ASSESSMENT OF WATER QUALITY USING SELECTED PHYSICO CHEMICAL PARAMETERS IN TEHRI RESERVOIR, GARHWAL HIMALAYA, INDIA

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Abstract: The present study was undertaken to assess the water quality of Tehri reservoir by using selected physico-chemical parameters during April 2018 to December 2018. Water quality is one of the most important aspects and critical factor for assessing the pollution level in surface water bodies. During the study, five sampling zones were chosen on the reservoir to analyse the water quality of Tehri reservoir. The physico-chemical parameters *viz.* Temperature, TDS, pH, Conductivity, alkalinity, Total Hardness, DO, BOD, chloride, and phosphate were analysed monthly using standard methods. The water quality index value of all five zones were 31.39, 33.62, 32.73, 34.30 and 31.70 respectively, shows the good water qualityof Tehri reservoir.

Keywords: Water Quality Index, physico-chemical parameter, Tehri reservoir.

Introduction

Reservoir that are created by dams also referred to as man -made lake suppress flood and provide water for some useful activities such as irrigation, human consumption, industrial use, aquaculture *etc.*(Coller *et al*, 1998). It has become the key issue of dam and reservoir project how to coordinate the relationship between construction and environmental protection and to realize their harmony development (Cai *et al*., 2007). Tehri reservoir (67 km long) was developed due to the construction of a 260.5 m high dam across the confluence of Bhagirathi and Bhilangana rivers on the highly rugged Lesser Himalayan terrain. Tehri reservoir provide about 300 cusecs of drinking water to Delhi, 200 cusecs to UP meeting the needs of 7 million people and stabilization of 0.604 million ha area of irrigation (Kumar and Anbalalagan, 2015). The Bhagirathi and Bhilangana are snow-fed rivers originating in the Himalayan glaciers Gangotri and Khatling The chemical composition of reservoir water is a complex multi component system, which has much in common with natural water around it. The composition of surrounding waters is affected by abiotic, biological, and anthropogenic factors. Under natural conditions, these factors interact in a complex manner and determine the transfer of major chemical components to the reservoir.

Water quality has become a big issue today, partly because of the tremendous growth in population changes in land use and urban expansion and development. Rural areas also contribute ton water quality problems. So the present study focus in the water quality status of the Tehri reservoir.

Material and methods

Description of Study Area

Tehri reservoir perched at an elevation of 1,700 meters. Tehri Dam is one of the five biggest dams (260.5 m high) of the world and biggest in Asia. It is located deep in the Garhwal hills of Uttarakhand state across the river Bhagirathi about 1.5 km downstream the confluence of the river Bhagirathi and Bhilangana to generate the hydroelectric power. The Bhagirathi and Bhilangana are the two major watersheds comprising 13 major sub watersheds and have a total 7,507.9 km^2 area. Geographically, the project site is situated at 30º 22’ 54” N latitude and 78º29’ 3” E longitude. The study area was confined to the long stretch of the riverine system

of Bhagirathi in Garhwal Himalaya. Subsistence and commercial fishing activities are also carried on the reservoir. Five sampling Zones have been selected for the study(Table 1 and Figure 1).Zone A was selected in upstream part of Bhagirathi, Zone B, C, D was at mid-section of the reservoir which represents the area of lentic water and having different human interference while Zone E was at the upstream part of Bhilangana.

Table. 1: Geo-coordinates of selected sampling zones in Tehri Reservoir

Sampling Zones	Geo coordinates
Zone A	30°27'03.05"N, 78°26'00.69"E
Zone B	30°25'30.45"N, 78°27'00.75"E
Zone C	30°23'57.40"N,78°26'00.69"E
Zone D	30°26'34.65"N, 78°33'35.53"E
Zone E	30°22'56.10"N, 78°29'50.53"E

Figure 1: Satellite map of Tehri reservoir with sampling zones and their geo-coordinates

Sampling procedure and laboratory analysis:
Monthly samples of sub-surface water in triplicate were collected during first week of each month in the early hours of the day (7 a.m. to 9 a.m.) from five sampling zones during April 2018 to December 2018. Iodine treated double stop par polyethylene bottles were used for collection of water samples. Bottles were kept in ice bucket and brought to the laboratory for analysis. The methods given by APHA *et al.* (2012), Trivedy and Goel (1998) were used for analyses of physicochemical features of the water. i.e. temperature and pH were determined using mercury thermometer and digital pH meter, respectively, total alkalinity, total hardness, chlorides, Hardness, DO, BOD were analyzed using titrimetric method and Phosphate was determined with the help of Syntonic spectrophotometer.

