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Assessment of Water Quality of River Yamuna at Agra

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Abstract: The present study assessed the quality of the River Yamuna water for drinking purpose in Agra region in terms of spatial variations by using Weighted Arithmetic Water Quality Index method. Our Study was undertaken during the months of January 2019 to April 2019. Six sampling sites were selected along the flow of Yamuna River towards Upstream to Downstream side and samples of river water were collected in each month for the analysis of different water quality parameters. The parameters that are assessed for determining water quality index are pH (7.2-8.2), Temperature (17.1- 25.7 °C), Total Alkalinity (68-110 mg/l), Acidity (36-80 mg/l), Total Dissolved Solids (687-1390 mg/l), Total Hardness (291-508 mg/l), Chloride (225-415) and Dissolved Oxygen (1.5-5.2 mg/l) were measured. The results shows that the status of water quality of Yamuna River is very poor (WQI between 76 to 100) and unsuitable for drinking purpose (WQI above 100).
Keywords: River Water, Water Quality Index, WAWQI, Yamuna River, Agra, Water Pollution, Dissolved Oxygen.

I.   INTRODUCTION.

A.   Overview of Yamuna River

'The Yamuna', also called 'Jamuna', is the largest tributary river of the Ganges in northern India, which is one of the most sacred rivers in India, emerges from an altitude of 6,387 meters at the Yamunotri glacier in the Bandarpunch mountain peaks in the Uppermost region of Himalayas, in the Uttarakhand state of India. Then it travels a total distance of 1,376 kilometers to join the River Ganga in Allahabad. The rivers Chambal, Sindh, Betwa and Ken are some of the main tributaries of the Yamuna River. The Yamuna has a drainage system of 366,223 square kilometers, which covers overall 40.2% of the entire Ganges Basin.

B.   Present Condition Of Yamuna River

The Yamuna River once had 'clear blue' water but now, it is known as one of the most polluted rivers in the world especially around New Delhi, Mathura and Agra. River Yamuna has actually been killed by Urbanization and Industrialization. 'The Capital City of India, New Delhi' which produces 1,900 million litres of sewage per day, dumps 58% of its waste into Yamuna. Untreated waste flowing into it from several towns along its banks in Haryana and Uttar Pradesh is the greatest enemy of River Yamuna. Wastewater generated by human creates many toxic substances into the river, while agricultural waste, industrial waste, immersion of idols and waste of human ashes deteriorating the water quality of Yamuna. The heavy load of pollution almost completely degrade the quality of water in the river, which makes it unsuitable for human consumption and for other uses also.

The index method was initially proposed by Horton in 1965.The water quality index aims at assessing the quality of water through a single numerical value, calculated on the basis of one system which convert all the individual parameters and their concentrations, present in a sample into a single value. This is an effective method that allows to compare the quality of various water samples based on a single numerical value and not only the parameters values of each sample. Any result of water quality measurements can serve as indicator of water quality. In this study different water quality parameters (i.e. pH, Temperature, Total Alkalinity, Acidity, Total Dissolved Solids, Total Hardness, Chloride and Dissolved Oxygen) of Yamuna River at different sampling stations were analyzed and then by using Weighted Arithmetic Water Quality Index Method, we calculate WQI of Yamuna River and determined the water quality status of Yamuna River in Agra Region.

II.   STUDY AREA & METHODOLOGY

River water samples were collected on monthly basis from (January 2019 to April 2019) at six different sampling stations in Agra from Upstream to Downstream side of river flow in sequential manner i.e. Kailash Mandir Ghat (U/S) S_1, RamBagh S_2, Jeevani Mandi S_3, Strachey Bridge S_4, Gurudwara HathiGhat S_5, TajMahal (D/S) S_6. The parameters which were analyzed are pH, Temperature, Total Alkalinity, Acidity, Total Dissolved Solids, Total Hardness, Chloride and Dissolved Oxygen.

