ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015

Study of Water Quality Status of Sai River in Uttar-Pradesh With Reference to Water Quality Index Assessment

Vineeta Kumari[1], Girdhari Lal Chaurasia[2]

[1]Forest Ecology & Environment Division, FRI (Deemed) University, Dehradun, India

[2]Department of Chemistry, University of Allahabad, Allahabad, UP, India

ABSTRACT : The aim of the study is to find out the water quality of the sai river- a holy river of Uttarpradesh. River Sai is an important river of Uttar-Pradesh, originate from a pond in village Bijgwan near Pihani in district Hardoi and travel about 600 km to form district boundary between Lucknow and Unnao. After passing through Hardoi, Raebareli and Jaunpur district it finally join the Gomati River at Rajepur in Jaunpur district. The sai is worshiped as holy river in UP. total six water samples from each districts were collected and 18 physicochemical parameters were analyzed and used for the calculation for the water quality index of the samples and categories water in the rating of 0-100 and result shows that the water quality at districts, Hardoi is good and the district Unnao and Lucknow are in excellent rating and the other three districts Raebareli ,Pratapgarh and Jaunpur was in moderate polluted categories the maximum water quality index is 71.056 and minimum at districts Lucknow 43.34.

KEYWORDS: Anthropogenic Activities, Correlation, Drinking Water, Physicochemical parameter, Water Quality Index

I. INTRODUCTION

Most ancient civilizations grew along the banks of rivers. Even today, millions of people all over the world live on the banks of rivers and depend on them for their survival. River Sai is an important river of Uttar-Pradesh, originate from a pond in village Bijgwan near Pihani in district Hardoi and travel about 600 km to form district boundary between Lucknow and Unnao. After passing through Hardoi, Raebareli and Jaunpur district where it finally join the Gomati River at Rajepur in Jaunpur district. In Hardoi local call the stretch as "Jhabar" from where a river called Bhainsta take shape. The river flows for a good 10 kms before getting it more popular name Sai. The total course of the river in the Raebareli is about 100 kms in length. The length of the Gomti river is 940 km and its drains a total area of 30,437 sq.km. The Sai catchment is bounded in north by Ghaghara catchment while in south by Ganga catchment. Throughout its journey Sai river travel in the alluvial terrain and transports the sediment derived from Himalayan terrain. In its long journey, the river receives water from other streams also namely Bhainsta, Loni, Sakarni and Bakulahi rivers.

Drinking water quality has become a critical issue in many countries, especially due to concern that fresh water will be a scarce resource in the future, so a water quality monitoring program is necessary for the protection of fresh water resources. [1].Water is an essential natural resource for agriculture, manufacturing, transportation and many other anthropogenic activities. It is essential for all forms of life and makes up 50-97% of the weight of plants and animals and about 70% human body. The WHO estimates that more than 20% of the world population has no access to safe drinking water and that more than 40% of all population lack adequate sanitation. Poor water quality is still a significant problem in many parts of the world. It can often limit the use of the vital resource and in more extreme cases can harm human and other life form. Water can be polluted by substances that dissolve in it or by solid particulates and insoluble liquid droplets that become suspended in it [2].

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015

Unfortunately most of the world's major rivers are heavily polluted. It is estimated that community waste from human activities accounts for four times as much wastewater as industrial effluents. It is estimated that community waste from human activities accounts for four times as much wastewater as industrial effluents, most of which is discharged untreated partially treated into the river.

Gupta and Pankaj [3] reported organic pollution in River Gomti due to anthropogenic activities. Majority of water characteristics of river Gomti at Sultanpur (Uttar Pradesh) were found to exceed the permissible limits due to sewage discharge and posed problems for the survival of aquatic life and human beings. The river also continuously receiving daily sewage, domestic and municipal and industrial wastewater from the city [4]. Shyamala et al. [5] found pollution at the banks of Cauvery River and Kalingarayan canal in and around Erode town, Tamilnadu. The study showed increased in the pollution load due to the movement of fertilizers, agricultural ashes, industrial effluents and anthropogenic wastes at river Cauvery [6]. Tripathi et al. [7] found degradation in water quality of River Rapti near Balrampur in Uttar Pradesh.

Water Quality Index (WQI) is a very useful and efficient method for assessing the suitability of water quality. It is also a very useful tool for communicating the information on overall quality of water to the concerned citizens and policy makers [8and 9]. WQI is a dimensionless number that combines multiple water-quality factors into a single number by normalizing values to subjective rating curves [10]. Factors to be included in WQI model could vary depending upon the designated water uses and local preferences Water quality indices (WQIs) have been developed to integrate water quality variables[11,12 and 13]. A WQI summarizes large amounts of water quality data into simple terms (e.g., excellent, good, bad, etc.) for reporting to managers and the public in a consistent manner. [14]

II. THE STUDY AREA

The network of sampling stations in the river course was finalized considering the locations of discharge of industrial effluents, sewage, and dumping waste. The entire path of the rivers from upstream (origin) Hardoi district via Unnao, Lucknow, Pratapgarh to Jaunpur district were covered for the study of the Physico-chemical properties of the various parameters at different location .The geological settings and sampling locations are shown below in Fig.1 & 2 and TABLE-1

