Article-48

Poll Res. 41 (1) : 306-312 (2022)

ISSN 0257–8050

EVALUATION OF WATER QUALITY THROUGH WATER QUALITY INDEX (WQI), GOMTI RIVER, JAUNPUR CITY

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(Received 2 August, 2021; Accepted 6 September, 2021)

ABSTRACT

Jaunpur is an ancient city situated on the bank of River Gomti which bisects the municipal area of Jaunpur city (located between 25°44′ to 25°46′ North latitude and 82°40′ to 82°43′ East longitude) in the north and south directions. Population growth and urbanisation rate in the city is very high during last few decades. The rate of environmental degradation has accelerated due to the population growth and the process of urbanisation and industrialisation has increased the level of pollutants. All the sources of water in Jaunpur city has been deteriorated with the growth of population, urbanisation and industrialization. The river serves as a major source of domestic water supply of the Jaunpur city, subsequently; the river receives back the untreated domestic wastewater from Jaunpur city (about 450 mld) directly during its course. It causes the river water quality deterioration. While entering the city Gomti river water quality can be seen less polluted but it increases as it run in the city core. The study aims to determine the water quality of river Gomti in Jaunpur city. Water quality variables are integrated to determine the water quality index value along the river. In order to determine the water quality, seven stations were selected along the stretch of river. Data has been collected on the water quality from Gomti river through sampling and analysis for pre and post monsoon, 2015 and 2016. The Water Quality Index (WQI) was calculated using the Weighted Arithmetic Index method. This method appears to be more systematic and gives comparative evaluation of the water quality of sampling stations. It is also helpful for public to understand the quality of water as well as being a useful tool in many ways in the field of water quality management.

KEY WORDS : Water Quality, Water Quality Index, Water Pollution etc.

INTRODUCTION

Rivers due to their role in carrying off the urban and industrial waste water and surface run-off through agricultural land in their huge drainage basins are the most vulnerable water bodies to pollution. The enormous threats to the integrity of the world's great river basins have threatened the basis of our economies, the fabric action of our communities and the sources of drinking water. River water dilutes and degrades water pollutants faster than stable water, but the world figure shows that water bodies like river in the world are severely polluted and in worse condition. Industries, agriculture and population concentrated along the river are the major sources for pollution (CWC, 2018; Rai *et al.*,

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2021). The main areas that are subject to water quality threats are largely correlated to population densities and areas of economic growth, with the future scenarios determined largely by the same factors. In Asia,, Africa and Latin America water quality of almost all the rivers are in worse condition since the 1990s (UNEP, 2016a).

There are lots of primary threats faced by the major river basins (Salween, Danube, La Plata, Rio Grande, Ganges, Indus, Murray-Darling, Nile, Yangtze and Mekong) of the world. Deterioration of water quality is one of the major considerable threat among the primary threats (Wong, 2007). World population resides in Afghanistan; Iran; Pakistan; Maldives; Bhutan; India; Nepal; Bangladesh; Sri Lanka are only one fourth of the total, but these region have 4.5 percent (1,945 billion m^3) of the world's annual water resources which are renewable (43,659 billion m^3). India by far largest in terms of population and area, in South Asia, is home to one-sixth of the world's population, while only endowed with 1/25th of the world's available water resources (UNEP, 2008). Further due to lack of water resources as well as increasing population pressure has caused water pollution. Many of the water bodies in India polluted with the organics and other bacterial contains due to regular discharge of untreated water through industrial and domestic sector.

River in India are polluted severely and have in worsened condition from pollution from multiple sources from domestic, industrial and other economic sectors. Union government, in 2017, said that out of 445 river stretches 275 river of India are heavily polluted. So the river water in these sources are unfit for the consumption and were heavily laden with bacteria and pollutants like zinc and lead.

There are numerous works on water quality assessment by computation of Water Quality Index (WQI). Sisodia and Moundiotya (2006); Ziauddin and Siddiqui (2007); Dhakad, Shinde and Choudhary (2008); Samantray *et al.* (2009); Kumar and Dua (2009); Razak *et al.* (2009); Parmar and Parmar (2010); Bharti and Katyal (2011), Chauhan, *et al.* (2012) and Kumar *et al.* (2021) had worked on assessment of water quality by water quality Index (WQI).

