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Determination of Physico-Chemical Parameters and Water Quality Index (WQI) of Sapana Dam Water at District Betul (M.P.)

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Abstract: ***The present investigation was carried out to evaluate the water quality index (WQI)of Sapana dam water located at District Betul (M.P.) along with the analysis of various physico-chemical parameters such as pH, Turbidity, Electrical Conductivity(EC), Total Hardness (TH), Total Alkalinity(TA), Total Dissolve Solids(TDS), Chloride, Nitrate, Oil & Grease, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).The WQI of any water body is a single number that indicates the water quality of whole water body in the form of single value and presents useful information of overall quality of water for public or for any other utilities as well as in the pollution abatement programme and in water quality management. The calculated values of WQI for all four sampling stations collected from Sapana dam in the first week of every month of Jan. 2020 to Mar. 2020 were recorded as 48.75, 47.71, 44.57 and 43.85 respectively. On the basis of calculated WQI values and analysis of studied physico-chemical parameters, the results reveals that the quality of Sapana dam water falls under "Good" category and can be used for domestic and irrigation purposes after some proper and necessary treatment.***

Keywords: Physico - chemical parameters, Water Quality Index (WQI), Sapana Dam, domestic and irrigation purpose

1. Introduction

For the human and industrial growth, water is considered to be the main requirement. Increase in population and industrialization the demand of fresh water increase in the last decades. This demand fulfilled by the water sources as rivers, dams, well and ponds which provide the water for human life, agriculture and irrigation purposes. Due to the waste discharged from the industrial and human activities, the quality of ground water has deteriorated, which affects human as well as aquatic life. Now- a- days, water quality assessment has become an important exercise to evaluate the nature and extent of pollution in order to take appropriate control measures.

2. Study Area

Sapana reservoir like others in the state was constructed for irrigation purpose and it is an important source of water supply to the wide agriculture, industrial and domestic area of District-Betul (M.P.) and also being used for fish culture. The dam was constructed in the year 1956 and its longitude and latitude are $77^0$59'05" and $21^0$15'15"respectively.The total length of the dam is 1790 sqm. and the catchment area is 44.75sqm. The gross capacity of the dam is 1690 cu.m. The sallow part of the reservoir gets exposed during summer session and the exposed land is used for agriculture purpose where in the farmers also used huge amount of chemical fertilizers and pesticides. For the purpose of this study, four sampling stations were identified on Sapana dam. The first two sampling stations namely S1 and S2 were located near village Ankawari and the last two namely S3 and S4 were near village Partapur, where domestic activities are mainly occurs and chemical fertilizers were used in a considerable amount.

3. Material and Methods

Water samples were collected in fresh one litre plastic bottles previously cleaned with 1:3 HNO_3 from 04 pre-selected sampling stations during the period of three months from Jan.2020 to Mar.2020 on monthly basis. Samples were collected during the first week of every month in the early hours of the day in between 7.00 AM to 10.00 AM. Analysis of physico-chemical parameters, the methods given by APHA (1992) were followed.

Water Quality Index Determination

Water quality index (WQI) is defined as the reflection of composite influence of different quality parameters on the overall quality of water. The water quality parameters are selected based on its direct involvement in deteriorating effect in water quality for human consumption. For WQI calculation, above mentioned twelve physico- chemical quality parameters have been selected. The weighed arithmetic WQI method was used for the calculation of water quality index of the Sapana dam water. Let there be n water quality parameters and quality rating or sub index (Q_n) number that reflects the relative value of n^{th} water quality parameter in polluted water with respect to its standard permissible value. Quality rating was calculated as follows:

$Q_n = 100 * (V_n - V_{I0}) / (S_n - V_{I0})$, Where,

Q_n = Quality Rating for the nth water quality parameter

V_n = Estimated value of nth water quality parameters of collected samples

S_n = Standard permissible value of nth water quality parameter

V_{I0} = Ideal value of nth water quality parameter in pure water (V_{I0} value is 0 for all other parameters except pH and dissolved oxygen which are 7 and 14 respectively).

Unit weight (W_n) for nth water quality parameter is a value inversely proportional to the recommended standard value S_n of the corresponding parameter.

$W_n = K/S_n$, Where,

W_n = Unit weight for nth water quality parameter
S_n = Standard permissible value of nth water quality parameter
K = Constant of Proportionality

The standards recommended by the Indian Council of Medical research (ICMR) and Indian Standards Institution (ISI) are considered for quality rating (Q_n) and Unit Weight (W_n). The overall WQI was calculated by aggregating the quality rating with the unit weight linearly and can be given by the following expression.
$WQI = \Sigma Q_n.W_n/\Sigma W_n$, Where,
Q_n= Quality Rating for the nth water quality parameter
W_n = Unit weight for nth water quality parameter

The ranges of WQI, the corresponding status of water quality and their possible use are summarized in Table 1.

