A Neural Network based Modeling using Neuro Solutions for Alum Dose Prediction

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Abstract- *The determination of an optimum coagulant (alum) dosage in a coagulation process for a water treatment plant is of importance to produce acceptable treated water qualities and maintain economic plant operation such as reduction of manpower and controlling the high cost of chemical coagulant. Failure of this will result in reduction of the efficiency in the sedimentation and filtration processes in the water treatment plant. Basically, jar tests are used to determine the optimum coagulant dosage. Jar test method is expensive, time-consuming, and does not validate responses to changes in raw water quality in real-time. Modeling, using artificial neural networks, can be used to reduce these limitations. In this paper, a neural network model using neuro solution software is developed to predict the required alum dosage in the Water Treatment Plant. The process models are also developed for the prediction of treated water qualities which are affected with alum dosage i.e. the parameters of turbidity, pH, hardness, TDS, alkalinity. Neural network models are developed with neuro solutions. Artificial Neural Network (ANN) techniques are applied to the control of alum dosing in a drinking water treatment plant. Output alum dose has been predicted with ANN and effect of addition of alum on considered parameters has also been studied.*

Keywords- Water parametrs, Turbidity, Alum Dose, Neural Network.

I. INTRODUCTION

Almost all the water treatment plants around the world uses conventional method such as jar test to determine the required alum dosage to raw water. The jar test method is expensive, time-consuming and does not validate responses to changes in raw water quality in real time. As the raw water parameters like pH, turbidity, hardness, TDS and alkalinity change over time, we have to repeat the jar test to determine the required (coagulant) alum dosage at any time. Jar test consume a lot of chemicals for testing, results in higher electricity bills and also require a skilled manpower to obtain good results in determining the required coagulant dosage.

Mostly to understand the relationships between raw water parameters and the optimum coagulant (alum) dosage required is done by deriving mathematical models and equations. But, to determine an exact mathematical model is difficult task because the relationships are very complex and highly non-linear. Therefore, a different method of modeling is necessary over conventional mathematical modeling. The artificial neural network (ANN) modeling is a method which is applicable to problems in which the cause-effect relationships are complex, non-linear and no mathematical formula exists, such as the case with determining the optimumcoagulant dosage. If enough data that represent all aspects of the problem domain is available, a model can successfully be developed. The artificial neural network becomes more convenient with use of Neuro Solutions software.

In addition to the quickness and convenience of using the ANN model for real-time application, the model could also be useful in operator training by simulating possible scenarios in which the operator would learn the results of various treatment options. All of the various uses show the numerous benefits of developing and utilizing an ANN model in WTP operations, particularly in determining optimum coagulant dosage instead of relying only to conventional method of jar testing.

In this work, the ANN models are used to model the required alum dosing of a Sangamner WTP. The developed models will enable the plant operators to obtain the required alum dosages and to predict the treated water parameters easily within a short period of time. In addition, the models of some treated water quality parameters such as turbidity, pH, alkalinity, hardness & TDS are also developed so that the plant operators can gain better understanding of the relationship between raw water qualities, applied alum dosage, and treated water qualities. The work had following objectives:

- To study variation of turbidity during the various rotations of water.
- To find out the optimum alum dose for various turbidity ranges.
- To find the effect of alum dose on other water parameters.
- To develop neural network based alum dose prediction and validation.