Study area

The river Gomti flows through the central and eastern part of the U.P., covering a total distance of about 941 Km and drains into the river Ganga at Kaithi near Varanasi. The catchment area of the Gomti basin is 31009 km^2. This river basin covers 14 districts partially or fully, flowing through both rural and urban areas. Lucknow, Sultanpur, and Jaunpur are the three major urban settlements on the banks of the river. Kathna, Sarayan, Reth, Luni, Kalyani, and Sai are the major tributaries of the river Gomti. Jaunpur is an ancient city situated on the bank of River Gomti which bisects the municipal area of Jaunpur city (located between 25°44′ to 25°46′ North latitude and 82°40′ to 82°43′ East longitude) in the north and south directions. The river flows 5.5 km of its course in Jaunpur city.

Sample Station

Water samples were collected for two periods, Pre-monsoon and Post-monsoon season, from eight (08) cites selected stations in Jaunpur city drained by Gomti River. The eight sample stations were taken from Nadiapar to Mianpur Ghat. All of them are located at entire stretch of 5.5 km along the course of Gomti River in Jaunpur city. First stations (Nadiapar Ghat) is situated at upstream (Before 2 km entering the city) course of the river. Further at downstream, Tarapur ghat sample station is located after one kilometre from Nadiapar ghat. The third station at Gular Ghat is located 2.4 kilometres downstream from Nadiapar ghat just before the Shahi Bridge. Hanuman Ghat (fourth station) is located in the left bank of Gomti River at east of Shahi Bridge. The other sample stations along the downstream are Balua ghat sample station, Miyanpur Ghat in the right bank and Chachakpur ghat sample station is located at the margin of the city (Fig. 1). The sampling stations listed are located on stable space, with little deviation on the geographic location. All the samples were collected physically from a depth of 08 to 10 cm bellow from the surface of the river water.

Analytical Methods

Some of the parameters e.g. pH, dissolved oxygen, Electrical conductivity and total dissolved solids were analysed directly at each of the station instantly using portable water analysis kit. Method of Eaton *et al.* (1998), Goel and Trivedy (1986) and Tandon (1995) were used to analyse the other parameters e.g. alkalinity, total hardness, calcium and magnesium ions. Water quality index was calculated to evaluate the seasonal variation of water quality.

Water quality index (WQI) was calculated for

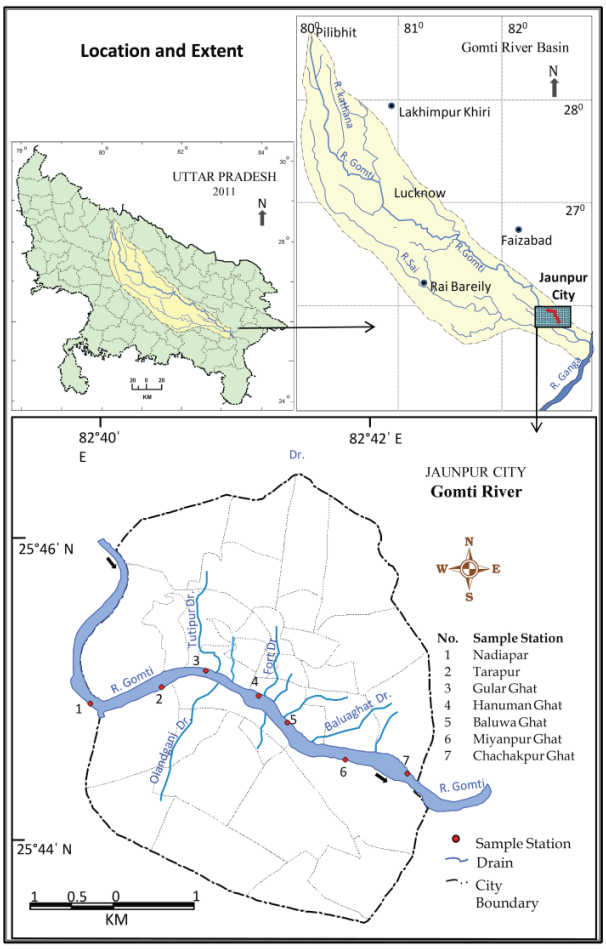

Fig. 1.

each month for assessing the suitability of water for biotic communities and also drinking purposes. Eleven important physico-chemical properties were taken under consideration using WHO standards. WQI for each station has calculated through pH, BOD, dissolved oxygen (DO), total dissolved solids (TDS), electrical conductivity (EC), total hardness, calcium (Ca) ions, magnesium (Mg) ions, Chloride, Alkalinity, COD and total alkalinity.

