Volume : 3 | Issue : 6 | June 2014 • ISSN No 2277 - 8160

Research Paper Microbiology

Water Quality Index of Mansi Ganga, Radha and Shyam Kunds of Govardhan, Mathura

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ABSTRACT

The present study deals with the analysis of physicochemical parameters such as pH, temperature, color, turbidity, alkalinity, hardness, sulphate, chloride, fluoride, nitrate, phosphate, total suspended solids, total dissolved solids, dissolved oxygen and biochemical oxygen demand and faecal coliforms in water samples of Mansi Ganga, Radha and Shyam kunds in Govardhan at Mathura. The mean value, standard deviation and percentage of coefficient of variance were computed for each parameter and compared with standards stated by World Health Organization (WHO). On comparison, parameters such as color, turbidity, hardness, sulphate, chloride, BOD and COD exceed the WHO limits for all the kunds. Water Quality Index was also calculated to detect the overall water quality. The WQI was found between 45-49 which denotes poor water quality indicating requirement of treatment before consumption and recreational purposes.

KEYWORDS : Kunds, Water Quality Index (WQI), physicochemical parameters

Introduction

Radha kund, Shyam Kund and Mansi Ganga are considered the most sacred *kunds* along the Govardhan Parvat *parikrama* route. They are among the most highly visited kunds from the 23 kunds that fall on the route. People take a dip in the holy waters of the *kund* along their religious tour. Many of the kunds have underground natural aquifers which constantly feed the kunds. Some receive their water from annual rain and overland flow.

The life of the local residents revolves around the kunds which serve a utilitarian and religious purpose, both at the same time. Many settlements don't have proper sewer system which results in discharge of their domestic waste water into the kunds creating a significant problem for the kund ecology.

Daily hundreds of pilgrims visit the kunds for the holy dip and consume the water as a holy offering from God (*Prasad*). One of the major sources for the contamination is the domestic waste and agricultural runoffs. Thus it is important to determine the water quality of the kunds. The study will aid in determining whether it is fit for consumption and if not what treatment should be carried for it to be fit for consumption. The problems relating to water attract the attention to the urgency for investigating the causes and suggesting solutions with an aim to prepare the future plan of action for maintenance of potable water

Water Quality Index (WQI)

Water quality can be determined by calculating the Water Quality Index (WQI) which is a single value indicator for the same. WQI is a dimensionless number that combines multiple water quality factors into a single number by normalizing values to subjective rating curves (Miller et al., 1986). Conventionally, it has been used for evaluating the quality of water for water resources such as rivers, streams and lakes, etc. Factors included in WQI vary depending upon the designated uses of the water body and local preferences. Some of the factors include dissolved oxygen (DO), pH, biological oxygen demand (BOD), total suspended solids (TSS), Faecal coliform bacteria, temperature, and nutrients (nitrogen and phosphorus) etc. These parameters are measured in different ranges and expressed in different units. The WQI takes the complex scientific information of these variables and synthesizes it into a single number.

In the present study, water quality of the water of all three kunds was determined using Water Quality Index and the different parameters of the kunds were compared by considering percentage coefficient of variance (%CV).

Material and Methods

Sampling

Water samples were collected during the year 2012 and 2013 from six sampling points (S1-S6) from all the kunds. Samples were collected from the surface from the different areas before sunrise. They were collected in HDPE (High density polyethylene) bottles and analyzed within 2 hrs of sampling.

Analysis

The study includes the analysis of physical, chemical and microbiological parameters which are as follows:

A. Physical Characteristics: The physical characteristics included temperature (Direct thermometer), color (Visual comparison), turbidity (Nephelometric method), total dissolved solids (TDS) (Evaporation method), total suspended solids (TSS), total solids (TS).

B. Chemical Characteristics: The chemical characteristics included pH (Direct pH meter), alkalinity (Titration method), hardness (EDTA method), dissolved oxygen (DO)(Winkler's method), chemical oxygen demand (COD) (Closed reflex method), biological oxygen demand (BOD) (Iodometric azide method),chloride (Argentometric method), nitrate (Brucine method) phosphate (Colorimetric Method), sulphate (Turbidimetric Method) and fluoride (SPANDS method).

