Application of the National Sanitation Foundation Water Quality Index in the Sabarmati River, Gujarat, India

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Abstract— A Water Quality Index provides a single number that expresses overall water quality at a certain location and time based on several water quality parameters. In the present study, water quality parameters of three different water stations along the Sabarmati river were collected to determine water quality index (WQI). Ten most important parameters - Biochemical Oxygen Demand, dissolved oxygen, Faecal Coliform, Nitrates, pH, Phosphate, temperature change, Total suspended solids, turbidity were considered for WQI. The WQI was assessed using National Sanitation Foundation (NSF) method. National Sanitation Foundation Water quality Index (NSFWQI) values vary between 53.97 to 73.97. The results of the WQI show that the water quality of stations are good and fair according to NSFWQI ranking.

Key words: Water Quality Index, NSF Water Quality Index, Dissolved Oxygen, Biochemical Oxygen Demand

I. INTRODUCTION

Fast growth in population, more effective agriculture and industrial development are the main reasons for the growing amount of pollutants in the waters. Wastewater from the human settlements contains organic material and nutrients, industrial wastewater contains heavy metals and complexes, insoluble chemical compounds, which are harmful to people, animals and plants. Fertilizers and pesticides are used in the agriculture and they are harmful for the surface and groundwater, traffic loads air, soil and water and irrigation burdens water with salt. In the developing countries these agglomerations are even worse than in developed countries because they do not have proper sanitation and the technique are often too old and noneffective [3]. The water quality index is a unitless single dimensional numbers between 0 to 100. A higher index value represents good water quality[6,15]. Therefore a numerical index is used as a management tool in water quality assessment.

Horton (1965) used the arithmetic aggregation function for the WQI. He selected 8 water quality variables for his index including dissolved oxygen (DO), pH, coliforms, specific conductance, alkalinity, chloride, carbon chloroform extract and sewage treatment. Similar to Horton (1965), Brown et al. (1970) also employed basic arithmetic weighting, although without the multiplicative variables. This effort was supported by the National Sanitation Foundation (NSF). Dinius (1972) developed a index based on multiplicative aggregation having decreasing scale, with values expressed as a percentage of perfect water quality corresponding to 100%. Similar work was carried out by Helmer & Rescher (1959), Dalkey & Helmer (1963) by introducing changes to Delphi method. Brown et al. (1972), Bhargava et al. (1998), Dwivedi et al. (1997); Bhargava (2006); Landwehr et al. (1976) gave multiplicative form of the index where weights to individual parameters were assigned based on a subjective opinion based on the judgment and critical analysis of the author. Dee et al. (1972, 1973) proposed a system for evaluating the environmental impact of large scale water resources projects. McClelland (1974) introduced the geometric mean form of weighting to the WQI.

The main focus of this study is to apply a National Sanitation Foundation Water Quality Index (NSFWQI) for three stations located on River Sabarmati, Gujarat.

A. Study Area:

Sabarmati River basin:

Three stations have been selected in the Sabarmati river basin. These stations have been selected on the river Sabarmati and its tributaries. The stations located on the Sabarmati river and its tributaries: are listed as follows:

1) Station-1 (S1) –Sabarmati river at Railway Bridge, at Ahmedabad city located in Ahmedabad district.
2) Station-2 (S2) - Sabarmati river at Hansol Bridge, at Ahmedabad city located in Ahmedabad district.
3) Station-2 (S3) - Khari river tributary of Sabarmati river, at Lali village located in Ahmedabad ditrict.

Fig. 1 shows the map of Sabarmati River Basin with stations under study.