It was done by considering eleven important physico-chemical properties using WHO standards. In order to calculate WQI eleven important parameters, pH, BOD, dissolved oxygen (DO), total dissolved solids (TDS), electrical conductivity (EC), total hardness, calcium (Ca) ions, magnesium (Mg) ions, Chloride, Alkalinity, COD (colorimetric analysis) and total alkalinity have been selected. These parameters maximum contribute for the quality of river.

RESULT AND DISCUSSION

Level of Water Parameter in Gomti River, Pre-monsoon, Jaunpur city

The study of various water parameter was made to acquire the their level during different season. Study shows that the pH during pre-monsoon period is high due to huge influx of sewage and waste water discharged from drains into Gomti River. In general, the pH level declines from Nadiapar ghat to Chachakpur sample stations due to increasing number of drains and sewage (Table 1). During post-monsoon period the pH level declines due to huge discharge of fresh water with an average of 7.68. The BOD is found high at all the sample stations. It varies from 6.5 mg/l (Nadiapar ghat) to 8.4 mg/l (Chachakpur) with an average of 7.45 mg/l during pre-monsoon period. BOD level during pre-monsoon is higher than post-monsoon period at Nadiapar to Miyanpur Ghat due to discharge of sewage water from various drains. It shows that the

Table 1. Water Quality during Pre-Monsoon, Gomti River, Jaunpur city, 2016

Sl. No.	Parameter	Nadiapar Ghat	Tarapur	Gular Ghat	Hanuman Ghat	Baluwa Ghat	Miyanpur Ghat	Chachak Pur	WHO Standard
1	pH	8	8.0	8	7.8	7.7	7.6	7.6	8.5
2	BOD (mg/l)	6.5	7.1	7.5	7.9	8.9	8.9	8.4	6
3	DO (mg/l)	3.9	3.7	3.6	2.1	2.6	2.5	2.9	5
4	Conductivity µ mohos/cm	430.7	437.0	443.2	459.8	460.3	465.7	466.5	300
5	Total Hardness (mg/L CaCO3)	202	209.3	212.5	223.5	225	249.5	258.5	500
6	Calcium (mg/L Ca^{++})	36	36.1	36.2	39.6	41.4	45	45.2	75
7	Magnesium(mg/L mg^{++})	21.7	22.2	24.7	25.3	26	26.4	26.2	50
8	Chloride (mg/L)	24.8	25.7	25.8	27.8	28.5	32.8	31.4	250
9	Alkalinity (mg/L CaCO3)	211.5	225.3	239	241	250.5	260	269	200
10	COD (mg/L)	9.5	14.4	15.7	19.9	19.3	20.9	20.7	10
11	T.D.S. (mg/L)	218.5	220.0	225.5	233.5	252	256	254	500

Source: Field survey, 2016

BOD level remains higher than the standard given by WHO guidelines. The DO (dissolved oxygen) is significant in determining the water quality criteria of water. Temperature plays an important function in determining DO in an aquatic body. DO levels observed during pre-monsoon ranging between 3.9 mg/l (Nadiapar Ghat) to 2.9 mg/l (Chachak Pur), with an average of 3.4 mg/l. During the early part of pre-monsoon period there is a gradual decline in DO level. For rest of the summer season it remains comparatively low when temperature of the river water increases and leads to increase in rate of respiration and organic decomposition. Whereas, during post-monsoon season the DO level remains high at all the sample stations, ranging between 4.5 mg/l (Nadiapar Ghat), to 3.9 mg/l (Chachakpur) with an average of 4.17 mg/l due to huge influx of fresh water.

Conductivity ranges between 430.7 µ mohos/cm (Nadiyapar ghat) to 466.5 µ mohos/cm (Chachakpur) with an average of 451.9 µ mohos/cm which is much extremely high than WHO standard (300 µ mohos/cm) but During post-monsoon season it ranges from 344.9 µ mohos/cm (Nadiyapar ghat) to 411.9 µ mohos/cm (Chachakpur) with an average of 377.2 µ mohos/cm, due to the flux of rain water in the river (Table 2). Total Hardness (TH) during pre-monsoon, ranges between 202 mg/l (Nadiyapar ghat) to 258.5 mg/l (Chachakpur) with an average of 225.7 mg/l, much below the standard limit of 300 µ mohos/cm. Whereas, during post-monsoon period TH ranges between 182 mg/l (Nadiyapar ghat) to 203.0 mg/l (Chachakpur) with an average of 194.0 mg/l. COD is a useful indicator of organic pollution in surface water (Nagwenya, 2006). Its level is low than the permissible limit at Nadiapar sample station both during the pre and post-monsoon period because it is located in the outer fringe of the city with no drains. However, other sample stations show high concentration of COD level during pre-monsoon ranging from 14.4 mg/l (Tarapur), 20.7 mg/l (Chachakpur).