Water quality index

In this study, for the calculation of water quality index (WQI), seven important parameters were chosen. The WQI has been calculated by using the standards of drinking water quality recommended by BIS. The weighted arithmetic index method (Brown *et al*., 1972) has been used for the calculation of WQI of the water body. Further quality rating of sub-index (qn) was calculated by using the following expression.

$$qn = \frac{100(Vn - Vio)}{Sn - Vio}$$

q_n= quality rating for the n^{th} water quality parameter

Vn= estimated value of the n^{th} parameter at a given sampling station.

Sn= standard permissible value of the n^{th} parameter

Vio= ideal value of n^{th} parameter in pure water.(*i.e*., 0 for all other parameters except the parameter pH and dissolved oxygen (7.0 and 14.6 mg/L respectively).

Unit wt. was calculated by a value inversely proportional to the recommended standard value Sn of the corresponding paramete0r.

Wn = K/Sn

Wn= unit wt. for n^{th} parameters

Sn = Standard value for n^{th} parameters.

K = constant for proportionally.

The overall water quality index was calculated by aggregating the quality rating with the unit wt. linearly and after calculating the WQI, the status of water quality has been match with Table 2.

$WQI = \Sigma q_n W_n / \Sigma Wn$

Table 2: Water Quality Index (WQI) and status of water quality (Chatterji and Raziuddin 2002).

Water quality index level	Water quality status
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unsuitable for drinking

Results & Discussion

Physico-chemical profile of Tehri reservoir

A total of 9 physico-chemical parameters were studied during the study period. The monthly variation of physico-chemical parameters of selected five zones were shown in Table 3 to Table 8.

Water temperature is a very significant factor that influences both biotic and abiotic characteristics of an aquatic ecosystem. The monthly variation in the surface water temperature of the selected five zones. Temperature ranged between the lowest value of 13.1^0C obtained from Zone A in December and highest of 31.1^0C obtained from Zone D in August. Dry season temperature was significantly higher than the wet season it can be due to direct relationship between bright sunshine, its duration and air temperature. Meteorological condition such as sunshine duration and absorption of the solar radiation by shallow reservoir water body might be responsible for monthly variation.

Total dissolved solid is a direct measure of all the dissolved substances, both organic and inorganic in waters. Maximum TDS was recorded 129.33 at Zone A during August where minimum TDS was found 82.02 at Zone D during December. Higher concentration of TDS in August is due to runoff and anthropogenic activities in the adjoining area of the reservoir.

The hydrogen ion concentration (pH) of water is considered as an index of environmental conditions. In present study, the pH values varied from7.1 at Zone A during December to 7.8 at Zone D during August. This is generally the normal range of pH in fresh water bodies very less contaminated by alkaline wastes. High pH was observed in month of august due to the weathering of rock. Conductivity is a measure of the ability of water to conduct an electric current. It is sensitive to variations in dissolved solids, mostly mineral salts. Decrease in Conductivity may be due to dilution by rain water and high conductivity values have beenreported to be indicative of an increase in the amount of polluting particles. Higher levels of conductivity reflect on the pollution status as well as trophic levels of aquatic body. Electrical conductivity (EC) ranged from121.2 μS/cm at Zone D during December to198.6 at Zone A.

Alkalinity refers to the presence of carbonate, bicarbonates and hydroxide ions that are commonly found in the form of carbonates of sodium, calcium and magnesium (Zafic, 1971). It is also a buffer for pH changes that helps in stabilizing the pH reservoir. Alkalinity ranges from 35.04mg/l at Zone D during month December to 54.03 at Zone A during August. Higher concentration of the total alkalinity in the month of August at Zone A could be due to higher CO_2 concentration and release of bicarbonates ions by sediments.

Total hardness is generally caused by the calcium and magnesium ions present in water. It ranges from 31.01 at Zone D during December to 59.02 at Zone A during August.

