered to predict the acid / alkali to be added to obtain the desired pH value. Sample dataset of a textile industry to test and validate are given in the Table 1.

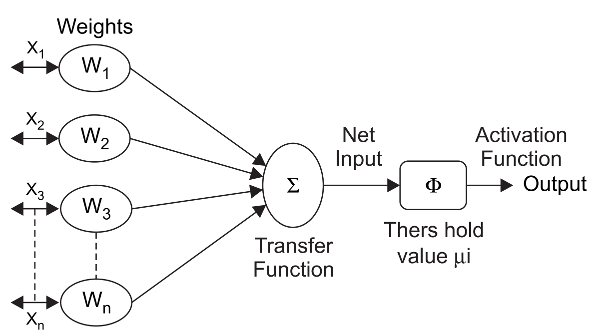

Figure 1: Structure of an ANN Model

Table 1
Sample Data Sets

S.No	*Parameter*	*Sample Input*										*Output From the Treated Water*
1	Ph	8.8	11	9.2	8.7	10.5	9.7	8.6	10.2	9.4	8.7	7
2	TDS (mg/l)	7000	6728	5948	6712	7896	8792	8200	9048	9048	7648	Max. 300
3	Turbidity (NTU)	52	49	37	43	50	36	47	40	39	47	NIL
4	COD (ppm)	990	750	820	890	967	855	789	747	910	960	100mg/L
5	BOD (ppm)	340	294	327	198	204	337	248	304	317	284	30mg/L
6	TSS (ppm)	72	67	54	78	62	49	65	70	57	66	NIL
7	Colour	Dark brown	Black	Dark brown	Dark violet	Grey	Black	Dark brown	Dark maron	Black	Grey	NIL
8	Mg Hardness (mg/l)	50	42	37	49	38	45	53	46	39	47	0
9	Carbonate Hardness (mg/l)	150	138	144	157	149	128	154	143	135	143	NIL

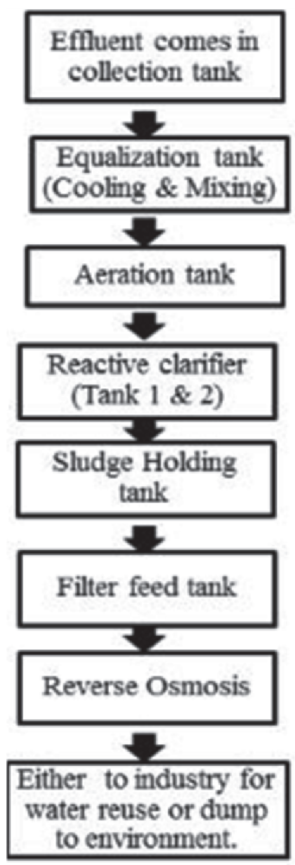

Figure 2: Process flow of the system

This work is mainly intended to treat the effluent water to meet the quality standards and bring the pH value to 7. The data sets are divided into three segments which are training, testing and validation data. The most widely used feed-forward backpropagation algorithm is used for training the ANN.

