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Application of a Neural Network Technique for Prediction of the Water Quality Index in the Kuakhai River

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Abstract—*River water quality is of great environmental concern since it is one of the major available fresh water resources for human consumption. Throughout the history of human civilization, rivers have always been heavily exposed to pollution, due to their easy accessibility to disposal of wastes. Surface water pollution by chemical, physical, microbial and biological contaminants can be considered as an epidemic all over the world. The paper presents a case study on the water quality analysis carried out at the Kuakhai River, Odisha, India.. The monthly water quality parameters are collected and analyzed from four selected gauging stations of Odisha during the months of January to December from 2011 to 2013. Twelve physical, chemical and biological water quality parameters viz., pH, TSS (Total suspended solid), TDS(Total Dissolved Solid) Biochemical Oxygen Demand (BOD), Nitrogen as nitrate (Nitrate-N), Total Coli-form Bacteria(TC), Dissolved Oxygen (DO), Chloride Total Alkali (TA), Total Hardness (TH), calcium and magnesium are selected for the analysis. Analysis of water quality for Kuakhai River is done by techniques such as pearsons'r Correlation, Analysis of variance (ANOVA) and Overall Water Quality Index (WQI). Modelling is done by using Artificial Neural Network (ANN).*

1. Introduction

Water is the most important natural resource not only of a state or a country, but of the entire humanity. The prosperity of a nation depends Primarily upon the judicious exploitation of this resource. Thus, it can be stated that the primary wealth of a nation is water, which flows in rivers and Streams. Surface water is considered as one of the most vital fresh water sources and used for domestic, agricultural and industrial activities all over the world. It is also one of the prime elements responsible for life in the earth. The six billon people on earth use nearly 30% of worlds total accessible renewal water supply surface water in the form of ponds ,lakes ,reservoirs ,rivers, streams, etc. provides valuable palatable water, which is used for the well being of humanity. Amongst these surface water resources, rivers are immensely important due to their tremendous water holding capacity and large perforated capillary network, which confirms the annual fresh water availability .since ancient time rivers plays major role in the concretion of the biotic community along the river banks, this forms the main basis of topography of the area. Yet billions of people are deprived of basic water availability. Among other countries in the world, India is one of the few selected countries endowed with reasonably good land as well as water resources. India is a country with vast geographic, biological and climatic diversity. WQI is an arithmetical tool used to transform large quantities of water quality data into a single cumulatively derived number. It represents a certain level of water quality while eliminating the subjective assessments of such quality5-7. It is intended as a simple, readily understandable tool for managers and decision makers to convey information on the quality and potential uses of a given water body based on various criteria. Water Quality Index (WQI) is a very useful and efficient method for assessing the suitability of water quality.

2. Description of study area

River Kuakhai is a distributor of river Mahanadi and the main source of water for Bhubaneswar (the capital city of Odisha) and its adjourning areas. River Kuakhai receives immense amount of domestic waste and waste water along with untreated sewerage generated from the city. Due to rapid urbanization the river is contaminated with the discharge of effluents. To ascertain the quality and physico – chemical characteristics of river Kuakhai a thorough study has been conducted through out the years 2011, 2012, 2013.

Sl no	Location of sampling points
1	Upstream near mancheswar
2	Near intake point palasuni
3	Downstream near pandra
4	downstream

Table -1:The detail locations

This data is collected from CPCB, Bhubaneswar, Odisha. This data is used for making prediction model for the year 2011-2013. The parameter for the study selected are pH, TDS, TSS, Total Alkalinity, TH, DO, Nitrate, BOD, Total Coli form Bacteria, Chloride, Calcium, Magnesium.

