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A STUDY ON WATER QUALITY INDEX OF POLLUTED WATER OF RIVER YAMUNA AT CITY OF TAJ

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ABSTARCT

Water is the prime need of life on earth, and is an indispensable constituents for all form of lives, including microorganisms to human-beings. Natural aquatic bodies like rivers are subjected to excessive pollution involving inorganic and organic components. Consequently, it is essential to monitor the river water quality by assessing its numerous physicochemical parameters. The present study was conducted to analyse and ascertain the physicochemical parameters (pH, total dissolved solids, total hardness, alkalinity, chlorides, DO, BOD, COD) of river Yamuna from two different sites (Kailash Temple, Hathi Ghat) of Agra city during two years i.e. from 2017-18 and 2018-19. The work focuses on the condition of river water in different seasons (monsoon, winter and summer) with respect to the physicochemical properties and calculation of Water Quality Index. Through the result obtained from the study it could be stated that; river water is not fit for drinking purpose and comes under grading 'E' of water quality index in all three seasons. Hence there is an urgent need to control the water pollution through adopting various technologies, implementing strict laws to make fit for human consumption and irrigation purposes.

Keywords: Inorganic, Organic, Physicochemical, Water Quality Index, Human, Irrigation

INTRODUCTION

In India River pollution has now reached to a point of crisis due to rapid growth of industrialization and unplanned urbanization. The whole aquatic life is affected because of contaminated water. The problem of water quality degradation is due to human activities such as discharge of industrial and sewage wastes, disposal of dead bodies and agricultural runoff which are main causes of environmental damage and pose serious health hazards (Meitei *et al*, 2004). Rivers are the main inland water resources for domestic, industrial and irrigation purposes and often carry large municipal sewage, industrial waste water and seasonal run off from agricultural land which are the main reasons for nutrient enrichment of river water as compared to other environments (Panda *et al*, 2006). Rivers play a major role in integrating and organizing the landscape and moulding the ecological setting of a basin. They are prime factors controlling the global water cycle and in the hydrologic cycle, they are the most dynamic agents of transport (Garrels *et al*, 1975).

The healthy aquatic ecosystem depends on the physico-chemical and biological characteristics of water (Venkatesharaju *et al*, 2010). Numerous factors like temperature, turbidity, nutrients, hardness, alkalinity and dissolved oxygen play vital role for the growth of plants and animals in water body, on the other hand biological oxygen demand indicate the pollution level of the water body (Kamal *et al*, 2007).

The quality and quantity of surface water in a river basin is influenced by natural factors such as rainfall, temperature and weathering of rocks and anthropogenic changes that curtail natural flow of the river, or alter its hydrochemistry (Raj and Azeez, 2009).

The Yamuna is the largest tributary river of the Ganges (Ganga) in northern India, originating from the Yamunotri Glacier at a height 6,387 meters on the south western slopes of Banderpooch peaks. Agra is situated in western U.P. between 27.11' degree Latitude North and 78.0' degree to 78.2' degree Longitude East. Its Altitude is 169 meters above sea level. (Gupta *et al*, 2013). Yamuna is one of the most polluted rivers in the world 85% of this pollution contributes by industrial and domestic sewage. This water is unfit for drinking, swimming and fisheries (Shrivastava *et al*, 2001).

Hence an attempt has been made to study the physico-chemical properties of Yamuna River in Agra city, Uttar Pradesh.

EXPERIMENTAL PROTOCOL

Study Site and Sample Collection

Water samples were collected from two different sites of Yamuna River of Agra i.e. Site-1 (Kailash Temple) and Site-2 (Hathi Ghat) in pre-strerilized bottles for consecutively two years i.e. from 2017-2018 and 2018-2019 in three season's viz. Monsoon (July-October), Winter (November- February) and Summer (March-June).

Physico-Chemical Analysis

The analysis of physico-chemical parameters such as Dissolved oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Chlorides, Total Hardness and Alkalinity were carried out by following the standard methods of APHA (1998) (Table-1).