A. Determination Of Water Quality Index By Weighted Arithmetic Water Quality Index (WAWQI) Method

Weighted Arithmetic Water Quality Index Method classifies the water quality according to the degree of purity by using the most commonly measured water quality variables. The calculation of WQI was made by using the following equation:

$$WQI = \Sigma \, Q_i.W_i \, / \, \Sigma \, W_i$$

The quality rating (Qi) for each parameter is calculated by using this expression:

$$Qi = 100[(V_i - V_0 \, / \, S_i - V_0)]$$

Where,

V_i = estimated concentration of ith parameter in analysed water.

V_0 = ideal value of ith parameter in pure water ,[$V_0 = 0$ (except pH =7.0 and Dissolved Oxygen = 14.6 mg/l)]

S_i = Standard permissible value of ith parameter.

The unit weight (W_i) for each water quality parameter is calculated by using the following formula:

$W_i = K/S_i$, [$\Sigma \, W_i = 1$]

Where,

K= proportionality constant and can also be calculated by using the following equation

$$K = [1/ \, (\, \Sigma 1/S_i)]$$

The rating of water quality according to this WQI is given in Table A.

Table A- Classification of Water Quality Index and Status Of Water Quality

Water Quality Index (WQI) Levels	Status Of Water Quality	Grading	Designated Best Use (Fresh Waters)
0-25	Excellent Water Quality	A	Drinking water source without conventional treatment but after disinfection.
26-50	Good Water Quality	B	Outdoor bathing
51-75	Poor Water Quality	C	Drinking water source with conventional treatment followed by disinfection.
76-100	Very Poor Water Quality	D	Propagation of wildlife,fisheries
Above 100	Unsuitable for Drinking.	E	Irrigation, industrial cooling, and controlled waste disposal.

Table B- Water Quality Criteria For Freshwater Classification (CPCB 1979).

Classes	Criteria
Class A	Dissolved Oxygen (minimum 6 mg/l), BOD (maximum 2 mg/l), MPN of coliforms per 100ml (maximum 50), pH (6.5-8.5)
Class B	Dissolved Oxygen (minimum 5 mg/l), BOD (maximum 3 mg/l), MPN of coliforms per 100ml (maximum 500), pH (6.5-8.5)
Class C	Dissolved Oxygen (minimum 4 mg/l), BOD (maximum 3 mg/l), MPN of coliforms per 100ml (maximum 5000), pH (6.0-9.0)
Class D	Dissolved Oxygen (minimum 4 mg/l), pH (6.5-8.5), Free ammonia as N (maximum 1.2 mg/l)
Class E	pH (6.0-8.5), Electrical conductivity (maximum μmhos 2250), Sodium absorption ratio, SAR (maximum 26), Boron (maximum 2 mg/l)

Table C- Drinking Water Quality Parameters as per Indian Standards/CPCB/WHO and their estimated unit weight.

S.No.	Water Quality Parameters	Limits According to Indian Standards /CPCB/WHO	Unit Weight $W_i = K/S_i$
1	pH value	6.5-8.5	0.35
2	Alkalinity, mg/l (as $CaCO_3$), Max	200	0.015
3	Total Dissolved Solids, mg/l, Max	500	0.006
4	Total Hardness,mg/l (as $CaCO_3$), Max	300	0.01
5	Chlorides, mg/l, Max	250	0.012
6	Dissolved Oxygen, mg/l	Not less than 4 mg/l	0.7
7	Temperature °C	Shall not exceed 30°C	0.1

III. OBSERVATION TABLE

Table 1- Calculated Values of V_i and Q_i for different parameters of Yamuna River at Sampling Station S_1 (Kailash Mandir Ghat) Agra.

