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Artificial Neural Networks Application in Prediction of Water Quality

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ABSTRACT: Recently artificial neural networks are used increasingly to predict the quality of water. Back propagation algorithm is widely used ANN type. For prediction water sample was collected at four stations. Water sample were analysed for 10 months from April-2014 to January-2015. Samples were analysed for pH, temperature, total Hardness, chlorides, Total dissolved solids and Sulphates. Inputs given to the network were pH, Temperature and Total hardness. The output results produced were sulphates, chlorides and total dissolved solids.

KEYWORDS: Artificial neural networks, Back propagation algorithm.

I. INTRODUCTION

Water is the most important natural resource not only of a state or a country, but of the entire humanity. Monitoring and Modelling of water quality is the crucial step in environmental monitoring and policy management.[1]

The concept of artificial neurons was introduced in 1943 by McCulloch and pitts. Over the past decade, Artificial Neural Network (ANN) research has found its way into the areas of hydrology, ecology, medical and other biological fields. Artificial neural networks have the capacity to learn from the pattern known before. Once the network has been trained with sufficient number of data sets, from this it can make predictions on the basis of its previous learning. A network first needs to be trained before interpreting new information. Back propagation algorithm is the most versatile and sensible technique which provides the most efficient learning procedure for neural networks.[2] The artificial neural network is trained by adjusting the values of connections(weights) to obtain a specific output from a particular input.[3]

The ANN always consists of atleast three layers: input layer, hidden layer and output layer. Each layer consists neurons, and each neuron is connected to the next layer through weights. Neurons in the input layer will send its output as input for neurons in the hidden layer and similar is the connection between hidden and output layer. Number of hidden layers and number of neurons in the hidden layer change according to the problem to be solved. The number of input and output neuron is same as the number of input and output variables. [2]

II. RELATED WORK

Various Studies are done on artificial neural networks. Khandelwal and singh [2] made an attempt to predict chemical parameters like Sulphates, chlorine, chemical oxygen demand, total dissolved solids and total suspended solids. They found ANN as the most suitable and acceptable model for predictions. Rankovic et, al.[4] used feed forward neural network model to predict the dissolve oxygen. Inputs given to the network were pH, temperature, chlorides, total phosphate, nitrites, nitrates, ammonia, iron, manganese and electrical conductivity. Heydariet ,al.[5] proposed artificial neural networks to derive and to develop models for the prediction of dissolve oxygen and specific conductance.

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III. METHODOLOGY

Ann has the ability to learn from the pattern acquainted before. Inputs are given to the neurons, these inputs are multiplied with their relative weights. These modified inputs are sent to a summing function. The output from the input layer is given as the input to the hidden layer. The output of the hidden layer is given as input to the output layer.