Table-1 Water quality Standards, Analytical method and Recommending Agencies

Water Quality Parameters	Units	Analytical Method	Standards (Desirable) and Recommended Agencies
pH	-	pH meter (Mettlertoledo)	6.5-8.5 (BIS/ICMR)
Dissolved Oxygen	mg/L	Titrimetric (Winkler Method)	5 (ICMR)
Biological Oxygen Demand	mg/L	Titrimetric (Winkler Azide Method)	5 (ICMR)
Chemical Oxygen Demand	mg/L	Titrimetric	10 (WHO)
Alkalinity	mg/L	Titrimetric	120 (ICMR)
Total Dissolved Solids	mg/L	TDS meter (HM Digital TDS-3)	500 (BIS)
Total Hardness	mg/L	Titrimetric	300 (BIS/ICMR)
Chloride	mg/L	Argentometric	250 (BIS/ICMR)

(Sources- BIS 2003, ICMR 1975 and WHO 1993)

Water Quality Index

WQI is a mathematical tool used to transform large quantities of water quality data into a single cumulatively derived number. It represents a certain level of water quality while eliminating the subjective assessments of such quality (Štambuk-Giljanović, 1999, 2003, Miller *et al*. 1986).

It is intended as a simple, readily understandable tool for managers and decision makers to convey information on the quality and potential uses of a given water body, based on various criteria (Štambuk-Giljanović, 2003). Furthermore it turns complex water quality data into information that is understandable and usable by the public. It gives the public a general idea of the water quality in a particular region.

For calculating WQI, the following steps were used:

- In the first step, unit weight (W_i) for various parameters is inversely proportional to the recommended standard ($V_{standard}$) for the corresponding parameter. W_i values were calculated by using the following formula proposed by Tiwari and Mishra (1985),

  $W_i = K / V_{standard}$ (1)

  where, K = proportionality constant, $V_{standard}$ = world widely accepted drinking water quality standard prescribed by WHO (2004).

  The constant of proportionality K in the above equation can be determined from the following condition,

  $\sum W_i = K \sum (1/V_{standard})$ (2)

- In the second step, Quality rating (Q_i) is calculated as,

  $Q_i = 100 (V_{actual} / V_{standard})$ (3)

  While, the quality rating for pH (Q_{pH}) was calculated on the basis of,

  $Q_{pH} = 100 [(V_{actual} - V_{ideal}) / (V_{standard} - V_{ideal})$ (4)

  where, V_{actual} = value of the water quality parameter obtained from the laboratory analysis, V_{ideal} = the ideal value of pH considered as equal to (7.00), $V_{standard}$ = value of the water quality parameter obtained from recommended WHO standard of corresponding parameter. This equation ensures that $Q_i = 0$ when a pollutant is totally absent in the water sample and $Q_i = 100$ when the value of this parameter is just equal to its permissible value. Thus the higher the value of Q_i is, the more polluted is the water. Then, the overall WQI was calculated using the method proposed by Ott (1978), Harkins (1974) on the basis of weighting and rating of the different physico-chemical parameters, as follows:

$$WQI = \sum_{i=1}^{i=n} W_i Q_i \quad (5)$$

Based on the calculated WQI, the classification of water quality types is given according to Tiwari and Mishra (1985), Brown *et al.* (1972) as shown in Table 2.

Table-2 Water quality index scale

WQI	**0-25**	**26-50**	**51-75**	**76-100**	**>100**
Water Quality	Excellent	Good	Poor	Very Poor	Unsuitable for drinking
Grading	A	B	C	D	E

RESULTS AND DISCUSSION

The results obtained from monthly analysis of water samples of river Yamuna to show the seasonal fluctuation of selected parameters during 2017-18 and 2018-19 are presented in Table 3 and 4 and Fig.1.

Physicochemical parameters

pH plays an important role to examine the water quality assessment as it has major influence on chemical and biological processes in the aquatic system (Ahmed *et al*, 2011). pH of the Yamuna river water sample varied between (7.5 –8.8) during monsoon, (7.6 –8.7) winter and (7.7 –8.3) summer seasons. Hence the river water showed alkaline nature throughout the study period, due to presence of alkali metals.

Total Dissolved Solids (TDS) includes a variety of organic substances and salts which readily dissolves in water and often impart a degree of hardness. The value of TDS ranged between (717-964 mg/L) during monsoon, (631-979 mg/L) winter, and (745-1079 mg/L) summer season. Hence in Site-1 (Kailash temple) maximum TDS was observed during summer while minimum in monsoon and winter season, while in Site-2 (Hathi Ghat) maximum TDS was observed during monsoon and moreover low values was observed in summer and winter seasons. The observation is in conformity with the Trivedy *et al*, 1984. The TDS values tend to be diluted by surface runoff and for most rivers there is an inverse correlation between discharge rate and TDS (Charkhabi and Sakizadeh, 2006).

