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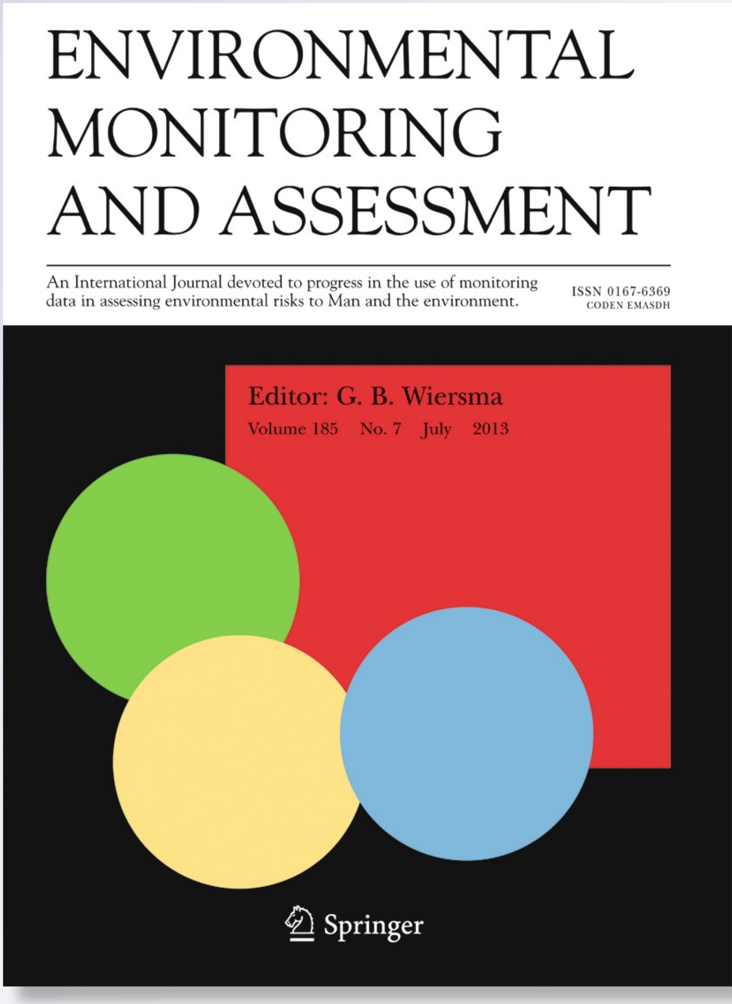

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Water quality analysis of surface water: a Web approach

**Poonam Prasad · Meenal Chaurasia ·
R. A. Sohony · Indrani Gupta · R. Kumar**

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Abstract The chemical, physical and biological characteristics of water with respect to its suitability describe its quality. Concentration of pesticides or fertilisers degrades the water quality and affects marine life. A comprehensive environmental data information system helps to perform and complete common tasks in less time with less effort for data verification, data calculations, graph generation, and proper monitoring, which helps in the further mitigation step. In this paper, focus is given to a web-based system developed to express the quality of water in the imprecise environment of monitoring data. Water samples were analyzed for eight different surface water parameters, in which four parameters such as pH, dissolved oxygen, biochemical oxygen demand, and fecal coliform were used for the water quality index calculation following MPCB Water Quality Standards of class A-II for best designated use. The analysis showed that river points in a particular year were in very bad category with certainty level of 0–38 % which is unsuitable for drinking purposes; samples in bad category had certainty level that ranged from 38 to 50 %; samples in medium to good category had certainty levels from 50 to 100 %, and the remaining samples were in good to excellent category, suitable for drinking purposes, with certainty levels from 63 to 100 %.

Keywords Water quality analysis · Web based · Environment · Monitoring · Surface water · Outlier

P. Prasad (✉) · M. Chaurasia · R. A. Sohony · I. Gupta · R. Kumar
CSIR-NEERI,
Nagpur, Maharashtra, India
e-mail: poonam.prasad20@gmail.com

Introduction

Drinking water quality, quantity and availability are the most important issues as mentioned by Dahiya et al. (2007). Monitoring of water quality and decision making on the data are challenging however attempts have been made to get the water quality index using parameter (Parmar and Parmar 2010). Information on the status and changing weightage should be varied on the basis of the season, rainfall, water intake of individuals, ambient temperature, and occupational, residential, and other environmental factors (Dahiya et al. 2007; Alberta Sustainable Resource Development Communications 2012).