Dissolved oxygen is most important indicator for growth of biota, assessment of water quality and important regulator of metabolic processes of organisms and community. It can be used as an index of water quality, primary production and pollution. The minima and maxima of the concentration of DO in reservoir are directly related with the minima and maxima of phytoplankton present in the reservoir (Shashikanth and Raina, 1990). The main source of DO is dissolution from atmosphere and the photosynthesis. Dissolve Oxygen (DO) fluctuated between the lowest value 8.12 obtained in a month of August and highest value 10.44 recorded in a month of December at zone A. The limiting factors affecting the DO content are mainly temperature, photosynthesis, respiration and decomposition processes. No significant difference was found in Dissolve Oxygen concentration among the Zones.

Biological oxygen demand means an essential requirement of oxygen by all biotic organisms for their metabolic activities in aquatic system. Biological oxygen demand increases as the bio degradable organic content increases with large numbers of consumers occurred in river. BOD ranges from 0.6 at Zone D during December to 1.3 at Zone A during August it isdue to high temperature favours microbial activity.

Chloride is one of the most important parameter in asses the water quality. It is of the opinion that higher concentration of Chloride indicates higher degree of organic pollution. In the present investigation chloride ranges from 4.01 at zone D during December to 5.90 mg/l at zone A during August.

Phosphate isconsidered to be most significant among the nutrients responsible for eutrophication in any aquatic system and it is primary initiating factor too (Adeyeno, 2003). In the present study phosphate ranges from0.01 during December at Zone D to 5.08 mg/l during August at Zone A.

Water quality index:

Water quality index of the present body is established from important physico-chemical parameters for calculations of water quality index. Water quality index obtained for the water body in different zones of study area *i.e.* zone A, zone B, zone C, zone D and zone E were 31.39, 33.62, 32.73, 34.30 and 31.70 respectively (Table 9). Which indicate the good quality of water (Chatterji and Raziuddin 2002). The water quality rating study clearly shows that the water body is good and it is suitable for human consumption aquatic life and irrigation. The above water quality is also supported by the following physico-chemical parameter variation observed during the different month of study.

Among all the physicochemical parameters selected for water quality index calculation, pH is an important parameter which determines the suitability of water for various purposes. pH values were important for plankton growth (Chisty, 2002). In the present study pH range from 7.1 to 7.8. In today's study pH of water body was found to be slightly alkaline. Puttaiah and Kambalagere(2008) have made similar observations in their studies. Electrical conductivity and total dissolved solid were also found within a permissible limit when compared to IS 10500:2012. Aswal *et al.*, 2016 also show the same trend of electrical conductivity in their study of Ganga River. The total alkalinity of the reservoir is the reflection of its carbonates and

bicarbonates profiles (Wetzel, 2001) with the likelihood of silicates and phosphates contribution. The values of alkalinities varied from 35.04 to 54.03 shown in Table 3 and Table 4.Total hardness in a present study ranged from 31.01 to 54.02 as shown in a Table 3 and Table 4.The concentration of dissolved oxygen regulates the distribution of flora and fauna. The present investigation indicated that the concentration of dissolved oxygen fluctuated between 8.12 to10.44. Monthly the concentration of dissolved oxygen was more during December and least during August it was due to the effect of temperature and water mixing.Bio chemical oxygen demand is a parameter to assess the organic load in a water body Kamboj *et al.,* 2016 also found the high value of dissolve oxygen of Ganga River. Many researchers have recorded higher BOD value in polluted water. The BOD ranged between 0.6 mg/l to 1.3 mg/l.Chloride is one of the most important parameter in assessing the water quality. In the present study the concentration of chloride fluctuated between 4.01 mg/l to 5.90 mg/l. similar observation has been made by Sharma *et al*., (2008), Sharma *et al.,* (2018), Kumar *et al.,* (2018). From the foregoing observation of physico-chemical parameters it can be concluded that water body shows good characteristics. High DO, low BOD and low nitrate indicate that water is suitable all aquatic organisms.Hence application of water quality index techniques for the overall assessment of the water quality of a water body is a useful tool.