Alkalinity of water is a measure of weak acid present in it and of the cations balanced against them (Sverdrap *et al*, 1942). Total alkalinity in water ranges from (185-387.2 mg/L) during monsoon, (156.2-612 mg/L) winter and (284.5-790 mg/L) summer seasons. Hence in both sites higher values of alkalinity were observed during summer and lower values during winter and monsoon season. Similar findings were observed by Ugale and Hiware, 1999 and Pratibha *et al*. 2005.

Chloride occurs naturally in all types of aquatic system. Maximum concentration of chloride is an indicator of pollution because of organic wastes of industrial and animal origin. The value of chlorides in the present study were ranging from (283-657 mg/L) during monsoon, (441-622.2 mg/L) winter, (622.2-763.5 mg/L) summer season. The result of this analysis agree with Abdel (2005). Chlorides are troublesome in irrigation water and also harmful to aquatic life (Rajkumar *et al*, 2004).

Total Hardness is used to describe the effect of dissolved minerals (mostly Mg and Ca) determining suitability of water for industrial, drinking and domestic purposes attributed to presence of bicarbonates, sulphates, chloride and nitrates of Ca and Mg (Taylor, 1949). The variation in total hardness during study period at both sites were ranging between (381.7-624.7 mg/L) during monsoon, (457-649.2 mg/L) winter and (703-795 mg/L) summer season. Hence higher values of total hardness were found during summer and lower values were observed in monsoon and winter season.

Dissolved oxygen (DO) is one of the important factor of water quality and reflects the physical and biological processes prevailing in the water (Trivedi and Goel, 1984). Dissolved oxygen ranged between 3.6-5.4 mg/L during monsoon, 4.1-5.5 mg/L winter and 1.8-2.7 mg/L during summer. Low level of DO is again an indicator of heavy pollution of aquatic bodies. Hence low level of DO was found in summer season while higher values were observed

during monsoon and winter seasons. Higher value of DO during winter seasons due to the fact that the solubility of oxygen in water increases with decrease in temperature (Singh *et al*, 1980 and Ali, 1999). When the water is polluted with excessive concentration of organic matter, a lot of dissolved oxygen would be rapidly consumed in the biological aerobic decay which would affect the water quality; the decreased dissolved oxygen in water would affect the aquatic lives (Chhatwal, 2011).

Biological or Biochemical Oxygen Demand is a measure of the oxygen in water that is required by the aerobic organisms. The biodegradation of organic materials exerts oxygen tension in the water and increases the BOD (Abida, 2008). During the study period BOD varied from 20.7-32.8 mg/L during monsoon, 14.2-23.4 mg/L winter and 40.4-57.6 mg/L during summer season. High BOD level indicates decline in DO because the oxygen that is available in the water is being consumed by bacteria leading to the inability of fish and other aquatic organism to survive in the river (Pathak and Limaye, 2011). Hence maximum BOD was recorded in summer while minimum was in monsoon and winter season. These results are accordance with the study of Seenaya and Zafar (1979).

Chemical Oxygen Demand is a measure of the oxidation of reduced chemicals in water. It is used to measure the amount of organic compounds in water (Kumar *et al*, 2011). In the present study COD was found to be ranging from (121.1-285.2 mg/L) during monsoon, (132.2-234.7 mg/L) winter and (293.9-482.3 mg/L) during summer seasons. COD was recorded higher in summer than in winter and monsoon seasons. Khan *et al*, (2003) observed similar trends in COD values. Maximum COD have been reported to be associated with high organic matter content and sewage disposal in rivers (Mishra and Ram, 2007).

Assessment of Water Quality Index (WQI)

Calculation of water quality index (seasonal) is presented in Table-5 and Fig.2. WQI values obtained from the study of physicochemical analysis of river Yamuna in different seasons during different years showed that river water is unsuitable for drinking and it comes under grading ‘E’ which may be due to anthropogenic activities along the river. It is strictly advised not to consume water without proper treatment.

The results indicates that during summer season status of river water is much poorer in comparison to monsoon and winter seasons. Result shows the similarity with the research done by Kumar *et al*. 2015 in which it is stated that on the basis of WQI values of upstream of Mathura and Agra, the river water is not suitable for drinking purpose. Various researchers like Trivedi and Pathak (2007), Chauhan and Singh (2010) also estimated WQI in their studies on different water bodies. The WQI values clearly showed that Yamuna river water of Agra city isn’t suitable for drinking purpose hence, highest priority should be given to water quality monitoring and various technologies should be adopted to make fit for human consumption and agricultural usage.