Parameters	January 2019		February 2019		March 2019		April 2019	
	V_i	Q_i	V_i	Q_i	V_i	Q_i	V_i	Q_i
pH	7.2	13.33	7.3	20	7.4	26.66	7.6	40
Temperature °C	17.6	58.67	18.9	63.00	22.5	75.00	25.7	85.66
Total Alkalinity, mg/l (as $CaCO_3$)	68	34	72	36	78	39	86	43
Total Dissolved Solids, mg/l	687	137.4	738	147.6	783	156.6	804	160.8
Total Hardness, mg/l (as $CaCO_3$)	291	97	312	104	334	111.33	356	118.6
Chloride, mg/l	225	90	246	98.4	261	104.4	292	116.8
Dissolved Oxygen, mg/l	5.2	97.91	4.9	101.04	4.6	104.16	4.5	105.20

Table 2- Calculated Values of V_i and Q_i for different parameters of Yamuna River at Sampling Station S_2 (RamBagh) Agra.

Parameters	January 2019		February 2019		March 2019		April 2019	
	V_i	Q_i	V_i	Q_i	V_i	Q_i	V_i	Q_i
pH	7.4	26.66	7.4	26.66	7.5	33.33	7.8	53.33
Temperature °C	17.4	58.00	18.6	62.00	22.2	74.00	25.4	84.66
Total Alkalinity, mg/l (as $CaCO_3$)	78	39	78	39	84	42	96	48
Total Dissolved Solids, mg/l	816	163.2	845	169	886	177.2	912	182.4
Total Hardness, mg/l (as $CaCO_3$)	306	102	335	111.66	357	119	372	124
Chloride, mg/l	251	100.4	273	109.2	288	115.2	311	124.4
Dissolved Oxygen, mg/l	4.1	109.37	3.7	113.54	3.5	115.62	3.2	118.75

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Table 3- Calculated Values of V_i and Q_i for different parameters of Yamuna River at Sampling Station S_3 (Jeevani Mandi) Agra.

Parameters	January 2019		February 2019		March 2019		April 2019	
	V_i	Q_i	V_i	Q_i	V_i	Q_i	V_i	Q_i
pH	7.3	20	7.3	20	7.5	33.33	7.7	46.66
Temperature °C	17.5	58.33	18.8	62.66	22.3	74.33	25.6	85.33
Total Alkalinity, mg/l (as CaCO$_3$)	74	37	76	38	82	41	90	45
Total Dissolved Solids, mg/l	864	172.8	881	176.2	919	183.8	954	190.8
Total Hardness, mg/l (as CaCO$_3$)	328	109.33	363	121	378	126	394	131.33
Chloride, mg/l	279	111.6	294	117.6	316	126.4	337	134.8
Dissolved Oxygen, mg/l	3.7	113.54	3.5	115.62	3.4	116.66	3.1	119.79

Table 4- Calculated Values of V_i and Q_i for different parameters of Yamuna River at Sampling Station S_4 (Strachey Bridge) Agra.

Parameters	January 2019		February 2019		March 2019		April 2019	
	V_i	Q_i	V_i	Q_i	V_i	Q_i	V_i	Q_i
pH	7.5	33.33	7.6	40	7.7	46.66	8.1	73.33
Temperature °C	17.2	57.33	18.4	61.33	22.0	73.33	25.2	84.00
Total Alkalinity, mg/l (as CaCO$_3$)	82	41	90	45	90	45	104	52
Total Dissolved Solids, mg/l	962	192.4	1026	205.2	1101	220.2	1156	231.2
Total Hardness, mg/l (as CaCO$_3$)	365	121.66	389	129.66	418	139.33	426	142
Chloride, mg/l	302	120.8	327	130.8	352	140.8	388	155.2
Dissolved Oxygen, mg/l	2.8	122.91	2.5	126.04	2.2	129.16	1.8	133.33

Table 5- Calculated Values of V_i and Q_i for different parameters of Yamuna River at Sampling Station S_5 (Gurudwara HathiGhat) Agra.

Parameters	January 2019		February 2019		March 2019		April 2019	
	V_i	Q_i	V_i	Q_i	V_i	Q_i	V_i	Q_i
pH	7.4	26.66	7.4	26.66	7.6	40	7.9	60
Temperature °C	17.3	57.66	18.5	61.66	22.1	73.66	25.3	84.33
Total Alkalinity, mg/l (as CaCO$_3$)	76	38	80	40	88	44	100	50
Total Dissolved Solids, mg/l	1018	203.6	1073	214.6	1138	227.6	1210	242
Total Hardness, mg/l (as CaCO$_3$)	393	131	414	138	446	148.66	479	159.66
Chloride, mg/l	318	127.2	342	136.8	371	148.4	396	158.4
Dissolved Oxygen, mg/l	2.5	126.04	2.2	129.16	2.1	130.20	1.7	134.37

Table 6- Calculated Values of V_i and Q_i for different parameters of Yamuna River at Sampling Station S_6 (Taj Mahal) Agra.

