Proceedings of GLOGIFT 09
November 12 – 14, 2009
National Institute of Industrial Engineering
Mumbai, India

Assessment for Surface Water Quality of Damoder River Using Water Quality Index Programming

R. K. Verma
Research Scholar
National Institute of Industrial Engineering,
Mumbai, India
ravindraraj2008@gmail.com

S. Murthy
Associate Professor
National Institute of Industrial Engineering,
Mumbai, India

R. K. Tiwary
Scientist E 1,
Central Institute of Mining and Fuel Research (CSIR),
Dhanbad, India.

Sangeeta Verma
Department of Remote Sensing and GIS,
Birla Institute of Technology, Ranchi

Amardip Singh
Environmental Planner,
Sai Consulting Engineer Services,
Amritsar, Punjab, 1ndia

Richa Gautam
Research Scholar
National Institute of Industrial Engineering,
Mumbai, India

Abstract

Water is among the most essential requisites that nature provides to sustain life for plants, animals and human beings. With the increase in population it has been put under tremendous pressure due to human and other biological activities. Water Quality Index (WQI) is a useful tool for the quick assessment of any water system into simple terms such as excellent, acceptable, slightly polluted, polluted and heavily polluted. In the present article each water quality observation are scored as viz. Excellent, Acceptable, Slightly Polluted, Polluted and Heavily Polluted water scheme used for surface water quality classification, the concentration ranges in these classes are defined in Indian scenario considering Indian Standards and CPCB criteria. Standards by the European Community (EC), WHO etc. and the reported facts about the pollution effects of important water quality indicator parameters on the surrounding were also taken into account. (Sargaonkar and Deshpande, 2003).The present work is based on programming coded in Turbo C++ to evaluate the WQI values of Damoder river for assess the water quality and results indicate that all the

21 sampling points have acceptable to slightly polluted range and their water can be used for drinking purpose only after disinfection.

Keywords: *Damoder River, WQI, Surface water quality.*

1. Introduction

Increasing dearth of water in developing countries has made river water quality evaluation a relevant issue in recent years (Ongley, 1998). However, Water quality observations have little significance by themselves. A pollution parameter which has a specific value is usually meaningful only in the context of knowledge of natural background levels and regulations. Conventional water quality regulations contain quality classes which use crisp sets, and the limits between different classes have inherent imprecision (Silvert, 2000). The methods which contain upper and lower limits have two ambiguities. Methods to integrate several variables related to water quality in a specific index are increasingly needed in national and international scenarios. Several authors have integrated water quality variables into indices, technically called water quality indices (WQIs) (Bolton et al., 1978; Bhargava, 1983; House, 1989; Mitchell and Stapp, 1996; Pesce and Wunderlin, 2000; Cude, 2001; Liou et al., 2004; Said et al., 2004; Silva and Jardim, 2006; Nasiri et al., 2007) for estimation of surface water quality.

The water quality index (WQI) has been considered to give a criteria for surface water classification based on the use of standard parameters for water quality characterisation (Couillard and Lefebvre, 1985; House and Newsome, 1989; Smith, 1989; Melloul and Collin, 1998; Nives, 1999; Pesce and Wunderlin, 2000; Swamee and Tyagi, 2000; Bordalo et al., 2001; Cude, 2001; Nagel, 2001; Jonnalagadda and Mhere, 2001; Liou et al., 2003; Herna´ndez-Romero et al., 2004). This can also be employed as a tool to translate multiple variables into a single suitable criterion and establish background levels of water quality based on the water quality standards for a given water system (Ott, 1978). Such WQI will give idea about increase or decrease in pollution rate for the water body under consideration. Monthly or seasonal changes in the water quality can be quickly assessed with help of such an Index. WQI is accurate and timely information to assess the water system.

The main purpose of this study is to assess the water quality status of Damoder river during summer season (May-July, 2009), a WQI was applied to the data set, which were collected for this study. It is based on the Horton (1965), an earliest attempts to generate a score describing general water quality for river. Therefore, normally for the determination of WQI requires, first step is normalization, where each parameter is expressed on a 0-100 scale, Rivers with WQI values between 0-40, 40-60 and 60-80 indicates Heavily polluted, Polluted and Slightly polluted respectively, while waters of Acceptable and Excellent quality have WQI values of 80-100, and 100, respectively. The next step is to apply a weighting factor in accordance with the importance of the parameter as an indicator of water quality (Nives, 1999; Pesce and Wunderlin, 2000; Jonnalagadda and Mhere, 2001) and then finally, all of the sub-indices are aggregated by a linear sum specific aggregation function in term of computer programming to evaluate the overall WQI values of the river.

2.0 Materials and methods

2.1 Study Area

The Damoder River Basin (DRB) is a sub-basin and part of the Ganges Rivers spread over an area of about 23,370,98 sq. km. in the states of Jharkhand and West Bengal. The geographical boundary of the basin lies between $22^0$15' to $24^0$30' N latitude and $84^0$15' E longitude (Figure. 1), and mainly drained by the Damoder river. The River originates near Chandwa village, Palamau district, on the Chota Nagpur Plateau in the Jharkhand state in eastern India, and flows eastward for about 592 km through the states of Jharkhand and West Bengal to the estaury of the River Hooghly. It has a number of tributaries and subtributaries, such as Barakar, Konar, Bokaro, Haharo, Jamunai, Ghari, Guaia, Khadia and Bhera.