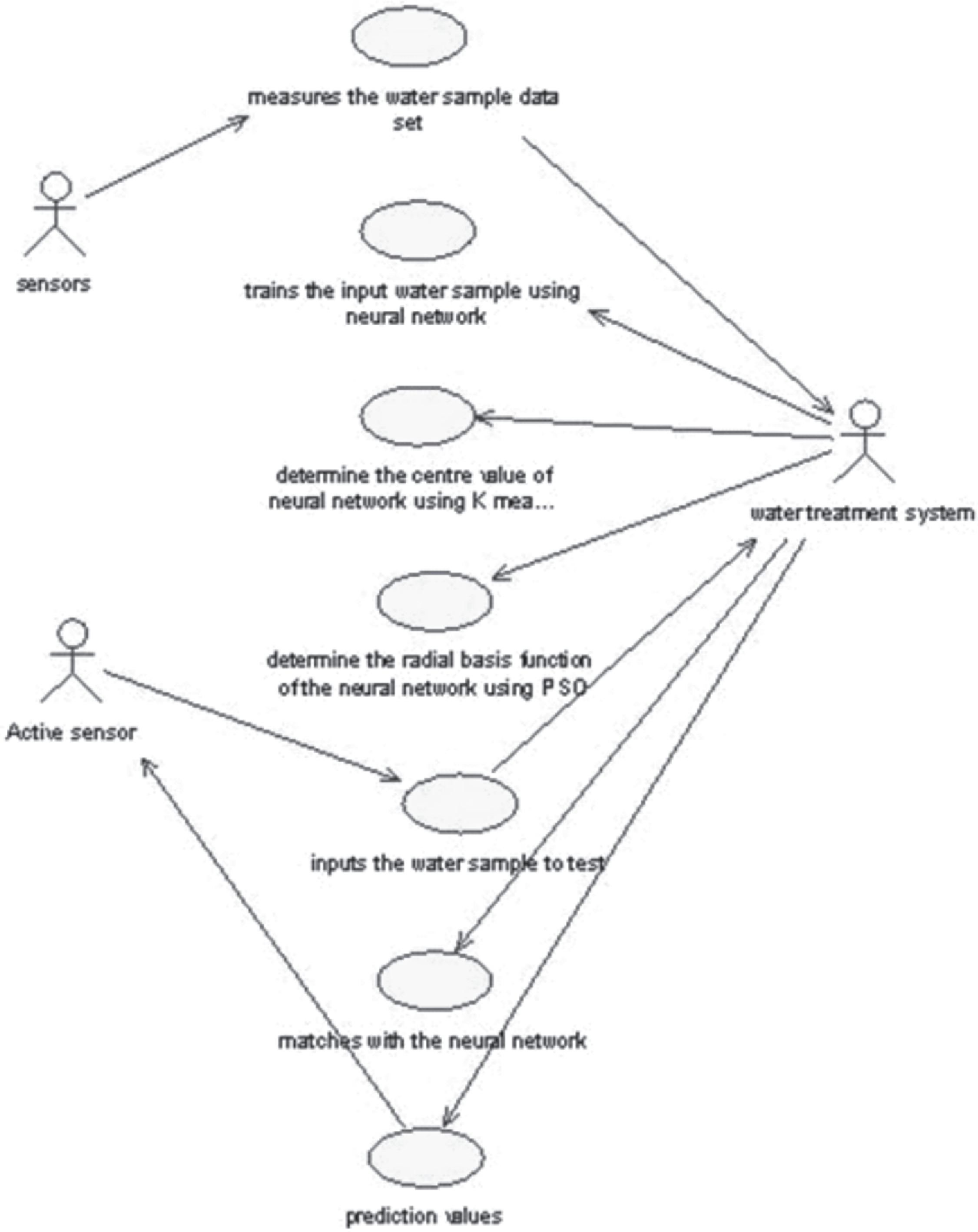

Figure 3: Usecase Diagram for Prediction of water quality

(i) Training Water Sample Datasets

The input water sample datasets are trained using the neural network. Where the input signals are send to the input layer, after which these signal are multiplied with weight function. The weight function between the hidden signals and input level is fixed as one, where as the weight between the hidden and output is adjustable. The learning process usually consist of two stages, in the first stage, according to all the outputting data to determine the number of hidden neurons, and the center of the radial basis function of the hidden nodes Xc; The second stage, to determine the weights from the hidden to output layer W2.

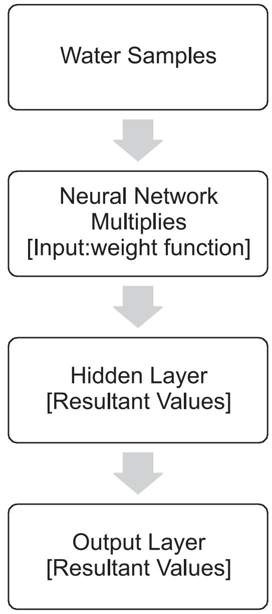

Figure 4: Training the datasets

(ii) Testing

The test input water sample is given as input to the neural network, the neural network matches with the trained input. Finally classifies the test input sample.

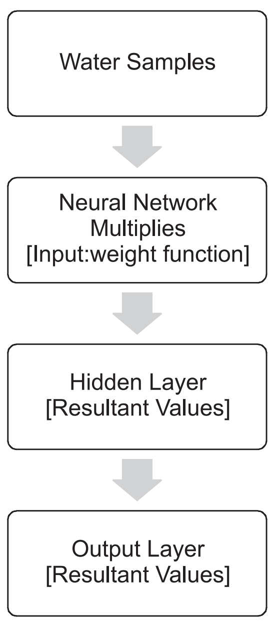

Figure 5: Training the datasets

C. Predicting dosage of acid or alkali to control pH

pH value of an effluent from a textile industry may be either high or low and very rarely in a neutral state. In the water treatment process pH value is controlled in the Primary Clarifier. If there is a usage of biological treatment then the pH value should be neutral because microorganism will be killed if the water is highly acidic or alkali [5]. To control the pH value various chemicals are used. If the water is of low pH value then sodium hydroxide, sodium carbonate, calcium carbonate or calcium hydroxide is added and if water is alkali then sulphuric or hydrochloric acid may be added.

