Rapid Assessment of Water Quality Index of Ramganga River, Western Uttar Pradesh (India) Using a Computer Programme

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Abstract: Rivers play an imperative role in the development of nation and sustenance of life, which are being polluted due to speedy urbanization, industrialization and other developmental activities. For the rapid assessment of WQI in terms of pollution level and the quality of river Ramganga of western Uttar Pradesh India, a computer programme was prepared based on the eight physico-chemical parameters viz. pH, Biological Oxygen Demand, Dissolved Oxygen, Total Alkalinity, Total Hardness, Total Solids, Total Suspended Solids and Chloride. Water quality index (WQI) is a useful tool for quick estimation of quality of any water resource. The river water was classified into permissible, slight, moderate and severe on the basis of the pollution strength at six sampling stations selected from upstream to downstream of the river for a period of three years. The water of upstream sampling stations from SS1 to SS4 were found in between slight to permissible range of the pollution while downstream sampling stations SS5 and SS6 were extremely polluted ranged from severe to moderate. High pollution load in downstream was caused by the effluent drainage from sugar industry as well as electroplating units of brass industries located in Moradabad. [Nature and Science 2010;8(11):1-8]. (ISSN: 1545-0740).

Key words: Computer programme, Water quality index, River Ramganga, Anthropogenic activities.

1. Introduction

Environmental pollution is one of the most horrible crises that we are facing today. Due to the increased urbanization and industrialization surface water pollution has become an crucial problem. It is necessary to obtain precise and appropriate information to observe the quality of any water resources and the development of some useful tools to keep watch on the quality of such priceless water resources to retain their excellence for various beneficial uses.

Water quality index is one of the most effective tools to monitor the surface as well as ground water pollution and can be used efficiently in the implementation of water quality upgrading programmes. The objective of an index is to turn multifaceted water quality data into simple information that is comprehensible and useable by the public. Water quality index was first formulated by Horton (1965) and later on used by several workers for the quality assessment of different water resources. It is one of the aggregate indices that have been accepted as a rating that reflects the composite influence on the overall quality of numbers of precise water quality characteristics (Tiwari and Mishra, 1985). Water quality index provide information on a rating scale from zero to hundred. Higher value of WQI indicates better quality of water and lower value shows poor water quality.

Much of the work has been done on the water quality indices of several rivers of India and abroad by various workers viz., Bhatt and Pathak (1992), Kumar and Shukla (2002), Patil *et.al.* (2006), Sindhu and Sharma (2007), Santosh and Shrihari (2008), Ramakrishanaiah *et.al*. (2009), Samantray *et.al.* (2009). Earlier attempts were made to assess the water quality index of river Ramganga in a very small stretches by Pandey and Sharma (1999) and Sinha *et.al.* (2004). The present study was aimed to assess rapid and accurate calculation of WQI of river Ramganga from Kalagarh hydroelectric dam to district Moradabad covering a distance of about 100 km in order to compare the pollution level between upstream and downstream sampling stations.

1.1 Study area

River Ramganga is spring fed river and important tributary of holy river Ganga, originated in the southern slopes at Dudhatoli (3,110 masl) of middle Himalaya of Uttrakhand state. The river enters the plains at Kalagarh where a famous hydroelectric dam has been constructed in 1975 responsible for the obstruction of continuous natural flow of water in downstream. The substratum of the river at upstream and somewhat middle segment consists of bedrocks, boulders and gravels while it is composed of sand, silt and clay at downstream. The river traverses near about 158 km before it meets the reservoir and continuous to downstream for about 322 km before joining river Ganga at Kannauj of Uttar Pradesh. The total catchment area of the basin is 32,493 km^2. The study area of the river catchments

lie between North latitude 29°29′42″ and 28°49′32″ and east longitude 78°45′37″ and 78°47′53″. Moradabad is the first major city in the way of Ramganga situated on the right bank where brass, iron, steel, sugar, paper and pulp, and food industries are established.

