Assessment of Water Quality of the River Gomti, India by Water Quality Index

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***Abstract*—Globally the various sources of pollution are continuously affecting the water quality of most of the rivers. Due to the heavy discharge of partially or untreated wastewater in the urban stretches, water pollution has now become one of the most significant problems concerning water bodies. Considering the heavy pollution load due to natural and anthropogenic activities, the Gomti River has been chosen to conduct this study. Total eight parameters, namely pH, electrical conductivity, TDS, TH, chloride, DO, BOD and alkalinity, have been selected to develop the water quality index. These parameters were measured at seven sampling stations (S1 to S7) along the Gomti River for the years 2013 – 2017 in the urban stretch of Lucknow city. The weighted arithmetic water quality index (WAWQI) was used to calculate the water quality index. The results of the study revealed that all of the water samples fall under different categories of poor (50 to 75), very poor (75 to 100), and unsuitable (>100). As the Gomti river entered the Lucknow city, its water quality was under fair index category, while the index worsens to marginal as it advanced within the city premises. During 2017, the recorded values of WQI was found in the range of 71.11 (minimum at S1) to 165.33 (maximum at S7), whereas in 2013, these were in the range of 67.90 (minimum at S1) to 143.63 (maximum at S7). To augment the water quality, effective wastewater treatment measures are urgently required to support any plan for sustainable river restoration.**

Keywords*—*Gomti River, Lucknow, WQI, Water quality, Water pollution

I. INTRODUCTION

The rivers play a vital role in the development of our nation, but during the process rivers are polluted due to an increasing number of industries, urbanization, and many other developmental activities [1]. These freshwater sources provide water for domestic, industrial, agricultural, and recreational purposes and have great importance in our lives being primary water resources. On one side, the water resources have been stressed due to increasing demand as a result of population growth, climate change, drought, but on the other side, the wastewater generated from industrial and agricultural activities deteriorates the quality of these water resources [2]. Inadequate wastewater treatment facilities with increasing sewage generation compound the problem of wastewater disposal to the rivers. This huge quantity of raw or partially treated wastewater is mostly discharged into nearby water bodies, mainly in the rivers. Therefore, it is imperative to monitor the quality of water resources within acceptable limits for sustainable use.

The ecological sustainability of water resources, underlying economic reasons, and human health requirements demand immediate control on water pollution and restoration of natural resources. The suitability of the water for human consumption can be quantified in terms of the water quality and is being used in multiple scientific publications that relate the necessities of sustainable water management [3]. Monitoring of river water quality is required to control the outbreak of diseases and to check the deterioration of its water quality, as it also provides a scope for pollution prevention and control [4].

About 70% of the river water in India is contaminated due to the presence of pollutants, thereby making them unfit for various designated municipal and industrial uses as per the data reported by the WHO (World Health Organization), CPCB (Central Pollution Control Board), BIS (Bureau of Indian Standards) and, ICMR (Indian Council of Medical Research) [5]. River water quality assessment using various parameters and techniques has been reported by Santosh et al. (2008) [6]; Yisa and Jimoh (2010) [7] and Shah et al. (2015) [8]. The water quality index is an efficient approach for determining river water quality in a consolidated form for its use, suitability, and application and to be utilised by the concerned agencies for policy making. The water quality index uses various mathematical equations to determine the water quality indices by incorporating the different physical, chemical, and biological parameters.

Horton (1965) [9], for the first time and later, Brown et al. (1970) [10] proposed the use of a Water Quality Index. Afterward, different methods are proposed by various researchers to calculate water quality indexes. Presently, the various Water Quality Indexes are being used worldwide e.g. US National Sanitation Water Quality Index (NSFWQI), British Columbia Water Quality Index (BCWQI), Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI), Weighted Arithmetic Water Quality Index (WAWQI) Oregon Water Quality Index (OWQI) [11]. Many countries like India [12], United Kingdom [13], Egypt [14], United States [15], Canada [16], Spain [17], Brazil [18], Iran [19], Argentina [20], and Malawi [21] are using these WQI to evaluate the quality of river waters.

Various physical, chemical, and biological parameters are the basis for the evaluation of WQI. The biggest challenge is to develop cost-effective pollution control strategies in developing countries. Therefore, for such circumstances, just a few critical parameters must be utilized to assess WQI. The water quality of numerous Indian rivers has been thoroughly contemplated, examined, and answered by their reasonableness for their different beneficial uses [22].

In the present study, a long-term evaluation of the water quality is done for interpreting the Province of Gomti River in the stretch of Lucknow city by creating a WQI to break down and translate a gigantic dataset into significant information for propriety of the stream water in the study locations for human usage.