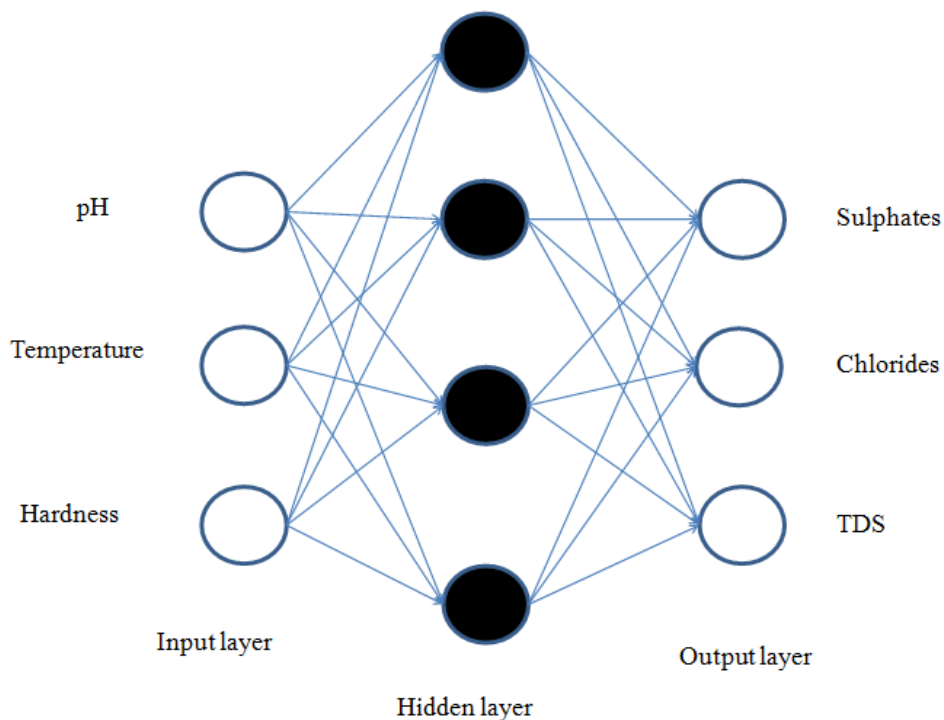


Fig 1- Back propagation Neural Network

The BP neural network is a typical multilayered structure, it is composed of one input layer, one output layer, and one or more hidden layers and all the layers are interconnected [6]. Each layer consists of neurons, and each neuron is connected to the next layer through weights i.e. neurons in the input layer will send output as input for neurons in the hidden layer and similar is the connection between hidden and output layer.

Number of hidden layers and number of neurons in the hidden layer change according to the problem to be solved. The number of input and output neurons is the same as the number of input and output variables [5].

Network training

During training of the network, data is processed through the input layer to the hidden layer, until it reaches the output layer (forward pass). The output is compared to the measured values (true output). The difference or error between both is processed back through the network (backward pass) updating the individual weights of the connections and the biases of the individual neuron. The input and output data are represented as vectors called training pairs. The process is repeated for all the training pairs in the data set. Sigmoid activation function is used as transfer function for all nodes in the hidden layer as well as the output layer. The mean squared error is used as an objective function to calculate the error between predicted outputs and measured values.

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IV. RESULT AND ANALYSIS

A. Ground water Quality Results

Table 1 shows the measured and predicted results for ground water

SL No	Input			Output					
	pH	Temperature	Hardness	Sulphates		Chlorides		TDS	
				Measured	Predicted	Measured	Predicted	Measured	Predicted
1	8	28.5	286	162	156	182	180	453	460
2	7.9	29	253	185	183	195	194	435	440
3	7.6	28.1	276	175	176	170	173	650	653
4	7.8	28.3	280	184	180	208	205	605	600

Table 2 shows the measured and predicted values for surface water

SL No	Input			Output					
	pH	Temperature	Hardness	Sulphates		Chlorides		TDS	
				Measured	Predicted	Measured	Predicted	Measured	Predicted
1	7.2	25.6	175	2.8	2.4	79	72	430	432
2	7.4	25.7	182	3.2	3.0	82	88	448	450
3	7.1	26	173	2.3	2.2	57	56	428	425
4	7.3	26.2	174	2.5	2.7	60	59	426	422

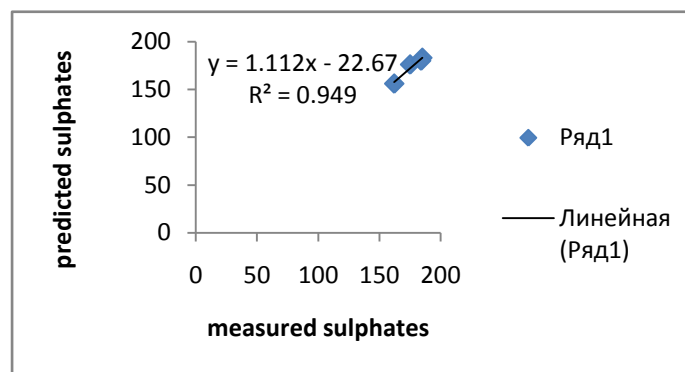


Fig -2: Graph between measured and predicted sulphates for ground water

Fig 2 shows the comparison between the measured sulphates and predicted sulphates for ground water. coefficient of correlation is found to be 0.9496, which is closer to one.