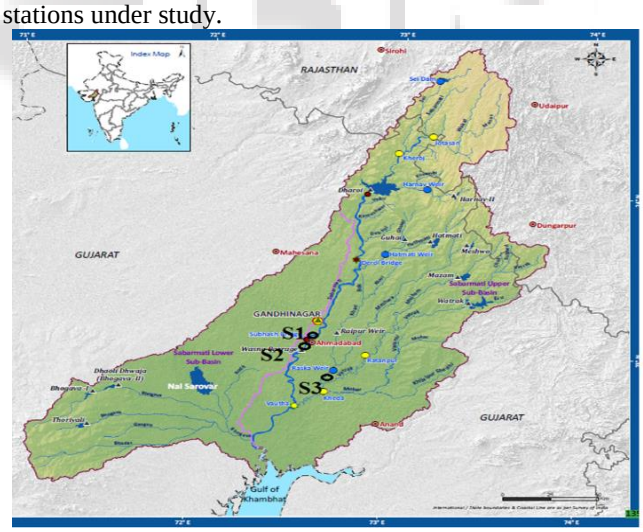

Fig. 1: Map of Sabarmati River Basin with stations under study

II. METHODOLOGY

The application of The National Sanitation foundation Water Quality Index (NSFWQI) is carried out on to assess the water quality at the three stations on Sabarmati river.

The NSFWQI method generates results from the convergence of expert's opinions. The index developed by NSF represented the general water quality status of monitoring stations using 9 quality parameters. Parameters required for this index are:

faucal coliforms, Biochemical Oxygen demand (B0D5), turbidity, pH, Total Suspended solids (TSS), dissolved Oxygen (D0) in %, Nitrate Nitrogen (N03), Phosphate (P04) and Temperature (ΔT). The NSFWQI used logarithmic transforms to convert water quality variable results into subindex values. Scientists were asked to graph the level of water quality ranging from 0 (worst) to 100 (best) from the raw data. Curves drawn were then averaged to obtain a weighting curve for each parameter. Results of the nine parameters are compared to the curves and a numerical value, or "Sub index value," is obtained. To estimate the final index the equations (1) and (2) are used (NSF, 2003). Table 1 shows the ranking criteria of NSF Water Quality Index and Table 2 shows the weights of the water quality parameters.

$$\sum_{i=1}^{n} \text{Ii X Wi} \quad (1)$$

$$\sum_{i=1}^{n} \text{Wi} = 1 \quad (2)$$

Ii= Sub-index of each parameters

Wi= Weighting factor

n= Number of sub-indices

Quality	Value
Very good	90 - 100
Good	70 - 90
Fair	50 - 70
Bad	25 - 50
Very bad	0 - 25

Table 1: NSF Water Quality Index ranking

Parameters	Weight
DO%	0.17
Faecal Coliform	0.16
pH	0.11
BOD5	0.11
ΔT	0.1
T.PO4	0.1
NO3	0.1
Turbidity	0.08
Solids	0.07

Table 2: Importance rate and parameter's weight in NFSWQI

Data base for Water Quality:

Water quality concentration for the parameters Biochemical Oxygen Demand, dissolved oxygen, Faecal Coliform, Nitrates, pH, Phosphate, temperature change, Total suspended solids, turbidity for the stations S1, S2 & S3 has been collected for the present study for a four year period from State Pollution Control Board. Water quality parameter concentration at stations is shown in table 3.

Year	BOD (mg/l)	DO (mg/l)	Faecal Coliform MPN/100 ml	Nitrates (mg/l)	pH	Phosphate (mg/l)	Temp. deg.C	Suspended Solids (mg/l)	Turbidity (NTU)
Station S_1									
2005	2.1	7	1500	0.19	7.8	0.075	25	6	1.8
2006	4	7.2	75	0.1	8	0.13	20	28	2.1
2008	1	5.7	40	0.3	8.1	0.01	22	34	0.3
2009	8	8.9	90	0.11	8.2	0.01	26	20	0.3
Station S_2									
2005	1.5	8.4	460	0.22	7.9	0.08	27	8	1.4
2006	3.2	9.9	15	0.1	8.6	0.07	23	14	0.8
2008	3	9.5	15	0.5	8.5	0.01	22	12	0.2
2009	12	8.8	200	0.16	8.4	0.01	26	10	0.4
Station S_3									
2005	10	7.6	460000	0.51	7.2	0.058	30	6	1.3
2006	18	4.2	430000	1	7.3	0.062	29.6	8	3.5
2008	19	3	16150	0.9	7.5	0.078	29.5	10	8.6
2009	20	2.7	2100	0.17	7.7	0.064	28	16	7.3

Table 3: Water quality parameter concentration at stations

III. RESULTS

Results of sub index for parameters for the Stations on Sabarmati River.