II. Study Methodology

A. Description of the study area

Gomti is one of the major groundwater-fed rivers that start from Gomathtal (earlier known as Fulhar Jheel) in Pilibhit district, and after traveling 940 kms, it drains into the River Ganges (Ganga river) close to Saidpur in Ghazipur district of U.P. From the origin to its confluence, 23 major and minor tributaries, contribute to the River Gomti. Gaichi (Gaihaaee) is the first tributary of Gomti, which originates after traveling 20 km from the origin. River Gomti continues being narrow stream till Mohammadi Kheri (Lakhimpur Kheri district), which is 100 km from origin and river is well defined here as many tributaries join it downstream, many tributaries as River Kathana and River Sarayan join the River Gomti at Mailani and Lakhimpur, respectively. River Sai joins River Gomti in Jaunpur district nearby Rajepur.

Throughout the year (except monsoon season), the flow of River Gomti is characterized as slow-moving whereas, during monsoon, heavy rainfall causes a manifold increase in its runoff. Thus, the monsoon season is the time when River Gomti gets maximum water budget. The river receives an annual discharge of about 7390 x 106 m^3 [23]. The flow velocity and river level both increase during the monsoon season, resulting in flood conditions in the low-lying areas. Generally, the rise and fall of 3 m in the water level is seen every year.

This river enters in Lucknow after traveling around a distance of 240 km. Lucknow, known as the city of Nawab's is the capital of U.P. (India), is located at 26° 52′N latitude and 80° 56′E longitude. The city has a humid subtropical climate, with a hot summer for April to June and a winter season from December to February. The temperature varies from 48.9^{0}C to 1.67^{0}C during the year. In July to September, the city gets annual precipitation of around 900 mm from the southwest monsoon. The city's elevation varies from 100 to 130 m above mean sea level at different locations and inclines towards the east. Lucknow is one of the fastest-growing cities in India, with an expected population of 4.7 million by 2031 from 2.8 million in the year 2011. Water is lifted from the River Gomti at Gaughat pumping station to supply water to Lucknow city. There are 28 significant drains, out of which 14 drains are available in the Cis-Gomti area, and the other 14 are in the Trans-Gomti area, in the city. Few drains are as big as to carry 78 MLD of sludge discharge, but others carry only 0.5 MLD discharge and increases the pollution level in it..

The primary drinking water source for the city is River Gomti, which is polluted due to the daily discharge of excessive untreated domestic wastes. Besides Lucknow, 14 other towns benefit from its drinking water supplies located at its bank. The discharge in the River Gomti during a lean period is around 500 MLD. It reaches approximately 55,000 MLD during the Monsoon season. Most of the time, the average discharge is about 1500 MLD/year [24]. There is a low water discharge in the post-monsoon season, which results in the depositional phase of the river.

B. Data collection

The important parameters that are considered to assess the surface water quality and indexing include pH, Electrical Conductivity, TDS, Total Hardness, Chloride, DO, BOD, and Alkalinity. The monthly data collection of all the above mentioned water quality parameters was done at seven sampling stations i.e., (S1) Station-1 Manjhi Ghat (S2) Station-2 Up Stream water intake (S3) Station-3 Kuriyaghat (S4) Station-4 Downstream Mohan Meakins (S5) Station-5 Nishat Ganj Bridge (S6) Station-6 Upstream Barrage and (S7) Station-7 Downstream after meeting STP Nala Bharwara of Gomti river by Uttar Pradesh Pollution Control Board, Lucknow (UPPCB, Lucknow) for the years 2013 – 2017. The details of sampling stations are presented in Fig. 1.

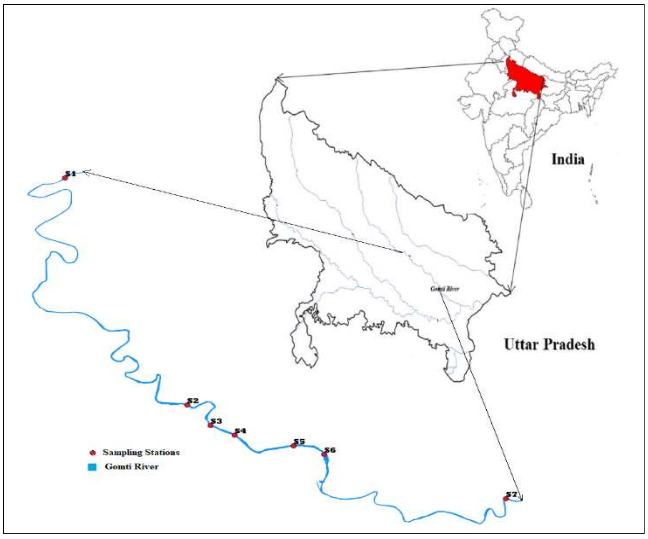

Fig. 1. Map showing sampling stations in Lucknow city of the Gomti River.

