INTERNATIONAL JOURNAL OF PHARMACEUTICS & DRUG ANALYSIS
VOL.5 ISSUE 12, 2017; 467 – 474; http://ijpda.com; ISSN: 2348-8948

Research Article

ASSESSMENT OF WATER QUALITY INDEX (WQI) AND SUITABILITY OF SAGAR DIGHI, KOCH BIHAR, WEST BENGAL, INDIA

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Date Received: 3rd December 2017; Date accepted: 11th December 2017; Date Published: 12th December 2017

Abstract

The aim of the study was to find out the Water Quality Index (WQI) of Koch Bihar Lake or Sagar Dighi in order to assess its suitability for drinking, bathing and swimming purposes. Water sample were collected in three bottles, two glass bottles with the capacity of 100 ml each and one large PVC (1 litter capacity) bottle for laboratory analysis. Total 20 bio-physico-chemical parameters were used for WQI calculation for drinking purpose and six physico-chemical parameters were used for WQI calculation for bathing and swimming purposes. The calculation of the WQI was done using weighted arithmetic water quality index which was originally proposed by Horton (1965) and developed by Brown et al (1972). The WQI of Sagar Dighi obtained for drinking and Bathing/ recreational use indicates Unsuitable for drinking and poor quality for humans uses respectively. We therefore strongly recommend that an urgent effort must be taken to develop ecosystem-based management strategies.

Key words: Bio-Physico-Chemical Parameters, Weighted Arithmetic Index Method, Water Quality, Water Quality Index, Sagar Dighi.

INTRODUCTION

The district of Koch Bihar is situated in the Himalayan Tarai Region of West Bengal. A number of artificial wetlands (ponds) are present in Koch Bihar town, most of which were created at the time of 'Koch dynasty' for drinking water. The most important is Sagar Dighi which situated in the middle of the town. Now it is used by surrounding dwellers and daily workers of the town for bathing, swimming, washing and other domestic purposes. Runoff from surrounding, solid waste by the visitor and tourist directly disposes to this pond. As a result the Water quality of the pond water is gradually changing. So the monitoring of water quality is very essential. Water quality refers to the different physical, chemical and biological characteristics of water [13]. Evaluating the water quality from a large number of samples, each containing concentrations for many parameters is very difficult [2]. A water quality index (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 [4]. A water quality index provides a single numerical value that expresses overall water quality at a certain location and time, based on several water quality parameters. In general WQI can give an indication of water health. The objective of the study therefore was to calculate the Water Quality Index (WQI) of Sagar Dighi in order to assess its suitability for drinking, bathing and swimming.

Materials and Methods:

Description of Study Area:

Koch Bihar Lake or Sagar Dighi is selected for study. It is the most important freshwater body which is situated in the heart of Koch Behar town. It extends between 26°19'12"N to 26°19'21"N and 89°26'21"E to 89°26'28"E and the total surface area of this lake is 14.60 hectare which was excavated by Maharaja Harendra Narayan in 1807 AD. It commonly attracts various migratory birds in the winter season. Among all ponds in Koch Bihar town the most spectacular is Sagar Dighi, with grand structures arrayed all around it. These buildings,

built mostly between 1880 to 1920, are now offices of the district administration like Office of the District Magistrate, Administrative Building of North Bengal State Transport Corporation, BSNL Office on the West; Office of the Superintendent of Police, District Library, Municipality Building on the South, Office of the BLRO, Sate Bank of India (Cooch Behar Main Branch) etc on the East and RTO office, Foreigner's enrollment office, District Court and so on the North. Although this lake was excavated for drinking water supply and flood control, now it is used for bathing, swimming, washing clothes, fishing, morning and evening walk around the lake, resting or gossiping place, boating etc.