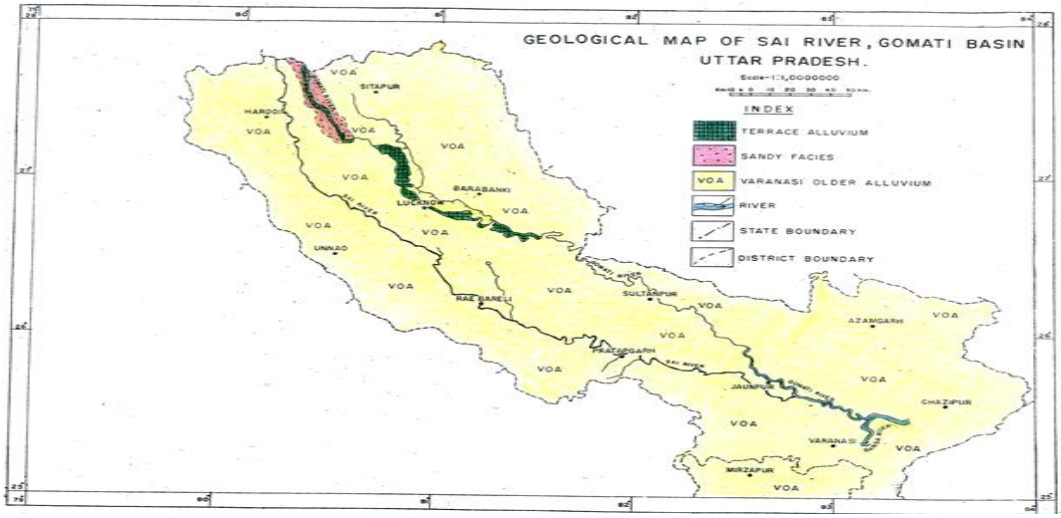


Fig: 1 Map of Geological setting covers entire route of Sai River, at six districts in Gomati Basin Uttar-Pradesh

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015

TABLE -1 showing Sampling Locations of six districts on the basis of Latitude (N) and Longitude (E) aspects

S.N.	Location	Sampling Date & Time	Latitude (N)	Longitude (E)
1	Bagholi, Hardoi	5/4/2010, 10:00AM	26^0 53' to 27^0 47'	79^0 41' to $80^0$49'
2	Mohaan, Unnao	5/4/2010, 3:00PM	20^0 05' to 270 02I	80^0 03' to $81^0$03'
3	Bani, Lucknow	6/4/2010, 10:00AM	26^0 30' to 27^0 09' 30''	80^0 33' 50''to 8101 3I 05''
4	Allahabad Road, Raebareli	6/4/2010, 4:00PM	80^0 41^I to 81^o 34^I	25^0 43'to 26^o20'
5	Chilbila, Pratapgarh	7/4/2010, 4:00PM	25^o 34^I to 26^o 11^I	81^0 19' to $82^0$27'
6	Jalalpur Station ,Jaunpur	7/4/2010 , 6:00PM	25. 46	82.44

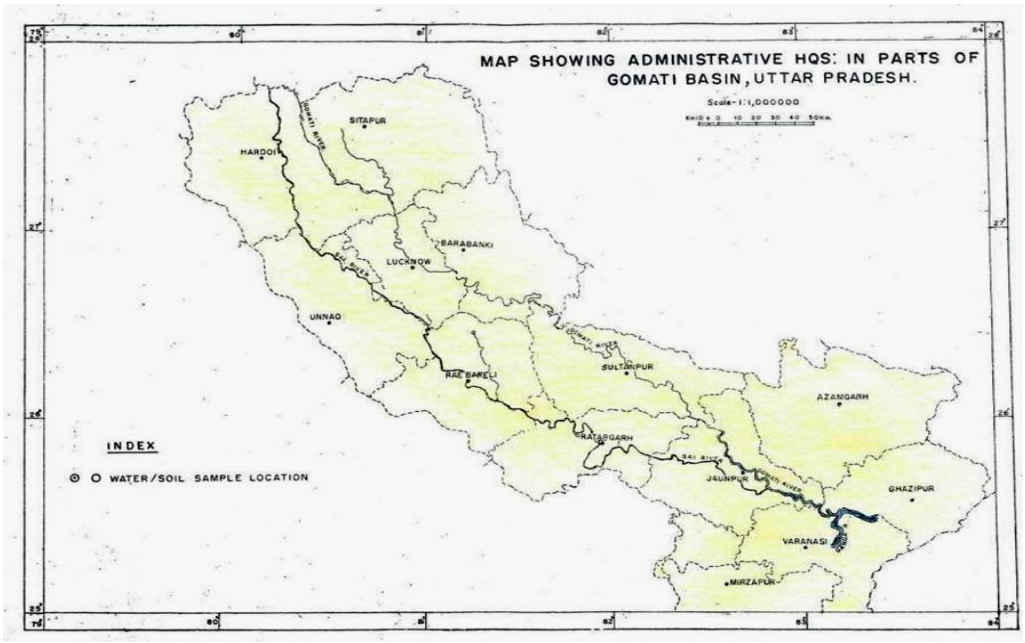


Fig.: 2 Map showing Sampling Locations from upstream to downstream of Sai River at Six districts in Parts of Gomati Basin, Uttarpradesh