C. Calculation of Water Quality Index (WQI)

In this study, Weighted Arithmetic Index method Brown et al. 1970) [10] has been adopted to calculate the Water Quality Index (WQI) using the above mentioned selected parameters i.e. pH (units), Electrical Conductivity (µS/cm), Total Dissolved Solids (mg/l), Total Hardness (mg/l, $CaCO_3$), Chloride (mg/l), Dissolved Oxygen (mg/l), Biochemical Oxygen Demand (mg/l) and Alkalinity (mg/l, $CaCO_3$).

In this method, water quality parameters are multiplied by a weighting factor and then combined by simple arithmetic mean. At first, the quality rating scale (Qi) is calculated for each parameter to assess water quality, using the following equation:

$$Qi = \frac{(V_{observed} - V_{ideal})}{(V_{standard} - V_{ideal})} X\ 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots.. (1)$$

Where,

Qi = Quality rating of the ith parameter for n numbers of water quality parameters.

$V_{observed}$ = Observed value of the water quality parameter (laboratory analysis).

V_{ideal} = “The Ideal value of the water quality parameter”.

V_{ideal} for pH = 7, V_{ideal} for DO= 14.6 mg/l and V_{ideal} for other parameters = 0.

$V_{standard}$ = Standard of the water quality parameter (BIS and ICMR).

Relative (unit) weight (Wi) is inversely proportional to the recommended standards (Si) for the corresponding parameter and was calculated using equation 2:

$$\mathrm{Wi} = \frac{K}{X_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (2)$$

Where,

Wi = Relative (unit) weight for nth parameter

Xi = Standard permissible value for n^{th} parameter

K = Proportionality constant

Finally, the overall WQI was calculated by using the following equation:

$$\mathrm{WQI} = \frac{\sum Q_i W_i}{\sum W_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.... (3)$$

Where,

Qi = Quality rating

Wi = Relative weight

Calculation of WQI involves both standards of drinking water and relative weights assigned to each parameter, as given in Table 1. By considering WQI for humans uses the maximum permissible WQI was 100 scores for drinking purposes. The range of WQI, category, status, and water usage are presented in Table 2.

TABLE 1 RELATIVE WEIGHT (W_n) OF THE PARAMETERS USED FOR WQI DETERMINATION

Parameter	Unit	ICMR/BIS standard (V_s)	Unit weight (W_n)
pH	-	6.5-8.5	0.218412144
Electrical conductivity	µS/cm	300	0.006188344
TDS	mg/l	500	0.003713006
Total hardness	mg/l	300	0.006188344
Chloride	mg/l	250	0.007426013
DO	mg/l	5	0.371300644
BOD	mg/l	5	0.371300644
Total alkalinity	mg/l	120	0.01547086

III. RESULTS AND DISCUSSIONS

A. *Water quality of River Gomti*

The statistical summary for the years 2013-2017, of the selected water quality parameters at sampling stations (S1 – S7) of the River Gomti is presented in Annexure - I. Variation in pH was observed at the sampling stations (S1 – S7), is due to low annual variations in free CO_2. The pH value can explain water quality deterioration [6]. The pH changed its nature from alkaline to acidic as it moves from S1 to S7 (Fig. 2) and also through pre and post-monsoon to monsoon period at the sampling station. From Annexure - I, it can be deduced that the range of pH lies between 6.89 (August 2013, 2014) to 8.89 (June 2017), which exceeds the ICMR standard of 6.5 to 8.5 at some of the sampling stations. Overall, the pH value was within the alkaline range, due to its direct reception of domestic waste discharge and leached from the accumulation of organic waste along the banks of the river. Santosh et al. (2008) [6] and Shah et al. (2015) [8] reported similar results in the pH range 5.9 – 8.0 and 6.5 for River Netravathi and River Sabarmati, respectively.