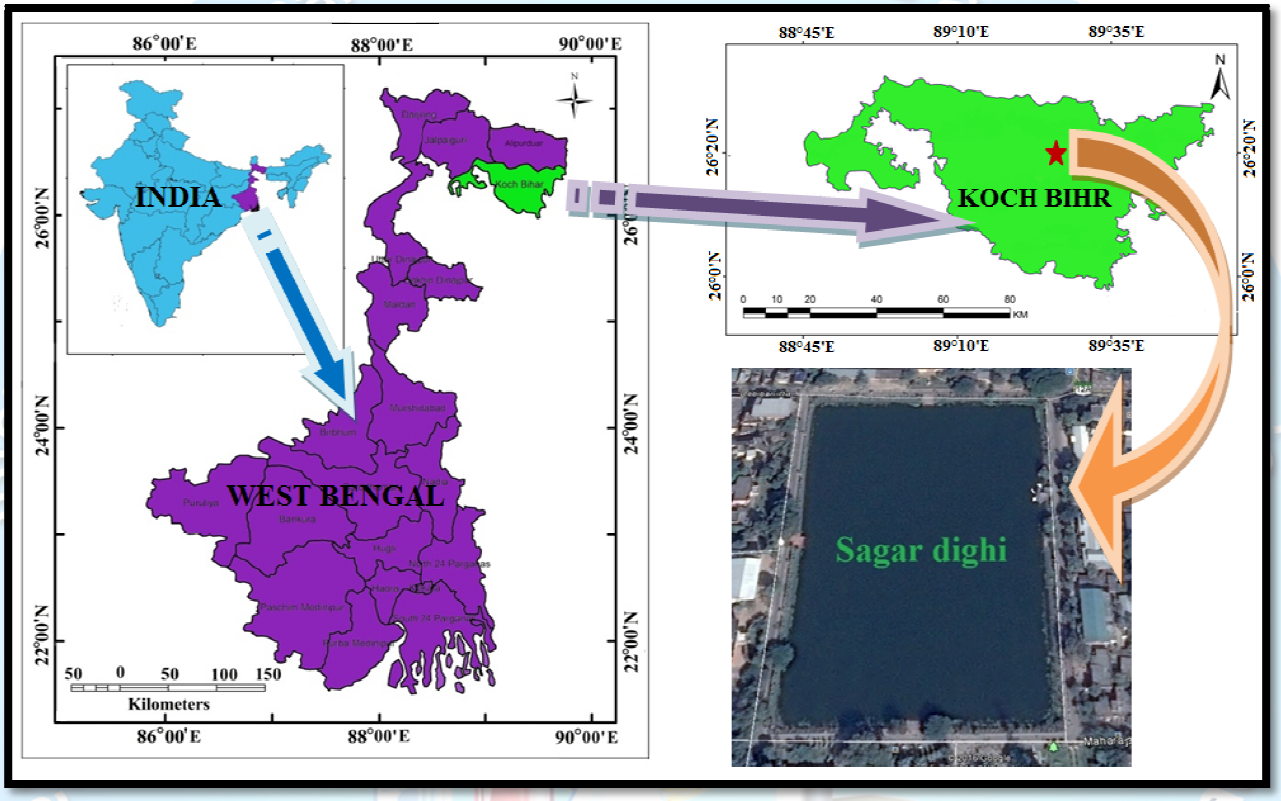

Fig1: locational map of sagar dighi.

Mode of Study:

Water Quality Parameter data is derived by three modes. Water PH, Total dissolved solids, Electrical Conductivity are measured in situ by digital instrument. Dissolved O2(DO) , BOD, FREE CO_2,Chloride ,Total Hardness , Bicarbonate, Total Alkalinity are analysed from collected water sample in laboratory and other Water Quality Parameter are collected from secondary source i.e. West Bengal Pollution Control Board. (Table-1).

Sample Collection: Water samples were collected in 2nd weak of pre-monsoon (June, 2017) and post-monsoon (September, 2017) period from selected site of the study area. Collection of samples took place within 9:30 am by dipping well labeled sterilized plastic and glass containers at the approximate depth of 1.00 ft. All water sample were collected in three bottles , two glass bottles sinking it in the water carefully and slowly so that no air bubbles were introduced with the capacity of 100 ml each (among them in one glass bottle 2ml of $MnSO_4$ followed by 2ml alkaline iodide solution is added)and one large PVC (1 litter capacity) bottle. Physicochemical parameters were analysed in the laboratory in the same day as early as possible except BOD.

Water Analysis Methods:

Physical and chemical analysis of the samples was

done according to Standard Methods as per APHA[3], 1995. Methods used and Source of Data for physical and chemical analyses of water are shown in below mentioned in Table 1.