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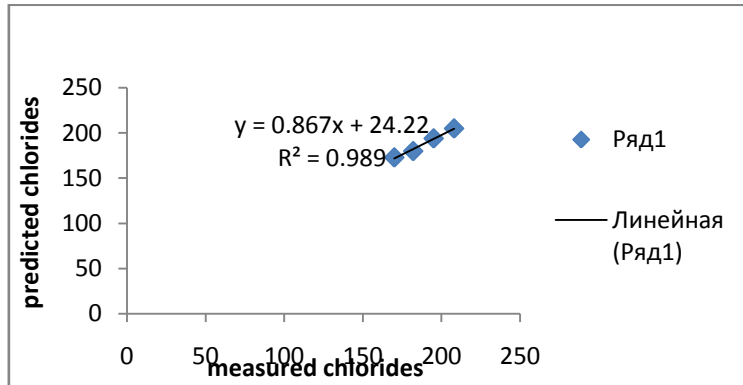


Fig -3: Graph between measured and predicted chlorides of ground water

Fig 3 shows the comparison between the measured chlorides and predicted chlorides for ground water. Correlation coefficient is found to be 0.9892.

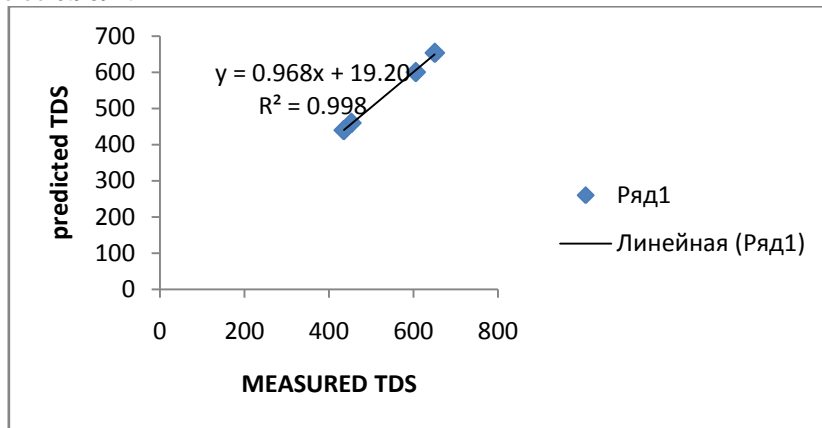


Fig 4: Graphs between measured and predicted TDS for ground waters

Fig 4 shows the comparison between the measured TDS and predicted TDS for ground water. Correlation coefficient is found to be 0.9985

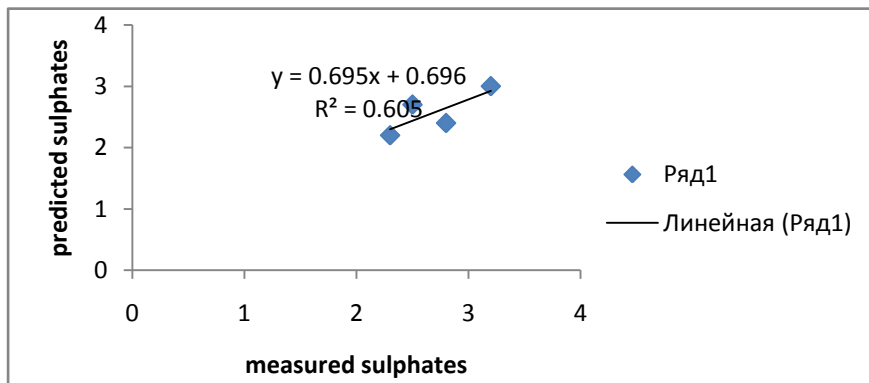


Fig 5: Graphs between measured and predicted sulphates for surface waters

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Fig 5 shows the comparison between the measured sulphates and predicted sulphates for surface water. Correlation coefficient is found to be 0.6057