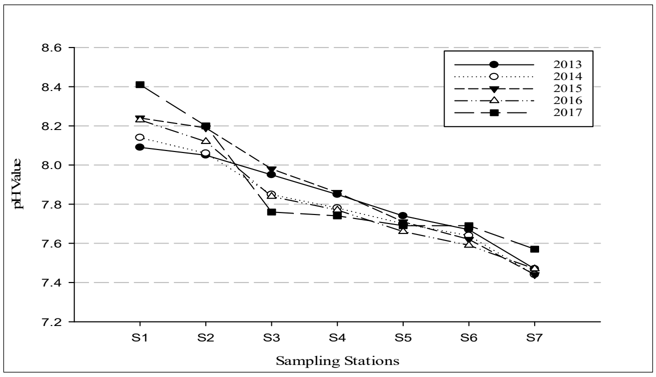

Fig. 2. Mean values of pH variations at the sampling stations of the Gomti River

In this study, EC values observed for the water samples of the River Gomti for stations S1 – S7 ranged between 172.0 – 560.2 µS/cm, 180.8 – 582.4 µS/cm, 201.0 – 772.5 µS/cm, 212.0 – 795.6 µS/cm, 224.6 – 558.5 µS/cm, 221.6 – 882.6 µS/cm and 240.6 – 984.2 µS/cm respectively for years 2013 – 2017 which exceeds the ICMR standard of 300 µS/cm at most of the sampling stations. The recorded data indicates that EC concentrations ranged from 172.0 µS/cm as the minimum value for station "S1" in July 2015, while regarding 984.2 µS/cm as the maximum value for station "S7" in May 2017. All Stations (S1 - S7) showed higher EC values, mainly during April, May, and June. It is noticed that EC had been gradually increased from S1 to S7, and from 2013 to 2017, as shown in Fig. 3. Sewage discharge and anthropogenic activities may have contributed to the increased level EC values [5]. Station S1 and S2 have lower EC values. As stated by Avvanavar and Shrihari (2008) [25], Land cover pattern, i.e., semi-green area and forest area, which resulted in less soil erosion of the topsoil, may have contributed to lower EC values at station S1 and S2.

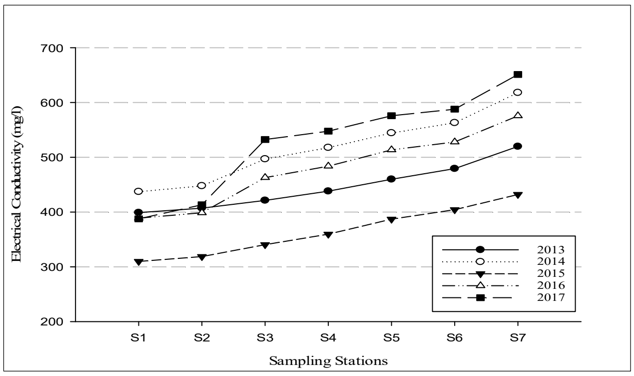

Fig. 3. Mean values of Electrical Conductivity variations at the sampling stations of Gomti River

TABLE 2 WQI RANGE, CATEGORY, STATUS AND POSSIBLE USAGE OF THE WATER SAMPLE

Value of WQI	Category of Water	Water Quality Status (WQS)	Possible Usage
0 – 25	A	Excellent	Drinking, irrigation and industrial
26 – 50	B	Good	Drinking, irrigation and industrial
51 – 75	C	Poor	Irrigation and industrial
76 – 100	D	Very poor	Irrigation
Above 100	E	Unsuitable for drinking and fish culture	Proper treatment required before use

High TDS in water indicates more ionic concentration, which is not suitable for human consumption and induces an adverse physicochemical reaction in the human body [26]. The river water recorded the TDS value ranged between 112 mg/l to 616 mg/l. In the case of the "S1" station, the TDS value recorded 112 mg/l as a minimum in July 2015, while maximum value was recorded 616 mg/l for station "S7" in June 2017, which was mostly in the desirable limit of 500 mg/l with few exceptions. Downstream region stations have higher TDS values than the Upstream stations [27]. Ascending trends in TDS were observed at each sampling station from S1 (upstream) to S7 (downstream) and with every consecutive year from 2013 to 2017 (Fig. 4). This may be due to the strong presence of dissociated electrolytes and dissolved organic matter, entering into the river water through several points and non-point sources. Jindal and Sharma (2010) [5] reported similar results for Potrero de los Funes River, had a TDS in the range of 156-582 mg/l, which may be due to the sewage discharges and anthropogenic activities along the bank of the river.

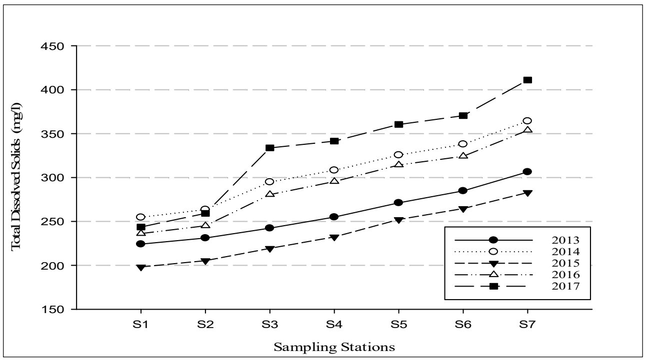

Fig. 4. Mean values of TDS variations at the sampling stations of Gomti River

Hardness values of water samples observed at stations S1, S2, S3, S4, S5, S6, and S7 ranged between 120 – 236 mg/l, 128 – 244 mg/l, 134 – 256 mg/l, 140 – 262 mg/l, 148 – 274 mg/l, 156 – 282 mg/l and 170 – 294 mg/l respectively for the years 2013 – 2017 (Fig. 5) which was in the desirable limit of 300 mg/l. The recorded data indicates that the total hardness concentrations ranged from 120 mg/l as the minimum value for station "S1" in August 2013 as well as August 2014, while regarding 294 mg/l as maximum value at station "S7" in July 2017. Based on the data collection, River Gomti water can be categorized as moderately hard to hard water. Bora and Goswami (2017) [28] was found similar results and reported the hardness in the range of 52 - 296 mg/l for River Kolong, Assam, India.

