A Comparative Study of Water Quality of River Yamuna using Fuzzy Logic and NSF WQI

Salila Bharti, A. K. Gupta
Research Scholar, Professor
Delhi Technological University, New Delhi

Abstract:- **The water quality of river as a whole is highly debatable, subjective and uncertain in nature. A water quality index generated as single number demonstrates overall quality of water. In this paper, an Artifical Intelligence technique, Fuzzy logic is used to develop Fuzzy Water Quality Index (FWQI). The study was conducted along the stretch of river Yamuna at five different locations – Palla, Nizamuddin, Agra Canal (Kalinidi Kunj), OKHLA and Agra Canal (Madanpur Khadar). Various parameters considered in the study are dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH,and total coliform (TC). The model developed is compared with National Sanitation Foundation Water Quality Index (NSF WQI). The study showed that FWQI gives fine results when compared with NSF WQI. Therefore, it is concluded that the health of river Yamuna is in miserable condition and stern actions need to be taken to change the current scenario.**

Keywords – **Artificial Intelligence, Fuzzy logic, FWQI, NSF WQI**

I. Introduction

In developing countries, lack of fresh water in rivers has made water quality assessment an important subject and frequent topic of discussion in recent years. The water quality assessment has become more relevant with increasing pollution caused due to agricultural, urban and industrial activity. To incorporate various factors for assessment, efforts are being made to develop an elaborate and comprehensive index that represents an integrated as well as overall quality of water.

National Sanitation Foundation (NSF) of USA was the first to come up with an overall and comprehensive water quality known as the Water Quality Index (WQI) [2]. Since then, various modified and improved water quality indices have been developed on the basis of WQI by several authors [8,9,10], however the use of such conventional indices has raised several problems and one of the primary problems is that the values with different distances from a limit have the same effect on the final index score[13]. Also, the uncertainties and subjectivities of environmental issues are not dealt properly using conventional indices [6]. Moreover, when water quality assessment reports are generated, emphasis on individual parameters is given. These reports are written for specialists without providing institutional players like decision makers and manager, who are not often specialist, an idea about the water quality. So an elaborate, integrated and overall representative of water quality index is of great need in international and national scenarios.

Monitoring water quality and making quantitative and qualitative judgment on the basis of real data is becoming a exigent task for engineers at all stages of the process, that is, from collection to storage till interpretation of the result, as it is seen that uncertainties pile up along the chain.

The approximations and assumptions involved in the conventional methods as well as complexities and limitations of the deterministic models used for calculation of various water quality indices inspired the environmental engineer to develop a more advance evaluation technique which is capable of taking into account the uncertainties, vagueness and inaccuracy that is associated with water quality. Now-a-days computational methods based on artificial intelligence such as genetic algorithms, neural networks, knowledge- based systems and fuzzy logic are been increasingly used for environmentalproblems [11]. They are being increasingly used as an instrument for water quality modeling. Conventional methodologies cannot quantify and classify various environmental effects of subjective characters. Fuzzy technique can syndicate these different approaches. And so, for this, new technique for the management of environmental parameters are being developed [3, 6].

Fuzzy logic is an artificial intelligence (AI) interface based computational methods, introduced by [1] and is one of the most important techniques in the area of AI, having the ability to mirror human expertise and thoughts in the indices. Moreover, it's a highly dependable method when it comes to reporting and assessing the result in linguistic terms which are easily understandable by decision makers, managers, non-experts and public in general [6,10].

Henceforth, much emphasis is being paid on the development of environmental indices especially for water quality involving fuzzy logic.[4,5,7,13,14,15,16,17]. Therefore the purpose of the present study is to assess the water quality of River Yamuna using fuzzy index. The assessment is representative of overall water quality using parameters that are practical and easy measurable. The result so obtained using fuzzy index was related and compared using WQI developed by NSF.