Table 1: Summary of Water Quality Index (WQI)and Corresponding Water Quality Status (WQS)

S.No.	WQI	WQS	Possible Uses
1	0 - 25	Excellent	Drinking, Irrigation and Industrial
2	26 - 50	Good	Domestic, Irrigation and Industrial
3	51 - 75	Fair	Irrigation and Industrial
4	76 - 100	Poor	Irrigation
5	101 - 150	Very Poor	Restricted use for Irrigation
6	>150	Unfit for Consumption	Proper Treatment Essential before use

4. Results and Discussion

The observed values of studied twelve physico-chemical parameters in all the samples and their corresponding WQI values are presented in tabular form. Among all parameters, DO and BOD were found to be the highest influencing parameters in WQI determination. The summary of observations of physico-chemical parameters and WQI values of the water samples from all four water sampling stations are presented in table 1, 2, 3, 4, 5, 6 and 7.

Table 2: Range of physico-chemical parameters studied during Jan.2020 to Mar.2020

S.No.	Parameter	Average values of sampling stations				Range
		S1	S2	S3	S4	
1	pH	7.4	7.4	7.4	7.3	7.3 - 7.4
2	Turbidity	7.2	7.2	6.2	6.4	6.2 - 7.2
3	Elec.Cond.	218	218	220.6	232.8	218 - 232.8
4	Total Hardness	104.4	110.1	102.5	112.5	102.5 - 112.5
5	Total Alkalinity	114.8	108.6	38.2	126.6	38.2 - 126.6
6	TDS	138.1	324	344.1	354.1	138.1 - 354.1
7	Chlorides	48.4	42.2	32.2	31.2	31.2 - 48.4
8	Nitrate	20.2	24.5	28.5	25.5	20.2 - 28.5
9	Oil & Grease	0.42	0.34	0.42	0.44	0.34 - 0.44
10	DO	7.2	7.8	8.1	7.8	7.2 - 8.1
11	BOD	3.8	4.2	3.8	3.2	3.2 - 4.2
12	COD	78.6	84.6	64.6	54.6	54.6 - 84.6

Table 3: Calculation of WQI of water samples at sampling station S1

S.No	Parameter	Unit	Month			Test Value	Std. Value	Ideal Value	Relative Weight Wn	Quality Rating Qn	Quality Weight Wn*Qn
			JAN	FEB	MAR						
1	pH		7.4	7.3	7.5	7.4	8.5	7	0.11764	26.6667	3.13725
2	Turbidity	NTU	7.1	7.2	7.3	7.2	10	0	0.1	72	7.2
4	Elec.Cond.	µmhos/cm	210	220	224	218	300	0	0.00333	72.6667	0.24222
5	Total Hardness	mg/l	98.4	106.4	108.6	104.4	300	0	0.00333	34.8	0.116
7	Total Alkalinity	mg/l	110.6	115.4	118.6	114.8	200	0	0.005	57.4	0.287
8	TDS	mg/l	136	138.4	140	138.1	500	0	0.002	27.62	0.05524
9	Chlorides	mg/l	45.5	48.4	51.4	48.4	250	0	0.004	19.36	0.07744
10	Nitrate	mg/l	18	20.4	22.2	20.2	45	0	0.02222	44.8889	0.99753
11	Oil & Grease	mg/l	0.4	0.42	0.44	0.42	10	0	0.1	4.2	0.42
12	DO	mg/l	7.1	7.2	7.4	7.2	6	14	0.16666	85	14.1667
13	BOD	mg/l	3.7	3.8	3.9	3.8	10	0	0.1	38	3.8
14	COD	mg/l	78	78.6	79.2	78.6	250	0	0.004	31.44	0.12576
									0.62820	514.042	30.6251
ΣWn = 0.628203 ΣWn*Qn = 30.6251 WQI = 48.7504											

Table 4: Calculation of WQI of water samples at sampling station S2

S.No	Parameter	Unit	Month			Test Value	Std. Value	Ideal Value	Relative Weight Wn	Qualiy Rating Qn	Quality Weight Wn*Qn
			JAN	FEB	MAR						
1	pH		7.3	7.4	7.5	7.4	8.5	7	0.11764	26.666	3.13725
2	Turbidity	NTU	7	7.2	7.4	7.2	10	0	0.1	72	7.2
4	Elec.Cond.	µmhos/cm	212	220	222	218	300	0	0.00333	72.666	0.24222
5	Total Hardness	mg/l	109	110.5	111	110.1	300	0	0.00333	36.7	0.12233
7	Total Alkalinity	mg/l	107.2	108.6	110	108.6	200	0	0.005	54.3	0.2715
8	TDS	mg/l	322	325	325	324	500	0	0.002	64.8	0.1296
9	Chlorides	mg/l	41.2	42.4	43.1	42.2	250	0	0.004	16.88	0.06752
10	Nitrate	mg/l	23	24.5	26.2	24.5	45	0	0.02222	54.444	1.20988
11	Oil & Grease	mg/l	0.32	0.34	0.36	0.34	10	0	0.1	3.4	0.34
12	DO	mg/l	8.2	7.8	7.6	7.8	6	14	0.16666	77.5	12.9167
13	BOD	mg/l	4.1	4.2	4.3	4.2	10	0	0.1	42	4.2
14	COD	mg/l	83.4	84	86.6	84.6	250	0	0.004	33.84	0.13536
									0.62820	555.19	29.9723
ΣWn = 0.628203 ΣWn*Qn = 29.9723 WQI = 47.71125											