C. Microbiological Characteristics: The microbiological analysis includes Faecal coliform count

All the physico-chemical parameters were analyzed by the methods given by Trivedy and Goyal (1992) and APHA (2005).All chemicals and dehydrated culture microbiological media used in testing belong to Merck Ltd.

The observed values were compared with the recommended standards stated by WHO, 2002. The calculation of Water Quality Index was done by using the software Keith Alcock's Javascript WebMaster 2008. The data obtained was reported and compared.

Statistical analysis through %CV and Standard Deviation was done (Rosner, 2006). The water quality index values for the kunds were compared with the standards stated by CCME, 2005 and quality of water was thus determined.

Results and Discussion

Physico-chemical characteristics of surface water of Mansi Ganga, Radha and Shyam kund in Govardhan at Mathura, Uttar Pradesh is shown in Table 1. pH has no direct adverse effects on health; however, High pH induces the formation of tri halo methane which is toxic. pH below 6.5 starts corrosion in pipes, thereby releasing toxic metals such as Zn, Pb, Cd and Cu etc. (Trivedy and Goel, 1986). The pH values of water samples of present study ranged from 6.4-8.4 for all the kunds. These values are within the prescribed limit of standards (WHO

2001; 2002).

The mean values of the parameters obtained during the year were compared with the WHO standards. temperature, pH, fluoride, nitrate and phosphate values are within the limits prescribed by WHO. The alkalinity of Mansi Ganga also falls within the range while that of Radha and Shyam kunds is above the range. Also TDS values of Radha and Shyam kund fall in the given range but TDS value of Mansi Ganga kund fails to fall within the limit. The values of other parameters such as color, turbidity, hardness, sulphate, chloride, BOD and COD exceed the WHO limits (WHO 2001, 2002).

Table. 1:Physicochemical parameters of Mansi Ganga, Radha and Shyam Kunds

Parameter	Manasi Ganga	Radha Kund	Shyam Kund	WHO limits
Temperature (°C)	27.57	27.76	27.71	20-40
pH	7.21	7.22	7.19	5.5-9.0
Colour	35.21	28.51	30.03	15
Turbidity(NTU)	64.65	41.42	41.38	5
Alkalinity(mg/l)	180.96	303.17	299.03	200
Hardness(mg/l)	1,820.26	1332.72	1334.49	200-500
Sulphate(mg/l)	864.33	595.48	580.87	250
Chloride(mg/l)	1,534.74	684.51	674.48	250
Fluoride(mg/l)	0.71	0.75	0.74	1.5
Nitrate(mg/l)	0.85	0.62	0.62	20
Phosphate(mg/l)	0.82	0.82	0.82	5
TSS (mg/l)	62.17	57.92	57.93	0
TDS (mg/l)	1,488.61	775.61	775.08	1000
DO (mg/l)	6.76	6.97	6.96	5
BOD (mg/l)	24.45	15.03	15.02	5
COD (mg/l)	46.35	45.93	46.25	30

Statistical analysis of selected parameters is carried out to further analyse the data in terms of Std Deviation and %CV. The analysis shows the variation in the values of the different parameters throughout the year (Table 2, 3, 4). Further WQI was also calculated to check the suitability of the samples under study for consumption and recreational purposes.

Table 2: Water quality parameters of Mansi Ganga, Std Deviation, %CV and comparison with WHO standards

Study Parameters	Range	Mean	SD	%CV	WHO Standard value	Result
Temperature (°C)	7 - 44	27.57	11.05	40.1	40±5	In limit
pH	6.4 - 8.3	7.21	0.53	7.33	5.5-9.0	In limit
D.O. (mg/l)	4.0- 9.0	6.79	0.013	-	5	High
Turbidity (NTU)	29 - 116	64.65	30.14	46.62	10	High
Fecal Coliform (CFU)	210 - 613	385.46	17.71	4.58	0	High
BOD (mg/l)	18 - 31	24.45	3.14	12.83	5	High
Phosphate (mg/l)	0.65 - 1.1	0.82	0.07	8.12	5	In limit
Nitrate (mg/l)	0.53 - 1.2	0.85	0.12	13.6	20	In limit
TSS (mg/l)	48-120	62.17	12.32	19.82	0	High

Table 3: Water quality parameters of Radha Kund, Std Deviation, %CV and comparison with WHO standards