The system reads the pH value, trains the input water samples using neural network. The output of the ANN provides the amount of chemicals to be added to the clarifier to bring back the pH value to its normality.

D. Predicting Dissolved Oxygen

To determine the quality of the water the major parameters to be tested are pH, BOD, COD, TDS, TSS, COLOR. Among these COD (Chemical Oxygen Demand) is a widely known parameter used to measure water quality. It is a measure of water pollution resulting from organic matter. COD (Chemical Oxygen Demand) is a widely known parameter used to measure water quality. It is a measure of water pollution resulting from organic matter. BOD (biochemical oxygen demand) is also an important parameter as it measures the amount of biodegradable organic matter in water. So it is necessary to estimate the effluents COD and BOD in the wastewater treatment plant. The monitoring of the COD results for wastewater compliance is increasing [4][6].

COD and BOD are monitored from the sequencing batch reactor in waste water treatment plant and this reactor consists of five major steps such as Fill, React, Settle, Decant and Idle. In this reactor biomass is mixed to aid the biological growth that facilitates subsequent waste reduction. To make the solid waste to settle down aeration is done followed by the discharge of clarified effluent and at the end the sludge is removed.

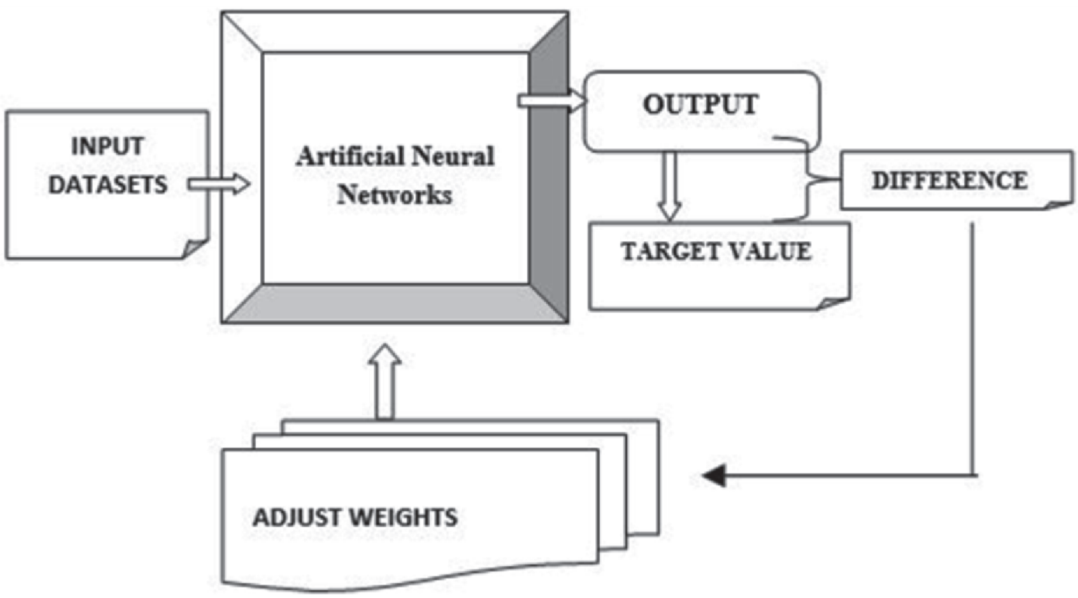

Figure 6: Block diagram of the Effluent Treatment System

Soft measurement techniques are used to monitor the COD and BOD in the effluent of the reactor. Continuous sample of data are selected separately for COD and BOD.

Two identical neural networks have been used , one to predict the amount of acid to be added (if the pH value ranges from (0 to 6.5)) and another network to determine the amount of alkaline to be added if the pH value ranges from (7.5 to 14)

3. RESULTS AND DISCUSSION

The test samples are taken from a textile industry and the model is created using Neural Network toolbox in MatLab. 25 Sample data sets given in Table 2 have been used to train the ANN.