Table 5: Calculation of WQI of water samples at sampling station S3

S.No	Parameter	Unit	Month			Test Value	Std. Value	Ideal Value	Relativ Weight Wn	Quality Rating Qn	Qualit Weight WnQn
			JAN	FEB	MAR						
1	pH		7.3	7.4	7.5	7.4	8.5	7	0.11764	26.6667	3.13725
2	Turbidity	NTU	6	6.3	6.4	6.2	10	0	0.1	62	6.2
4	Elec.Cond.	µmhos/cm	218	221	223	220.6	300	0	0.00333	73.5333	0.24511
5	Total Hardness	mg/l	100.4	103.1	104.2	102.5	300	0	0.00333	34.1667	0.11389
7	Total Alkalinity	mg/l	117.1	118.6	120.2	38.2	200	0	0.005	19.1	0.0955
8	TDS	mg/l	341.2	343	348.2	344.1	500	0	0.002	68.82	0.13764
9	Chlorides	mg/l	31.6	32.2	33	32.2	250	0	0.004	12.88	0.05152
10	Nitrate	mg/l	27.6	28.4	29.5	28.5	45	0	0.02222	63.3333	1.40741
11	Oil & Grease	mg/l	0.4	0.43	0.43	0.42	10	0	0.1	4.2	0.42
12	DO	mg/l	7.9	8.2	8.4	8.1	6	14	0.16666	73.75	12.2917
13	BOD	mg/l	3.7	3.8	3.9	3.8	10	0	0.1	38	3.8
14	COD	mg/l	63.8	64.6	65.6	64.6	250	0	0.004	25.84	0.10336
									0.62820	502.29	28.0033
ΣWn = 0.628203 ΣWn*Qn = 28.0033 WQI = 44.57694											

Table 6: Calculation of WQI of water samples at sampling station S4

S.No	Parameter	Unit	Month			Test Value	Std. Value	Ideal Value	RelativWeight Wn	Quality Rating Qn	Quality Weight WnQn
			JAN	FEB	MAR						
1	pH		7.2	7.3	7.4	7.3	8.5	7	0.11764	20	2.35294
2	Turbidity	NTU	6.3	6.3	6.6	6.4	1o	0	0.1	64	6.4
4	Elec.Cond.	µmhos/cm	231.8	232.5	234.2	232.8	300	0	0.00333	77.6	0.25867
5	Total Hardness	mg/l	111.8	112.4	113.5	112.5	300	0	0.00333	37.5	0.125
7	Total Alkalinity	mg/l	125.3	127.6	127	126.6	200	0	0.005	63.5	0.3165
8	TDS	mg/l	353.5	354	355	354.1	500	0	0.002	70.82	0.14164
9	Chlorides	mg/l	30.4	31.5	31.8	31.2	250	0	0.004	12.48	0.04992
10	Nitrate	mg/l	24.8	25.5	26.2	25.5	45	0	0.02222	56.6667	0.25926
11	Oil & Grease	mg/l	0.42	0.44	0.47	0.44	10	0	0.1	4.4	0.44
12	DO	mg/l	7.7	7.8	7.9	7.8	6	14	0.16666	77.5	12.9167
13	BOD	mg/l	3	3.2	3.5	3.2	10	0	0.1	32	3.2
14	COD	mg/l	53.4	55.2	55.2	54.6	250	0	0.004	21.84	0.08736
									0.62820	538.107	27.548
ΣWn = 0.628203 ΣWn*Qn = 27.548 WQI = 43.85202											

Table 7: Calculated WQI values at different sampling stations of Sapana dam during Jan. 2020 to March. 2020

S.No.	Sampling stations	Calculated WQI values
1	S1	48.7504
2	S2	47.7112
3	S3	44.5769
4	S4	43.8520

5. Conclusion

The present study concluded that the Sapana dam water is not much polluted. All the parameters are within permissible limits except DO which is slightly higher in Mar.2020. Hence, it requires some proper treatment to minimize the contamination especially domestic wastes and agricultural runoff. Present investigation is helpful to create the awareness among people and Government authorities to maintain the Sapana dam water at its highest quality and purity levels. On the basis of calculated WQI values and analysis of studied physico-chemical parameters, the results reveals that during the study period, the quality of Sapana dam water falls under "Good" category and it was concluded that during the study period, the Sapana dam water was fit for domestic, irrigation and fish production purposes and it may be used for domestic and irrigation purposes after some proper and necessary treatment.

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