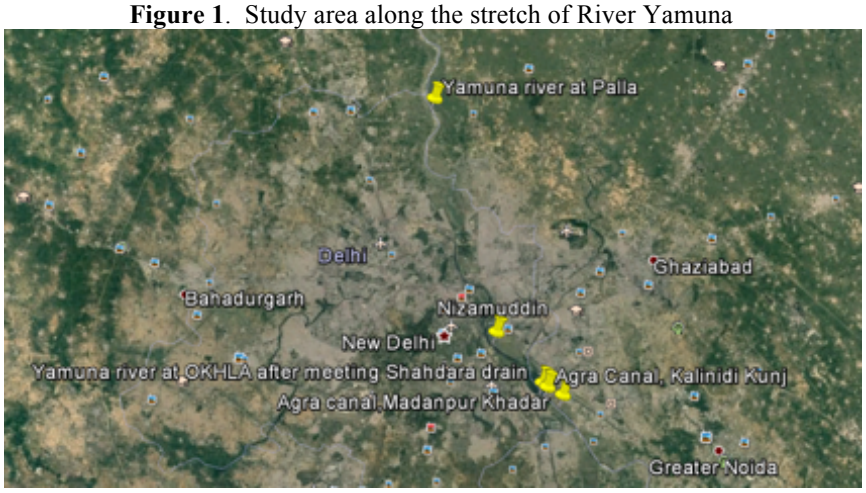
II. Material And Methods

Study Area

Yamuna,one of the major rivers of India, originates from Yamuotri Glacier and ends up meeting Ganga at Allahabad. Water quality parameters of river Yamuna were accessed at five different locations i.e at palla, Nizamuddin, Agra canal(Kalindi

Kunj),Okhla after meeting Shahdara drain and at Agra canal at Madanpur Khadar. The sampling points are shown in figure below. The data of various water quality parameters were taken from Central Pollution Control Board.

Figure 1. Study area along the stretch of River Yamuna



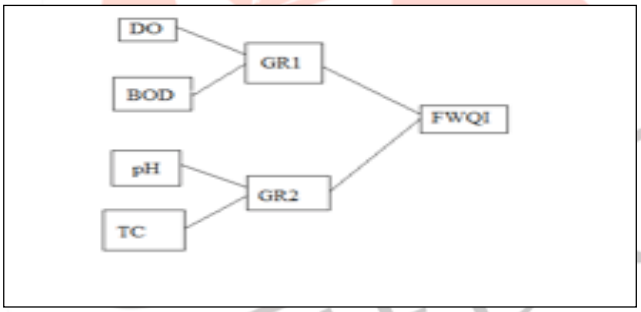
For the study , daily averages of five pollutants are taken that are BOD (Biochemical Oxygen Demand), DO (dissolved oxygen), pH, total Coli form and COD(Chemical Oxygen Demand) for five years 2011 to 2015 at five stations. The water quality indices are calculated using Water Quality Index as given by National Sanitation Foundation. The Fuzzy Water Quality Index is calculated using graphical user interface of MATLAB by fuzzy logic.

Fuzzy Water Quality Index using Fuzzy Logic

For calculation of fuzzy water quality index, four parameters were taken i.e. DO, BOD, pH and total coliform. These four parameters were grouped into two parameters i.e DO and BOD were grouped as G1 and the other two parameters i.e. pH and totalcoli form were grouped as G2.

G1 and G2 were grouped together to form FWQI.

Figure 2. Grouping of Parameters to form FWQI



Calculation of Water Quality as given by National Sanitation Foundation

Water quality index, as given by National Sanitation Foundation, is calculated by taking nine parameters into consideration. The various nine parameters used in calculation are Dissolved Oxygen saturated (%), Fecal coliform, pH, BOD, Temperature, Total Phosphate, Nitrate, Turbidity, Total Solids. These nine parameters are chosen based on their importance and so a weighted mean is used to combine the values. For the calculation of WQI using NSF , four parameters have been used i.e. DO, BOD, Total Coliform and pH. The indices were calculated using the online calculator made available by NSF. The water quality is given in the range of 1 to 100.

Table 1- Calculation of WQI by NSF

Water Quality Index Calculator							
1	**Parameter**	**Test Result**	**Units**	**Q-value**	**Weighing factor**	**Weighing Factor**	**Subtotal**
2	pH	7.5	pH units	92	0.12	0.12	10.99
3	Change in Temp		Degrees C	NM	0.11	NM	NM
4	DO	5	% saturation	5	0.18	0.18	0.83
5	BOD	36	mg/L	2	0.12	0.12	0.24
6	Turbidity		NTU	NM	0.09	NM	NM
7	Total Phosphorous		mg/L	NM	0.11	NM	NM

8	Nitrate Nitrogen		mg/L	NM	0.10	NM	NM
9	E-Coli		CFU/100 ml	NM	0.17	NM	NM
10	Fecal Coliforms	16000000	CFU/100 ml	2	0.17	0.17	0.34
11					TOTALS	0.59	12.40
		NM= NOT MEASURED			Water Quality Index		21.02
					Water Quality Rating		Very Bad

III. Result and Discussion

Water quality index using fuzzy logic toolbox and NSF (National Sanitation Foundation) are calculated subsequently. The correlation between the two is further checked to ascertain the SSrelevancy of Fuzzy index. If the coefficient of correlation comes above 0.6, it means that correlation isgoodand Fuzzy index can be used to check the health of rivers. Further monthly and Yearly analysis of different parameters are carried out.

In this study, a robust artificial intelligence tool for river water quality management in the form of the FWQI is presented.

The fuzzy water quality index as derived from fuzzy logic tool box using graphical user interface showed good correlation when compared with the standard water quality index of National Sanitation Foundation. The table below depicts the correlation between FWQI and WQI by NSF at different sites.