Table. 3: Monthly variation of physico-chemical parameters of Tehri reservoir at sampling zone A

Parameters	Zone A									
	April	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Mean ±S.D**
WT	21.2	24.5	27.1	29.1	29.8	28.2	24.1	18.6	13.1	23.97± 5.51
TDS	94.18	96.52	97.54	126.32	129.33	121.21	95.32	93.12	83.97	104.91 ±16.25
pH	7.2	7.3	7.3	7.5	7.6	7.3	7.2	7.2	7.1	7.29±0 .17
C	141.9	147.2	151.2	193.2	198.6	148.2	141.6	139.8	123.4	153.90 ±25.13
Alk	39.01	41	47.01	49.02	54.03	44.02	37.08	37.01	36.08	42.70± 6.25
TH	34.02	35.02	46.05	52.02	59.02	38.8	34.09	33.09	32.06	40.46± 9.67
DO	10.18	9.56	9.18	9.55	8.23	10.05	10.19	10.32	10.44	9.74±0 .71
BOD	0.8	1.1	1	1.2	1.3	1.2	1	0.9	0.8	1.03±0 .18
Chl	4.21	5.32	5.58	5.64	5.9	5.47	5.09	4.16	4.08	5.05±0 .71
P	0.03	1.05	2.12	4.18	5.08	3.16	2.02	0.04	0.02	1.97±1 .88

Table 4: Monthly variation of physico-chemical parameters of Tehri reservoir at sampling zone B

Parameters	Zone B									
	April	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Mean**
WT	21.6	24.8	27.4	29.7	30.4	28.8	24.6	19.1	13.23	24.40±5.6 3
TDS	94.12	96.48	97.43	125.38	126.82	121.08	94.32	92.1	82.12	103.32±16 .50
pH	7.3	7.2	7.4	7.6	7.7	7.7	7.5	7.3	7.2	7.44±0.22

C	141.2	146.8	149.8	150.6	191.8	148.2	141.2	138.6	123.2	147.93±18.46
Alk	39	40.09	46.09	48.09	53.08	44.01	36.03	36.09	36.01	42.05±6.12
TH	33.09	34.09	46.01	51.08	58.06	38.08	34.01	33.02	31.04	39.83±9.59
DO	10.12	9.43	9.16	9.45	8.21	10.03	10.16	10.29	10.4	9.69±0.71
BOD	0.8	1	0.9	1.1	1.2	1.2	1.1	1	0.8	1.01±0.15
chl	4.19	5.28	5.47	5.63	5.87	5.42	5.09	4.12	4.04	5.01±0.71
P	0.03	1.02	2.01	3.19	5.02	3.04	2.02	0.03	0.02	1.82±1.73

Table. 5: Monthly variation of physico-chemical parameters of Tehri reservoir at sampling zone C

Parameters	**Zone C**									
	April	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Mean**
WT	21.8	25.9	28.2	29.8	30.8	29.2	24.8	19.32	13.43	24.81±5.72
TDS	94.1	93.52	97.32	129.28	126.44	120..32	93.42	91.16	82.09	101.28±17.85
pH	7.3	7.3	7.5	7.6	7.7	7.6	7.4	7.3	7.2	7.42±0.19
C	140.9	146.2	148.3	149.9	191.2	147.8	139.8	138.2	121.6	147.10±18.63
Alk	38.8	40.01	46.01	47.08	53.02	43.08	35.08	36.02	36	41.68±6.10
TH	33.01	34.06	45.09	51.03	58.01	38.04	33.07	33.01	31.02	39.59±9.59
DO	10.09	9.41	9.12	9.43	8.19	10.03	10.14	10.27	10.38	9.67±0.71
BOD	0.7	1.1	1.1	1	1.2	0.9	0.8	0.8	0.7	0.92±0.19
chl	4.17	5.29	5.47	5.61	5.87	5.45	5.03	4.12	4.02	5.00±0.71
P	0.02	1.02	2.01	3.18	5.01	3.02	2.02	0.03	0.02	1.81±1.73

Table. 6: Monthly variation of physico-chemical parameters of Tehri reservoir at samplingzone D

Parameters	**Zone D**									
	April	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Mean±SD**
WT	21.9	24.9	28.8	29.9	31.1	29.4	25.2	19.8	13.5	24.94±5.74
TDS	94.02	93.43	97.06	128.76	128.87	120.28	93.28	91.02	82.02	103.19±17.73
pH	7.4	7.3	7.5	7.7	7.8	7.6	7.5	7.4	7,.2	7.53±0.17
C	140.2	142.1	147.2	148.3	190.6	195.3	136.2	135.1	121.2	150.69±25.27
Alk	38.2	40.01	45.05	47.02	53.01	43.03	35.06	36.01	35.04	41.38±6.17