III. MATERIAL & METHODS

Six water samples were collected in 1 liter polyethylene bottle. All the water quality parameters were analyzed as per the standard procedure given by APHA (15), BIS (16) & WHO (17), ICMR. The collected water samples, and soil samples from investigation sites were subjected to physico-chemical analysis to determine, PH, DO, BOD, Conductivity, total suspended solids, total solids, hydrogen ion concentration, Calcium, Magnesium, total Alkalinity, phosphate, chloride, fluoride, nitrate, nitrite, and total hardness, and residual chlorine.

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015

TABLE: 2 Physico-chemical analysis of water Samples of Sai River at six Districts sampling locations from Upstream to Downstream of river

Parameter	Unit	Standard.	Hardoi (Bagholi)	Unnao (Mohaan)	Lucknow (Bani)	Raebareli (Allahabad Road)	Pratapgarh (Chilbila)	Jaunpur (Jalalpur)
PH	-	6.5-8.5 (BIS)	7.82	8.25	8.31	8.41	8.47	8.37
DO	(mg/l)	6.0 (BIS)	7.3	7.4	7.5	7.5	7.2	7.1
BOD	(mg/l)	5.0 (ICMR)	6.5	3.5	4.0	3.5	11.0	11.5
Conductivity	(µs/cm)	300 (BIS)	580	544	406	627	674	668
TDS	(mg/l)	1000 (WHO)	384	359	269	415	445	442
Na	(mg/l)	200 (WHO)	33.7	33.2	22.1	57.0	64.4	66.1
K	(mg/l)	12 (WHO)	8.0	7.5	6.7	8.5	8.2	8.2
Cl	(mg/l)	25 (WHO)	33.53	23.37	19.30	57.91	14.21	56.90
Total Alkalinity	(mg/l)	600 (BIS)	236	200	170	234	284	264
Total Hardness	(mg/l)	500 (WHO)	212	190	144	178	190	204
Phosphate	(mg/l)	6 (BIS)	0.77	0.20	0.05	1.81	0.69	0.16
Sulfate	(mg/l)	200 (WHO)	30.3	71.4	33.7	36.1	45.1	42
Ammo. N	(mg/l)	5 (BIS)	0.59	0.51	0.01	0.50	1.65	0.83
Fluoride	(mg/l)	1.5 (WHO)	0.52	0.59	0.59	0.71	0.71	0.78
COD	(mg/l)	200 (WHO)	14.8	11.6	14.4	14.6	25.6	26.4
Nitrate	(mg/l)	45 (WHO)	0.44	0.22	0.11	0.42	0.825	0.5
Ca	(mg/l)	200 (BIS)	36	36	24	24	40	36
Mg	(mg/l)	100 (BIS)	22	23	20	30	24	21

In the present study 18 key parameters were taken for the water quality analysis and their standard and observed values were compared.

Calculation of Water Quality Index -The calculation of WQI was made using weighed Arithmetic method in following steps- [18] Let there be water quality parameters and quality rating (qn) corresponding to nth term parameter is a number reflecting relative value of this parameter in the polluted water with respect to its standard permissible limits value. qn values are given by the relationship .

$qn = 100 (Vn – Vi) / (Vs – Vi)$

Where Vs- standard value, Vi- ideal value, in most cases Vi = 0 except in certain parameters like pH, dissolved oxygen etc., calculation of quality rating for pH and DO (Vi was not zero).

$q\ PH = 100 (V\ pH – 7.0) / (8.5-7.0)$ and $q\ DO = 100 (V\ DO – 14.6) / (5.0-14.6)$

Calculation of Unit Weight –The unit weight (Wn) to various water quality parameters is inversely proportional to the recommended standards for the corresponding parameters.

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015

Wn = k /Sn
Where Wn = unit weight for the nth parameter, Sn= standards permissible value for nth parameter, k= proportionality constant
The unit weight (Wn) values in the present study are taken study are taken. [19]

Calculation of WQI -

WQI = $\Sigma q_n Wn / \Sigma Wn$
Where n= i-n

The suitability of WQI values for human consumption is rated as follows [20]
0-25 = Excellent, 26-50 = Good, 51-75 = Bad, 76-100 = Very bad and above it = Unfit

The WQI and overall WQI of all the samples taken were calculated according to the procedure explained above and are presented in TABLE-3.