Table-3 Physico-chemical parameters of river Yamuna (Site- 1 Kailash Temple) from January- December during 2017-18 and 2018-19

Months	Year	pH	TDS	Alkalinity	Chloride	Total Hardness	DO	BOD	COD
July	2017-18	8.9	778	193	248	682	3.6	28.5	97.9
	2018-19	7.6	1042	175	763	280	4.8	21.9	143.5
August	2017-18	9.8	884	168	265	586	2.4	16.7	117.5
	2018-19	9.3	926	182	524	385	6.4	13.4	128.5
September	2017-18	8.2	828	246	235	764	4.8	19.7	116.4
	2018-19	6.6	885	189	583	534	5.2	21.1	284.5
October	2017-18	8.4	1224	198	384	467	3.6	23.5	152.8
	2018-19	6.5	968	195	424	782	5.2	26.4	263.4
MONSOON	2017-18	**8.8**	**928**	**201**	**283**	**624.7**	**3.6**	**22.1**	**121.1**
	2018-19	**7.5**	**955**	**185**	**573.5**	**495.2**	**5.4**	**20.7**	**204.9**
November	2017-18	9.4	864	117	567	599	6.5	14.2	93.5
	2018-19	7.6	828	176	625	624	4.4	12.3	128.5
December	2017-18	9.2	725	238	442	409	4.8	11.7	102.5
	2018-19	9.4	624	168	562	684	5.4	16.9	103.9
January	2017-18	6.6	507	138	738	385	4.6	12.8	124.5
	2018-19	9.3	887	142	268	726	5.4	16.9	98.5
February	2017-18	6.2	428	132	742	435	6.4	18.3	208.4
	2018-19	8.5	1024	230	648	563	3.6	26.7	253.2
WINTER	**2017-18**	**7.8**	**631**	**156.2**	**622.2**	**457**	**5.5**	**14.2**	**132.2**
	2018-19	**8.7**	**840**	**179**	**525.7**	**649.2**	**4.7**	**18.2**	**146.0**
March	2017-18	7.6	826	245	659	678	3.7	38.4	355.6
	2018-19	8.8	1183	628	489	338	2.9	32.6	524.4
April	2017-18	8.2	948	287	735	774	2.8	38.5	306.8
	2018-19	9.6	1072	702	868	762	2	23.3	455.8
May	2017-18	9.8	1135	209	797	838	1.6	38.8	229.8
	2018-19	6.2	1068	721	756	889	0.8	57.5	309.3
June	2017-18	7.6	1074	397	863	890	1.4	46.2	283.5
	2018-19	6.6	994	598	506	823	1.8	48.8	480.3
SUMMER	**2017-18**	**8.3**	**995**	**284.5**	**763.5**	**795**	**2.3**	**40.4**	**293.9**
	2018-19	**7.8**	**1079**	**662.2**	**654.7**	**703**	**1.8**	**40.5**	**442.4**

***All values are expressed in mg/L except pH.**

Table-4 Physico-chemical parameters of river Yamuna (Site- 2 Hathi Ghat) from January- December during 2017-18 and 2018-19.