Important source of water for human being comes from the surface water bodies which is now under sever environmental stress due to developmental activities. Most of the water bodies disappeared due to encroachment and pollution as mentioned by Yogendra and Puttaiah (2008).

The surface water quality in a region largely depends on the nature and extent of the industrial, agricultural, and other anthropogenic activities in the catchments. The dynamic nature and easy accessibility for the waste disposal directly or indirectly affects the river system as mentioned by Daneshmand et al. (2011).

Aquatic ecosystems functions and condition is evaluated by water quality measurements which includes spatial patterns and temporal trends. With this measurement the influence of human activities, risks to human and ecosystem health can be evaluated and further using decision-support tools such as water quality modelling are making it more beneficial for management and education. Water quality measurement also provides support to the development of water policies and management practices (Alberta Environment and Sustainable Resource Development 2012). Efficient use of water strategies should help to reduce the escalating demand for irrigation water, complementarily between water pricing, water rights, and local water governance by Veettil et al. (2011).

Water quality study at different stations gives details of undesirable and unsuitable change in water parameter. The National Sanitation Foundation (NSF) Water Quality Index (WQI), which was developed in the early 1970s, can be used to monitor water quality changes in a particular water supply over time, or it can be used to compare a water supply quality with other water supplies in the region or from around the world. Assessments of water quality are very important for knowing its suitability for various purposes by Puri et al. (2011). A WQI gives the mechanism for well presentation of a cumulatively derived, numerical expression defining a certain level of water quality parameter. The objective of WQI is to turn complex water quality data into information that is understandable and usable communally; such a rating scale allows for simplicity and consumer clarity (Kumar and Dua 2009; Yogendra and Puttaiah 2008).

WQI involves the prediction of water pollution using mathematical tools and techniques. It can also be used to predict water quality in terms of the real observed data at a high frequency and over a long period of time. So far, a number of water quality models have been widely applied to assess water quality by Booth et al. (2007). Neural Network for modeling of river water quality is explained in by Singh et al. (2009).

The objective of this study is to investigate the water quality of the river of Maharashtra by using WQI in the form of a software system. This web information system, or web-based information system, is an information system that uses Internet Web technologies to deliver information and services to common users or other information systems/applications. It is a software system whose main purpose is to publish and maintain data by using hypertext-based research (Wikipedia 2012).

Research methodology

The software developed is in open-system platform, developed in Apache 2.2.11, PHP version 5.3.0, MYSQL 5.1.36.

The following are tasks performed by the systems:

- Conversion of Excel data of surface water into Mysql database
- Various calculations are performed on these data such as:

  Outlier calculation
  Descriptive statistics
  Subindex calculations based on NSF equation
  Calculation based on water quality index
  Grade and categories on WQI
  Graphical representation of surface water

The data set used in this study was generated through continuous monitoring of the water quality of rivers of Maharashtra. Surface water quality data consist of the following parameters: pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), fecal coliform (FC), total coliform (TC), ammonia (NH_3), nitrate, temperature. etc. in Excel sheet; these Excel sheets were initially imported into the database, and calculation was executed on these data based on MPCB Water Quality Standards of class A-II. DO and percentage of DO values were imported into the database for subindex calculation based on NSF equations, and then, the river Excel sheet was inserted. There were some conditions like no value should be zero; if it includes any zero value, then the software will not permit the Excel sheet to enter into the database; no negative number should enter into the database, pH values should be less than 14, DO values should be less than 14, TC should always be greater than FC, null values should not enter into the

Table 1 Original and modified weights for the computation of NSF WQI based on DO, fecal coliform, pH, and BOD

S. no.	Water parameters, weightage
1.	DO, 0.31
2.	pH, 0.22
3.	BOD, 0.19
4.	FC, 0.3

These are the modified weights by CPCB (2001)

database, and the same river Excel sheet should not be entered into the database. If any of these conditions were not fulfilled, then a popup message will emerge, and it will not allow the Excel sheet data to enter into the database. Various validation tests are being used in the system to get the data in the proper format.

Outlier calculation

Once the data are imported successfully into the database using the developed software, outlier calculation was performed on the water parameters. An *outlier* is defined as an observation that "appears" to be inconsistent with other observations in the data set. Outliers can provide useful information about the process (Walfish 2006).