Calculation Water Quality Index (WQI)

Water Quality Index embodied a specific number (as grade) that represent the basically water quality at a definite location. Ziauddin A. and Siddiqui, N. A. 2007 has defined it as a score showing the compound weight of various water quality parameters on the overall quality of water. Selection of many parameters might expand the water quality index, so different water parameters should be use as to the intended use of water (Sisodia and Moundiotya, 2006). Weighted Arithmetic Index method has been used for calculation of WQI Present study (Chauhan and Thakor, 2012). The present analysis starts with the quality rating of each parameters, thus quality rating (Qi) was calculated.

$$\textit{Quality rating}\ (\text{Qi}) = 100 \left[\frac{(Vn - Vi)}{(Sn - Vi)} \right] \quad .. (1)$$

Where, V_n = Estimated value of the n^{th} parameter at a given sampling.

V_i = Ideal value of n^{th} Parameter in pure water.

S_n = Standard permissible value of nth parameter.

Each of the ideal values (V_i) are used as zero for drinking water except for pH=7.0 and dissolved oxygen=14.6mg/L.

Calculation of Relative weight (W_i) was done by a value inversely proportional to the recommended standard (S_i) of the corresponding parameters:

Table 2. Water Quality during Post-Monsoon, Gomti River, Jaunpur city, 2016

Sl. No.	Parameter	Nadiapar Ghat	Tarapur	Gular Ghat	Hanuman Ghat	Baluwa Ghat	Miyanpur Ghat	Chachak Pur	WHO Standard
1	pH	7.9	7.8	7.8	7.7	7.6	7.5	7.5	8.5
2	BOD (mg/l)	6.1	7.3	7.7	8.2	8.5	8.8	8.7	6
3	DO (mg/l)	4.5	4.4	4.4	4.1	4.0	3.9	3.9	5
4	Conductivity µ mohos/cm	344.9	348	355.1	377.2	394.9	408.4	411.9	300
5	Total Hardness (mg/L CaCO3)	182	183	188.5	198.5	201	202.5	203	500
6	Calcium (mg/L Ca++)	27	28.6	35.6	39.2	41.2	42.4	42.6	75
7	Magnesium(mg/L mg++)	18.1	18.6	19.2	20.1	21.7	22.6	22.7	50
8	Chloride (mg/L)	22.5	23.1	24.3	26.5	29.3	26.2	25.1	250
9	Alkalinity (mg/L $CaCO_3$)	203.2	208.3	213.5	217	225.5	232	235.5	200
10	COD (mg/L)	11.55	16.01	17.7	20.42	20.1	21.7	18.3	10
11	T.D.S. (mg/L)	192	202.5	219	222.5	227.5	238.5	239.5	500

Source: : Field survey, 2016

$$\textit{Relative weight}\ (W_i) = \frac{1}{Si} \quad .. (2)$$

Generally, WQI are discussed for a specific and intended use of water. In this study the WQI for drinking water is considered. The overall WQI was calculated by using the following equation:

$$\textit{Water Quality Index}\ (WQI) = \frac{\Sigma\, Wi\, Qi}{\Sigma\, Wi} \quad .. (3)$$

$$\text{WQI} = {}^{\Sigma\, Wi\, Qi}/_{\Sigma\, Wi} = {}^{44.29}/_{0.63} = \mathbf{69.86}$$

On the basis of different parameters for pre and post monsoon period classified WQI as good (below 100), moderately good (100 to 110), moderately poor (110 to 120) and poor (120 and above) (Table 5).

The data acquired from sampling stations shows that the parameters at downstream and the WQI is ranging from good to severe. The water quality is comparatively good in relation to the other six stations being located at upstream of river Gomti in Jaunpur city. As per the observed data these stations hold good quality of water for the purpose of drinking with conventional treatment. The sample stations particularly second station which is located at Tarapur have reasonably poor in quality during pre-monsoon season due to heavy influx load (solid waste) and waste water discharged before the monsoon. But during monsoon season the quality water become change to better due to commingle of fresh water due to rainfall and surface runoff.