The study area includes a stretch of about 110 km from d/s of Tenughat dam to d/s of Baraker river. This divided into ten stretches to take advantage of the presence of bridges or confluence points of tributaries for sample collection. In addition, four other sites were established in the upstream tributaries, the Konar river (sampling points 18), Jamunia rivers (sampling point 19), Garganalla (sampling point 20) and Barakar river (sampling points 21) just before their conjunction to form the Damoder (as shown in Figure, 1), each stretch receives wastewater from industries and coalwasheries, mine water, municipals and sewage, through out its course and tributaries like Konar river, Garganalla, and Jamunia river, joins the river containing various types of waste including domestic and industrial waste.

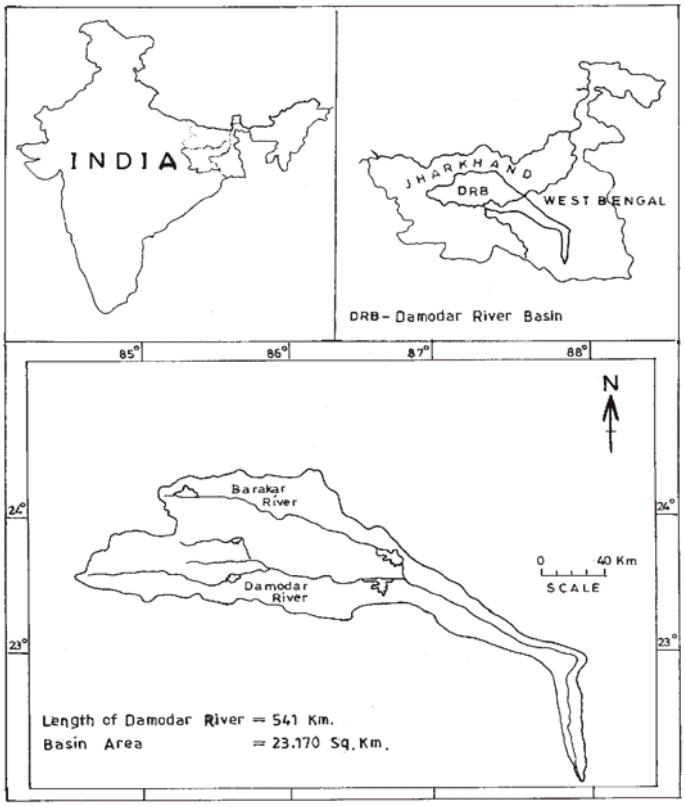


Fig. 1: Map showing the study ar
of surface water quality monitorin
(S1….S17, T1..T4) in Damoder
river basin.

***Sampling points:**

S1- Damoder River, near Tenughat Dam;

S2- Damoder River, U/S confluence of Konar River;

S3- Damoder River, D/S confluence of Konar River;

S4- Damoder River, U/S near Kargali Coal Washery;

S5- Damoder River, D/S near Kargali Coal Washery

S6- Damoder River, U/S near CTP,Chandrapura;

S7- Damoder River, D/S near CTP, Chandrapura

S 8- Damoder River, U/S Confluence Jamunia River

S 9- Damoder River, U/S Telmocho Bridge

S 10- Damoder River, D/S Telmocho Bridge

S 11- Damoder River, Jamadoba near Pump House

S 12 –Damoder Riv , near Domgarh (Sindri)

S13- Damoder River, U/S Muhalbani Bridge.

S14- Damoder River, D/S Muhalbani Bridge.

S 15- Damoder River, U/S Panchet Dam.

S 16- Damoder River, D/S Panchet Dam

S 17- Damoder River, D/S Barakar River.

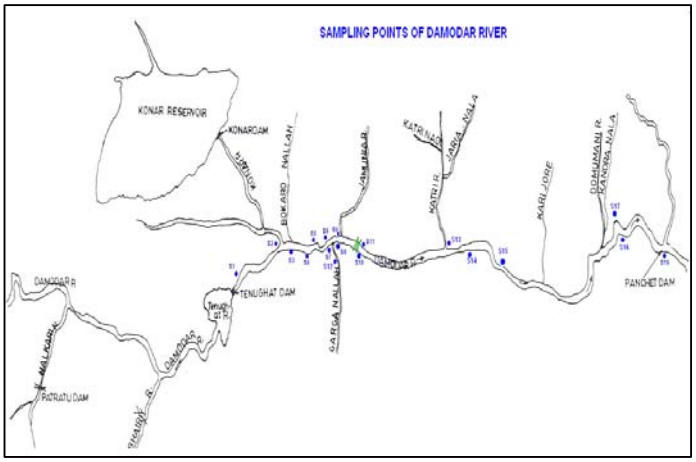
T 1- Konar River

T 2 – Jamunia River

T 3 – Garganalla. and

T 4- Barakar River.

 # CTP- Chandrpra thermal power plant



2.2 Description of sampling points

A total of twenty one sampling points were chosen for collection of samples in the study area from d/s Tenughat dam to d/s of Baraker river along the stretch of the river to determine the water quality index, as described in Table 1.

Table 1: Sampling Points -Damoder river and its tributaries

S. No	Sampling point	Code	Approx Distance from Tenughat dam in km)	Description
1.	Damoder River, D/S Tenughat Dam;	S1	0.3	Sampling point (23^0 44 N 85^0 55 E elev. 754ft) is near the bridge, which is downstream location from Denughat dam.
2.	Damoder River, U/S confluence of Konar River	S2	12	Sampling point is upstream of Damoder river confluence with Konar river. The water from this area is used for drinking and bathing.
3.	Damoder River, D/S confluence of Konar River	S3	12.2	Sampling point is upstream of Damoder river confluence with Konar river. The water from this area is used for drinking and bathing.
4.	Damoder River, U/S of Kargali Coal Washery	S4	22	Sampling point is upstream of a temporary bridge near water treatment plant, of kargali coal washery. The water from this area is mainly used for bathing , fishing etc.
5.	Damoder River, D/S of Kargali Coal Washery	S5	22.2	Sampling point is 200 m downstream from S4 and activities observed area bathing, swimming, fishing etc.