Water quality Standards:

The values obtained were compared with standards prescribed by BIS[5], WHO[22] and CPCB[18]. The following table reveals the parameters, with their units which are evaluated, in water samples. The water quality index is calculated by using the standard of drinking water and Bathing/ Recreational Use of Water quality prescribed by the World Health Organization, Bureau of Indian Standards and Central Pollution Control Board(Table 2). In calculation BDL (Below Detectable Level) treated as zero(0)

Water Quality Index Calculation:

A Water Quality Index (WQI) is a compilation of a number of parameters that can be used to determine the overall quality. In order to keep the health of any aquaculture system at an optimal level, certain water quality indicators or parameters must be monitored and controlled. A numbers of water quality indices have been formulated all over the world which can easily judge out the overall water quality within a particular area promptly and efficiently. For example, US National Sanitation Foundation Water Quality Index (NSFWQI) [5], Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI) [5], British Columbia Water Quality Index (BCWQI), and Oregon Water Quality Index (OWQI)[12, 17, 1].

Brown et al. (1970) developed a paying great rigor in selecting parameters, developing a common scale, and assigning weights for which elaborate Delphic exercises were performed [5]. This effort was supported by the National Sanitation Foundation (NSF) and that is why also referred as NSFWQI. This work seems to be the most comprehensive and has been discussed in various papers [8]. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose [10].

Here the calculation of the WQI was done using weighted arithmetic water quality index which was originally proposed by Horton (1965)[15] and developed by Brown et al (1972)[8] in the following form:

$WQI = \Sigma QiWi / \Sigma Wi$

Further, the quality rating scale (Qi) for each parameter is calculated according to Brown et al (1972)[8] by using the following equation:

$Qi = 100 \{(Va-Vi)/ (Vs-Vi)\}$

Where,

Va = actual value of the water quality parameter obtained from laboratory analysis.

Vi = ideal value of the water quality parameter can be obtained from the standard tables. All the ideal values (Vi) are taken as zero except pH and dissolved oxygen [16] For pH, the ideal value is 7.0 and for dissolved oxygen, the ideal value is 14.6 mg/l.

Vs = recommended standard value of i^{th} parameter.

The unit weight for each water quality parameter is calculated by a value inversely proportional to recommended standard (Vs) for the corresponding parameter using the following expression.

$Wi = K / Vs$

Wi is Unit weight of factor

K is proportionality constant.

Table 3 shows a classification of water quality, based on its quality index due to Brown et al (1972)[8], Chatterji and Raziuddin (2002) [9]etc.

Results and Discussions

Table 4, 5, 6 & 7 deals with calculation of the water quality index (WQI) of the of Sagar Dighi for drinking and Bathing/ recreational use of water in pre-monsoon period (June, 2017) and post-monsoon period (september, 2017) using the weighted arithmetic index formula as follows: $WQI = \Sigma QiWi / \Sigma Wi$.

Table:1 Mode of Water Quality Analysis

Sl. No	Parameters	Method Adopted/Instrument/Source of Data
1	Ammonia-N	WBPCB
2	BOD	Titrimetric Method (five days incubation)
3	Boron	WBPCB
4	Calcium	WBPCB
5	Chloride	Argent metric Method
6	COD	WBPCB
7	Conductivity	HM Digitals Aquapro digital water tester (Model AP-2)
8	Bi-carbonate	Titration Method
9	Dissolved O2(DO)	Winkler's Method
10	Fluoride	WBPCB
11	Magnesium	WBPCB
12	Nitrate-N	WBPCB
13	pH	HM Digitals pH Hydrotester (Model pH-80)
14	Sodium	WBPCB
15	Sulphate	WBPCB
16	Total Alkalinity	Titration Method
17	Total Coliform	WBPCB
18	Total Dissolved Solids(TDS)	HM Digitals Aquapro digital water tester (Model AP-1)
19	Total Hardness as CaCO3	Conventional titration method.
20	Turbidity	WBPCB

N.B.:WBPCB= West Bengal Pollution Control Board

Table 2. Standard for drinking water and Bathing/ recreational use of water.

Sl. No	Parameters	Unit	Drinking Water		Bathing/ Recreational Use of Water	
			Standard	Recommended Agency	Standard	Recommended Agency
1	Ammonia-N	mg/l	0.3	WHO	--	
2	BOD	mg/l	2	CPCB	3	CPCB
3	Boron	mg/l	0.3	BIS	--	
4	Calcium	mg/l	75	BIS	--	
5	Chloride	mg/l	250	BIS	600	CPCB
6	COD	mg/l	10	WHO	--	
7	Conductivity	µs/cm	300	ICMR (1975)	--	
8	Bi-carbonate	mg/l	244	BIS	--	
9	Dissolved O_2(DO)	mg/l	6	CPCB	5	CPCB
10	Fluoride	mg/l	1	BIS	1.5	CPCB
11	Magnesium	mg/l	30	BIS	--	
12	Nitrate-N	mg/l	45	BIS	--	
13	pH	Unit	6.5 - 8.5	BIS	6.5 - 8.5	CPCB
14	Sodium	mg/l	180	BIS	--	
15	Sulphate	mg/l	200	BIS	--	
16	Total Alkalinity	mg/l	200	BIS	--	
17	Total Coliform	MPN/100ml	50	CPCB	500	CPCB
18	Total Dissolved Solids(TDS)	mg/l	500	BIS	--	
19	Total Hardness as $CaCO_3$	mg/l	300	BIS	--	
20	Turbidity	NTU	5	BIS	--	