3. Methodology

Proper management of water resources is very important to meet the increasing demand of water in the future. The quality of water is characterized by various physical-chemical parameters. These parameters change widely due to many factors like source of water, type of pollution, seasonal fluctuations, etc. Statistical analysis viz., descriptive statistics, correlation and regression analysis of the physical & the chemical properties of a river basin gives a fairly good amount of information like their average values and possibly prediction of one variable (usually the one which is difficult to evaluate). Such studies have been carried out by many scholars in the past. Water quality monitoring is the cornerstone of watershed management, yet the desire to collect additional information is often frustrated by the lack of resources to support the sampling effort. Regression models are useful, especially when only limited data are available in developing countries like India. Mass balance studies using water quality and flow data are extensively used during recent years to study the in-stream reactions and pollution loading patterns (Plummer and Back, 1980, Yuretich and Batchelder 1988, Jain 1996). Regression models are relatively cheaper and less time consuming (Chandrasekhar and Satyaprasad 2005). In the present investigation an attempt has made to assess the trend of the surface water quality of Kuakhai River basin using statistical methods. The surface water quality data of Kuakhai River basin has been used for the study for the years 2011, 2012 and 2013. Since the river is not perennial, the available data of the selected locations like were taken for the analysis.

The correlation coefficients among all the surface water quality characteristics were calculated. Linear regression equations were developed for the pairs of parameters, which have a significant influence on each other ($r > 8$ with significant 0.01; two tailed and $N = 8$).
The correlation analysis on surface water quality parameters reveals that all parameters are more or less correlated with each other. The correlation coefficient (r) of >8 was taken in to account to find the regression equations. The ANN and Windows Excel were used as the statistical analysis tool.

3.1. Water quality index

To find the WQI of surface water quality in the biological charterstics of water at 4 different sample point locations are shown in fig were taken into account. The parameters are PH, TDS, TSS, ALK, BOD, TH, DO, Nitrate, Tc, Cl, Ca & Mg. The three years surface water quality data during the year 2011, 2012 and 2013 which are available with the OSPCB were used for the study to understand the surface water quality charteristics of the kuakhai basin.
The water index was calculated considering 12-physico-chemical parameters using ICMR & ISI standard, by using the following formula.
The water index was calculated considering 12-physico-chemical parameters using ICMR & ISI standard, by using the following formula.
$WQI = \sum q_i w_i / \sum w_i$
Where,
q_i = quality rating of the $_n$th water quality parameter
w_i = unit weight factor
The quality rating,
$Q_i = 100(v_n - v_{i0})/(s_n - v_{i0})$
Let there be ‘a’ water quality parameters and quality rating (knee) corresponding to $_{north}$ parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value.
Hence
q_n = Quality rating of respective physico-chemical parameters
v_n = value of respective physicochemical parameter
v_{i0} = ideal value of the respective parameter in water (7 for PH and 14.6 mg/l for DO for all other physicochemical parameter)
s_n = BIS permissible limit for respective physicochemical parameter
unit weight (w_n) was estimated by applying formula

$$w_n = k/s_n$$

Here, k = constant for propertionlity
Avarage water quality index was estimated by using equation

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Avarage water quality index was estimated by using equation