Months	Year	pH	TDS	Alkalinity	Chloride	Total Hardness	DO	BOD	COD
July	2017-18	9.4	698	406	680	143	3.4	43.4	224.6
	2018-19	8.4	950	228	544	287	2.6	38.6	252.8
August	2017-18	8.8	524	278	662	249	5.4	18.5	246.8
	2018-19	7.6	966	345	890	347	5.2	22.4	258.9
September	2017-18	6.4	924	386	462	745	4.6	32.8	362.8
	2018-19	7.7	968	484	682	846	3.2	33.2	208.7
October	2017-18	8.8	725	308	773	390	4.8	36.8	306.8
	2018-19	8.2	975	492	512	565	3.8	16.4	315.8
MONSOON	2017-18	**8.3**	**717**	**344.5**	**644.2**	**381.7**	**4.5**	**32.8**	**285.2**
	2018-19	**7.9**	**964**	**387.2**	**657**	**511.2**	**3.7**	**27.6**	**259**
November	2017-18	7.6	972	284	493	217	4.2	20.9	206.8
	2018-19	7.2	1028	583	462	282	4.5	22.4	254.6
December	2017-18	7.9	826	672	359	584	3.5	21.2	372.9
	2018-19	9.1	896	763	763	386	5.2	24.2	236.8
January	2017-18	8.2	726	652	350	382	4.4	16.7	135.3
	2018-19	8.4	964	478	582	592	5.3	20.8	254.8
February	2017-18	6.8	528	528	562	863	4.5	15.2	110.8
	2018-19	7.7	1028	624	265	375	7.2	26.5	192.8
WINTER	2017-18	**7.6**	**763**	**534**	**441**	**511.5**	**4.1**	**18.5**	**206.4**
	2018-19	**8.1**	**979**	**612**	**518**	**408.7**	**5.5**	**23.4**	**234.7**
March	2017-18	8.4	938	547	865	582	3.1	48.5	273.9
	2018-19	9.1	728	825	564	693	4.6	26.2	246.8
April	2017-18	7.6	665	821	887	790	2.7	57.4	485.5
	2018-19	9.2	827	528	564	806	1.2	43.2	412.9
May	2017-18	8.9	656	826	502	877	1.6	62.4	520.8
	2018-19	6.4	619	974	738	784	3.8	52.6	576.2
June	2017-18	6.6	724	856	592	892	0.8	62.4	575.9
	2018-19	6.2	886	833	623	778	1.2	78.2	693.5
SUMMER	2017-18	**7.8**	**745**	**762.5**	**711.5**	**785.2**	**2.0**	**57.6**	**464.0**
	2018-19	**7.7**	**765**	**790**	**622.2**	**765.2**	**2.7**	**50.0**	**482.3**

***All values are expressed in mg/L except pH**

Fig 1: Seasonal variation in physico-chemical parameters of River Yamuna of Site-1 and Site-2 during 2017-18 and 2018-19

Table-5 Water quality index value of Yamuna River in different seasons

Sampling Sites	Seasons	WQI (2017-18)	WOI (2018-19)	Water Quality Status	Grading
Site-1 (Kailash Temple)	Monsoon	243.6	240.1	Unsuitable	E
	Winter	181.0	217.0	Unsuitable	E
	Summer	408.4	426.4	Unsuitable	E
Site-2 (Hathi Ghat)	Monsoon	346.8	302.3	Unsuitable	E
	Winter	223.0	266.5	Unsuitable	E
	Summer	561.9	504.7	Unsuitable	E

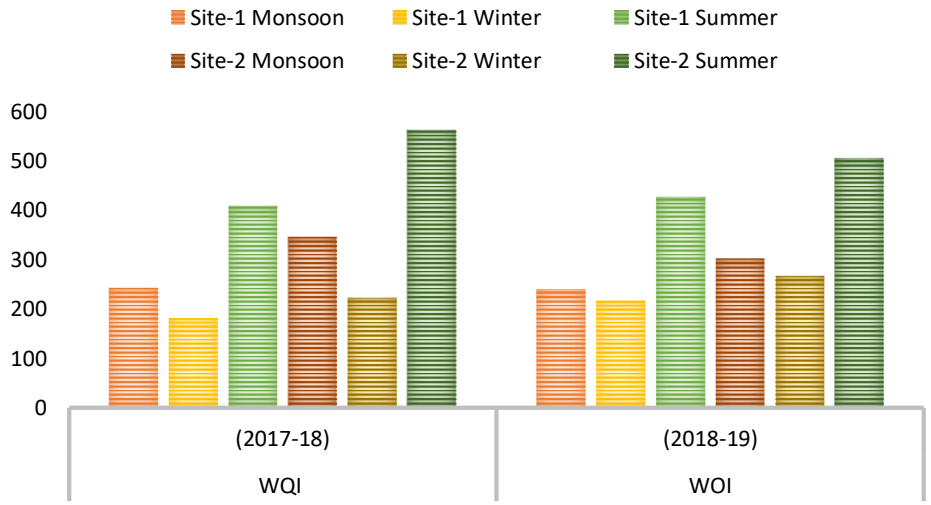

Fig 2: Seasonal variation in Water quality index of River Yamuna

CONCLUSION

Water body management necessarily requires an understanding of biological and physicochemical conditions. From the analysis of physicochemical parameters of Yamuna river water in Agra city, it could be clearly stated that river water quality is not healthy due to rise in alarming levels of organic and inorganic wastes which is a consequence of anthropogenic activities, that directly or indirectly influences the aquatic system and impose serious health hazards to terrestrial life forms including human-beings. Therefore to control further pollution, regular monitoring and implementation of strict laws is needed to regulate the environmental hazards and to improve the water quality status of river Yamuna.

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