Table -3 showing the procedure for Calculations of Water Quality Index of river at site-1 Hardoi

Parameter	Standard. Value (S_n)	Observed Value(Vn)	Unit wt (Wn)	Quality rating (Qn=Vn-Vi0/Sn-Vi0x100)	WQI= (Wn . Qn)
PH (-)	6.5-8.5 (BIS)	7.82	0.07083	54.66	3.8715678
DO (mg/l)	6.0 (BIS)	7.3	0.10035	84.88	8.517708
BOD (mg/l)	6.0 (WHO)	6.5	0.12042	130	15.6546
Conductivity (µs/cm)	300 (BIS)	580	0.002007	193.33	0.3866
TDS (mg/l)	1000 (WHO)	384	0.00060	38.4	0.2304
Na (mg/l)	200 (WHO)	33.7	0.00301	16.85	0.0507185
K (mg/l)	12 (WHO)	8.0	0.05017	66.666	3.333
Cl (mg/l)	250 (WHO)	33.53	0.0024084	13.412	0.0323015
Total Alkalinity (mg/l)	600 (BIS)	236	0.0010035	39.33	0.0128
Total Hardness (mg/l)	500 (WHO)	212	0.0012042	42.4	0.05088
Phosphate (mg/l)	6 (BIS)	0.77	0.10035	12.8	1.28
Sulfate (mg/l)	200 (WHO)	30.3	0.0030105	15.15	0.04545
Ammonical N (mg/l)	5 (BIS)	0.59	0.12042	11.8	1.420956
Fluoride (mg/l)	1.5 (WHO)	0.52	0.4014	34.66	13.912524
COD (mg/l)	200 (WHO)	14.8	0.00301	7.400	0.02222
Nitrate (mg/l)	45 (WHO)	0.44	0.01338	0.9778	0.013083
Ca (mg/l)	200 (BIS)	36	0.00301	18.00	0.054
Mg (mg/l)	100 (BIS)	22	0.006021	22.00	0.132

WQI=48.92

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015

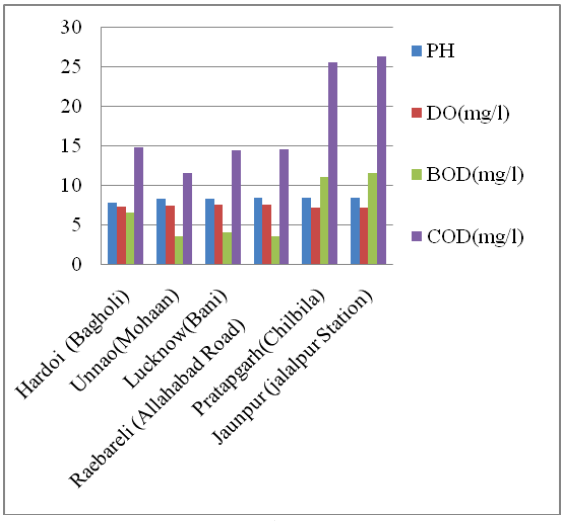
As the above table all other sampling stations water quality index were calculated and compared with the different categorization group suitable for drinking purposes shown below in TABLE -4

TABLE: 4 showing the Water Quality Index of six samples and quality rating on the basis of calculated water quality index at each sampling locations

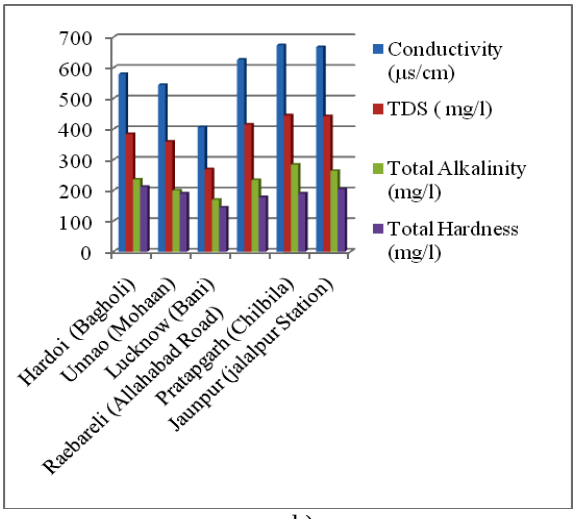
WQI	Quality Rating	Hardoi (Bagholi)	Unnao (Mohaan)	Lucknow (Bani)	Raebareli (Allahabad Road)	Pratapgarh (Chilbila)	Jaunpur (Jalalpur)
0 – 25	**Excellent**		43.98	43.34			
26-50	**Good**	48.92					
51-75	**Moderately Polluted**				51.02	70.4988	71.056
76-100	**Very Poor**						
100and above	**Unsuitable for Drinking purposes**						

IV- RESULT & DISCUSSION

The water quality index assessed by the various physico-chemical parameters at six sampling sites and their results, rating are shown as table 2, 3& 4 and figure- 3a), 3b), 3c),3d), 3)e, & 4(Water quality index at six sampling locations are shown below in fig-4)



a)