II. LITERATURE REVIEW

J Satheesh Kumar in 2013 developed alum dosage predictor using ANN and ANFIS using MATLAB and comparison between both was made. In 2014 Oladipupo Bello demonstrated the application of multiple model predictive control strategy to achieve effective coagulation control in water treatment plants. Discussion and examination of a general overview of modelling and control strategies for coagulation process in WTPs in the last two decades has been done by Oladipupo in 2016. Evaluation of optimal dose and pH of an in-line alum facility to inlets in kukkarahalli lake, Mysore has been reported by Roopa C in 2014.This research paper has been reviewed for knowing the effect on parametrs by addition of alum. Akbar Bhagvand in 2010 concluded that the coagulation process and turbidity removal was considerably affected by pH, coagulant dosage, as well as initial turbidity of water for both alum and ferric chloride. The effectiveness of the functioning of the Artificial Neural Network depends mainly on the quality and quantity of the data entered for its training and calibration since it will allow to obtain a network with a significantly small mean square error was reported by A. J. León-Luque in May 2016 where author has optimized the modeling of alum dosage. Development and comparison of models of adaptive neuro-fuzzy inference system and multilayer back-propagation networks for the coagulation chemical dosing unit of water treatment plant was made by Oladipupo Bello in 2014. JurekPatoczka , the research scholar concluded from his experimental analysis that addition of chemicals or coagulants to the water increases the total dissolved solids. In 2011 GianiApostol concluded that a neutral pH, moderate coagulant doses and a higher load in suspensions of raw water presented a favorable influence on suspension removal efficiency. A model was developed to provide water treatment operators with a tool that enables prediction of chemical reagents and treatment conditions for selected removal of turbidity, based on raw water quality data by AlaaHusaeenWadie in 2013. In 1997 Claude Gagnon addressed the development of neural network models for the prediction of the coagulant dosage for the Sainte-Foy water treatment plant. The ANN predictive model for coagulant dosing can make the operation of water treatment plant more effective and accurate was reported by R.F. Olanrewaju in 2012. H.R Maier concluded that Back-propagation neural networks have the potential to be a useful tool for modelling environmental variables in 2001. M. Franceschi in 2002 demonstrated that optimal design method is an efficient approach for optimisation of coagulation–flocculation process and appropriate for raw water treatment and, in later studies, this methodology may be applied on other parameters, like OD or final pH.A. B. Sengul in 2016 used the artificial neural network model to obtain the optimal predicting model for the optimal alum dosing in real time for water treatment plant.

III. METHODOLOGY

3.1 Collection of Water Samples

In this work samples of raw water were collected at the Pravarariver, Sangamner. The samples were collected during various rotations from July 2015 to April 2016. Collection of water samples were throughout the rotations to study different raw water parameters.

3.2 Experimental Analysis of Water Samples

The raw water samples were experimentally tested to know the raw water parameters pH, turbidity, hardness, TDS and alkalinity respectively. Mainly the water parameter turbidity was been focused in order to decide the optimum alum dose. Alum dose by jar test was suggested for the varying turbidity rotations wise. The effect of alum dosage on other water parameters were tested and desired alum dose was suggested, taking all parameters into the consideration.

3.3 Jar Test

Jar test is the most widely used experimental methods for coagulation-flocculation[5]. A flocculator jar test apparatus is used in the experiments to coagulate sample of raw water using alum coagulant. It is carried out as a batch test, accommodating a series of five beakers together with six spindle steel paddles. Before operating the jar test, the sample is mixed homogenously. Alum of varying concentrations are added in the beakers. The whole procedures in the jar test are conducted in different rotating speed. After the desired amount of alum is added to the suspensions, the beakers are agitated at various mixing time and speed. After the agitation being stopped, the suspensions are allowed to settle for 30 and 60 and 120 minutes. Finally, a sample is withdrawn using a pipette from the middle of supernatant for physicochemical test which represent the final concentration. All tests are performed at anambient temperature for different turbid ranges. In the experiment, test were performed to reduce turbidity and observe the effect on other water parameters.

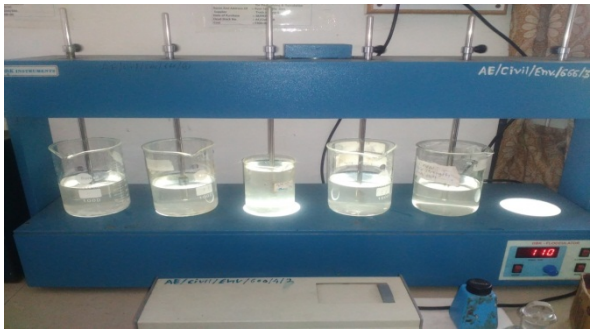

Fig 1: Jar test

3.4 Artificial Neural network with Neuro Solutions

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurones) working in unison to solve specific problems. Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques.
Neuro Solutionsis an easy-to-use neural network software package for Windows. It combines a modular, icon-based network design interface with an implementation of advanced artificial intelligence and learning algorithms using intuitive wizards or an easy-to-use Excel interface. Perform sales forecasting, sports predictions, medical classification, and much more with Neuro Solutions.