2. Materials and Methods

For the assessment of river water quality, six sampling stations were selected covering about 100 km stretch along the course of river Ramganga viz. Kalagarh (SS1, 29°29′42″ N - 78°45′37″), Seohara (SS2, 29°14′38″N - 78°39′13″ E), Mishripur (SS3, 29°04′06″ N -78°41′49″ E), Agwanpur (SS4, 28°56′58″ N - 78°43′27″ E), Lalbagh (SS5, 28°50′29″ N - 78°47′24″ E), and Katghar (SS6, 78°47′24″ E - 78°47′53″ E). Monthly sampling was conducted at six sampling stations during entire study period from June 2005 to May 2008 and subjected to physico-chemical analysis followed by the methods given in APHA (1995), Trivedy and Goel (1987) and Golterman (1975).

In present investigation, classification of river Ramganga of western Uttar Pradesh for their various beneficial uses has been done more realistically and accurately by using water quality index (WQI) taking parameters such as pH, Biological Oxygen Demand, Dissolved Oxygen, Total Alkalinity, Total Hardness, Total Solids, Total Suspended Solids and Chloride. The method for calculating water quality index by a computer programming based on the calculation as suggested by Tiwari and Mishra (1985), Singh (1992), Patel and Desai (2006), and Dwedi and Pathak (2007). There are two fundamental steps for calculating WQI. (1) Firstly, a quality rating was calculated for each water quality parameter used in the indices and (2) Aggregating these sub indices into over all index.

2.1 Weight Assigned and Rating Scale:

Weighing means the relative importance of each water quality parameter that play some significant role in overall water quality and it depend on the permissible limit in drinking water set by National and International agencies viz., ICMR and WHO etc. In this method, the quality scale rating was assign to each significant parameter and also weighed according to its relative importance. Those parameters, which have low permissible limits and can influence the water quality to a large extent even fluctuate a little, allocate high weighing while parameter having high permissible limit and are less harmful to the water quality allocate low weighing. The maximum weight of 4 has been assigned to the parameters such as pH, BOD, Dissolved Oxygen and Total Solids for their major role in controlling the overall water quality whereas other parameters like Total hardness, Total Suspended Solids, and Chloride has been assigned weight 2. Total Alkalinity has been assigned with weight 3 (Table 1). After allocation of weight, the unit weight for each parameter was calculated by the following formula.

Unit weight (Wi) = W/ ∑W
∑ Wi = 1
Where,
W = Weight assigned to parameter.
∑W = Sum of weights of all parameters

In order to calculate water quality index, each parameter has also been assign a rating value, which fall between 0 to 100 **(**Table 2). The rating (qi) values have been assigned to the parameters by dividing the range of its concentration in the water into four stages as Permissible, Slight, Moderate and Sever. The rating scale (qi) = 0 implies that the concentration of the parameter in water remained exceed by the standard maximum permissible limits and water is highly polluted, the rating scale (qi) = 100 denotes the excellent water quality since the parameter remained within the prescribed permissible limit for drinking water.

Table 1: Water quality parameters used in calculating WQI.

Parameters	Standard values	Weight assign	Unit weight
PH	7-8.5	4	0.16
Total Hardness	100 - 500	2	0.08
B.O.D	1 – 6	4	0.16
Total Alkalinity	<120	3	0.12
Dissolved Oxygen	>6	4	0.16
Total Solids	500 -1500	4	0.16
Total Suspended Solids	<100	2	0.08
Chloride	200 - 500	2	0.08

Table 2: Quality rating scale for water quality parameters (qi)

Parameters	Permissible 100	Slight 80	Moderate 50	Severe 0
PH	7.0-8.50	8.6-8.8	8.9-9.2	>9.2
		6.8-7	6.5-6.7	<6.5
Total Hardness	<100	101-300	301-500	>500
B.O.D	<1.0	1.1-3.0	3.1-5.0	>6.0
Total Alkalinity	<50	50-85	85-120	>120
Dissolved Oxygen	>6.0	4.5-5.9	3.0-4.4	<3.0
Total Solids	<500	501-1000	1001-1500	>1500
Total Suspended Solids	<30	30-65	66-100	>100
Chloride	<200	200-400	401-600	>600

The other ratings falling between these two extreme limits representing intermediate conditions of the water. Now, sub index (SI) was calculated as follows-

Sub Index (SI)i = qi x Wi

Where,

(SI)i = Subindex of i^{th} parameter.