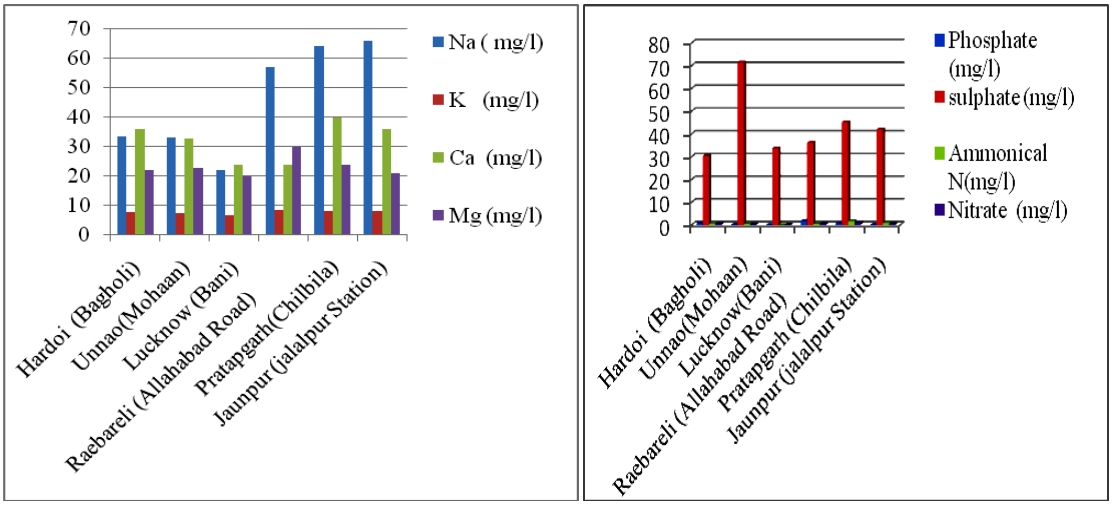
b)

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

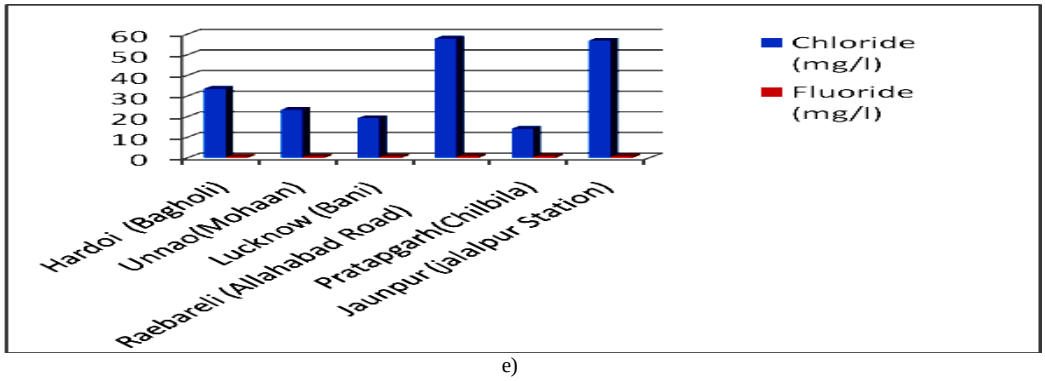
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015



c) d)



e)

Fig: 3 Analytical results of various parameters were taken in combined form at Six sampling locations combined parameters depicted as a)Concentrations of PH, DO BOD, & COD b) Concentrations of EC, TDS, TA, & TH c)Concentrations of Na, K,Ca & Mg d)Concentrations of PO_4^{2-}, SO_4^{2-}, Ammonical N & NO_3^- e) Concentrations of Chloride & Fluoride

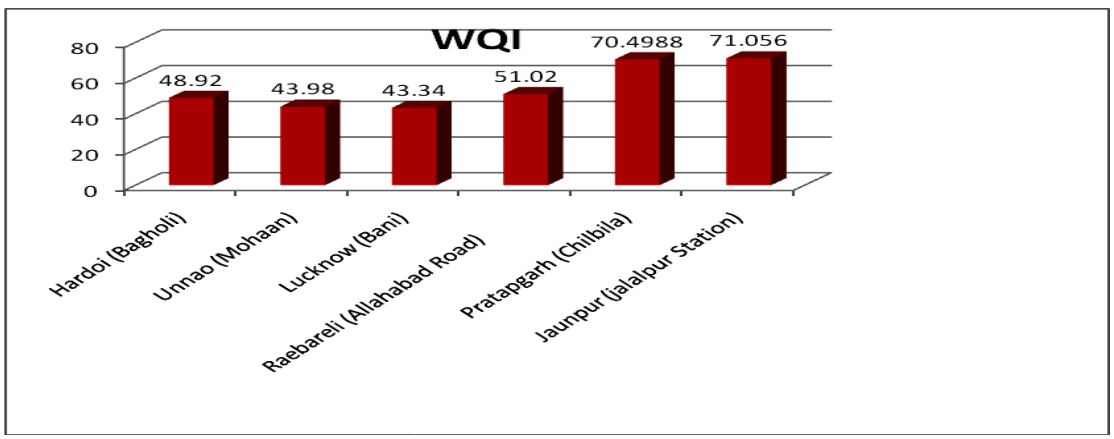


Fig: 4 showing the Water Quality Index value of six sampling locations on the basis of calculations of physicochemical parameters