Neural networks are long, complicated mathematical equations and Neuro Solutions is designed to make the technology easy and accessible to both novice and advanced neural network developers. There are three basic phases in neural network analysis: training the network on your data, testing the network for accuracy and making predictions/classifying from new data

IV. RESULTS AND DISCUSSIONS

It is observed that all the raw water parameters considered in the investigations have changed with the addition of desired alum dose. Each and every parameter was tested experimentally before and after addition of alum dose and effect of the same was observed. Parameters pH, turbidity, hardness, TDS and alkalinity changes accordingly with respect to variation in the alum dose rotation wise. The pH was found to be decrease , turbidity was decreased, hardness was decreased , TDS was found to slightly increase , and alkalinity was decreased. After the experimental analysis the artificial neural network was build using neuro solutions software. All the parameters were considered while training the network to gain the output alum dose. Trained network was obtained with neuro solutions.

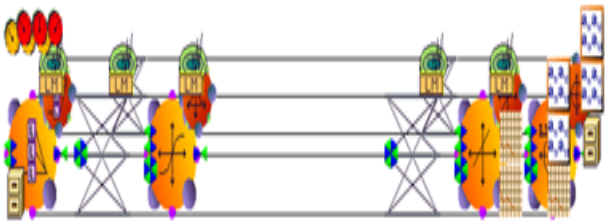

Fig 2: Trained network for all parameters by neuro solutions

The Fig 2 shows the trained network for all parameters. The network is obtained by run of neuro solutions software. When this network is run we get the actual output alum dose.

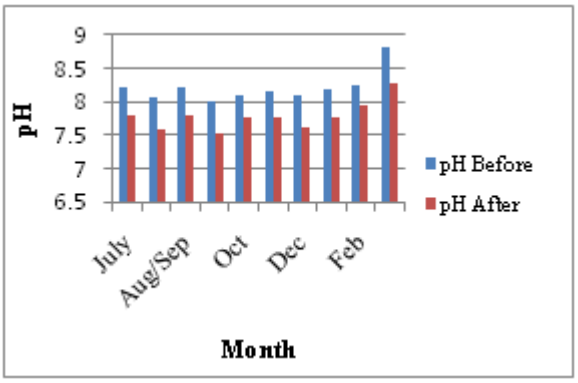

Fig 2: Effect of addition of alum on pH

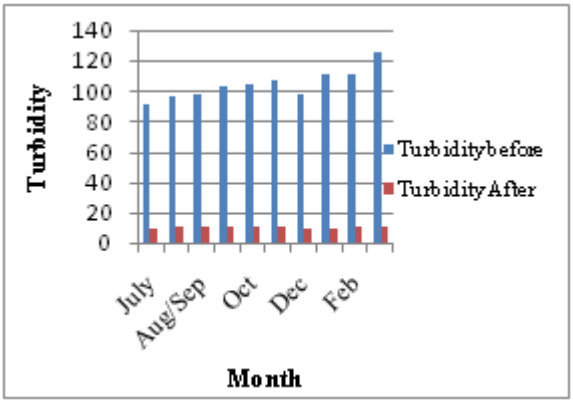

Fig 3: Effect of addition of alum on turbidity

From Fig 2 it is observed that pH has changed from the range of 8-8.8 to 7.5-8. The pH was checked before the jar test was found to be in the range of 8 to 8.5. The alum dose was added according to the varying turbidity and again the pH was checked and was found to be in between 7.5 to 8.Hence pH decreases with addition of the alum dose to the water.