6.	Damoder River, U/S CTP, Chandrapura t	S6	30	Sampling point is near ash pond of Chandrapura thermal power Plant. Activites are mainly washing, cleaning, bathing etc.
7.	Damoder River, D/S CTP,Chandrapura	S7	30.2	Sampling point is 200 m downstream from S6 and activities observed bathing, swimming, fishing etc.
8.	Damoder River, U/S Confluence Jamunia River	S8	41.5	Sampling point ($23^0$41'N 86^0 10' E elev. 535 ft) is down stream of Chandrapura thermal power plant, Chandrapura.
9.	Damoder River, U/S Telmocho Bridge	S9	44.2	Sampling point ($23^0$43'N $86^0$12'E elev.503 ft) is near Telmocho bridge on Bokaro - Dhanbad Boarder and it is upstream of Damoder river confluence with Garganalla.
10.	Damoder River, D/S Telmocho Bridge	S10	44.4	Sampling point (23^0 44'N $86^0$12' E elev. 496 ft) is 200 m down stream from S7. The water is used for domestic usage like washing, cleaning, bathing etc.
11.	Damoder River, Near Jamadoba Pump House	S11	66	Sampling point is near bridge nearby Jamadoba coal washery, Tata Iron& steel company Ltd.
12.	Damoder River, near Domgarh (Sindri).	S12	81	Sampling point (23^0 38'N 86^0 29' E elev. 501 ft), nearby Sindri. This location is close to BIT, Sindri.
13.	Damoder River, U/S Muhalbani Brigde	S13	95	Sampling point is near of bridge. The water from this area used for drinking ,fishing, bathing, etc.
14.	Damoder River, D/S Muhalbani Brigde	S14	95.2	Sampling point is near of bridge. The water from this area used for drinking ,fishing, bathing, etc.
15.	Damoder River, U/S Panchet Dam	S15	106.2	Sampling point (23^0 40'N $86^0$44' E elev. 386 ft) is near Panchet dam.
16.	Damoder River, D/S Panchet Dam	S16	106.4	Sampling point is 200 m downstream from S15 and activities observed bathing, swimming, fishing etc.
17.	Damoder River, D/S Barakar River.	S17	110.2	Sampling point is near the downstream of confluence point of Damoder river with Barakar river.
18.	Konar River	T1	12	Sampling point location is (24^0 20' N 85^0 36' E elev. 386 ft) near the confluence point of Damoder with Konar river. This river contributes main water in Tilaiya dam.
19.	Jamunia River	T2	43	Sampling point is near of bridge and it is 2 km upstream from the confluence point of Damoder river with Jamunia.
20.	Garganalla	T3	43.5	Gargnalla is mainly carrying effluent of Bokaro Steel Plant and Domestic sewage from Bokaro. Sampling point is near the confluence point of Damoder river with Garganalla.
21.	Barakar River	T4	110	Sampling point is near Baraker river bridge and activities observed are bathing, swimming, fishing etc.

2.3 Sample collection and analysis

Twenty one sampling points were selected as sampling stations; the water samples were collected in polythene bottles from each point during summer season (May - July, 2009) from representative sampling points in each area, which was carried out as per standard sampling methods (IS:2498, 1966-Part-I; APHA,1998). Water temperature was recorded on spot and pH values of water samples were measured by Orion pH electronic meter. Samples for BOD and DO were collected separately in 300 ml BOD (glass) bottles. BOD was determined as per the Standard Methods (APHA, 1998). The total suspended solids and total dissolved solids were separated by filtering the water through 0.42 mm Watmann filter paper and determined according to standard procedures. Nitrate (NO_3^-) was determined photometrically by measuring the intensity of the yellow colour developed by the reaction of Brucine with nitrate (Jenkins and Medsker, 1964). Sulphate (SO_4^{--}) and Total coliform (MPN)/100 ml were determined by gravimetric and multiple tube method respective, according to standard procedures (APHA, 1998). The result of analysed samples is shown in Table 2.

Table 2: Data (May-July, 2009) of the Damoder River water quality.

S. No	Para-meters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	T1	T2	T3	T4
1.	pH	8.6	6.5	6.7	8.3	7.2	6.0	6.1	6.92	8.0	8.3	8.02	8.03	7.99	9.22	7.96	7.89	7.79	8.54	7.88	8.04	8.08
2.	Total Hardness	74	88	72	76	78	110	268	84	90	88	152	123	102	101	127	125	126	62	110	134	77
3.	BOD	3.1	3.0	4.3	4.6	2.2	1.6	2.8	3.1	3.2	7.1	3.6	4.9	3.6	12	12.2	4.1	2.2	2.0	3.4	7.2	3.4
4.	Total Alkalinity	140	120	150	130	135	120	145	145	130	140	180	130	160	160	120	120	130	180	160	200	140
5.	DO	7.4	7.8	6.8	7.2	6.8	6.3	5.4	6.2	8.0	6.2	6.0	5.4	5.9	5.8	6.2	4.7	6.8	6.2	6.0	5.7	6.1
6.	TDS	215	240	480	708	720	493	1153	178	190	270	194	215	310	520	144	130	110	559	200	1450	310
7.	TSS	118	170	190	275	305	160	170	290	125	386	170	92	423	180	130	159	176	108	310	430	215
8.	Cl-	21	23.5	22.5	22	24.5	20.5	18.5	34	28.5	31	31.5	30	44	34	33	32	28.5	23	30.5	59	23
9.	NO_3^-	25.1	12.5	14.1	17.6	13.8	9.5	22.4	11.3	13.3	15.4	15.2	14.4	17.2	17.4	13.2	12.8	14.7	15.1	19.6	23.4	15.3
10.	SO_4^{--}	17.9	18.9	88.47	93.41	88.7	325	600	96.4	63.4	104	106	120	89.9	107	60.5	110	85.5	89.7	73.6	142.4	160.5
11.	Total Coliform	4	93	460	240	240	93	93	240	93	120	240	93	1100	1100	460	460	460	1100	240	5000	460
12.	**WQI**	**72.2**	**74.2**	**71.1**	**72.8**	**70.2**	**71.0**	**67.6**	**71.6**	**74.2**	**71.6**	**73.6**	**70.0**	**75.6**	**79.6**	**71.0**	**71.0**	**72.0**	**70.1**	**72**	**66.2**	**71**