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015

PH: The presence of hydrogen ion concentration is measured in terms of pH range. In our investigation the pH value of surface water ranged from 7.82 to 8.47 indicating that the nature of water is slightly basic.
The minimum pH recorded at sample location 1(Bagholi, Hardoi), while the max at sampling location-5(Chilbila, Pratapgarh) **(Table: 3, Fig: 3a**).which was within the higher permissible range, prescribed by BIS and WHO drinking water standards. It has been mentioned that the increasing pH appear to be associated with increasing use of alkali detergents from domestic sewages in residential and alkaline material from different types of industrial discharge.
Dissolved Oxygen (DO): DO is one of the important parameter in surface water quality assessment. In our study DO of river water ranged from 7.1 to 7.5 mg/l **(Table-3, Fig: 3a**). The minimum DO recorded at Jalalpur, Jaunpur and the max was noted at sampling locations Bani, Lucknow & Raebareli (Allahabad Road), which was above the max permissible range as prescribed by BIS and WHO drinking water standards.
Biological Oxygen Demand (BOD): BOD is an important parameter of surface water quality and which indicates the level of organic contamination in surface water. In our study the BOD of surface water ranges from 3.5 mg/l to 11.5 mg/l (**Table- 3 & Figure-3a**). The min BOD recorded at locations Unnao & Raebareli and the max value was noted at Jaunpur which was above the max permissible range as prescribed by WHO drinking water standards.
Total Alkalinity (TA): the total alkalinity in water is due to the presence of different types ions. Values of alkalinity range 170-284 mg/l (**Table: 3 Fig: 3b).** At sampling Bani, Lucknow**)** recorded low value, while at location-5Chilbila, Pratapgarh it was high. These values are within max permissible limit prescribed by BIS. Increased in Excessive alkalinity of river may cause eye irritation in human. If alkalinity value in drinking water is higher than 200 mg/l, the taste of the water becomes unpalatable for drinking.

Ammonical Nitrogen (Amm.N): Ammonical nitrogen is the amount of nitrogen found in the form of Ammonia. Values of alkalinity range 0.01-1.65 mg/l **(Table-3 & Fig-3d)**. The minimum value is at the sampling location -3 Bani, Lucknow and maximum at sampling Location-5 Chilbila, Pratapgarh. The results are within the permissible limit of BIS.
Total Dissolved Solids (TDS): The total dissolved solids are expressed by the weight of residue left when a water sample has been evaporated to dryness. The range of TDS varied from 269 to 445 mg/l in the study. The min value recorded at sampling locations 3 Bani, Lucknow and max value was recorded at site-5 Chilbila, Pratapgarh. Which was within the permissible limit prescribed by BIS and WHO standard (**Table: 3, Fig-3b**).
Chloride: In the present study the Chloride concentration in surface water was in range 14.21to 57.91 mg/l). The min Chloride observed at location Chilbila, Pratapgarh and the max at location Raebareli. All the observed values were within the permissible range as prescribed by BIS drinking water standards (**Table- 3, Fig- 3e**).
Chemical Oxygen Demand (COD)-Chemical oxygen demand is the amount of oxygen required for the chemically degradation of the carbonaceous and nitrogenous contaminants in water. In the present study the COD concentration in surface water was in range 11.6 to 26.4(**Table-3 & Fig-3a**). Minimum at site-2 Mohaan, Unnao and maximum at site-6 Jalalpur, Jaunpur. The results are within the permissible limit of WHO.
Nitrate:-The average value of Nitrate was observed as in range 0.11to 0.825 mg/l **(Table-3 & Fig-3d)**. All the values of Nitrate were within permissible range as prescribed by BIS and WHO drinking water standards. Sample of location 3 Bani Lucknow showed lowest value and sampling location -5 had recorded high value of Nitrate.
Sulphate and Phosphate (SO4 & PO4): sulphate ion is one of the major anions occurring in natural waters. The concentration varied from 30.3 to 71.5 mg/L **(Table-3 & Fig-3d)**. minimum at sampling location-1 Bagholi, Hardoi and maximum at sampling location-2 Mohaan, Unnao. The sulphate content in surface water samples are within the limit prescribed by WHO. Many sulphate components are readily soluble in water. Most of sulphate components originate from the oxidation of sulphite ores, presence of shales and the solution of gypsum and anhydrite. Under anaerobic conditions, sulphate ion is reduces to sulphate ion, which establishes equilibrium with hydrogen ion to form hydrogen sulphide. The presence of hydrogen sulphide leads to corrosion of pipes [21]. Phosphate an essential nutrient for living organisms occurs in water as both dissolved and particulate species.
A mixture of CaH2 (Po4)2 and gypsum, marked under the name of super phosphate of lime, is used as phosphate fertilizer [22]. PO4 in the surface water and groundwater samples were well below the permissible limit and the concentration varied from 0.05 to 1.81 mg/L **(Table-3 & Fig-3d).**The results are within the permissible limit of BIS.