Parameters	January 2019		February 2019		March 2019		April 2019	
	V_i	Q_i	V_i	Q_i	V_i	Q_i	V_i	Q_i
pH	7.6	40	7.7	46	7.9	60	8.2	80
Temperature °C	17.1	57.00	18.3	61.00	21.9	73.00	25.1	83.67
Total Alkalinity, mg/l (as $CaCO_3$)	94	47	98	49	102	51	110	55
Total Dissolved Solids, mg/l	1150	230	1184	236.8	1276	255.2	1390	278
Total Hardness, mg/l (as $CaCO_3$)	429	143	462	154	488	162.67	508	169.33
Chloride, mg/l	352	140.8	378	151.2	390	156	415	166
Dissolved Oxygen, mg/l	2.3	128.12	2.1	130.20	1.8	133.33	1.5	136.45

Table 7- Water Quality Index (WQI) of Yamuna River at Six Different Sampling Station in Agra during the months of January to April 2019.

Sampling Stations	January 2019 WQI Value	February 2019 WQI Value	March 2019 WQI Value	April 2019 WQI Value
S_1 (Kailash Mandir Ghat) Agra.	85.57	87.00	93.42	100.16
S_2 (RamBagh) Agra.	95.28	98.81	104.01	114.54
S_3 (Jeevani Mandi) Agra.	96.32	98.45	105.25	113.72
S_4 (Strachey Bridge) Agra.	108.01	113.30	119.51	132.98
S_5 (Gurudwara HathiGhat) Agra.	108.21	110.95	118.23	129.19
S_6 (Taj Mahal) Agra.	114.57	118.91	127.49	138.28

IV. RESULTS AND DISCUSSION

The study which were done to evaluate the Water Quality Index of River Yamuna in Agra during the months of January to April 2019, reveals that a large number of samples from all the river water samples collected from different sampling station goes beyond the highest level of WQI and were severly polluted due to which it can not be used for drinking purpose. Excluding pH and temperature, all the water quality parameters were not lies within the standard permissible limits of drinking water as prescribed by BIS and CPCB.

Some control measures which are suggested to improve the status of water quality in Yamuna River are as follows :-

A. The wastewater which discharged directly into the river must be treated properly before discharging into the river as per the guidelines prescribed by CPCB.
B. Spreading Awareness among the local people residing near the yamuna river to actively take participation in water pollution prevention activities and provide their contribution for minimizing pollution.
C. Creation of Barricades/Bar Fence along the banks of Yamuna river so as to prevent direct disposal of domestic waste and other polluting substances into the river.
D. Planting trees along the bank of yamuna river which may help in preventing the agricultural runoff flowing into the river, that contains pesticides and fertilizers which pollutes river water.

V. CONCLUSION

Following conclusions were drawn from the analysis of water quality parameters of Yamuna River in our study:-

A. In all the water samples, dissolved oxygen content were less than 4 mg/l at all the sampling stations taken during February to April 2019, only in January D.O. content was more than 4 mg/l.

B. Total Dissolved Solids, Total Hardness and Chlorides values were found exceeding the maximum permissible limit as per BIS during our study period from January to April 2019.

C. Only parameters, pH and Temperature of all the river water samples were lies within the standard permissible limit as prescribed by BIS and WHO.

D. About one-third of the river water samples having WQI value ranges between 76 to 100, which shows very poor water quality status and in remaining water samples WQI value was above 100 which shows water can not be used without treatment for drinking purpose.

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Fig 1:- Sampling Sites Location Of Yamuna River At Agra.

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