Table 2
Data Sets

Ph	*TDS(ppm)*	*TSS(ppm)*	*Target value*
1	26	31	55
2	25	30	50
2.5	24	29.8	45
3	23	29.6	40
3.5	22	29.4	35
4.3	21	29.2	30
4.5	20	29	25
5	19	28.8	20
5.5	18	28.6	15
6	17	28.4	10
6.5	16	28.2	5

Set of input p is created with the targets t,

p = [1 26 31;2 25 30;2.5 24 29.8;3 23 29.6;3.5 22 29.4;4 21 29.2;4.5 20 29;5 19 28.8;5.5 18 28.4;6 17 28.4;6.5 16 28.2;7 15 28]

Input vectors are defined in one matrix

t=[56;55;50;45;40;35;30;25;20;15;10;5]

Transpose of both the input and the target is set as

t=t'

p=p'

Training of the network is done by the following codes

net1=newff(minmax(p),[3,1],{'tansig','purelin'},'trainscg');

etp=newff(minmax(p),[3,1],{'tansig','purelin'},'trainscg');

[net1,tr]=train(net1,p,t);

[etp,tr]=train(etp,p,t);

And the network is simulated acid=sim(etp,p)

Below table specifies the amount of chemical dosage predicted value with the list of parameters using MAT Lab toolbox

Table 3
Tested Values

Ph	*TDS*	*TSS*	*Result*
1.3	25	33	54.2
4.7	24	31	26
5.2	19	28.8	20

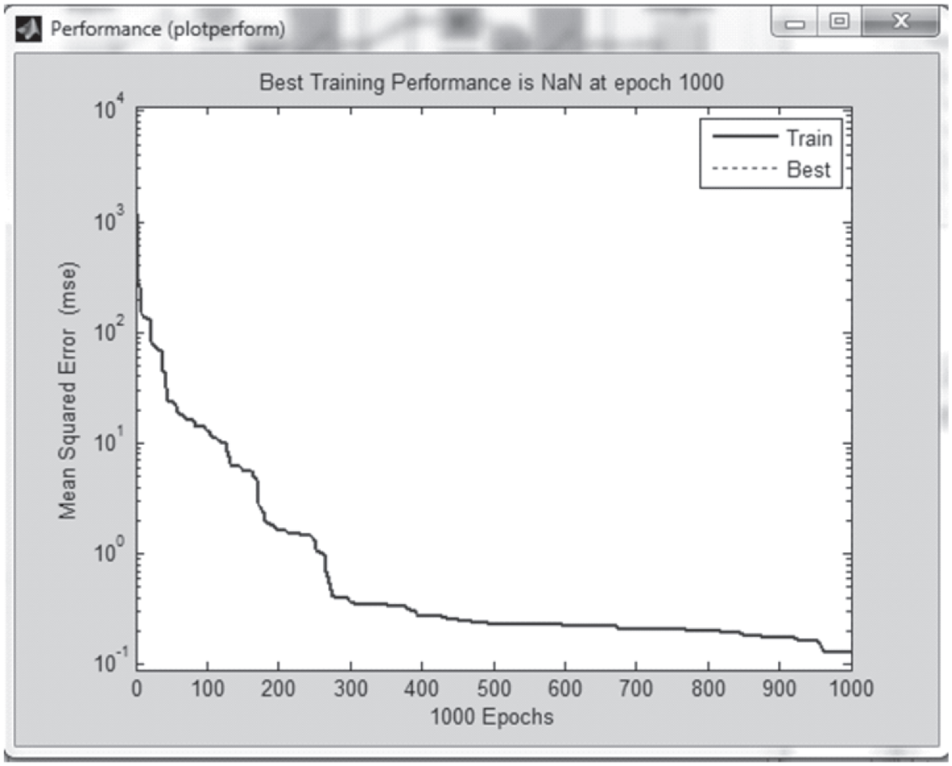

Figure 7: Performance of Training the System using Neural Network

4. CONCLUSION

Industries require massive amount of water for various purposes and they deposit polluted water with the huge depletion of oxygen demands, color, dissolved solids, toxic metals and contamination of non- biodegradable organics. The pressure of producing higher quality of treating the water at lower cost has been increased. Thus to improve the operating performance of the wastewater treatment plant.ANN model is trained to predict the amount of acid or alkali dosage at the first phase of water treatment by using backpropagation training algorithm, such that it reaches the desired value (Ph=7)

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