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015

Sodium and Potassium (Na & K): Sodium and potassium are the most important minerals occurring naturally. The Flux of these ions through cell membranes and other boundary layers send signals that turn metabolic reactions on and off. The minimum value is location -2 Bani, Lucknow and maximum at location -6 Jalalpur, Jaunpur (range 22.1-66.1of the study) Sodium in river water found to be within the limit of BIS (16). (Fig.5) Potassium content in the study area was found in the range of 6.7 to 8.5 mg/L**(Table-3 & Fig-3c)**. minimum at location 3 Bani, Lucknow and maximum at location-4 Raebareli. Surface water lies within the safe range of WHO [17] limit of 12 mg/L (Fig. 5). Excess amount of potassium present in water may lead nervous and digestive disorder [23].

Calcium and Magnesium (Ca & Mg): Calcium and magnesium ions present in groundwater is particularly derived from leaching of lime stones dolomites, gypsum and anhydrites, whereas the calcium ion is also derived from cation exchange process [24]. Ca2+ in surface water ranged from 24 to 40 mg/L **(Table-3 & Fig-3c)** and minimum at Location 3Bani, Lucknow and 4 Raebareli and maximum at location-5 Chilbila, Pratapgarh found to be within the BIS limit. Calcium is very essential for nervous system and for formation of bones and teeth. Mg2+ in surface water ranged from 20 to 30 mg/L and minimum at Location -3Bani and Maximum at location 4 Raebareli. Magnesium is found within the permissible limit of BIS (16) & WHO (17).

Fluoride: The concentration of fluoride content present in water is higher and low then various problems are arises in human, animal and plants and also it a source of water pollution [25]. In study it varies in the range of 0.52-o.78 (**Table-3 & Fig-3e**).Minimum at location 1 Bagholi, Hardoi and maximum at location- 6 Jalalpur, Jaunpur.

Electrical Conductivity (EC): EC is the measure of capacity of a substance or solution to conduct electrical current through the water. The range of EC varied from 406-674 µs/cm in this study. The min and max value were reported at location -2 Bani, Lucknow and location-5 Chilbila, Pratapgarh **(Table- 3, Fig-3b)**. The max value is above the upper limit prescribed by BIS (16) standard. High conductivity at the sites indicates the mixing of sewerage in river water as these sites are located near populated towns [26]

Total Hardness: Hardness is a measure of the ability of water to cause precipitation of insoluble calcium and magnesium Salts of higher fatty acids from soap solution [27]. In present study it is obtained in the range of 144-212(**Table-3 & Fig-3b**).The minimum at location-3 Bani, Lucknow & maximum at location-1 Bagholi, Hardoi. The results found within the permissible limit of BIS.

V - CONCLUSION

The river is the base of agriculture, industries and drinking need well known. Water quality index is an informative decision making preliminary tool about the quality of the river water. Which is helpful for the water managers and policy makers other bodies related to environmental conservation for plan effectively. Sai River found in the range of excellent and good at district Unnao, Lucknow and Hardoi respectively and the other sites fall under the moderate polluted categories. There is urgent need for making the policy for the conservation of the small rivers and tributaries and monitoring of the river water quality. Water quality can be improved by creating awareness in local public about the degrading status of river, by making farmers understand about proper use of fertilizers and pesticides in farms and also formulating action plan to save the river from drastic pollution [28].

VI - ACKNOWLEDGEMENT

The authors are highly thankful to the GSI, Northern region Lucknow for providing analytical facilities and support to accomplish this work properly and UGC for financial assistance.

REFERENCES

[1] Pesce, S.F., and Wunderlin, D.A., "Use of water quality indices to verify the impact of Cordoba city (Argentina) on Suquia River", Water Research,vol. 34, no.11, pp. 2915- 2926, 2000.

[2] OGWO, P.A., and OGU, O.G., "Impact of Industrial Effluents Discharge on the Quality of Nwiyi River Enugu South Eastern Nigeria", IOSR Journal of Environmental Science, Toxicology and Food Technology, vol.8, no.11, pp. 22-27, 2014.

[3] Gupta, A.K., and Pankaj, P.K., "Comparative study of eutrophication and heavy metal pollution in rivers Ganga and Gomti with reference to Human Activities", Natl. Environ. Pollu. Technol., vol.5, no.2, pp. 229-232, 2006.

[4] Verma, S., and Khan, S.A., "Water quality criteria and Arpna river water of Bilaspur city (C.G.)", Current World Environment, vol. 2, no.2,

ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015

pp. 199- 204, 2007.
[5] Shyamala, G., Shivananad, K.P., and Babu, S.S "A Preliminary report on the physico chemical nature of water pollution in and around Erode own, Tamil Nadu", Natl. Environ. Pollu. Technol.,vol. 7, no.3, pp. 555-559, 2008.
[6] Begum, A., and Harikrishna, "Study on the Quality of Water in Some treams of Cauvery River", Journal of Chemistry, vol.2, no.5, pp.377-384, 2008.
[7] Tripathi, V.M., Tewari, D.D., Tiwari, H.D., Tiwari, S., and Uppadhya, M.P., "Physico–chemical characteristics of river Rapti nearby industrial area Balrampur, U.P. India", Natl. Envirron. and Pollu. Technol., vol.7, no.1, pp. 73-77, 2008.
[8] Asadi, S.S., Vuppala, P., and Anji, R.M., "Remote sensing and GIS techniques for evaluation of groundwater quality in Municipal Corporation of Hyderabad (Zone-V), India" Int. J. Environ. Res. Public Health, vol. 4, no.1, pp. 45-52, 2007.
[9] Buchanan, S., and Triantafilis, J., "Mapping water table depth using geophysical and environmental variables", Groundwater, vol. 47, no.1 pp. 80- 96, 2009.
[10] Miller, W. W., Joung, H. M., Mahannah, C. N. and Garrett, J. R., "Identification of water quality differences Nevada through index Application", J. Environmental Quality, vol. 15, no. 3, pp. 265-272, 1986.
[11] Cude, C., "Oregon water quality index: A tool for evaluating water quality management effectiveness", Journal of the American Water Resources Association, vol.37, no. 1, pp. 125–137, 2001.
[12] Liou, S., Lo, S., and Wang, S., "A generalized water quality index for Taiwan", Environmental Monitoring and Assessment, vol. 96, no.1-3, pp.35- 52, 2004.
[13] Said, A., Stevens, D., and Selke, G., "An innovative index for evaluating water quality in streams", Environmental Management, vol. 34, no.3, pp. 406–414, 2004.
[14] Saksena, D.N., Garg, R.., and Rao, R.J., "Water quality and pollution status of Chambal river in National Chambal sanctuary", Madhya Pradesh, J. Environ. Biol., vol. 29, no.5, pp. 701-710, 2008.
[15] APHA., Standard methods for the examination of water and waste water. American Public Health Association Washington D.C. (2005).
[16] Bureau of Indian Standards, Indian Standards (IS: 10500) Drinking Water Specification: New Delhi (2004).
[17] World Health Organization; Guidelines for drinking Water Quality: Vol.1, Recommendation 2nd Edition; Geneva, WHO (2008).
[18] Brown, R.M., Mccleiland, N.J., Deiniger, R.A., and Oconnor M.F.A., "Water quality index- crossing the physical barrier", Proc. Int. Conf. on water pollution research, Jerusalem, vol. 6, pp.787-797, 1972.
[19] Krishnan,J.S.R., Rambabu,K., and Rambabu C, "Studies on water quality parameters of bore waters of Reddigudum Mandal", Ind. J.Env. Proct., vol.16, no.4, pp.91-98, 1995.
[20] Mishra, P.C., and Patel, R.K., "Quality of drinking water in Rourkela, outside steel town ship", Journal of Env. Poll, vol. 8(920), pp.165-169, 2001.
[21] Sawyer, N., Clair, L., Perry, G., and Perkin, F., Chemistry for environmental engineering: 4th ed., Tata McGraw-Hill, New Delhi (2000).
[22] Gupta, M.K., Singh, V., Raj, P., Uanshi., Raj, K., and Dass, S.,"Groundwater Quality Assessment of Tehsil Kheragarh, Agra (India) with Special Reference to Fluoride".Environ. Monit. Assess. vol. 59, no.3, pp.275-285, 1999.
[23] Raja, G., and Venkatesan, P., "Assessment of Groundwater Pollution and its Impact in and around Punnam Area of Karur District, Tamilnadu India", E- Journal of Chemistry, vol.7, No. 2, pp.473-478, 2009.
[24] Kumar, S.K., Rammohan, V., Sahayan, J.D., and Jeevanandam, M., **"**Assessment of groundwater quality and hydro-geochemistry of Manimuktha River basin, Tamil Nadu, India" ,Environmental Monitoring and Assessment, vol.159, no.1-4, pp.341-351, 2008.
[25] Yadav, S.S., and Kumar,R., "Assessment of ground water pollution due to fluoride content and water quality in and around Tanda Taluka of Rampur district,Uttar Pradesh, India", Journal of Chemical and Pharmaceutical Research, vol. 2, no. 4, pp.564-568, 2010.
[26] Srivastava, A., Kumar, R., Gupta,V., Agarwal, G., Srivastava, S., and Singh,I., "Water quality assessment of Ramganga River at Moradabad by Physico-Chemical Parameters Analysis", VSRD-TNTJ,vol. 2, no.3, 119-127, 2011.
[27] Kalra, N., Kumar,R., Yadav,S.S., and Singh, R.T., "Water quality index assessment of ground water in Koilwar block of Bhojpur (Bihar)", Journal of Chemical and Pharmaceutical Research, vol. 4, no.3, pp.1782-1786, 2012.
[28] Jalal, F.N., and Sanal Kumar M.G., "Water Quality Assessment of Pamba River of Kerala, India in Relation to Pilgrimage Season", International Journal of Research in Chemistry and Environment, Vol. 3, no.1, pp.341-347, 2013.

BIOGRAPHY

Vineeta Kumari is Research Scholar in Forest Research Institute Dehradun (UK) at Forest Ecology & Environment Division.

Girdhari Lal Chaurasia is Research Scholar in University of Allahabad (UP) at Department of Chemistry