Study Parameters	Range	Mean	SD	%CV	WHO Standard value	Result
Temperature (°C)	8 - 44	27.76	10.8	38.92	40±5	In limit
pH	6.4-8.4	7.22	0.51	7.04	5.5-9.0	In limit
D.O. (mg/l)	5-8.7	6.97	1.17	16.85	5	High
Turbidity (NTU)	13-94	41.42	24.57	59.32	10	High
Fecal Coliform (CFU)	144-410	263.18	11.67	4.42	0	High
BOD (mg/l)	9.8-20.8	15.03	3.18	21.15	5	High
Phosphate (mg/l)	0.68-1.01	0.82	0.07	8.16	5	In limit
Nitrate (mg/l)	0.33-0.82	0.62	0.1	16.79	20	In limit
TSS (mg/l)	40-95	57.92	10.52	18.17	0	High

Table 4: Water quality parameters of Shyam Kund, Std Deviation, %CV and comparison with WHO standards

Study Parameters	Range	Mean	SD	%CV	WHO Standard value	Result
Temperature (°C)	8 - 44	27.71	11.05	39.89	40±5	In limit
pH	6.5-8.3	7.19	0.53	7.35	5.5-9.0	In limit
D.O. (mg/l)	5-8.6	6.96	1.22	17.53	5	High
Turbidity (NTU)	14 -95	41.38	30.14	72.83	10	High
Fecal Coliform (CFU)	139 - 398	260.97	7.09	3.11	0	High
BOD (mg/l)	9.9-20.9	15.02	3.14	20.88	5	High
Phosphate (mg/l)	0.6-0.97	0.82	0.07	8.05	5	In limit
Nitrate (mg/l)	0.34-0.83	0.62	0.12	18.45	20	In limit
TSS (mg/l)	40 - 99	57.93	12.32	21.27	0	High

Temperature affects the speed of chemical reactions, the metabolic rates of organisms as well as how pollutants and other pathogens interact with aquatic residents (Digital atlas, 2006). Water temperatures fluctuate naturally both daily and seasonally. The maximum daily temperature is usually higher after noon and the minimum is around day break. Temperature of the water samples range from 7-44 °C throughout the year according to the season. The %CV values for temperature for Mansi Ganga, Radha Kund and Shyam Kund are 40.1, 38.92, 39.89 respectively. The % CV values are almost same for all the kunds under study.

The %CV values for pH of the water samples for Mansi Ganga were 7.33, for Radha Kund it was 7.04 and for Shyam Kund it was 7.35 % coefficient variance values are observed to be higher for Mansi Ganga and Shyam Kund than Radha Kund.

Dissolved Oxygen concentration is extremely crucial in determining the nature of the microbial flora and also the purity of water (Agrawal and Rajwar, 2010). DO range of the three kunds falls between 4-9 mg/l. All water samples were found to exceed the permissible limit stated by the WHO 2001, 2002. The % CV values of three kunds i. e Mansi Ganga, Radha, Shyam Kunds are 52.09, 16.85 and 17.53 respectively. The percent coefficient of DO for Mansi Ganga is extremely high in comparison to the Radha and Shyam Kunds.

Turbidity is one of the most important parameters to decide the suitability of water for various purposes like drinking and recreation. Turbidity content of water samples of the kund range from 13-116 NTU. The turbidity values were seen to exceed the prescribed WHO limit which is 10 NTU. The calculated value of %CV of turbidity was 46.62 for Mansi Ganga, 59.32 for Radha Kund and 72.83 for Shyam Kund. Shyam Kund shows the highest variance in the values for all the sampling points throughout the year in comparison to the other two kunds. One of the possible reasons for higher turbidity could be due to the surface runoffs and domestic wastes that flow down to these kunds (Agrawal and Rajwar, 2010).

Faecal coliforms detection is the major test for microbiological anal-

ysis of water. The greatest microbiological risks are associated with ingestion of water that is polluted with human and animal excreta and waste water discharges. Consumption of such contaminated water leads to waterborne diseases like jaundice, cholera, diahorrea etc..Faecal coliform content of the kund water samples ranged from 139-410 CFU. The permissible limit of faecal coliform defined by WHO is zero CFU. All the kunds exceed the given limit. The value of %CV of faecal coliform of water samples of Mansi Ganga, Radha and Shyam Kund were 4.58, 4.42 and 3.11 respectively (WHO, 2008 and Fenwick 2006).