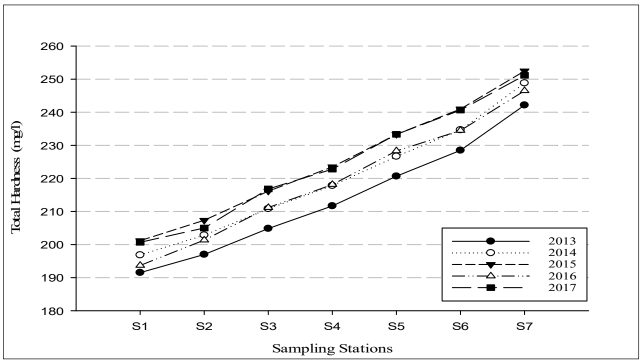

Fig. 5. Mean values of Total Hardness variations at the sampling stations of Gomti River

The chloride concentration in the water samples studied from 2013 to 2017 at Stations S1, S2, S3, S4, S5, S6, and S7 ranged between 8 – 17 mg/l, 11 – 19 mg/l, 12 – 22 mg/l, 13 – 24 mg/l, 14 – 27 mg/l, 15 – 29 mg/l and 18 – 33 mg/l respectively (Fig. 6), which was found within the BIS desirable limit, i.e., 250 mg/l. However, in September 2017, the chloride was very low (8 mg/l) at Station S1, while a high value (33 mg/l) was found at the Station S7 in October 2016 due to surface run-off from inorganic fertilizers dependent agricultural fields, irrigation discharge, animal feeds, etc [28]. This result is supported by the findings of Bora and Goswami (2017) [28], where they reported the chloride range of 19.88–94.56 mg/l for River Kolong, Assam, India.

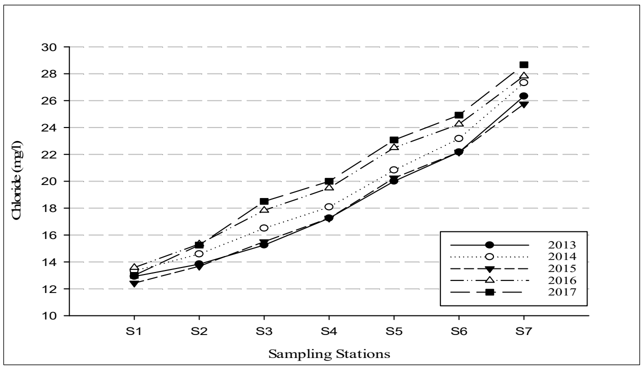

Fig. 6. Mean values of Chloride variations at the sampling stations of Gomti River

In this study, a large variation in DO which is a principle pollution indicator has been noticed. The DO for the studied water samples during 2013 – 2017, for stations S1, S2, S3, S4, S5, S6 and S7 ranged between 4.7 – 11.4 mg/l, 2.9 – 11.9 mg/l, 0.7 – 9.5 mg/l, 1.3 – 8.4 mg/l, 1.1 – 6.0 mg/l, 0.6 – 5.1 mg/l and 0.3 – 3.8 mg/l respectively. The annual average concentration of DO is depicted in Fig. 7. This gradual decrease in DO at stations S1 to S7 advances within the city premises at S3, S4, S5, S6, and worsen to marginal at S7. Discharge of industrial and domestic wastewater adds organic matter into the river, which increases microbial activity for their degradation process and results in a low concentration of dissolved Oxygen [7]. At stations S1, DO levels for most of the months were sufficient for aquatic life's survival. The minimum DO observe for S1 was 4.7 mg/l in August 2013 and August 2014. In summer, with the rise in temperature of the stream, the oxygen solubility decreases. Metabolism, growth, and reproduction of bacteria responsible for the biodegradation of the organic matter is directly affected by the temperature. As the temperature increases, the rate of biodegradation and biological activity increases, increasing the demand for oxygen in the water. At station S7, the minimum DO level was observed (0.30 mg/l), mainly due to the high level of organic pollutants, low flow during summer, and an increase in the water temperature. A DO value of 6.5 – 15 mg/l was reported by Sharma et al. (2008) [29], which was found under the prescribed limit as per WHO. Yisa and Jimoh (2010) [7] also reported similar DO values ranged between 3.1 – 5.2 mg/l for River Landzu.