Similarly, in Fig 3, effect of addition of alum on turbidity can be observed. As the water sample were tested for different rotations of river water turbidity was found to vary according to the seasons. The addition of alum decreases the turbidity. Hence from the figure 3 the change can be observed easily.

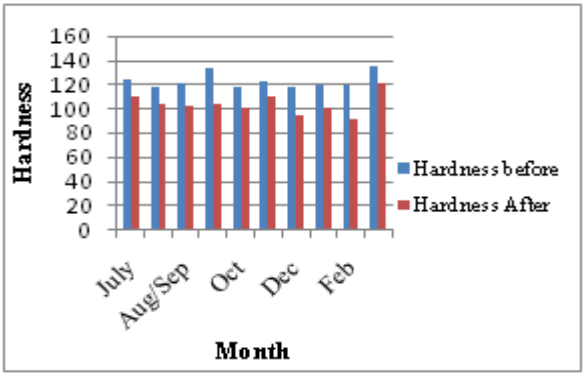

Fig 4: Effect of addition of alum on hardness

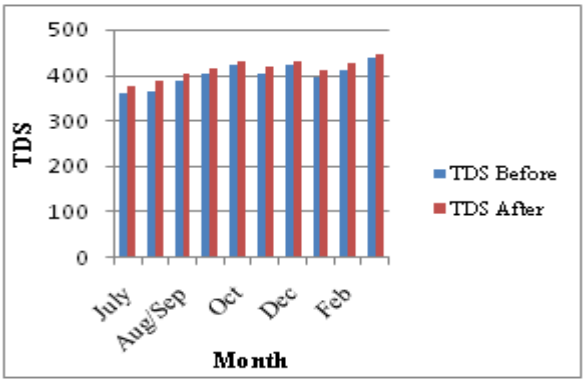

Fig 5: Effect of addition of alum on TDS

The effect of alum dose on hardness and TDS can be observed from Figure 4 and Figure 5 respectively. Hardness is found to be decreased with addition of the alum dose to the water sample. The slight increase in TDS is found after addition of the alum dose as the particles settles and increases the dissolved solids. For varying rotations percentage change in the raw water parameters after addition of alum is seen to be varying.

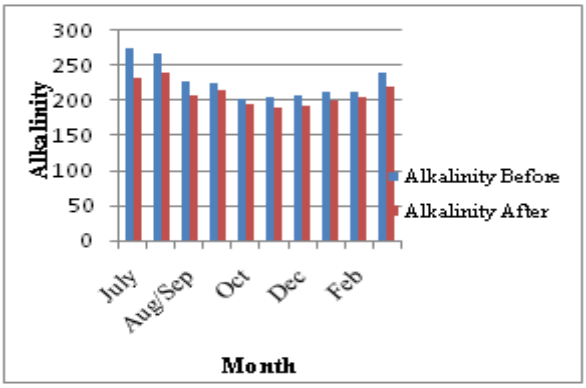

Fig 6: Effect of addition of alum on Alkalinity

Fig 6 shows the effect of addition of alum dose on the alkalinity of raw water parameter. Alkalinity decreases with the addition of alum dose to the water. The alkalinity changes from range of 270-240 to 230-180. Hence alkalinity also varies with the addition of alum to the water.

V. CONCLUSIONS

The following conclusions can be drawn from the above literature review , methodology, results & discussions, and the study of neural network.

1. ANN help in operational cost reduction, reduced error in dosing and ensuring quality of treatment process.
2. From the results it is seen that according to varied turbidity alum dose varies.
3. The alum dose also have effect on other parameters.
4. It is seen that addition of alum decreases pH, turbidity, hardness, alkalinity.
5. The addition of alum dose increases TDS .
6. The ANN predictive model for coagulant dosing can make the operation of water treatment plant more effective and accurate.
7. The less error produced by ANN model indicated effective utilization of resources.
8. One of the advantage of the ANN dosing model is that there will be no need for jar testing again.

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