*All the units are in mg/L, except pH, total coliform

2.4 Indexing approach

The water samples were analysed to determine the water quality parameters such as pH, Dissolved oxygen (DO), Biochemical oxygen demand (BOD_5),Total suspended solids (TSS), Total dissolved solids (TDS), Total Hardness, Total Alkalinity, Chloride (Cl^-), Sulphate(SO_4^{--}), Nitrate (NO_3^-), and Total Coliform (MPN)/100ml are considered as the significant indicator parameters of surface water quality in the present study. The concentrations (levels/ranges) of these parameters in the specified classes are defined with due consideration of CPCB standards/criteria and IS 10500. For parameters and classes not included in the CPCB standards, reference was made to the standards defined by other agencies (Sargaonkar and Deshpande, 2003).(Appendix).

For calculating the water quality index normally steps are followed in which the rating scale has been assigned to the parameters, which is also assigned weighed to water quality variables is to denote each variable's importance to the overall water quality. A larger weight value implies greater importance of the variable. In assigning the weight of each variable, the most challenging factor is that different people may have different opinion. Accordingly, a WQI needs to assign weights by combining the opinion of a group of experts. In the present study, it has been assigned weights W_i to various water quality parameters to be considered here are given in Table 4. These weights range from 1 to 4. The maximum weight assigned is 4, for parameters like pH, DO, BOD_5, MPN. The other parameters like Total hardness, TDS, Cl^-, has been assigned 2, Total alkalinity and NO_3^- has been assigned 3 and SO_4^{--} has been

assigned 1, according to their relative importance in drinking water, by similar consideration.

The rating scale (q_i) for the eleven water quality parameters considered here is given in Table 3. It can be express by dividing the values for the parameters in five classifications such as excellent, acceptable, slightly polluted, polluted and heavily polluted. The Quality rating q_i ranges from 0-100. Finally, the sub-index aggregation of WQI mathematically combines sub-indices to an overall index values. The aggregation function of WQI, given by the following equation, is based on the linear sum aggregation function;

$$WQI = \sum (q_i \times W_i)_n$$

Table 3: Rating scale for water quality parameters based on a proposed classification

	Classification	Excellent	Acceptable	Slightly Polluted	Polluted	Heavily Polluted
	Rating	100	80	60	40	0
S. No	Parameters		Concentration	Limits/ ranges		
1.	pH	6.5-7.5	6.0 - < 6.5	5.0 - < 6.0	4.5 - < 5	<4.5 - ≥ 9.5
2.	Total Hardness	< 300	300- ≤ 400	400- ≤ 500	500 -≤ 600	> 600
3.	BOD_5	≤ 1.5	1.5 - ≤ 3	3 - ≤ 6	6. ≤ 12	> 12
4.	Total Alkalinity	≤ 200	200- ≤ 325	325.1 - ≤ 450	450- ≤ 600	> 600
5.	DO	> 7.0	5.1 - 7.0	4.1 - 5.0	3.0 - 4.0	< 3.0
6	TDS	≤ 500	500- ≤ 1500	1500 - ≤ 2100	2100-≤ 3000	> 3000
7.	TSS	≤ 30	30 - ≤ 60	60- ≤ 80	80 - ≤ 100	> 100
8.	Cl^-,	≤ 150	151- ≤ 250	251 - ≤ 600	601 - ≤ 800	> 800
9.	NO_3^-,	≤ 20	20- ≤ 45	45 - ≤ 50	50 - ≤ 100	> 100
10.	SO_4^{--},	≤ 150	151- ≤ 250	250- ≤ 400	400 - ≤ 1000	> 1000
11.	MPN/100ml	≤ 50	51- ≤ 500	501 - ≤ 5000	5001- ≤ 10,000	> 10,000

(Sargaonkar and Deshpande, 2003).

Table 4: Water quality parameters standards and weight assigned, (Indian standard 1991, 10:500).