BOD values over 5 mg/l were undesirable. The present study showed that water samples at stations S1, S2, S3, S4, S5, S6, and S7 ranged between 2.3 – 3.3 mg/l, 3.1 – 4.2 mg/l, 3.6 – 9.0 mg/l, 4.5 – 10.0 mg/l, 6.0– 11.5 mg/l, 6.5 – 12.5 mg/l and 8.5 – 18.6 mg/l respectively during 2013 – 2017 (Fig. 8) with values exceeding the desirable limit. It was observed that the maximum value of BOD (18.6 mg/l) was found at sampling station S7 in September 2017 and minimum (2.3 mg/l) at sampling station S1 in September 2017. Less water current and higher decomposition of organic matter at high temperatures resulted in a high value of BOD [30]. At any site when DO increases, BOD decreases. BOD and DO are inversely proportional to each other with respect to temperature [31]. Similar results were also presented by Shah and Joshi (2017) [8], where DO values range between 3.0 to 19.0 mg/l for the River Sabarmati in Gujarat, India.

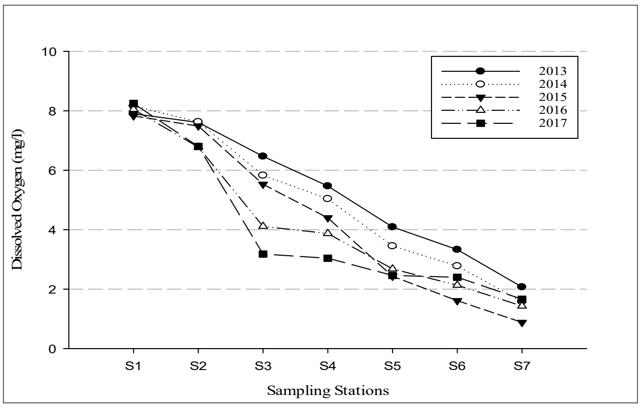

Fig. 7. Mean values of DO variations at the sampling stations of Gomti River

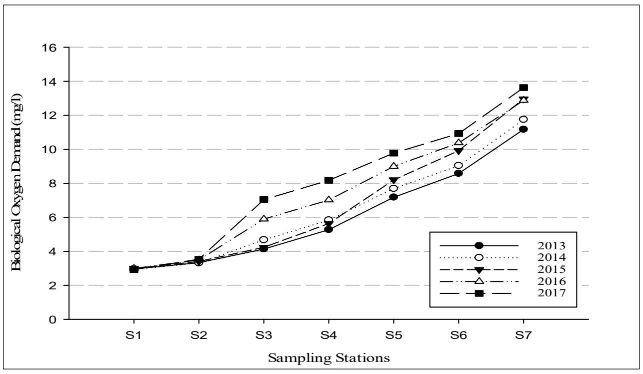

Fig. 8. Mean values of BOD variations at the sampling stations of Gomti River

Alkalinity is the capability of an aqueous solution to neutralize acids. It is due to the presence of carbonate, bicarbonate, and hydroxide ions. The average alkalinity concentration (as $CaCO_3$) for the monitored water samples during 2013 – 2017, for stations S1, S2, S3, S4, S5, S6, and S7 ranged between 142 – 252 mg/l, 148 – 264 mg/l, 156 – 272 mg/l, 162 – 278 mg/l, 168 – 286 mg/l, 172 – 298 mg/l and 146 – 316 mg/l respectively (Fig. 9) which exceeded the BIS prescribed limit of 120 mg/l. It was observed that the maximum value of alkalinity was found at sampling station S7 during July 2014, and a minimum was observed at sampling station S1 during August 2013 and 2014. Bora and Goswami (2017) [28] reported the similar kind of results in River Kolong, Assam, India.

B. *Water quality index of Gomti River*

The summary of the WQI values of the water samples from all the seven sampling stations (S1 – S7) for each year (2013 – 2017) is presented in Table 3. The results revealed that all of the water samples fall under poor (between 50 to 75), very poor (between 75 and 100), and unsuitable (>100) categories. These stations recorded the highest WQI values during 2017, ranging from 71.11 at Station S1 to 165.33 at Station S7.

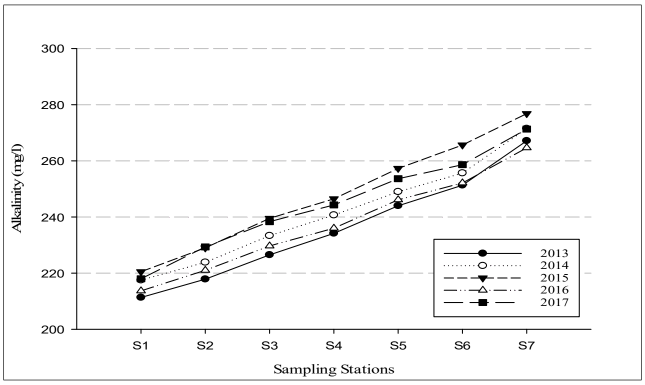

Fig. 9. Mean values of Alkalinity variations at the sampling stations of River Gomti

The WQI of the water samples collected at stations S1 and S2, was found better than other sampling stations. The WQI values ranged between 67.90– 71.11 for S1 and 71.35 – 78.39 for S2 for all the consecutive years 2013 - 2017. Samples collected at stations S1 and S2 have better water quality conditions, as these stations are present in the out skirts of the Lucknow city and have less urban agglomeration. Similar results were also observed by Iqbal et al. (2019) [33] for the River Gomti. The WQS at sampling station S3 and S4 was observed poor for 2013 – 2015 and was unsuitable in 2016 and 2017 because of the contamination contributed by the close-by urban settlements.

