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Water Quality Modelling of Mahi Basin Using Neural Network and ANFIS

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Abstract –Dissolved oxygen (DO) Biochemical Oxygen demand (BOD)concentrations have been used as primary indicator of stream water quality. A problem of great social importance is determining how to best retain the quality of stream water and maintain DO and BOD concentrations using various pollution control activities. Application of ANFIS technique is used to estimate BOD and DO concentrations at upstreme and downstream of Mahi river basin , Monthly data sets on temperature, pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD) and dissolved oxygen (DO) at three locations, namely, Mataji (upper basin), paderdibadi (upper basin) and Khanpur (lower basin) have been used for the analysis. The performance of the ANFIS models was assessed through the correlation coefficient (R), mean squared error (MSE), mean absolute error (MAE) . Study results show that the adaptive neuro-fuzzy inference system is able to predict the biochemical oxygen demand and dissolved oxygen with reasonable accuracy, suggesting that the ANFIS model is a valuable tool for river water quality estimation.. The results also suggest that ANFIS method can be successfully applied to establish river water quality prediction model**.**

I. INTRODUCTION

Water plays an important role in our daily life and without it no life on the earth. According to the study of Hydrology, river is defined as a natural stream flow in a channel. River water quality is affected by a wide range of natural and human pollution.

Water quality modeling is one of the important elements in water resource management. The development of water quality models depend on the various objectives & purposes, and based on a number of different modeling techniques. The uses for which river models have been developed include, environmental impact assessment (climate, river use or land use change (long-term) and combined sewer overflows or accidental spills (short-term)); flood forecasting; planning and consent setting; and operational (on-line) management.

- Water quality management is a critical component of overall integrated water resources management. Most users of water depend on adequate levels of water quality. When these levels are not met, these water users must either pay an additional cost for water treatment or incur at least increased risks of damage or loss. As populations and economies grow, more pollutants are generated. Many of these are waterborne, and hence can end up in surface and groundwater bodies. Increasingly, the major efforts and costs involved in water management are devoted to water quality protection and management. Conflicts among various users of water are increasingly over issues involving water quality as well as water quantity. Natural water bodies are able to serve many uses, including the transport and assimilation of waterborne wastes. But as natural water bodies assimilate these wastes, their quality changes. If the quality drops to the extent that other beneficial uses are adversely affected, the assimilative capacities of those water bodies have been exceeded with respect to those affected uses. Water quality management measures are actions taken to ensure that the total pollutant loads discharged into receiving water bodies do not exceed the ability of those water bodies to assimilate those loads while maintaining the levels of quality specified by quality standards set for those waters.

Water Quality Modeling involves the prediction of water pollution using mathematical simulation techniques . A typical water quality model consist of formulation representing physical mechanism that determine position and momentum of pollutants in water bodies Models provide the ability to develop a credible and defensible water quality management program The Mahi river is taken for the study purpose of water quality modeling and its related water quality data , point and diffuse sources data are collected which is used for the analysis of work. ANFIS modeling is an artificial intelligence technique which is an hybridization of neural network an fuzzy logic , which is used for the model calibration and validation

II. STUDY AREA

The study area of Mahi river basin is located near village VASAD in Anand taluka of district Anand in Gujarat State, India. The latitude and longitude of the study area are 22.45^{o} N and 73.0667^{o} E, respectively. The type of bed of river is rocky covered with sand.

The basin is comprised of two sub-basins: Mahi upper sub basin (65.11% of total basin area) consisting of 41 watersheds and Mahi lower sub basin (34.89% of total basin area) consisting of 22 watersheds. The Mahi river and its tributaries constitute an inter-state river system flowing through the states of Madhya Pradesh, Rajasthan and Gujarat. Mahi river is comprised of several tributaries on both the banks, viz. Som, Anas, Panam and others. The basin falls into three Agro-Climatic Zones and two Agro-Ecological Zones. As per the assessment of LULC (2005-06), a large part (63.63%) of the basin is covered with agricultural land. Forest area spreads over 19.29% and water bodies occupy 4.34% of the total basin area. Red and black soils are predominant in the basin but red and yellow soils are also found at few places. Fertile tracts are found along the banks of Mahi. Major part of the basin area lies in the elevation zones of 100-500 m. As per 2001 census, the total population within the basin is about 1,27,70,704 and spreads in 15 districts.