S. No	Water Quality Parameter	Permissible Limit	Desirable Limit	Weight Wi	Unit weight
1	pH	No Relaxation	6.5-8.5	4	0.13
2	Total Hardness	600	300	2	0.07
3	BOD_5	-	-	4	0.13
4	Total Alkalinity	600	200	3	0.1
5	DO	-	-	4	0.13
6	TDS	2000	500	2	0.07
7	TSS	-	-	2	0.07
8	Cl^-,	1000	250	1	0.03
9	NO_3^-,	No Relaxation	45	3	0.1
10	SO_4^{--},	400	200	1	0.03
11	Total Coliform (MPN)/ 100ml	-	-	4	0.13
Sum				$\sum W = 30$	$\sum W_i = 0.99$

WQI calculation:

The unit weight of each parameter is calculated as follow:

Weight assigned to independent parameter = W

Unit weight of independent parameter = W_i

Unit weight (Wi) = Weight assigned to parameter / Sum of weights of all parameters

Therefore, $Wi = W / \sum W$

$\sum Wi = 1$

Degree of pollution rating (qi) is considered as follows:

Excellent = 100

Acceptable = 80

Slightly polluted = 60

Polluted = 40

Polluted and heavily polluted = 0

Sub-index (SI) value for each variable calculated as:

$$\text{Sub index (SI)} = q_i \times W_i$$

Therefore, water quality index (WQI) for 'n' parameters can be calculated as:

$$WQI = \sum (q_i \times W_i)_n$$

2.5 WQI programming

The Proposed computer programs has been coded in Turbo C ++ to calculate the water quality index for Damoder river are shown in Table 2. The details of the programs are given in appendix.

3.0 Results and discussions

Parameters such as pH, Dissolved oxygen (DO), Biochemical oxygen demand (BOD_5), Total suspended solids (TSS), Total dissolved solids (TDS), Total Hardness, Total Alkalinity, Chloride (Cl^-), Sulphate (SO_4^{--}), Nitrate (NO_3^-), and Total Coliform (MPN)/100ml have been considered out of number of indicators given in various National and International agencies to assess the water quality of Damoder river as shown in Table 2. A critical observation of Table 2 reveals that the water from none of these sampling points is fit for human consumption directly. The highest value of WQI obtained is 74.2 at U/S of Damoder river near confluence of Konar river, While lowest value observed is 66.2 for Garganalla, which show poor water quality among the all sampling points. This could be because effluent of Bokaro thermal power plant as well as domestic sewage from Bokaro city is discharged into the river at this point. All the 21 sampling points have WQI values lying between 74.2 to 66.2, which shows that all these sampling points can be classified as acceptable - slightly polluted range and their water can be used for drinking purpose only after disinfection.

An observation of data shows that most of the sampling points the values of MPN coliform show much higher values as compared to Indian Standards and CPCB norms for drinking water. Therefore, it is suggested that as the MPN has greater value so proper treatment, like disinfection etc., should be strictly followed if used for drinking purpose.

4.0 Conclusions

In this paper, a robust decision making tool for water quality management in the form of WQI programming, is discussed. Which can normally be use to evaluate overall WQI values in term of Pollution load. Therefore it can definitely very useful for assess water quality status of the any water system and can be used as a powerful tool in formulating the pollution control strategies in terms of treatment required at different levels. However, the result indicated that although the surface water quality at all sampling points are in the range of acceptable to slightly polluted which indicates that disinfection is essential if the source is to be used for drinking purpose.

Acknowledgements:

The Corresponding author is thankful to Dr. Amitabha de, Research Dean, and BoR Committee members, National Institute of Industrial Engineering, Mumbai for the encouragement and support to carryout the research.

5.0 References

APHA, AWWA, 1998. Standard methods for the examination of water and wastewater (18th edn). American Public Health Association, New-York.

Bhargava, D. S.: 1983, 'Use of a water quality index for river classification and zoning of Ganga River', *Environmental Pollution (Series B)* **6**, 51–67.

Bhargava, D. S.: 1985, 'Expression for drinking water supply standards', *Journal of Environmental Engineering, ASCE* **113**(3), 304–316.

Horton, R. K.: 1965, 'An index number system for rating water quality', *Journal of Water Pollution Control Federation* **37**(3), 300–306.

Indian standard specification for drinking water: 1991, IS-10,500- 1991, Indian Standards Institution, New Delhi, Gr. 6.

M. B. Chouule, A.I.Wasif and V.R. Naik: 2009, Proceeding of International Conference on Enery and Environment, march 19-21, 2009.

Prati, L., Pavanello, R. and Pesarin, F.: 1971, 'Assessment of surface water quality by a single index of pollution', *Water Research* **5**, 741–751.

Sargoankar, A. and Deshpande, V.: 2003, 'Development of an overall index of pollution for surface water based on a general classification scheme in Indian context', *Environmental Monitoring and Assessment* **89**, 43–67.

Smith, D. G. (1990). "A better water quality indexing system for rivers and streams." *Water Res.*, 24 (10), 1237–1244.

Walski, T. M., and Parker, F. L. (1974). "Consumers water quality index." *J. Envir. Engrg. Div.*, 100(3), 593–611.

Appendix

Programs for calculation of water quality index (WQI)