The WQI analysis unveiled the fact that sampling stations S5, S6, and S7 has the highest level of pollutants along the entire reach of the Gomti River. The sample's WQI values from stations S5, S6, and S7 during the sampling year were in the unsuitable water category (WQI>100), hence making the water unfit for any use, including irrigation, fish culture, and drinking. Not only high sewage disposal and eutrophication, but the lack of sufficient flow leads to the stagnancy of river water, which results in a high pollution level of sampling stations, which in turn reduces the self-purification capacity of the River Gomti River. In 2011, Rehana and Majumdar [33] reported similar impacts of altered river flow in River Tunga Bhadra. In addition to the above reasons, a continuous increase in the population, which resulted in riverbed encroachment and exploitation of river water for various chores, contributed to the deterioration of the water quality of the River Gomti.

IV. Conclusion

In the current study WAWQI has been found effective to determine the water quality status of River Gomti in Lucknow at seven sampling stations (S1 to S7), by considering eight water quality parameters. Out of the eight parameters, DO and BOD was found to have the highest influence on the WQI scores. The study concludes that water samples fall under either poor and very poor or unsuitable category. The current water quality index of the Gomti River indicates the threatened quality of the water, which is attributable to the recurrent release of waste effluents by numerous discharges pouring down directly into the river by anthropogenic sources. The water quality index of river Gomti shows variation at its entry in the city and when it leaves the city as index worsen to

TABLE 3 SUMMARY OF WQI OF THE RIVER GOMTI

Sampling Station	2013		2014		2015		2016		2017	
	WQI	*WQS*	*WQI*	*WQS*	*WQI*	*WQS*	*WQI*	*WQS*	*WQI*	*WQS*
S1	67.9	Poor	67.64	Poor	70.52	Poor	69.6	Poor	71.11	Poor
S2	71.35	Poor	71.45	Poor	74.27	Poor	76.72	Very Poor	78.39	Very Poor
S3	80.36	Very Poor	85.73	Very Poor	85.21	Very Poor	101.14	Unsuitable	112.44	Unsuitable
S4	91.39	Very Poor	96.55	Very Poor	98.35	Very Poor	109.61	Unsuitable	121.28	Unsuitable
S5	109.63	Unsuitable	115.53	Unsuitable	123.28	Unsuitable	127.52	Unsuitable	134.88	Unsuitable
S6	122.11	Unsuitable	127.46	Unsuitable	137.86	Unsuitable	139.06	Unsuitable	143.72	Unsuitable
S7	143.63	Unsuitable	149.74	Unsuitable	161	Unsuitable	158.79	Unsuitable	165.33	Unsuitable

marginal value as it travels through the city premises. The study shows the value of WQI increases from year 2011 to 2017 and from sampling station S1 (entry) to sampling station S7 (exit) by passing years, which gives the impression that pollution is ascribed to various sources. It has been summarized that, to augment the water quality, effective wastewater treatment measures of the polluting sources are urgently required to support any plan for sustainable river restoration.