The water quality sub- index of individual parameter was calculated for the stations and is shown in Table 4, 5 and 6.

Year	Sub Index (BOD)	Sub Index (DO)	Sub Index (Faecal Coliform)	Sub Index (Nitrates)	Sub Index (pH)	Sub Index (Phosphate)	Sub Index (Temp.)	Sub Index (sus. solids)	Sub Index (turbidity)
2005	78	68	20	97	90	97	80	81	94
2006	61	72	47	97	84	95	67	84	93
2008	95	49	55	97	80	100	74	85	98
2009	42	90	45	97	77	100	88	84	98

Table 4: Sub Index value for the parameters for S1 station

Year	Sub Index (BOD)	Sub Index (DO)	Sub Index (Faecal Coliform)	Sub Index (Nitrates)	Sub Index (pH)	Sub Index (Phosphate)	Sub Index (Temp.)	Sub Index (sus. solids)	Sub Index (turbidity)
2005	90	86	29	97	87	97	91	81	95

2006	66	98	67	97	63	97	77	83	97
2008	67	95	67	97	66	100	73	82	98
2009	28	89	37	97	70	100	89	82	98

Table 5: Sub Index value for the parameters for S2 station

Year	Sub Index (BOD)	Sub Index (DO)	Sub Index (Faecal Coliform)	Sub Index (Nitrates)	Sub Index (pH)	Sub Index (Phosphate)	Sub Index (Temp.)	Sub Index (sus. solids)	Sub Index (turbidity)
2005	34	77	2	96	92	98	81	81	95
2006	14	30	2	96	93	98	82	81	89
2008	13	18	9	96	93	97	82	82	79
2009	12	16	18	97	91	97	88	83	81

Table 6: Sub Index value for the parameters for S3 station

Results of NSFWQI:

The equation (1) of NSF water quality index was used by using weighted factor of individual parameter shown in table 2 and subindex of each water quality parameter based on their respective testing values which can be found by water quality index calculator or water quality index curve of respective parameters (Table 4, 5 & 6). The results of NSFWQI is shown in Table 7.

$$WQI = 0.11\ IBOD + 0.17\ IDO + 0.16\ IFaecal\ Coli. + 0.1\ INitrates + 0.11\ IpH + 0.1\ IPO4 + 0.1\ I\ \Delta T + 0.07\ Isolids + 0.08\ ITurbidity \quad (3)$$

Station	Name of station	Year	NSF Water Quality index	Average Water Quality Index
S_1	Sabarmati river at Railway bridge, Ahmedabad	2005	68.16	70.12
		2006	69.05	
		2008	71.32	
		2009	71.93	
S_2	Sabarmati river at Hansol bridge, Ahmedabad	2005	74.83	73.97
		2006	76.43	
		2008	76.34	
		2009	68.27	
S_3	Khari river tributary of Sabarmati river, Ahmedabad	2005	62.37	53.97
		2006	51.91	
		2008	49.98	
		2009	51.61	

Table 7: NSF Water Quality Index for the stations

IV. CONCLUSIONS

The average NSF water quality index obtained for the stations, S1, S2 and S3 are 70.12, 73.97 and 53.97 respectively. From the table 1, it can be concluded that the water quality at station S1 and S2 is good whereas water quality at station S3 is fair. Stations S1 and S2 are located in Ahmedabad district and the river is polluted due to anthropogenic sources and discharge of untreated or partially treated sewage into the water bodies at these locations. S3 is located on the downstream of the river Sabarmati where high pollution is evident due to partially treated industrial waste water discharge in the river at this location. The NSFWQI can be useful to water quality management agencies for assessment of river water quality. The results can be useful for decision making and policy framing for water quality issues.

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