There are various approaches to outlier detection depending on the application and number of observations in the data set. This outlier is calculated using a formula agreed on by MPCB standards. The formula is given below (Verma and Quiroz-Ruiz 2006).

$$TN11up = (x(n) - x(n-2)/x(n) - x(1))$$

$$TN11lp = (x(3) - x(1)/x(n) - x(1))$$

The table in the database is updated after the calculation of the outlier with a "null" value; whenever the outlier lies in the upper or lower value of any of the water parameters in the database, then the data are imported successfully into the database. The software includes features such as view, add, edit, delete, and print data.

Subindex calculation based on NSF equation

For subindex calculations, DO values from two different tables were checked, and if they were equivalent, then percentage saturation of DO value was stored in the third table along with the DO value. VLOOKUP formula was specified in the Excel data sheet for corresponding the DO with the percentage saturation DO value. In the same way, SELECT query using Equijoin conditions was used to match the DO value with the percentage of DO value in this software. Once the DO value matched with the percentage of DO value, then these values were inserted in another table with the proper station number to perform additional calculations. For subindex calculation based on the NSF equation, four water parameters such as percentage of DO value, DO value, FC, pH, and BOD were used. Certain conditions and formulae were applied on these parameters as specified by the standards; then the identical table was updated with the proper station no., month, year, and new calculated values of DO, pH, BOD, and FC were utilized for the calculation of WQI.

Weights used for calculation are the modified weights by CPCB (2001) as shown in Table 1.

The NSF WQI is expressed mathematically as:

$$NSFWQI = \sum_{i=1}^{p} W_i I_i ,$$

where I_i=subindex for the ith water quality parameter

W_i=weight (in terms of importance) associated with water quality parameter

p=number of water quality parameters

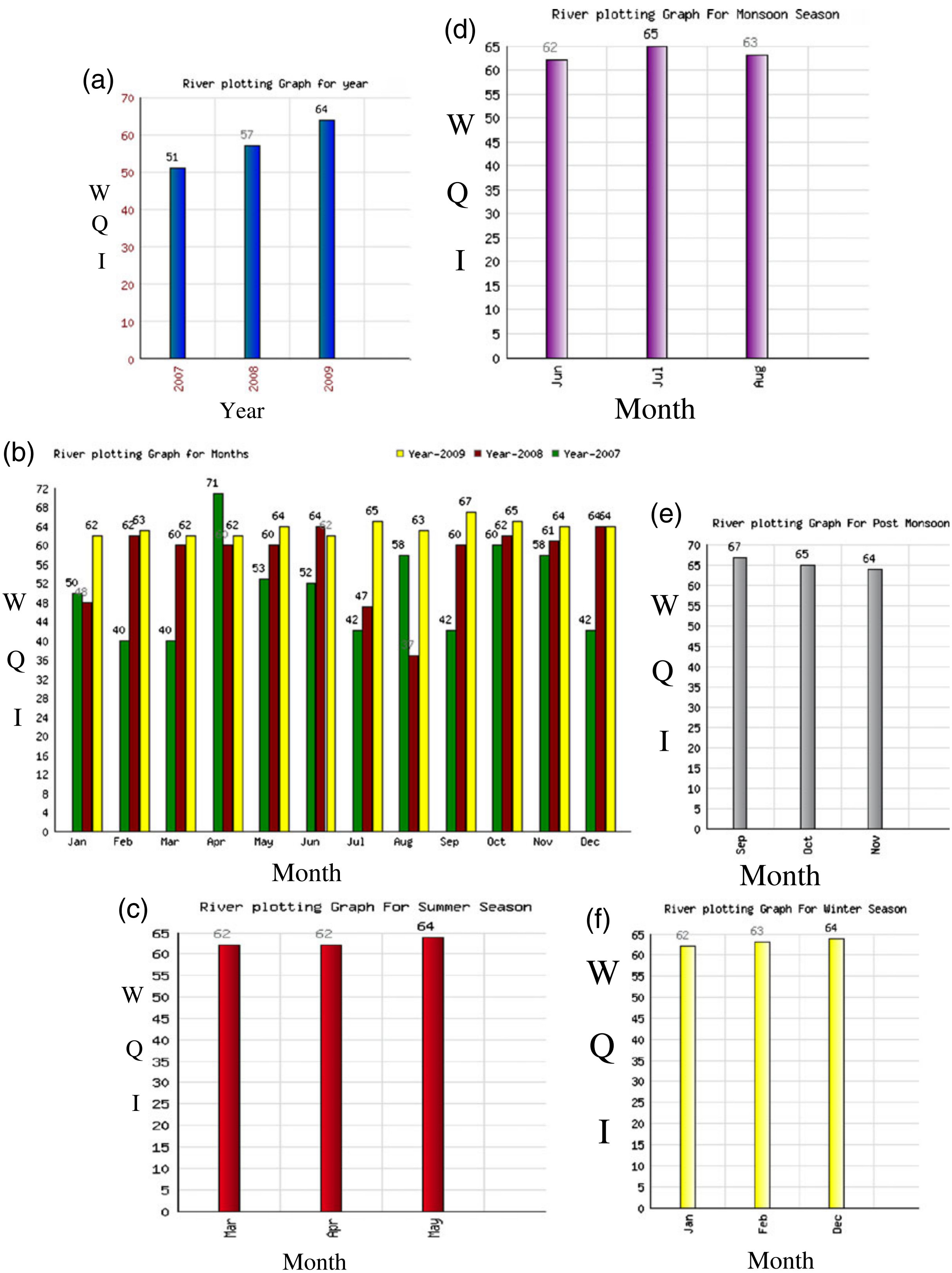
The range of the NSF WQI corresponding to various designated best use classification is given in Table 2.