The correlation at different site shows that good correlation exists between them and therefore the performance of the fuzzy model is found to be excellent at an overall level . The new index is believed to assist decision makers in reporting the condition of river health and investigation of spatial and temporal changes in the river. The fuzzy logic concepts, if used logically, could be an effective tool for some of the environmental policy matters and integrated environmental management.

Table 2- Correlation between FWQI and WQI by NSF at different sites

Sites	**Correlation between FWQI and NSF WQI**
Palla	0.82058
Niizamudin	0.90838
Agra Canal (Kalinidi Kunj)	0.8930
OKHLA	0.902117
Agra Canal (Madanpur Khadar)	0.86459

IV. Conclusion

River Yamuna, a perennial and one of the prominent rivers of India, flows through three major states i.e. uttarakhand, Punjab and Uttar Pradesh and through the capital city of India Delhi. It is widely used for irrigation followed by domestic purpose , industrial and other uses. Consequently, the study becomes even more pertinent because of the ongoing industrialization and urbanization. and so, the water quality indices evaluated, has been done by considering five parameters i.e biochemical oxygen demand (BOD), dissolved oxygen (DO), pH, and total coliform (TC) and chemical oxygen demand(COD). The concentration of various parameters, considered in the study are taken for five years from jan 2011 to june 2015 at five stations. The FRHI evaluated using the parameters were compared with standard WQI by NSF. In this study, the evaluation of the indices has been done at five locations along the stretch of river Yamuna to acknowledge the suitability of River Yamuna for designated use and level of treatment needed for each parameters. Since, both the indices show that the water quality of Yamuna River is very poor, hence stern action and proper monitoring needs to be done to control pollution.

References

[1] L.A. Zadeh, Fuzzy sets. Inf. Cont. 8 (1965) 338–353.

[2] Ott,W.R. Water Quality Indices: a Survey of Indices Used in the United States. US Environmental Protection Agency, Washington, DC.(1978)

[3] W. Silvert, Ecological impact classification with fuzzy sets, Ecol. Mod. 96 (1997) 1–10.

[4] Sasikumar, K., Mujumdar, P.P. Fuzzy optimization model for water quality management of a river system. J. Water Resour. Plan. Manage. (1998) 124, 79-88.

[5] Lu, R.S., Lo, S.L., Hu, J.Y. Analysis of reservoir water quality using fuzzy synthetic evaluation. Stoch. Environ. Res. Risk Assess. (1999) 13, 327-336.

[6] Silvert, W. Fuzzy indices of environmental conditions. Ecol. Modell.130 (2000) 111-119.

[7] Chang, N.B., Chen, H.W., Ning, S.K. Identification of river water quality using the fuzzy synthetic evaluation approach. J. Environ. Manage. 63(2001), 293-305.

[8] S. Liou, S. Lo, S. Wang, A generalized water quality index for Taiwan, Env. Monit. Assess. 96 (2004) 35–52.

[9] Said, A., Stevens, D., Selke, G An innovative index for evaluating water quality in streams. Environ. Manage. 34,(2004) 406-414.

[10] McKone, T.E., Deshpande, A.W Can fuzzy logic bring complex environmental problems into focus. Environ. Sci. Tech. 15,(2005) 42-47.
[11] K.W. Chau, A review on integration of artificial intelligence into water quality modelling. Mar. Poll. Bull. 52 (2006) 726–733.
[12] F. Nasiri, I. Maqsood, G. Huang, N. Fuller, Water quality index: A fuzzy river pollution decision support expert system. J. Wat. Res. Pla. Manag. 133 (2007) 95–105.
[13] Icaga, Y Fuzzy evaluation of water quality classification. Ecol. Indic. 7,(2007), 710-718.
[14] Mirabbasi, R., Mazloumzadeh, S.M., Rahnama, M.B Evaluation of irrigation water using fuzzy logic. Res. J. Environ. Sci. 2,(2001) 340-352.
[15] Lermontov, L. Yokoyama, M. Lermotov, M.M. Soares, River quality analysis using fuzzy water quality index: Ribeira do Iguape river watershed Brazil. Ecol. Ind. 9 (2009) 1188–1197.
[16] Sowlat, M.H., Gharibi, H., Yunesian, M., Mahmoudi, M.T., Lotfi, S A novel, fuzzy-based air quality index (FAQI) for air quality assessment. Atmos. Environ.45 (12) (2011), 2050e2059
[17] H. Gharibi, A.H. Mahvi, R. Nabizadeh, H. Arabalibeik, M.Yunesian, M.H. Sowlat, A novel approach in water quality assessment based on fuzzy logic. J. Env. Manag. 112 (2012) 87–95.