Wi = Unit weight of i^{th} parameter.

qi = quality rating of i^{th} parameter.

Finally, water quality index for "n" parameter was calculated as-

$WQI = \sum (qi \times Wi)_n$

On the basis of above calculation, a computer programme was prepared for the rapid assessment of water quality index.

2.2 Computer programme for calculation of water quality index of river Ramganga

```
// WaterQualityIndex.cpp : Defines the entry point for the console application.
//

/*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 RAMGANGA RIVER */
/*************************************************/
#include <stdio.h>
#include <math.h>
#include <conio.h>
void main()
        {
                char option = 'n';
                do
                {
                FILE *filePtr;
                    float DO = 0.0,PH = 0.0,BOD = 0.0,CHLOR = 0.0,HARD = 0.0,TSS = 0.0,TS = 0.0,TOALK = 0.0,G = 0.0,WQI = 0.0, SI = 0.0;
                float DO1,PH1,BOD1,CHLOR1,HARD1,TSS1,TS1,TOALK1;
                float G1,G2,G3,G4,G5,G6,G7,G8,LWQI, WQI1;
                char date[12];

        filePtr=fopen("RAMGANGA.txt","a");
                printf("\nPlease press enter after giving the value");
                printf("\nPH OF THE RAMGANGA RIVER WATER (PH)= ");
                scanf("%f",&PH);
                char newLine = '\n';
                fputc(newLine, filePtr);
                fprintf(filePtr,"%f\t",PH);
                    printf("\nTOTAL HARDNESS OF RIVER WATER AS CaCO3 (HARD), mg/l= ");
                scanf("%f",&HARD);
                fprintf(filePtr,"%f\t",HARD);
                printf("\nBOD OF RIVER WATER (BOD), mg/l= ");
                scanf("%f",&BOD);
                fprintf(filePtr,"%f\t",BOD);
                    printf("\nTOTAL ALKALINITY OF RIVER WATER (TOALK), mg/l= ");
                scanf("%f",&TOALK);
                fprintf(filePtr,"%f\t",TOALK);
                    printf("\nDISSOLVED OXYGEN CONCENTRATION IN RIVER WATER(DO), mg/l= ");
                scanf("%f",&DO);
                fprintf(filePtr,"%f\t",DO);
```

```
                printf("\nTOTAL SOLIDS
            PRESENT IN RIVER WATER
            (TS), mg/l= ");
            scanf("%f",&TS);
            fprintf(filePtr,"%f\t",TS);
            printf("\nTOTAL SUSPENDED
SOLIDS PRESENT (TSS),mg/l= ");
            scanf("%f",&TSS);
            fprintf(filePtr,"%f\t",TSS);
                printf("\nCHLORIDE
            PRESENT IN RIVER WATER
            (CHLOR), mg/l= ");
            scanf("%f",&CHLOR);
            fprintf(filePtr,"%f\t",CHLOR);
            printf("\nLAST WATER
QUALITY INDEX CALCULATED (LWQI)= ");
            scanf("%f",&LWQI);
            fprintf(filePtr,"%f\t",LWQI);
                printf("\nSpecify the date for
            the given data in (dd/mm/yyyy)
            format ");
            scanf("%s",&date);
            printf("%s", date);

            /* UNIT WEIGHTS OF
DIFFERENT PARAMETERS */
            PH1=0.16f;
            HARD1=0.08f;
            BOD1=0.16f;
            TOALK1=0.12f;
            DO1=0.16f;
            TS1=0.16f;
            TSS1=0.08f;
            CHLOR1=0.08f;

            /* SCALE RATING FOR
PARAMETER PH */
            if(PH<6.5 || PH>9.2)
                  G1=0;
            else if(PH<=6.7 || PH>=8.9)
                  G1=50;
            else if(PH<7 || PH>=8.6)
                  G1=80;
            else if(PH<=8.5 || PH>=7)
                  G1=100;
            /* SCALE RATING FOR TOTAL