A. Computer Program No.1

/* Program written for calculating water*/

/* Quality Index for Damoder River*/

```
include<stdio.h>
#include<conio.h>
#include<math.h>
#include<stdlib.h>
void main()
{
FILE *f7;
float
DO,PH,BOD,CHLOR,THARD,TSS,TDS,TOALK,NITRATE,SULPHATE,MPN,G,WQI;
float
```

```
DO1,PH1,BOD1,CHLOR1,THARD1,TSS1,TDS1,TOAL
K1,NITRATE1,SULPHATE1,MPN1;

float G1,G2,G3,G4,G5,G6,G7,G8,G9,G10,G11,SI1;

f7=fopen("f7","w");

//clrscr();

Printf ("PH OF THE DAMODAR RIVER WATER
(PH)=\n");

scanf("%f",&PH);

fprintf(f7,"PH=%f\n",PH);

printf ("TOTAL HARDNESS OF RIVER WATER AS
CaCO3(HARD),mg/I=\n");

scanf("%f",&THARD);

fprintf(f7,"THARD=%f\n",THARD);

printf("BOD OF RIVER WATER(BOD),mg/I=\n");

scanf("%f",&BOD);

printf ("TOTAL ALKALINITY OF RIVER
WATER(TOALK),mg/I=\n");

scanf("%f",&TOALK);

fprintf(f7,"TOALK=%f\n",TOALK);

printf ("DISSOLVED OXYGEN CONCENTRATION IN
RIVER WATER\n");

printf("DO),mg/I=\n");

scanf("%f",&DO);

printf("TOTAL SOLIDS PRESENT IN RIVER
WATER(TS),mg/I=\n");

scanf("%f",&TSS);

fprintf(f7,"TS=%f\n",TSS);

printf("TOTAL SUSPENDED SOLIDS PRESENT
(TSS),mg/I=\n");

scanf("%f",&TSS);

fprintf(f7,"TSS=%f\n",TSS);

printf ("CHLORIDE PRESENT IN RIVER
WATER(CHLOR),mg/I=\n");

scanf("%f",&CHLOR);

fprintf(f7,"CHLOR=%f\n",CHLOR);

printf ("NITRATE PRESENT IN RIVER
WATER,mg/I=\n");

scanf("%f",&NITRATE);

fprintf (f7,"NITRATE=%f\n",NITRATE);

printf ("SULPHATE PRESENT IN RIVER
WATER,mg/I=\n");

scanf("%f",&SULPHATE);

fprintf(f7,"SULPHATE=%f\n",SULPHATE);

printf (" TOTAL MPN PRESENT IN RIVER
WATER,mg/I=\n");

scanf("%f",& MPN);

fprintf(f7,"TCOLIFORM=%\n",MPN);

 /*UNIT WEIGHTS OF DIFFERENT PARAMETERS*/

PH1=0.13;

THARD1=0.07;

BOD1=0.13;

TOALK1=0.1;

DO1=0.13;

TDS1=0.07;

TSS1=0.07;

CHLOR1=0.03;

NITRATE1=0.1;

SULPHATE1=0.03;

MPN1=0.13;

/*SCALE RATING FOR PARAMETER PH*/

If (PH<4.5||PH>=9.5)

G1=0;

else if(PH>=4.5||PH<5)

G1=40;

else if(PH>=5||PH<6)

G1=60;

else if(PH>=6||PH<6.5)

G1=80;

else if(PH>=6.5||PH<=7)

G1=100;

/*SCALE RATING FOR TOTAL HARDNESS,(mg/l)*/

if(THARD<300.0)

G2=100;

else if(THARD=>300||THARD<400)

G2=80;

else if(THARD=>400||THARD<500)

G2=60;

else if(THARD>=500||THARD<=600)

G2=40;

else if(THARD>600)

G2=0;

/* SCALE RATING FOR B.O.D.(5-DAY),(mg/l)*/

if(BOD<1.5)

G3=100;

else if(BOD=>1.5||BOD<3)

G3=80;

else if(BOD=>3||BOD<6)

G3=60;

else if(BOD=>6||BOD<=12)

G3=40;

else if(BOD>12)

G3=0;

/* SCALE RATING FOR TOTAL
ALKALINITY,(mg/l)*/

if(TOALK<200)

G4=100;
```

```
else if(TOALK=>200||TOALK<325)
G4=80;
else if(TOALK=>325||TOALK<450)
G4=60;
else if(TOALK=>450||TOALK<=600)
G4=40;
else if(TOALK>600)
G4=0;
/* SCALE RATING FOR DISSOLVED OXYGEN,(mg/l)*/
if(DO>7)
G5=100;
else if(DO=>4.4||DO=<7.0)
   G5=80;
else if(DO=>4.1||DO=<5.0)
G5=60;
else if(DO=>3.0||DO=<4.0)
G5=40;
else if(DO<3.0)
G5=0;
/*SCALE RATING FOR TOTAL DISSOLVED SOLIDS,(mg/l)*/
if(TDS<=500.0)
G6=100;
else if(TDS>500||TDS<1500)
G6=80;
else if(TDS=>1500||TDS<2100)
G6=60;
else if(TDS=>2100||TDS<=3000)
G6=40;
else if(TDS>3000)
G6=0;
/*SCALE RATING FORE TOTAL SUSPENDED SOLIDS,(mg/l)*/
if(TSS<30)
G7=100;
else if(TSS=>30||TSS<60)
G7=80;
else if(TSS=>60||TSS<80)
G7=60;
else if(TSS=>80||TSS<=100)
G7=40;
else if (TSS>100)
G7=0;
/* SCALE RATING FOR CHLORIDES,(mg/l)*/
if(CHLOR<150)
G8=100;
else if(CHLOR=>150||CHLOR<250)
G8=80;
else if(CHLOR=>250||CHLOR<600)
G8=60;
else if(CHLOR=>600||CHLOR<=800)
G8=40;
else if(CHLOR>800)
G8=0;
/*SCALE RATING FOR NITRATE,(mg/l)*/
if(TSS<20.0)
G9=100;
else if(NITRATE=>20||NITRATE<45)
G9=80;
else if(NITRATE=>45||NITRATE<50)
G9=60;
else if(NITRATE=>50||NITRATE<=100)
G9=40;
else if(NITRATE>100)
G9=0;
/*SCALE RATING FOR SULPHATE,(mg/l)*/
if(SULPHATE<150.0)
G10=100;
else if(SULPHATE=>151||SULPHATE<250)
G10=80;
else if(SULPHATE=>250||SULPHATE<400)
G10=60;
else if(SULPHATE=>400||SULPHATE<=1000)
G10=40;
else if (SULPHATE>1000)
G10=0;
/*SCALE RATING FOR TOTAL NUMBER OF COLIFORM, (MPN/100Ml)*/
if(MPN<=50.0)
G11=100;
else if(MPN>50||MPN<=500)
G11=80;
else if(MPN=>501||MPN<=5000)
G11=60;
else if(MPN=>5001||MPN<=10000)
G11=40;
else if (MPN>10000)
G11=0;
/* CALCULATING WATER QUALITY INDEX(WQL) */
WQI=G1*PH1+G2*THARD1+G3*BOD1+G4*TOALK1
+G5*DO1+G6*TDS1+G7*TSS1+G8*CHLOR1
+G9*NITRATE1+G10*SULPHATE1+G11*MPN1;
```

```
printf("_____\
n");

printf("WATER QUALITY INDEX=%3.2f\n",WQI);

printf("_____\
n");

fprintf(f7,"WATER QUALITY INDEX=3.2f\n",WQI);

/* ASSESSING DEGREE OF POLLUTION */

if(WQI>80)

printf("DEGREE OF POLLUTION :

 EXCELLANT-ACCEPTABLE RANGE\n");

else if(WQI>60)

printf("DEGREE OF POLLUTION :

ACCEPTABLE-SLIGHTLY POLLUTED \n");

else if(WQI>40)

printf("DEGREE OF POLLUTION :

SLIGHTLY POLLUTED- POLLUTED\n");

else if(WQI>=0)

printf("DEGREE OF POLLUTION :

POLLUTED - HEAVY POLLUTED RANGE\n");

RANGE\n");

printf("_____")
;

getch();

fclose(f7);

printf("END OF PROGRAM");

}
```