$$Avg\ WQI = \sum q_n w_n / \sum w_n$$

3.2. Actual water quality index

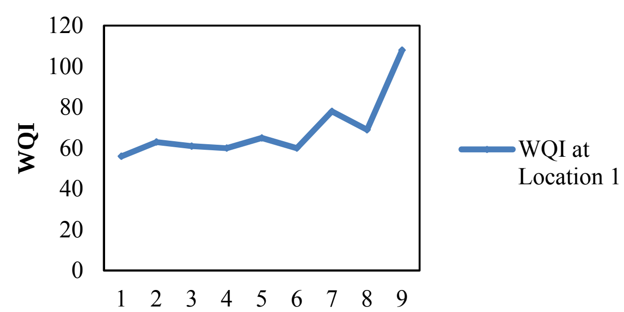

Figure.1- WQI at location 1

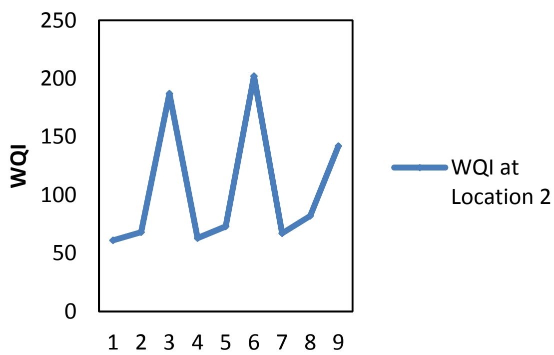

Figure.2- WQI at location 2

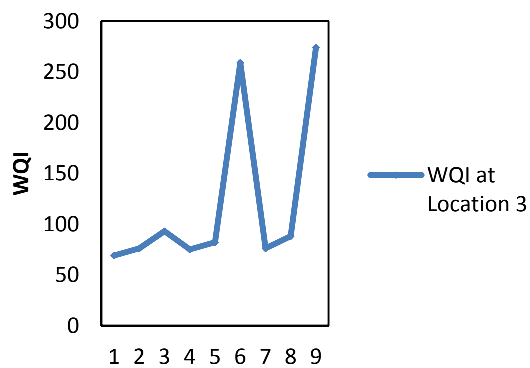

Figure.3- WQI at location 3

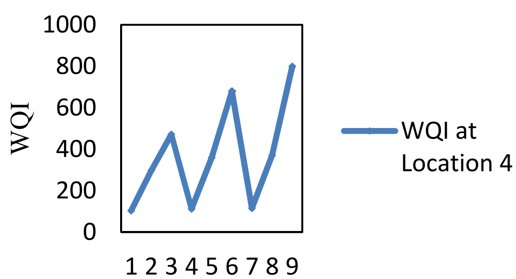

Figure.4- WQI at location 4

3.3. ANN predicted water quality index

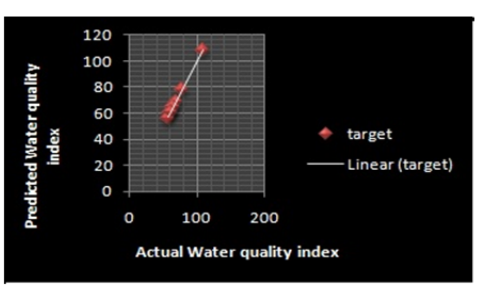

Figure.5- WQI at location 1 predicted by ANN

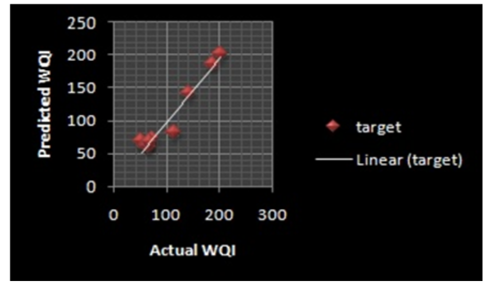

Figure.6- WQI at location 1 predicted by ANN

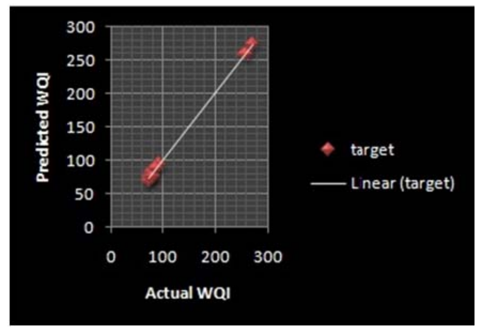

Figure.7- WQI at location 1 predicted by ANN

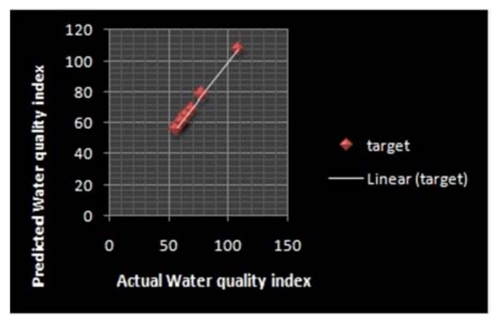

Figure.8- WQI at location 1 predicted by ANN

4. Results and discussion

Depending on the data availability and to ensure Kuakhai river water quality, twelve water quality parameters were selected in WQI. With too many variables, small individual changes are not detectable in the aggregated water quality index value . Understanding water quality parameters and their characteristics is important to identify the quality of the water, to know the reasons which led to changes in the quality, and to help in interpreting these changes**.** These parameters include: PH, TSS, TDS, ALK, TH, DO, BOD, TC ,Nitrate, Ca, CL, Mg. The permissible limit of WQI for drinking water is 100. It was found that WQI is below 100 in winter in all locations except near Kanti after mixing with Gangua Nala. In summer and rainy seasons the WQI increases, many fold making the water not suitable for drinking and other purposes. It was also found that all the parameters are in increasing trend towards D/S as compared to U/S except DO content.