HARDNESS, (mg/l) */
            if(HARD<100.0)
                  G2=100;
            else if (HARD<=300.0)
                  G2=80;
            else if (HARD<=500.0)
            G2=50;
            else if (HARD>500.0)
                  G2=0;
            /* SCALE RATING FOR
B.O.D.(5-DAY), (mg/l) */
            if(BOD<=1.0)
                  G3=100;
            else if (BOD<=3.0)
                  G3=80;
            else if (BOD<=5.0)
                  G3=50;
            else if (BOD>6.0)
                  G3=0;
            /* SCALE RATING FOR TOTAL
ALKALINITY, (mg/l) */
            if(TOALK<50)
                  G4=100;
            else if(TOALK<=85.0)
                  G4=80;
            else if(TOALK<=120.0)
                  G4=50;
            else if(TOALK>120.0)
                  G4=0;
            /* SCALE RATING FOR
DISSOLVED OXYGEN,(mg/l) */
            if(DO>6)
                  G5=100;
            else if(DO>=4.9)
                  G5=80;
            else if(DO>=4.4)
                  G5=50;
            else if(DO<3)
                  G5=0;
            /* SCALE RATING FOR TOTAL
SOLIDS, (mg/l) */
            if(TS<500.0)
                  G6=100;
            else if(TS<=1000.0)
                  G6=80;
            else if(TS<=1500.0)
                  G6=50;
            else if(TS>1500.0)
                  G6=0;
            /* SCALE RATING FOR TOTAL
SUSPENDED SOLIDS, (mg/l) */
            if(TSS<30.0)
                  G7=100;
            else if (TSS<=65.0)
                  G7=80;
            else if (TSS<=100.0)
                  G7=50;
            else if (TSS>100.0)
                  G7=0;
            /* SCALE RATING FOR
CHLORIDES, (mg/l) */
            if(CHLOR<200.0)
                  G8=100;
            else if (CHLOR<=400.0)
                  G8=80;
```

```
                else if (CHLOR<=600.0)
                        G8=50;
                else if (CHLOR>600.0)
                        G8=0;
                /* CALCULATING WATER
QUALITY INDEX (WQI) */
                    WQI=G1*PH1+G2*HARD1+
                G3*BOD1+G4*TOALK1+G5*DO
                1+G6*TS1+G7*TSS1+G8*CHLO
                R1;
                    printf("\n----------------------------
                ------------------\n");
                printf("WATER QUALITY
INDEX = %3.2f\n",WQI);
                    printf("------------------------------
                ----------------\n");
                fprintf(filePtr,"%3.2f\t\t",WQI);
            /* CALCULATING THE
        SENSITIVITY INDEX */
                SI= (WQI-LWQI)/WQI;
                printf("SENSITIVITY INDEX
(SI)= %f",SI);
                fprintf(filePtr,"%f",SI);
                    printf("\n----------------------------
                ------------------\n");
                if(SI>0)
                        printf("SI>0: WATER
QUALITY IS 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");
                fputc('\t', filePtr);
                fputs(date,filePtr);
                fclose(filePtr);
                printf("\Do u want to enter another
entry press(Y/N)");
                fflush(stdin);
                scanf("%c",&option);
                }while(option == 'y' || option ==
'Y');
            printf("\nEND OF PROGRAM");
            }
```

With the help of above computer programme, all the observed values of selected parameters were feed as an input and results was obtained in the form of WQI and sensitivity index as an output.