B. Computer Program No 2.

Program for calculation of water//* quality Index (WQI) and to assess the*/Increase or Decrease in Pollution*/ By Calculating The Sensitivity Index*/*

Program Written for Calculating Water/ Quality Index for Damoder River*/*

```
#include<stdio.h>

#include<math.h>

void main()

{

FILE *f8;

float

DO,PH,BOD,CHLOR,HARD,TSS,TDS,TOALK,NO3,S04,
MPN,G,WQI;

float

DO1,PH1,BOD1,CHLOR1,HARD1,TSS1,TDS1,TOALK1,
NO31,SO41,MPN1;

float
G1,G2,G3,G4,G5,G6,G7,G8,G9,G10,G11,SI,LWQI,WQI1;

f8=fopen("f8","w");

//clrscr();

printf("PH OF THE DAMODER RIVER
WATER(PH)=\n");

scanf("%f",&PH);

printf("TOTAL HARDNESS OF RIVER WATER AS
CaCO3(HARD),mg/l=\n");

scanf("%f",&HARD);

fprintf(f8,"HARD=%f\n",HARD);

printf("BOD OF RIVER WATER(BOD),mg/l=n");

scanf("%f",&BOD);

fprintf(f8,"BOD=%f\n",BOD);

printf("TOTAL ALKALINITY OF RIVER WATER
(TOALK),mg/l=\n");

scanf("%f",&TOALK);

fprintf(f8,"TOALK=%f\n",TOALK);

printf("DISSOLVED OXYGEN CONCENTRATION IN
RIVER WATER\n");

printf("(DO),mg/l=\n");

scanf("%f",&DO);

fprintf(f8,"DO=%f\n",DO);

printf("TOTAL DISSOLVED SOLIDS PRESENT IN
RIVER WATER(TDS),mg/l=\n");

scanf("%f",&TDS);

fprintf (f8,"TDS=%f\n",TDS);

print f("TOTAL SUSPENDED SOLIDS
PRESENT(TSS),mg/l=\n");

scanf ("%f",&TSS);

fprintf(f8,"TSS=%f\n",TSS);

print f("CHLORIDE PRESENT IN RIVER
WATER(CHLOR),mg/l=\n");

scanf("%f",&CHLOR);

fprintf(f8,"CHLOR=%f\n",CHLOR);

printf("NITRATE PRESENT IN RIVER
WATER(NO3),mg/l=\n");

scanf("%f",&NO3);

fprintf(f8,"NO3=%f\n",NO3);

printf("SULPHATE PRESENT IN RIVER
WATER(SO4),mg/l=\n");

scanf("%f",&SO4);

fprintf(f8,"SO4=%f\n",SO4);

printf("TOTAL COLIFORM/100MLPRESENT INRIVER
WATER

(MPN),mg/l=\n");

scanf("%f",&MPN);

fprintf(f8,"CHLOR=%f\n",MPN);

printf("LAST WATER QUALITY INDEX
CALCULATED(LWQI)=\n");

scanf("%f",&LWQI);

fprintf(f8,"LWQI=%f\n",LWQI);

/*UNIT WEIGHTS OF DIFFERENT PARAMETERS*/

PH1=0.13;

THARD1=0.07;

BOD1=0.13;
```

```
TOALK1=0.1;
DO1=0.13;
TDS1=0.07;
TSS1=0.07;
CHLOR1=0.03;
NO31=0.1;
SO41=0.03;
MPN1=0.13;
/*SCALE RATING FOR PARAMETER PH*/
if(PH<4.5||PH>=9.5)
G1=0;
else if(PH>=4.5||PH<5)
G1=40;
else if(PH>=5||PH<6)
G1=60;
else if(PH>=6||PH<6.5)
G1=80;
else if(PH>=6.5||PH<=7)
G1=100;
/*SCALE RATING FOR TOTAL HARDNESS,(mg/l)*/
if(THARD<300.0)
G2=100;
else if(THARD=>300||THARD<400)
G2=80;
else if(THARD=>400||THARD<500)
G2=60;
else if(THARD>=500||THARD<=600)
G2=40;
else if(THARD>600)
G2=0;
/*SCALE RATING FOR B.O.D.(5-DAY),(mg/l)*/
if(BOD<1.5)
G3=100;
else if(BOD=>1.5||BOD<3)
G3=80;
else if(BOD=>3||BOD<6)
G3=60;
else if(BOD=>6||BOD<=12)
G3=40;
else if(BOD>12)
G3=0;
/*SCALE RATING FOR TOTAL ALKALINITY,(mg/l)*/
if(TOALK<200)
G4=100;
else if(TOALK=>200||TOALK<325)