BOD is a measure of water quality that reflects the degree of organic matter pollution of a water body. Types of micro-organism, pH, and the presence of toxins, some reduced mineral matter and nitrification process are the important factors influencing the BOD (Kumar and Bahadur, 2009). BOD values of the three kunds ranged from 9.8-31 mg/l. All the water samples of the kunds exceed the permissible limit given by WHO. The value of % CV of BOD is 12.83 for Mansi Ganga, 21.15 for Radha and 20.88 for Shyam Kund. The % CV of BOD was observed higher in Radha and Shyam Kund and lower in Mansi Ganga.

Phosphate is present in relatively low quantities in the kunds as the aquatic plants absorb phosphate more than their requirement and store it within (Mahananda *et al,* 2010). Phosphate content of the kunds varies from 0.6-1.1 mg/l. All the samples were found to be within the permissible limits given by the WHO i. e 5mg/l. The %CV values are 8.12, 8.16, 8.05 for Mansi Ganga, Radha and Shyam Kund respectively. The % CV of phosphate was almost same for all the three kunds studied.

Nitrates represent the final product of the biochemical oxidation of ammonia. Monitoring of nitrates in drinking water supply is very important because of health effects on humans and animals (Mahananda *et al* 2010). The values of nitrate ranged from 0.33-1.2 mg/l. All the samples were found to be within the permissible limits given by the WHO standards (20 mg/l). The computed % CV of nitrate was 13.6 for Mansi Ganga, 16.79 for Radha and 18.45 for Shyam kund. Variance was almost same in Radha and Shyam Kund and also higher than Mansi Ganga.

Total suspended solids (TSS) are found in the natural surface waters. TSS values of the water samples ranged from 40-120 mg/l. The values exceed the given permissible limit by WHO. The TSS % CV value for Mansi Ganga was 19.82 for Radha Kund it was 18.17 and for Shyam Kund it was 21.27. Shyam kund showed the highest variance among the three whereas variance at Radha and Shyam kund was similar.

Table 5: Physicochemical parameters at 6 different sampling points of Mansi Ganga Kund, Govardhan, Mathura

Study Parameters	S1	S2	S3	S4	S5	S6	Mean	WQI
Temperature (°C)	27.46	27.79	27.79	27.65	27.79	27.53	27.67	13
pH	7.30	7.28	7.21	7.25	7.23	7.19	7.24	92
D.O. (mg/l)	6.80	6.80	6.81	6.79	6.77	6.80	6.79	5.0
Turbidity (NTU)	64.33	64.33	65.33	63.67	63.00	66.25	64.49	31
Faecal Coliform (CFU)	374	391	385	377	418	368	385	31
BOD (mg/l)	24.6	24.53	24.59	24.47	24.49	24.52	24.53	7.0
Phosphate (mg/l)	0.81	0.8	0.81	0.81	0.82	0.82	0.81	46
Nitrate (mg/l)	0.86	0.85	0.84	0.84	0.86	0.83	0.85	96
TSS (mg/l)	67.67	69.08	69.42	69.67	70.75	70.58	69.53	86
Mean WQI								45

Table 6: Physicochemical parameters at 6 different sampling points of Radha Kund, Govardhan, Mathura

Study Parameters	S1	S2	S3	S4	S5	S6	Mean	WQI
Temperature (°C)	27.60	27.70	27.72	27.70	27.85	27.95	27.75	13
pH	7.27	7.30	7.22	7.23	7.25	7.28	7.26	92
D.O. (mg/l)	6.97	6.96	6.95	6.93	6.98	6.94	6.95	5.0
Turbidity (NTU)	39.67	40.42	39.58	40.58	41.58	43.25	40.85	44
Faecal Coliform (CFU)	248	261	252	273	267	278	263	35
BOD (mg/l)	14.91	15.16	14.86	15.00	14.92	14.94	14.96	20
Phosphate (mg/l)	0.81	0.81	0.82	0.82	0.81	0.83	0.82	46
Nitrate (mg/l)	0.61	0.64	0.61	0.62	0.61	0.61	0.62	96
TSS (mg/l)	61.83	61.5	60.67	61.67	60.33	62.75	61.46	87
Mean WQI								49