Station III (Gular Ghat) has moderately good quality of water ranging from 109.06 to 110.78 respectively for post and pre monsoon period due to the heavy discharges from Tutipur drain from northern part and Olandganj Drain from southern part of the city. The northern region of this points is highly dense populated area and domestic discharges as waste water and solid waste generation is very high and became results in form of river water pollution. Fourth station named Hanuman Ghat is situated almost mid of the city and have heavy load of population density. The region around this points is the older most part of the city, thus the region is developed as residential cum commercial area. Several small and huge waste water drains discharge huge amount of polluted water to the river without any treatment procedure. Fort drain is one of the major drains which join the river from northern part of the region. Thus this station have comparatively higher load of pollution and WQI ranges 115.31 to 115.89 from pre monsoon to post monsoon respectively. Station fifth also have highly polluted station, as several drains joins the point from Machharhatta ward, Rasmandal, Pyarali, Tadtala and Urdubazar ward from northern region whereas from Olandganj, Umarpur, Jahangirabad and Hussainabd ward from southern part of the city, which results the higher pollution load at Balua Ghat ranges between 120.83 to 122.50 WQI from Post to Pre-monsoon period respectively. Sixth sample station Miyanpur ghat have very high WQI from rest of the point as it ranges between 123.27 to 124.32 from pre-monsoon to post-monsoon period respectively. The region around this point is also highly population region of the city. Several drain discharges waste water from Miyanpur, Hussainabad, Rashmand and Machharhatta ward from both side of the river. There is decreasing trend in pollution can be seen in the last station

Table 3. Calculation of WQI, Gomti River, Jaunpur, U.P., 2018

Sl. No.	Parameters	Chachakpur	Ideal Value	WHO Standard	Quality Rating (Qi)	Relative Weight (Wi)	Weighted Qi Value
1	pH	7.6	7	8.5	40.0000	0.1176	4.71
2	BOD (mg/l)	8.4	0	6	140.0000	0.1667	23.33
3	DO (mg/l)	2.9	14.6	5	121.8750	0.2000	24.38
4	Conductivity µ mohos/cm	466.5	0	300	155.5000	0.0033	0.52
5	Total Hardness (mg/L)	258.5	0	500	51.7000	0.0020	0.10
6	Calcium (mg/L)	45.2	0	75	60.2667	0.0133	0.80
7	Magnesium(mg/L)	26.2	0	50	52.4000	0.0200	1.05
8	Chloride (mg/L)	31.4	0	250	12.5600	0.0040	0.05
9	Alkalinity (mg/L)	269	0	200	134.5000	0.0050	0.67
10	COD (mg/L)	20.7	0	10	207.0000	0.1000	20.70
11	T.D.S. (mg/L)	254	0	500	50.8000	0.0020	0.10
						0.6340	76.41

Source: Personal computation, 2018

WQI: Σ Wi Qi / Σ Wi =120.53

Table 4. WQI of Gomti River, Pre & Post Monsoon, Jaunpur, 2018

Sample St. No.	Sample Points	Pre-Monsoon WQI	Post-Monsoon WQI
I.	Nadiapar Ghat	95.29	92.87
II.	Tarapur	106.42	104.36
III.	Gular Ghat	110.78	109.06
IV.	Hanuman Ghat	115.31	115.79
V.	Baluwa Ghat	122.50	115.91
VI.	Miyanpur Ghat	124.32	119.00
VII.	Chachak Pur	120.53	114.02

Source: Personal computation, 2018

Table 5. Water Quality Classification Based on WQI Value

Sl. No.	WQI Value range	Water Quality
1	Below 100	Good
2	100-110	Moderately poor
3	110-120	Poor
4	Above 120	Severe

Source: Personal computation, 2018

(Chachakpur) is located almost the end of the stretch in the city area. The population density around this sample station is comparatively lower than the other station located at upstream. This station possess WQI ranges between 119.60 to 120.53 from post-monsoon to pre-monsoon period respectively.

CONCLUSION

The BOD, DO, TDS, COD and other parameters at some of the stations has been observed beyond the permissible limit; water sample are polluted and is not appropriate for beneficial uses without any conventional handling. The river water found severely polluted due to huge discharge of domestic, municipal as well as industrial waste through various drains from both side of river. The increase in value of alkalinity and total hardness were observed higher due to domestic and municipal waste discharges. Domestic waste, municipal waste and industrial effluents is very high from tarapur to Miyanpur ghat. According to above WQI values at various sampling stations there is general progressive Increase in WQI values along the downstream indicated that an increase in pollution is due to effluent discharge. The general progressive increase in WQI values along the downstream indicated as increase in pollution due to the discharge by various domestic and industries along the stretch. The poorer water quality index at Sampling Station VI is due to anthropogenic activities.

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