G4=80;
else if(TOALK=>325||TOALK<450)
G4=60;
else if(TOALK=>450||TOALK<=600)
G4=40;
else if(TOALK>600)
G4=0;
/*SCALE RATING FOR DISSOLVED OXYGEN,(mg/l)*/
if(DO>7)
G5=100;
else if(DO=>4.4||DO=<7.0)
G5=80;
else if(DO=>4.1||DO=<5.0)
G5=60;
else if(DO=>3.0||DO=<4.0)
G5=40;
else if(DO<3.0)
G5=0;
/*SCALE RATING FOR TOTAL DISSOLVED SOLIDS,(mg/l)*/
if(TDS<=500.0)
G6=100;
else if(TDS>500||TDS<1500)
G6=80;
else if(TDS=>1500||TDS<2100)
G6=60;
else if(TDS=>2100||TDS<=3000)
G6=40;
else if(TDS>3000)
G6=0;
/*SCALE RATING FORE TOTAL SUSPENDED SOLIDS,(mg/l)*/
if(TSS<30)
G7=100;
else if(TSS=>30||TSS<60)
G7=80;
else if(TSS=>60||TSS<80)
G7=60;
else if(TSS=>80||TSS<=100)
G7=40;
else if (TSS>100)
G7=0;
/* SCALE RATING FOR CHLORIDES,(mg/l)*/
if(CHLOR<150)
G8=100;
else if(CHLOR=>150||CHLOR<250)
G8=80;
else if(CHLOR=>250||CHLOR<600)
```

```
G8=60;
else if(CHLOR=>600||CHLOR<=800)
G8=40;
else if(CHLOR>800)
G8=0;
/*SCALE RATING FOR NITRATE,(mg/l)*/
if(TSS<20.0)
G9=100;
else if(NITRATE=>20||NITRATE<45)
G9=80;
else if(NITRATE=>45||NITRATE<50)
G9=60;
else if(NITRATE=>50||NITRATE<=100)
G9=40;
else if (NITRATE>100)
G9=0;
/*SCALE RATING FOR SULPHATE,(mg/l)*/
if(SULPHATE<150.0)
G10=100;

/*CALCULATING WATER QUALITY INDEX (WQI)*/
WQI=G1*PH1+G2*HARD1+G3*BOD1+G4*TOALK1+
G5*DO1+G6*TDS1+G7*TSS1+G8*CHLOR1
+G9*NO31+G10*SO41+G11*MPN1;
printf("-------------------------\n");
printf("WATER QUALITY INDEX=%3.2f\n",WQI);
printf("-------------------------\n");
fprintf(f8,"WATER QUALITY INDEX=%3.2f\n",WQI);
/*ASSESSING DEGREE OF POLLUTION*/
if(WQI>80)
printf("DEGREE OF POLLUTION:EXCELLENT-
ACCEPTABLE RANGE\n");
else if(WQI>60)
printf("DEGREEOFPOLLUTION:ACCEPTABLE-
SLIGHTLYPOLLUTED RANGE\n");
else if(WQI>40)
printf("DEGREEOFPOLLUTION:SLIGHTLYPOLLUTED
-POLLUTED RANGE\n");
else if(WQI>=0)
else if(SULPHATE=>151||SULPHATE<250)
G10=80;
else if(SULPHATE=>250||SULPHATE<400)
G10=60;
else if(SULPHATE=>400||SULPHATE<=1000)
G10=40;
else if (SULPHATE>1000)
G10=0;
/*SCALE RATING FOR TOTAL NUMBER OF
COLIFORM, (MPN/100Ml)*/
if(MPN<=50.0)
G11=100;
else if(MPN>50||MPN<=500)
G11=80;
else if(MPN=>501||MPN<=5000)
G11=60;
else if(MPN=>5001||MPN<=10000)
G11=40;
else if (MPN>10000)
G11=0;
printf("DEGREEOF POLLUTION:POLLUTED-HEAVY
POLLUTED RANGE\n");
printf("--------------------\n");
}/*CALCULATING THE SENSITIVITY INDEX*/
SI=(WQI-LWQI)/WQI;
printf("SENSITIVITY INDEX(SI)=%f\n",SI);
fprintf(f8,"SENSITIVITY INDEX(SI)=%f",SI);
printf("-------------------------\n");
if(SI>0)
printf("SI>0:WATER QUALITY IMPROVED\n");
if(SI==0)
printf("SI=0:NO CHANGE IN THE POLLUTION
STATUS\n");
if(SI<0)
printf("SI<0:POLLUTION IS INCREASING\n");
printf("--------------------\n");
getch();
fclose(f8);
printf("ENDOFPROGRAM
```