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ANNEXURE I: LOCATION WISE STATISTICS OF WATER QUALITY PARAMETERS

	pH	**Conductivity**	**T.D.S.**	**TH**	**Chloride**	**DO**	**BOD**	**Alkalinity**	**WAWQI**
S1									
Mean	8.05	366.10	222.00	178.00	12.50	8.05	2.80	197.00	67.31
Average	8.22	384.47	231.37	196.77	13.05	8.04	2.96	216.20	69.35
Standard error	0.05	12.01	6.04	3.86	0.22	0.24	0.02	3.85	0.96
Median	8.29	388.40	233.00	206.00	13.00	7.60	2.95	228.00	69.57
Mode	8.29	336.00	184.00	228.00	13.00	6.80	2.90	228.00	77.94
Standard deviation	0.36	93.80	47.21	30.16	1.73	1.89	0.15	30.07	7.53
Minimum	7.20	172.00	112.00	120.00	8.00	4.70	2.30	142.00	52.66
Maximum	8.89	560.20	332.00	236.00	17.00	11.40	3.30	252.00	81.97
S2									
Mean	7.88	381.60	232.00	186.00	15.00	6.90	3.65	206.00	76.09
Average	8.12	397.10	240.83	202.70	14.53	7.26	3.41	224.20	74.44
Standard error	0.04	12.66	6.38	4.06	0.24	0.27	0.03	3.76	1.17
Median	8.21	413.80	240.00	212.00	14.00	6.70	3.30	236.00	74.79
Mode	8.54	348.00	192.00	232.00	14.00	6.50	3.30	236.00	83.38
Standard deviation	0.32	98.92	49.84	31.70	1.86	2.13	0.24	29.34	9.10
Minimum	7.17	180.80	118.00	128.00	11.00	2.90	3.10	148.00	56.31
Maximum	8.58	582.40	346.00	244.00	19.00	10.90	4.20	264.00	95.87
S3									
Mean	7.75	486.75	305.00	195.00	17.00	5.10	6.30	214.00	98.97
Average	7.87	450.83	274.23	211.97	16.72	5.02	5.19	233.47	92.98
Standard error	0.04	18.94	10.86	4.08	0.31	0.31	0.19	3.91	2.33
Median	7.83	440.40	255.00	220.00	16.00	5.05	4.60	244.00	90.70
Mode	7.82	364.00	270.00	236.00	15.00	3.50	4.00	258.00	94.80
Standard deviation	0.29	147.98	84.81	31.90	2.39	2.41	1.49	30.57	18.17
Minimum	7.11	201.00	128.00	134.00	12.00	0.70	3.60	156.00	63.89
Maximum	8.38	772.50	482.00	256.00	22.00	9.50	9.00	272.00	134.05
S4									
Mean	7.65	503.80	316.00	201.00	18.50	4.85	7.25	220.00	109.41
Average	7.80	469.44	286.53	218.80	18.42	4.36	6.39	240.33	103.43
Standard error	0.03	19.04	10.98	4.11	0.33	0.22	0.19	3.94	2.09
Median	7.77	454.45	266.00	228.00	18.00	4.20	6.00	252.00	103.34
Mode	7.71	388.00	232.00	244.00	20.00	4.20	6.00	252.00	106.77
Standard deviation	0.25	148.77	85.77	32.14	2.59	1.74	1.48	30.75	16.34
Minimum	7.04	212.00	136.00	140.00	13.00	1.30	4.50	162.00	79.68
Maximum	8.26	795.60	496.00	262.00	24.00	8.40	10.00	278.00	139.15
S5									
Mean	7.58	541.55	345.00	211.00	20.50	3.55	8.75	227.00	121.82
Average	7.70	496.19	304.77	228.47	21.33	3.02	8.37	250.03	122.17
Standard error	0.03	19.95	11.36	4.13	0.37	0.15	0.19	3.95	1.94
Median	7.70	474.60	282.00	238.00	21.00	2.80	8.50	260.00	122.82
Mode	7.69	426.00	274.00	254.00	24.00	3.20	8.50	268.00	131.84
Standard deviation	0.22	155.84	88.70	32.25	2.93	1.19	1.49	30.88	15.14
Minimum	7.00	224.60	152.00	148.00	14.00	1.10	6.00	168.00	91.92
Maximum	8.15	858.50	538.00	274.00	27.00	6.00	11.50	286.00	151.73
S6									
Mean	7.52	552.10	357.00	219.00	22.00	2.85	9.50	235.00	126.94
Average	7.64	512.50	316.47	235.87	23.33	2.45	9.77	256.70	134.04
Standard error	0.03	20.12	11.35	4.10	0.41	0.14	0.19	4.03	1.95
Median	7.64	489.10	293.00	244.00	23.00	2.10	10.00	266.00	134.93
Mode	7.62	456.00	290.00	258.00	25.00	3.00	10.00	282.00	149.50
Standard deviation	0.22	158.38	89.24	32.24	3.23	1.12	1.53	31.59	15.30
Minimum	6.95	221.60	160.00	156.00	15.00	0.60	6.50	172.00	96.16
Maximum	8.09	882.60	554.00	282.00	29.00	5.10	12.50	298.00	157.72
S7									
Mean	7.36	612.40	394.00	232.00	25.50	2.05	13.55	251.00	157.22
Average	7.48	559.40	343.73	248.23	27.18	1.52	12.48	270.30	155.70

	pH	Conductivity	T.D.S.	TH	Chloride	DO	BOD	Alkalinity	WAWQI
Standard error	0.02	22.94	12.75	4.22	0.44	0.11	0.22	4.12	2.03
Median	7.50	513.50	314.00	258.00	28.00	1.20	13.00	278.00	159.89
Mode	7.43	489.00	342.00	258.00	29.00	1.00	13.00	296.00	170.87
Standard deviation	0.19	179.19	99.63	32.94	3.44	0.86	1.69	32.15	15.89
Minimum	6.89	240.60	172.00	170.00	18.00	0.30	8.50	186.00	113.53
Maximum	7.82	984.20	616.00	294.00	33.00	3.80	18.60	316.00	200.91