3. Results and Discussion

Results of water quality index obtained by the computer programme have been depicted in Table 4, which revealed many remarkable features regarding the pollution status of river Ramganga at six sampling stations from Kalagarh to Katghar. It was noted that none of the sampling station during entire study period, have WQI = 100 implies that the water of none of these sampling stations is fit for human consumption directly without treatment. Results revealed that at sampling station 1, Kalagarh, the WQI found varied from 52.80 to 90.40, the minimum value of WQI was recorded in the month of August 2006 and the maximum value was obtained in the month of October 2005, January and February 2006. The mean value (78.64 ± 1.39) of WQI at Kalagarh were found highest and fall between slight to permissible range of pollution but in most occasions it reached up to the permissible range indicating the water of the river at this station remained either cleaned or only slightly polluted all most throughout the year. Kalagarh is located at the upstream of the river having less anthropogenic activities

At sampling station 2, Seohara, the WQI of the river was found in the ranged between 64.00 to 91.20 with the mean value of 78.20 ± 1.05 which fall in the pollution range of slight to permissible and some of the time it was shifted toward the permissible range representing the lesser amount of pollution in the river. The mean value of water quality index were found to be almost same as Kalagarh station, therefore the river water quality at this station remained more or less similar to that of Kalagarh since it is devoid of any direct source of pollution and anthropogenic activities.

The water of sampling station 3, Mishripur, showed slight to permissible range of pollution but at most of the time it remained slightly polluted during the entire study period. The WQI varied between 54.40 and 82.40, minimum during August 2006 and maximum in the month of December 2005. The mean value of the WQI at this station was found 72.80 ± 0.91 indicating the increasing load of pollution in comparison to previous stations of upstream may be due to the occasional mixing of effluent discharged by the sugar industry at this station. The water at Agwanpur (SS 4) remained within slight to permissible pollution range. The value of water quality index varied from 54.40 to 82.40 with mean value of 71.30 ± 1.01.

Water of river Ramganga at Sampling Lalbagh (SS 5) and Katghar (SS 6) remained excessively polluted and reached up to the sever range of pollution. The mean value of water quality index at Lalbagh (SS5), was noted as 47.80 ± 1.01 with the range from 30.40 to 62.40 and at Katghar (SS 6), it was 48.98 ± 1.09 with the range from 35.20 to 62.40. The higher mean value of WQI at Katghar (SS 6)

indicates that river water gets self-purified as it travels from station 5 to 6. Similar result was reported by Kaur *et.al.* (2001). These two stations of Ramganga river receives copious amounts of domestic sewage of the city and effluent from several brass industries located in the vicinity of the city.

The water of the river Ramganga was classified on the basis of the pollution extent into five classes (Table 3). Class I represented excellent water quality (WQI between 90-100) fall in the permissible range of water. Class II represented slight to permissible range of pollution (WQI between 70-89) having good water quality while class III corresponded to moderate to slight range of pollution (WQI between 50-69) and the water quality remained satisfactory. Class IV and V both represented severe to moderate range of pollution but poor (WQI between 26-49) and unacceptable (WQI between 0-25), respectively.

Results presented in table 4 revealed that the water quality from SS1 to SS4 reflects good water condition at most of the time as the mean value of WQI fall in the range of slight to permissible while SS5 and SS6 in downstream gets polluted by adding the municipal sewage and industrial effluents and the mean value of WQI of these stations fall in the severe to moderate range of pollution indicating poor quality of water.

Table: 3 Degree of pollution in Ramganga river.

Class	WQI	Degree of pollution	Water quality
I	90-100	Permissible range	Excellent
II	70-89	Slight to permissible range	Good
III	50-69	Moderate to slight range	Satisfactory
IV	26- 49	Severe to moderate range	Poor
V	0-25	Severe to moderate range	Unacceptable

Table 4: Water quality index of Ramganga river at six sampling stations.