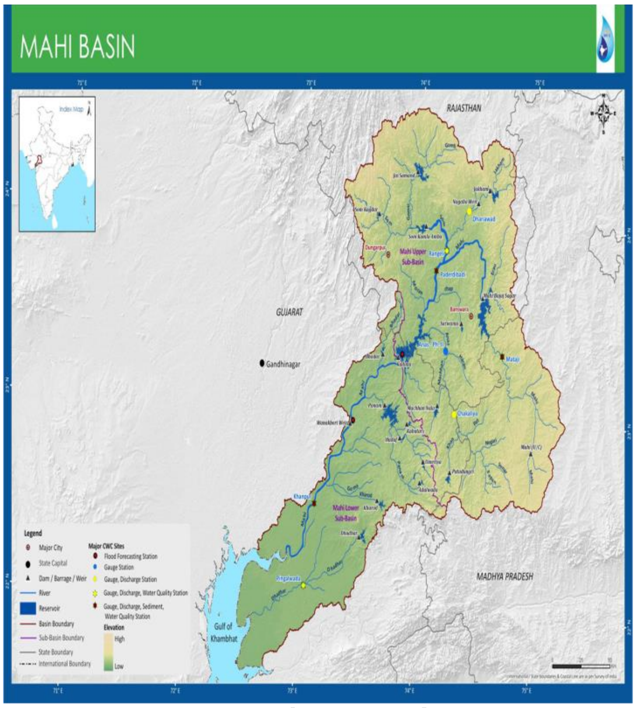

Fig. 1 Mahi Basin, India

III.METHODOLOGY

The aim of this study is to evaluate the ANFIS models to predicted future dissolved oxygen (DO) , BOD of Mahi river near VASAD. Hence, all the available water quality data were collected. Obseved Dissolved Oxygen & BOD is calculated with the use of "MATLAB" software using ANFIS model and from the ANFIS model get the predicted DO & BOD. ANFIS models are studied with input parameters such as pH , Temperature ,COD and one output parameter such as DO & BOD in the research. Using a given input/output data set, the toolbox function ANFIS constructs a fuzzy inference system (FIS) whose membership function parameters are tuned (adjusted) using either a back propagation algorithm alone or in combination with a least squares type of method. Finally, the performances of ANFIS are studied and the outputs are compared with the results of values of predicted DO & COD.

The ANFIS Editor GUI window includes four distinct areas to support a typical workflow. The GUI lets you perform the following tasks:

Loading, Plotting, and Clearing the Data

Generating or Loading the Initial FIS Structure
Training the FIS
Validating the Trained FIS

After you generate the FIS, you can view the model structure by clicking the **Structure** button in the middle of the right side of the GUI.

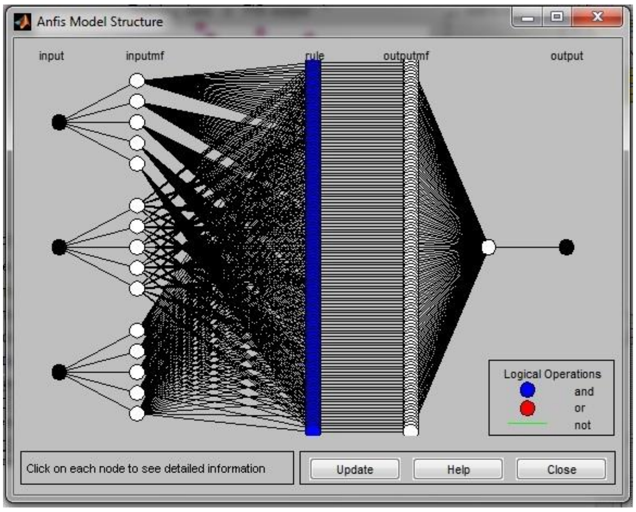

Fig. 2 ANFIS model structure

The branches in this graph are colour coded. Colour coding of branches characterize the rules and indicate whether or not *and*, *not*, or *or* are used in the rules. The input is represented by the leftmost node and the output by the right-most node. The node represents a normalization factor for the rules. Clicking on the nodes indicates information about the structure.