Table 7: Physicochemical parameters at 6 different sampling points of Shyam Kund, Govardhan, Mathura

Study Parameters	S1	S2	S3	S4	S5	S6	Mean	WQI
Temperature (°C)	27.48	27.66	27.78	27.78	27.93	27.82	27.74	13
pH	7.25	7.23	7.21	7.17	7.19	7.22	7.21	92
D.O. (mg/l)	6.93	6.93	6.89	6.98	6.95	6.94	6.94	5.0
Turbidity (NTU)	40.50	40.92	40.42	40.50	41.17	43.17	41.11	44
Faecal Coliform (CFU)	251	263	257	258	269	268	261	35
BOD (mg/l)	14.92	14.94	14.98	15	15.06	15.25	15.03	20
Phosphate (mg/l)	0.82	0.83	0.82	0.81	0.82	0.82	0.82	46
Nitrate (mg/l)	0.63	0.63	0.62	0.62	0.63	0.64	0.63	96
TSS (mg/l)	65.33	62.42	61.67	61.17	61.08	66.08	62.96	87
Mean WQI								49

Abbreviations: S1-S6: Various sampling points of the kunds

Water Quality Index (WQI) provides a single number that expresses overall water quality at a certain location and time. The WQI uses a scale from 0 to 100 to rate the quality of the water, with 100 being the highest possible score. The WQI is based on the results of nine parameters (chemical/physical tests/microbiological). The results are recorded and transferred to a weighting curve chart. A numerical value obtained from the chart which is then multiplied by a weighting factor. The nine resulting values are then added to obtain an index value known as WQI (CCME, 2005).

The Water Quality Index of Mansi Ganga, Radha Kund and Shyam kund are stated in Table 5, 6 and 7. The observed WQI values for Mansi Ganga, Radha and Shyam kund are 45, 49 and 49 respectively. The WQI for all the kunds studied ranges from 45-49 which shows that the water is of poor quality in all the kunds.

Interpretation of WQI results

Grading scale recommended by CCME 2001 was followed for data interpretation. It uses five categories or levels that correspond to specific levels of water quality impairment. Water quality index of Mansi Ganga, Radha and Shyam kunds ranged from 45-49. This indicates that the water is of poor quality in all the kunds, showing that the water is frequently threatened or impaired; conditions often depart from natural or desirable levels (CCME, 2005). The WQI was calculated to determine the suitability of the kund water for drinking and recreational purposes. An appropriate method needs to be adopted to treat the water to make it suitable for consumption.

WQI values range from 100 (excellent) to 0 (very poor). These scores were grouped into one of the five categories which indicate the over-

all status of water quality. Table 9 and 10 classifies the water of the kunds under the given categories (Kankal et al, 2012)

Table 8: Water quality indicators

Water Quality Indicators (CCME, 2005)	
Range	Quality
95-100	**Excellent:** Water quality is protected with virtual absence of threat or impairment; conditions very close to natural or desirable levels
80-94	**Good:** Water quality is protected with only minor degree of threat or impairment; conditions depart from natural or desirable levels
60-79	**Fair:** Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels
45-59	**Poor (Marginal):** Water quality is frequently threatened or impaired; conditions sometimes often depart from natural or desirable levels
0-44	**Very Poor:** Water quality is almost always threatened or impaired; conditions sometimes usually depart from natural or desirable levels (Unsuitable for drinking)

Table 9: Status of Kunds based on WQI indicators

Kund	Mansi Ganga	Radha Kund	Shyam Kund
WQI	45	49	49
Status	Poor	Poor	Poor

Conclusion

Water Quality Index (WQI) for Mansi Ganga, Radha and Shyam kund are 45, 49 and 49 respectively which indicates the poor quality of water. The high values of DO, BOD, TSS and Faecal coliform could contribute to the poor water quality. WQI plays a crucial role in determining the pollution hazards related to water. The study shows that the water is not suitable for drinking and recreational purposes as per the WQI values; however this water can be used for drinking and recreational purpose only after proper purification and disinfection.

Acknowledgement:
The author expresses his sincere gratitude to Dr S. K. Singh, Professor of Zoology at MSJ College, Bharatpur.

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