Months	SS1	SS2	SS3	SS4	SS5	SS6
June 05	86.80	76.80	79.20	76.40	38.40	35.20
July 05	66.00	81.60	64.00	81.60	38.40	52.40
Aug 05	79.60	76.80	65.20	65.20	52.40	46.40
Sept 05	68.80	64.00	72.00	67.20	30.40	52.40
Oct 05	90.40	72.00	70.40	72.00	59.20	59.20
Nov 05	78.40	81.20	70.40	72.00	59.20	59.20
Dec 05	81.60	91.20	82.40	84.80	52.40	62.40
Jan 06	90.40	75.20	70.40	75.20	56.00	52.80
Feb 06	90.40	86.00	81.20	80.40	54.40	46.40
Mar 06	81.20	75.20	72.00	70.40	43.20	46.40
Apr 06	82.80	81.20	70.40	62.40	46.40	46.40
May 06	71.60	82.00	78.00	76.40	46.40	46.40
June 06	81.60	82.40	81.20	78.00	46.40	50.40
Jul 06	65.20	75.20	72.00	67.20	38.40	38.40
Aug 06	52.80	65.20	54.40	54.40	30.40	38.40
Sept 06	60.80	75.20	70.40	62.40	48.00	51.20
Oct 06	81.20	84.40	70.40	67.20	54.40	54.40
Nov 06	76.80	81.20	75.20	67.20	54.40	54.40
Dec 06	82.80	81.20	75.20	75.20	44.00	44.00
Jan 07	86.40	70.40	75.20	70.40	40.80	56.80
Feb 07	82.80	91.20	78.00	62.40	46.40	50.40
Mar 07	79.60	78.40	75.20	67.20	46.40	46.40
Apr 07	81.20	81.20	75.20	75.20	46.40	44.00
May 07	84.80	88.00	75.20	75.20	46.40	46.40
June 07	82.80	81.20	67.20	75.20	46.40	46.40
July 07	73.60	78.40	75.20	67.20	46.40	54.40

Aug 07	67.20	67.20	72.00	72.00	54.40	46.40
Sept 07	75.20	73.20	72.00	70.40	51.20	56.00
Oct 07	75.20	75.20	70.40	72.00	59.20	59.20
Nov 07	84.40	81.20	72.00	72.00	59.20	56.00
Dec 07	81.20	70.40	81.20	75.20	62.40	44.00
Jan 08	81.20	75.20	70.40	68.00	40.80	40.80
Feb 08	81.20	81.20	72.00	70.40	48.00	48.00
Mar 08	82.80	78.40	67.20	75.20	46.40	46.40
Apr 08	81.20	81.20	75.20	75.20	46.40	44.00
May 08	81.20	75.20	72.80	68.00	40.80	40.80
Mean ± SE	78.64 ± 1.39	78.20 ± 1.05	72.80 ± 0.91	71.30 ± 1.01	47.80 ± 1.29	48.98 ± 1.09

On the basis of the present investigation, it was found that the water of none of the sampling station of Ramganga river is not fit for direct human consumption. The upstream of river from Kalagarh (SS1) to Agwanpur (SS4) was found to have relatively clean to slightly pollute and may be used as bathing, swimming, laundry, irrigation, pisciculture and industrial purposes but in downstream sampling stations it was excessively polluted and inappropriate for bathing, swimming and pisciculture. Variation in the WQI at six sampling stations during the entire study period is demonstrated in figure 1. An abrupt decline in the values of WQI at sampling station 5 is noticed.

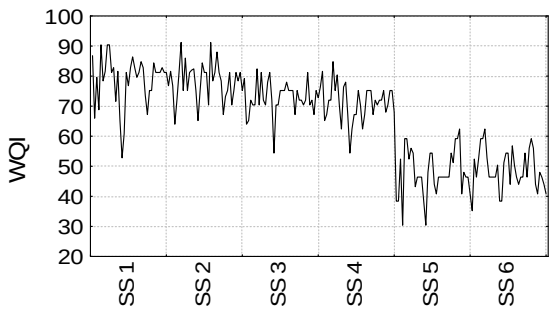

Figure 1: Spatial and temporal variation in WQI of Ramganga river at six sapling stations (Each sampling station represents 36 observations of three years, N = 216)

Therefore, it is concluded that the water quality index is an efficient tool to classify the water of the river for their various advantageous uses and give an rapid and precise idea about the pollution load in the river that may be worthwhile for policy makers.

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