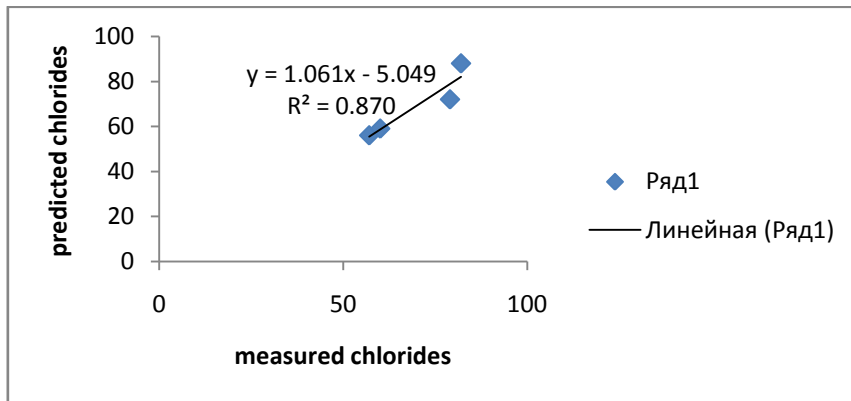


Fig 6: Graph between measured chlorides and predicted chlorides for surface water

Fig 6 shows the comparison between the measured chlorides and predicted chlorides for surface water. Correlation coefficient is found to be 0.8703

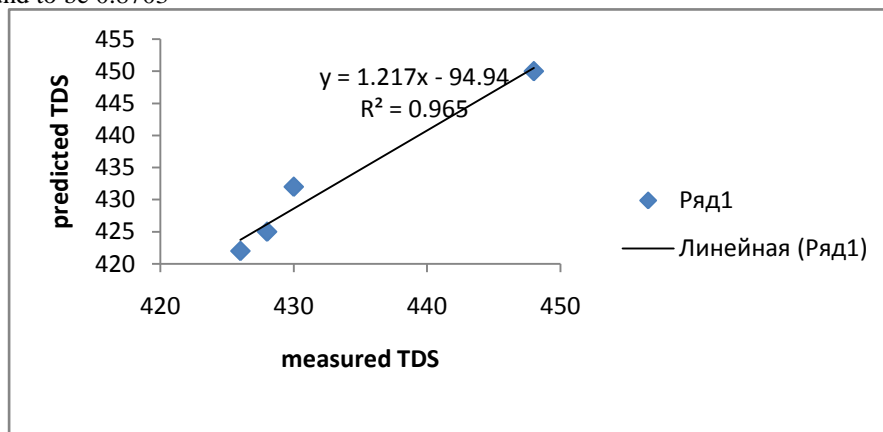


Fig 7: Graph between measured and predicted TDS for surface waters

Fig 7 shows the comparison between the measured chlorides and predicted chlorides for surface water. Correlation coefficient is found to be 0.9658

The graphs fig(2-7) between measured and predicted parameters show that prediction by ANN is very close to measured value. R_2 value is closer to one

V. CONCLUSION

The correlation co-efficient is 0.9496, 0.9892, 0.9985 for Sulphates, Chlorides, TDS respectively for ground water. Correlation co- efficient for surface waters are 0.605, 0.8703, 0.9658 respectively for sulphates, chlorides and TDS. It is observed that ANN has given very sound results. It can be used to predict future analysis. This method will help to avoid cumbersome techniques for chemical analysis. Usually the optimal model is identified as the one with a value of R^2 closer to 1

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