N.B.: (--): *not indicated.*

Table 3. Classification of water quality based on weighted arithmetic WQI method

WQI	STATUS
0 - 25	Excellent
26 - 50	Good
51 - 75	Poor
76 - 100	Very Poor
Above 100	Unsuitable for use

Source: Brown et al (1972), Chatterji and Raziuddin (2002)

Table 4: Calculation of Water Quality Index (WQI) of Sagar Dighi for drinking water in pre- monsoon period (June, 2017).

Sl. No	Parameter	Unit	Standard values (Vs)	Observed Value (Va)	Unit Weights (Wi)	Quality Rating (Qi)	WiQi
1	Ammonia-N	mg/l	0.3	0.347	0.375705816	115.6666667	43.45663939
2	BOD	mg/l	2	4.4	0.056355872	220	12.39829193
3	Boron	mg/l	0.3	0.011	0.375705816	3.666666667	1.377587992
4	Calcium	mg/l	75	8.02	0.001502823	10.69333333	0.01607019
5	Chloride	mg/l	250	14	0.000450847	5.6	0.002524743
6	COD	mg/l	10	25	0.011271174	250	2.817793621
7	Electrical Conductivity	µs/cm	300	75	0.000375706	25	0.009392645
8	Bi-carbonate	mg/l	244	18	0.000461933	7.37704918	0.003407705
9	Dissolved O2(DO)	mg/l	6	7.6	0.018785291	81.39534884	1.529035298
10	Fluoride	mg/l	1	BDL	0.112711745	0	0
11	Magnesium	mg/l	30	1.73	0.003757058	5.766666667	0.021665702
12	Nitrate-N	mg/l	45	0.43	0.002504705	0.955555556	0.002393385
13	pH(6.5-8.5)	Unit	6.5-8.5	8.8	0.013260205	120	1.591224633
14	Sodium	mg/l	180	4	0.000626176	2.222222222	0.001391503
15	Sulphate	mg/l	200	0.32	0.000563559	0.16	9.01694E-05
16	Total Alkalinity	mg/l	200	28	0.000563559	14	0.007889822
17	Total Coliform	MPN/100ml	50	14000	0.002254235	28000	63.1185771
18	Total Dissolved Solids(TDS)	mg/l	500	34	0.000225423	6.8	0.00153288
19	Total Hardness as CaCO3	mg/l	300	28	0.000375706	9.333333333	0.003506588
20	Turbidity	NTU	5	9.6	0.022542349	192	4.328131001
					Σ Wi=1		**Σ** Wi-Qi=130.6871463
WQI = ΣQiWi /ΣWi=130.6871463							

N.B.: BDL= Below Detectable Level

Table 5 : Calculation of Water Quality Index (WQI) of Sagar Dighi for Bathing/ recreational use in pre-monsoon period (June, 2017).

SlNo	Parameter	Unit	Standard values (Vs)	Observed Value (Va)	Unit Weights (Wi)	Quality Rating (Qi)	WiQi
1	BOD	mg/l	3	4.4	0.252274178	146.6666667	37.0002127
2	Chloride	mg/l	600	14	0.001261371	2.333333333	0.002943199
3	Dissolved O_2(DO)	mg/l	5	7.6	0.151364507	72.91666667	11.03699527
4	Fluoride	mg/l	1.5	BDL	0.504548355	0	0
5	pH(6.5-8.5)	Unit	6.5-8.5	8.8	0.089037945	120	10.6845534
6	Total Coliform	MPN/100ml	500	14000	0.001513645	2800	4.238206182
					Σ Wi=1		**Σ** WiQi=62.96291075
WQI = **Σ**QiWi /**Σ**Wi=62.96291075							

N.B.: BDL= Below Detectable Level

Table 6: Calculation of Water Quality Index (WQI) of Sagar Dighi for drinking water in post-monsoon period (september, 2017).