TH	33	34.02	45.02	51.01	57.06	38.02	33.01	32.08	31.01	39.36±9.45
DO	10.08	9.38	9.1	9.41	8.12	10.02	10.12	10.21	10.36	9.64±0.72
BOD	0.6	1	1	1.1	1.2	0.9	0.8	0.8	0.6	0.90±0.19
Chl	4.16	5.29	5.31	5.59	5.86	5.41	5.01	4.1	4.01	4.97±0.70
P	0.02	1.02	2.01	3.16	5.01	3.01	2.01	0.02	0.01	1.81±1.73

Table. 7: Monthly variation of physico-chemical parameters of Tehri reservoir at sampling zone E

Parameters	**Zone E**									
	April	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Mean±SD**
WT	22.1	24.7	27.3	29.4	29.9	28.5	24.3	18.7	13.7	24.29±5.39
TDS	94.16	96.54	97.48	126.12	126.89	121.13	94.89	93.16	83.88	103.81±16.23
pH	7.2	7.2	7.3	7.5	7.6	7.4	7.3	7.2	7.1	7.3±0.17
C	141.7	146.9	150.6	192.8	198.4	148.9	141.4	138.9	123.3	153.66±25.11
Alk	39.01	41.04	47.09	49.09	54.01	44.02	37.04	37.01	36.06	42.71±6.27
TH	34.07	35.01	46.03	51.09	58.09	38.09	34.05	33.06	32.02	74.61±101.44
DO	10.14	9.49	9.17	9.48	8.21	10.12	10.18	10.31	10.42	9.72±0.71
BOD	0.7	1.1	1.1	1.2	1.3	1.2	0.9	0.9	0.8	1.02±0.20
Chl	4.19	5.3	5.32	5.63	5.89	5.44	5.07	4.14	4.06	5.00±0.69
P	0.02	0.03	1.05	3.13	5.02	3.12	2.02	0.03	0.02	1.60±1.83

Abbreviations: WT= Water Temperature (˚C)**, TDS=** Total Dissolved Solid (mg/l)**, C=** conductivity (µS/cm)**, Alk=** Alkalinity (mg/l)**, TH=**Total hardness (mg/l)**, DO**= Dissolved oxygen (mg/l), **BOD=** Biological oxygen demand (mg/l)**, Chl=** chloride(mg/l), **P**= Phosphate (mg/l).

Table 8: Mean value of physico-chemical parameters at selected sampling zones.

Parameters	Zone A	Zone B	Zone C	Zone D	Zone E	BIS
Temperature	23.97	24.40	24.81	24.94	24.29	-
TDS	103.91	103.32	101.28	103.19	103.81	**500**
pH	7.29	7.44	7.42	7.53	7.3	**6.5-8.5**
Conductivity	153.90	147.93	147.10	150.69	153.66	-
alkalinity	42.70	42.05	41.68	41.38	42.71	**200**
Total Hardness	40.46	39.83	39.59	39.36	74.61	**200**
DO	9.74	9.69	9.67	9.64	9.72	-
BOD	1.03	1.01	0.92	0.90	1.02	-
Chloride	5.05	5.01	5.00	4.97	5.00	**250**
phosphate	1.97	1.82	1.81	1.81	1.60	-

Table. 9: water quality analysis of different sampling zones.

↓⟶	Zone A	Zone B	Zone C	Zone D	Zone E
Water Quality Index	31.394	33.626	32.735	34.303	31.703
Water Quality Status	Good Water Quality	Good water Quality	Good Water Quality	Good Water Quality	Good Water Quality

Conclusion: From the results obtained, it was found that the water quality index of five different zones ranges from 31.29 – 35.24. This shows that the status of water at Tehri reservoir is good. It was due to low pollution load and less human interference. Higher values of water quality index shows that the status of water body is entropic and not totally safe for human drinking purpose. All the evaluated values of physicochemical parameters are within the BIS limits. Dissolved oxygen is an important aquatic parameter whose presence is vital to aquatic fauna. It plays crucial role in life process of aquatic biota. The present study indicated that the Tehri reservoir is suitable for production of fish culture and other human consumption.

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