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River water modelling prediction using multi-linear regression, artificial neural network, and adaptive neuro-fuzzy inference system techniques

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Abstract

In this study, multi linear regression (MLR), artificial neural network (ANN) and adaptive neuro fuzzy inference system(ANFIS) techniques were developed to predict the Dissolve oxygen concentration at down stream of Agra city, using monthly input data which are dissolve oxygen(DO), pH, biological oxygen demand(BOD) and water temperature (WT) at three different places viz, Agra upstream, middle stream and downstream. Initially, 11 input parameters for all the three locations were used except DO at the downstream, then, 7 input for middle and downstream except DO at the target location and finally the downstream location was considered in the analysis. The performance was evaluated using determination coefficient (DC) and root mean square error (RMSE), the result of DO showed that both the ANN and ANFIS can be applied in modelling DO concentration in Agra city, and also indicate that, ANN model is slightly better than ANFIS and also indicates a considerable superiority to MLR.

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Keywords: Multilinear regression; artificial neural network; adaptive neuro fuzzy inference ; dissolve oxygen.

1. Introduction

Rivers at the initial stage are free from any impurities and considered the most clean water resource in all over the

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globe, but due the rapid increased in industrialization, human and urban development caused to loss their sustainability. For the sustainable development to be pursued , it is very essential to assess the quality of river (Farhad et al. 2013; Abba et al. 2015). Dissolved oxygen (DO) is the amount of oxygen in the dissolved form; it is one of the best variables in indicating the quality and health status of the ecosystem. It is crucial to ensure the concentration and range of DO which varies according to different national and international standard, However, it can range from 0-18 part per million (ppm). If the DO is less the aquatic animal are likely to lose their life in the receiving environment(Shaghaghian, 2010; Jain, 2014; Kisi and Murat, 2012).

The linear model of determining the water quality has been used in several literatures by considering the different characteristics of water. Thus, dynamic nature of the system defined the unsuitability of the traditional method to cope with the interactions and process taking place in the stream body (Lewis, 2005; Kisi and Murat, 2012). A convenient methodologies are paramount and played a vital role in solving the complex problems and nonlinear process involved in any water body, as such soft computing tool for example, Artificial neural network, genetic algorithms, Fuzzy theory etc. have found to be more accurate and significant in resolving the model simulation and forecasting of non-linear interaction, in which both the classical model and soft computing have their own advantage and limitation (Shaghaghian, 2010; Jang and Sun, 2001).

However, the prediction and determination of DO has been studied by many researchers for example, Sirilak at el. Used ANN in estimating the DO of a river (Areerachakul, 2011). Elshafie et al. (2007) determined the DO in a river using fuzzy logic. Ahour and Sadeghian (2013), simulate the DO concentration by employing ANN and ANFIS method (Ahour and Sadeghian, 2013). Applied MLP in predicting the DO concentration (Soyupak et al., 2003). Kisi 2012 used RBNN and MLP to modelled the DO (Kisi and Murat, 2012). Different type of classical model have been used to determine the water quality in River Yamuna, but due to the complexity of the system and some drawback the results were normally poor, soft computing techniques in the modern technology proved to be effective and flexible ways of determining the water quality of a river, in recent years, soft computing have been an exceptional performance over the experimental model (Sarkar and Pandey, 2015).

In this paper, MLR, ANN, and ANFIS were applied and compare for modelling the DO in Yamuna River of Agra downstream. By considering the upper stream, middle stream and downstream of Agra, which is one of the most important city in term of environmental pollution. The location of the down stream depicts the impact of wastewater discharge from Agra city. Agra city used the Yamuna water significantly for domestic and irrigation and contribute about 9% of pollution level in the river .

1.1 Study Area and Data Collection

The River Yamuna is the main tributary of Ganga River having length of 1,376 km. About 57 million people of north India depend on it. Comprises about 42% of the Ganga basin area in the Indian Territory, A total catchment area of Yamuna in 3,66,223 km^2. It is yearly discharge is almost 10,000m^3/s and supply approximately 70% of drinking water in Delhi, River leaves Delhi as polluted water because there are no efficient numbers of water treatment plant that can sustain the volume of water due to the rapid urbanization. Subsequently, the water reaches Agra as polluted water and Yamuna was the main source of municipal water in Agra, with the same condition of inadequate numbers of treatment plant to treat the polluted water, therefore, the consumers of Delhi and Agra take in high amount of harmful impurities and toxic in water (CSE 2008). The routine monitoring and evaluation of the entire river has been controlled by Central Pollution Control Board (CPCB) under the National River Conservation Program (NRCR) and National Water Quality Monitoring Program (NWQMP) (Pollution et al., 2006). Fig. 1 indicates the Yamuna River basin in India and locations of Agra city

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