By Pearsons'r correlation analysis, the majority of the samples of the study area is found to be alkaline. The TSS values are obtained with the mean value of 57.09 and the minimum and maximum as 6.6and 152 respectively. This range is slightly more than the limits prescribed by WHO (1984) for water used in domestic applications.

The TSS of the basin is between 6.2 to152 mg/l. TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage High concentrations of suspended solids can cause many problems for stream health and aquatic life. The TSS has significant co-relation (0.782) with Nitrate, CL and CA but poor correlation with other parameter. The poor co-relation of TH with ALK as well as TDS indicates a low disassociation capacity of dissolved solids. The most important is that the study area is heavily polluted due to domestic waste. The TC contains lies between the permissible value for domestic and industries application.

It gives a significant co-relation with CL, CL of the basin is between 6.6 to 23.6 mg/ between Total coli form bacteria and chloride is 0.768. It is found that CL with Sulphate and Ca has better positive Correlation having correlation value 0.909 and it gives the highest correlation value. From the descriptive statistical analysis, it is found that most of the water quality parameters are within the permissible limits of BIS. This may therefore be 107 treated as a rapid method of water quality monitoring.

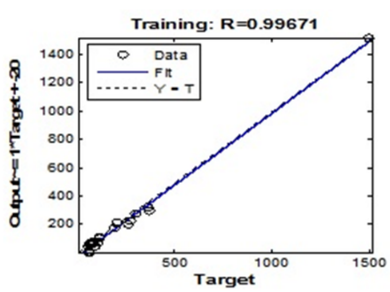

Figure.9- Regression training output on ANN result

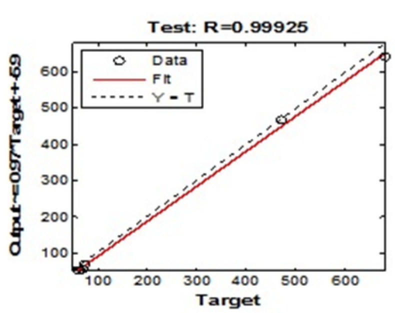

Figure.10- Regression testing output on ANN result

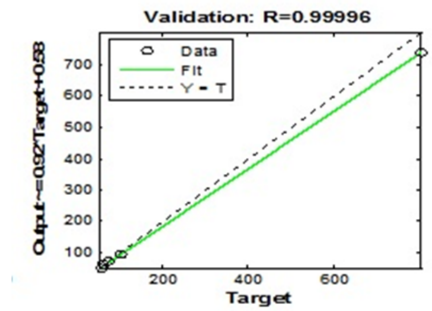

Figure.11- Regression validation output on ANN result

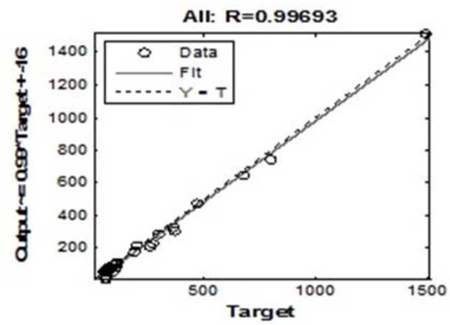

Figure.12- Total output on ANN result

5. Conclusion

River kuakhai is getting polluted due to domestic waste and waste water discharge at various points i.e at mancheswar and at Kanti. The total domestic waste of Bhubneswar having population 8.8 lakhs(2011) is discharged to river Kuakhai by making river water unfit for drinking as well as bathing and other activities which has been already proved by sample analysis at upstream and downstream of discharge points. In order to restore river water quality intact we must set up the septic tank of each household and the over flow of the septic tanks should be connected to the common drain carrying waste water. The waste water should be treated in the sewage treatment plant consists of grid chamber, primary clarifier, aeration tank and secondary clarifier.

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