These weightage values were used for WQI calculation for four parameters; these weight values are

Table 2 NSF WQI for various designated best use (CPCB 2001)

GE, good to excellent; MG, medium to good; Bad, bad; VB, very bad

NSF WQI	Description of quality (1978)	Remarks
If total<38	VB	Heavily polluted
If total<50	Bad	Polluted
If total<63	Medium to good	Nonpolluted
If total<100	Good to excellent	Nonpolluted


(a)
River plotting Graph for year
WQI
51
57
64
2007
2008
2009
Year
(d)
River plotting Graph For Monsoon Season
WQI
62
65
63
Jun
Jul
Aug
Month
(b)
River plotting Graph for Months
Year-2009
Year-2008
Year-2007
WQI
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
(e)
River plotting Graph For Post Monsoon
WQI
67
65
64
Sep
Oct
Nov
Month
(c)
River plotting Graph For Summer Season
WQI
62
62
64
Mar
Apr
May
Month
(f)
River plotting Graph For Winter Season
WQI
62
63
64
Jan
Feb
Dec
Month

◀ **Fig. 1** **a** Graph for year; **b** monthly graph; **c** summer season graph; **d** monsoon season graph; **e** postmonsoon season graph; **f** winter season graph

multiplied with pH, DO, BOD, and FC, and the total is calculated for each individual parameter. Then, the total is compared with certain standard values, and it will form categories according to it.

Results and discussion

Originally, the weights from NSF WQI were different from the modified one as shown Table 1 (CPCB 2001) where DO weightage is 0.31, pH weightage is 0.22, BOD weightage is 0.19, and FC weightage is 0.3. These weightage values were used for WQI calculation for four parameters; these weightage values were multiplied with pH, DO, BOD, and FC, and WQI total was calculated for each individual parameter. Then, the WQI total was compared with certain standard values, and it was set to further categories which are mentioned below in the table, and Fig. 1 shows the graphical representation of WQI total.

The WQI was calculated using NSF information software and compared with standard water quality rating. The values of water quality index, for example for River Amba, vary from bad, medium to good, and good to excellent at some locations.

The values of WQI of rivers vary from bad, medium to good, and good to excellent at some locations as shown in the graphs of Fig. 1, Fig. 1a representing the graph of the years 2007, 2008, and 2009. Figure 1b represents the monthly variations whereas Fig. 1c, d, e, and f show the summer seasonal, monsoon season, postmonsoon, and winter seasonal graphs, respectively. Table 2 represents the WQI categories which are further mapped according to the following color coding: GE—good to excellent, green; MG—medium to good, orange; bad, red, and VB, maroon, in order to get the results which can be easily understood with the help of color coding.

Conclusion

The developed software framework is easy to operate and allows easy viewing of the desired WQI values based on the data entered into the system. The analysis showed that river points in a particular year were in very bad category with certainty level of 0–38 %, which is unsuitable for drinking purposes. Samples in bad category had certainty levels that ranged from 38 to 50 %, samples in medium to good category had certainty levels from 50 to 100 %, and the remaining samples were in good to excellent category, suitable for drinking purposes, with certainty levels from 63 to 100 %. Results are shown in graphs of yearly, monthly, and seasonal bases which will further help in the proper understanding of the pollution level of the river at a particular station point. The system is useful for the decision maker, allowing him/her to get the desired output in less time.

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