Sl. No	Parameter	Unit	Standard values (Vs)	Observed Value (Va)	Unit Weights (Wi)	Quality Rating (Qi)	WiQi
1	Ammonia-N	mg/l	0.3	BDL	0.375705816	0	0
2	BOD	mg/l	2	4.3	0.056355872	215	12.11651257
3	Boron	mg/l	0.3	0.006	0.375705816	2	0.751411632
4	Calcium	mg/l	75	9.62	0.001502823	12.82666667	0.019276213
5	Chloride	mg/l	250	20	0.000450847	8	0.003606776
6	COD	mg/l	10	22	0.011271174	220	2.479658386
7	Electrical Conductivity	µs/cm	300	63	0.000375706	21	0.007889822
8	Bi-carbonate	mg/l	244	14	0.000461933	5.737704918	0.002650437
9	Dissolved O2(DO)	mg/l	6	6.2	0.018785291	97.6744186	1.834842358
10	Fluoride	mg/l	1	0.14	0.112711745	14	1.577964428
11	Magnesium	mg/l	30	1.15	0.003757058	3.833333333	0.014402056
12	Nitrate-N	mg/l	45	0.38	0.002504705	0.844444444	0.002115085
13	pH(6.5-8.5)	Unit	6.5-8.5	8.2	0.013260205	80	1.060816422
14	Sodium	mg/l	180	2.51	0.000626176	1.394444444	0.000873168
15	Sulphate	mg/l	200	1.18	0.000563559	0.59	0.0003325
16	Total Alkalinity	mg/l	200	22	0.000563559	11	0.006199146
17	Total Coliform	MPN/100ml	50	11000	0.002254235	22000	49.59316772
18	Total Dissolved Solids(TDS)	mg/l	500	28	0.000225423	5.6	0.001262372
19	Total Hardness as CaCO3	mg/l	300	22	0.000375706	7.333333333	0.002755176
20	Turbidity	NTU	5	13.1	0.022542349	262	5.906095429
					Σ Wi=1		**Σ** WiQi=75.3818317
WQI = ΣQiWi /ΣWi=75.3818317							

N.B.: BDL= Below Detectable Level

Table 7: Calculation of Water Quality Index (WQI) of Sagar Dighi for Bathing/ recreational use of water in post-monsoon period (september, 2017).

Sl. no	Parameter	Unit	Standard values (Vs)	Observed Value (Va)	Unit Weights (Wi)	Quality Rating (Qi)	WiQi
1	BOD	mg/l	3	4.3	0.252274178	143.3333333	36.15929878
2	Chloride	mg/l	600	20	0.001261371	3.333333333	0.00420457
3	Dissolved O_2(DO)	mg/l	5	6.2	0.151364507	87.5	13.24439432
4	Fluoride	mg/l	1.5	0.14	0.504548355	9.333333333	4.70911798
5	pH(6.5-8.5)	Unit	6.5-8.5	8.2	0.089037945	80	7.1230356
6	Total Coliform	MPN/100ml	500	11000	0.001513645	2200	3.330019143
					Σ Wi=1		**Σ**WiQi=64.57007039
WQI = **Σ**QiWi /**Σ**Wi=64.57007039							

N.B.: BDL= Below Detectable Level

The water quality Index for drinking obtained water in pre-monsoon (June, 2017) and post-monsoon (September, 2017) period are130.6871463 (Table 4) and 75.3818317 (Table 6) respectively. The water quality Index value (130.69) of June, 2017 indicates the Unsuitable for drinking and WQI (75.38) of September, 2017 indicate poor quality for human uses and must therefore be treated before use to avoid water related diseases.

The water quality Index for Bathing/ recreational use obtained in pre-monsoon (June, 2017) and post-monsoon (September, 2017) period are 62.96291075(Table 5) and 64.57007039(Table 7) respectively which indicate poor quality for humans uses.

Conclusion:

During the study, it is observed that the water quality of Sagar Dighi for drinking water in pre-monsoon period become unsuitable than post-monsoon period. We concluded that the water is not fit for drinking purpose without treatment (filtration, disinfection etc). Suitability of water quality for Bathing/ recreational use is become poor in post-monsoon period than pre-monsoon period. The Study show that the water of the Sagar Dighi is deteriorated very badly due to the addition of urban sewage, anthropogenic activities like washing, Bathing etc. Therefore an urgent effort must be taken to develop ecosystem-based management strategies with inputs from scientists, resource managers, policy makers, government and non-government organizations and environmentalist.

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