IV. RESULT

In the study the available quality data of 10 years is divided into two parts. One part is used for calibration and the other part is used for validation the performance of the ANFIS based real time quality prediction model.

At this point, the ANFIS model has been completely defined, in that the variables, membership functions, and the rules necessary to calculate Dissolved Oxygen, BOD are in place. It would be nice, at this point, to look at a fuzzy inference diagram and verify that everything is behaving the way we think it should. This is exactly the purpose of the Rule Viewer. From the View menu, select View rules.

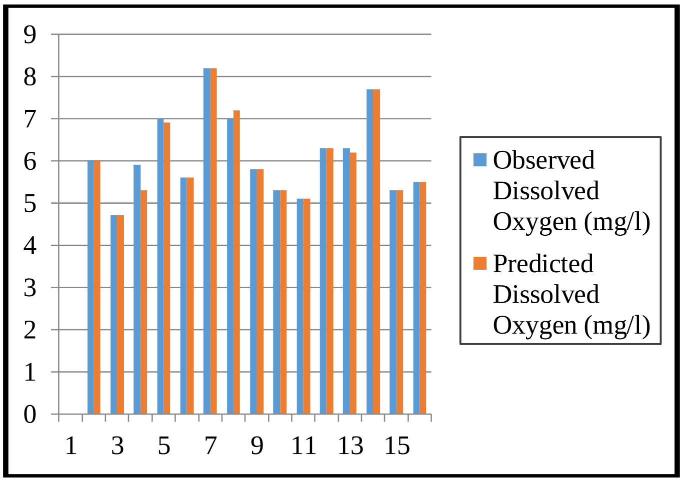

Figure 3 : Bar chart for Comparison between Observed & Predicted DO for Validation

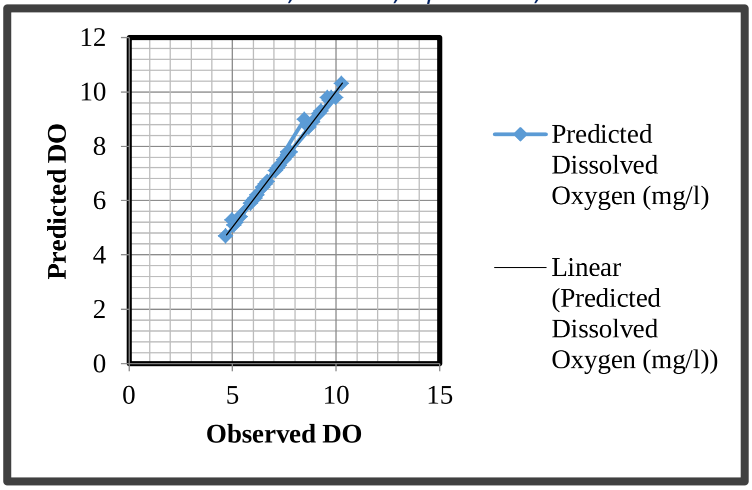

Fig : 4 Scatter Plot for Observed & Predicted DO for Training

The ANFIS model was tested and the results were compared by means of correlation coefficient and root mean square error statistics. 70 % monthly data were used for training and 30 % monthly data were used for validation for ANFIS model.

For ANFIS, model structure identification was done by Grid partition with a linear output MF and hybrid optimal method was used for model parameter identification.

V. CONCLUSION

Dissolved oxygen (DO) & BOD concentration has traditionally been used as a variable of water quality and for water systems. Therefore, modeling of water quality parameters is a very important aspect. The chemical, physical, and biological components of aquatic ecosystems are very complex and nonlinear. In recent years, computational-intelligence techniques such as neural networks, fuzzy logic, genetic algorithm, and combined neuro-fuzzy systems have become very effective tools to identification and modeling nonlinear systems.

The ability of ANFIS model in estimation of DO & BOD water quality parameter has been investigated in this study. Results of simulation presented in this research showed that the values of RMSE, R^2, CORRELATION, DECRIPENCY RATIO. ANFIS And ANFIS is best suited among other trials

The results showed that the temperature (T) is the most effective parameter to estimate DO and pH for BOD concentration in this stream-gauging station. ANFIS model can be successfully used in estimation of DO & BOD when only temperature data are available.

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