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RESEARCH ARTICLE

ASSESSMENT OF PHYSICO-CHEMICAL PARAMETERS AND WATER QUALITY INDEX OF RAM-GANGA RESERVOIR AT KALAGARH (UTTARAKHAND)

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ABSTRACT

The present study was undertaken to know the variation in a different season in response to physico-chemical properties and Water Quality Index of Ram-Ganga reservoir at Kalagarh in district Pauri Garhwal. The study was carried out over a period of one year from August 2015 to September 2016 from six sampling zone. In India, there is an enormous number of natural and man-made water bodies used for various purposes like irrigation, hydropower generation, etc. Physico-chemical parameters were monitored for the calculation of Water Quality Index for the monsoon, winter and summer season. For WQI using nine parameters are (pH, Total Dissolved Solid, DO, BOD, Total Hardness, Calcium, Magnesium, Total Alkalinity, and Chloride) selected. This study was observed that the water quality was found to be very poor water quality in monsoon and summer season to unsuitable for human consumption due to heavy rainfall in monsoon season, turbulent flow, soil erosion and other activities.

Key words: Water Quality Indices, Physico-chemical parameters, Ram-Ganga Reservoir.

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INTRODUCTION

Water is significant natural resources within earth's ecosystem. It is essential for sustaining the life and other activities of all living organisms. Water quality deterioration in reservoirs usually comes from excessive nutrient inputs, eutrophication, acidification, heavy metal contamination, organic pollution and obnoxious fishing practices. Water quality indicates the relation of all hydrological properties including physical, chemical and biological properties of the water body. Hence, water quality assessment involves analysis of physico- chemical, biological and microbiological parameters that reflect the biotic and abiotic status of aquatic ecosystem (Smitha and Shivashankar, 2013).Water quality is certainly affected by point and non-point sources of pollution. The term water quality was developed to give an indication of how suitable the water is for human consumption (Vaux, 2001), and is widely used in multiple scientific publications related to the necessities of sustainable water management (Parparov *et al*., 2006). In the case of water quality monitoring the main problem is complexity associated with analyzing the large number of measured variables (Boyacioglu, 2006), and high variability due to anthropogenic and natural influences (Simeonov, 2002). There are a number of methods to analyze water quality data that vary depending on informational goals, the type of samples, and the size of the sampling area. Research in this area has been extensive, as indicated by the number of methods proposed or developed for classification, modeling, and interpretations of monitoring data (Boyacioglu and Boyacigolu, 2007).

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One of the most effective ways to communicate information on water quality trends is by use of the suitable indices (Dwivedi and Pathak, 2007). Water quality indices are based on the values of various physico-chemical and biological parameters in a water sample. Water quality index (WQI) is one of the most effective tools to communicate information on the quality of water to concerned citizen and policy makers (WHO, 1993; APHA, 1992; ICMR, 1975). The WQI evaluates the values to each water quality parameter relative to its objective value. WQI is based on some important parameters that can provide a simple indicator of water quality. It gives the public general idea of the possible problems with water in a particular region. Nine parameters were taken for WQI calculations namely, pH, dissolved oxygen, total alkalinity, total hardness, calcium, magnesium, chlorides, total dissolved solids and biological oxygen demand. The water quality index is a unit less single dimensional number between 0 and 100. The present study deals with the assessment of physico-chemical characteristics of water and on the basis of selected quality parameters, water quality index is determined of surface water of Ram-Ganga reservoir, Kalagarh, Uttrakhand.

MATERIALS AND METHODS

Study Area: Ram-Ganga reservoir is situated between 78°-45'-35'' E and 29°-31'-13'' N. The Ram-Ganga dam is also known as Kalagarh dam. It is located at 3.5 km North of Kalagarh in district Pauri Garhwal, Uttarakhand. The Kalagarh dam on the river Ram-Ganga was built for irrigation and power generation in 1963-1974. The dam is a part of the Ram-Ganga multipurpose project used as irrigation and hydroelectric power services. The morphometrics and hydrological data of the reservoir are shown in Table 2.

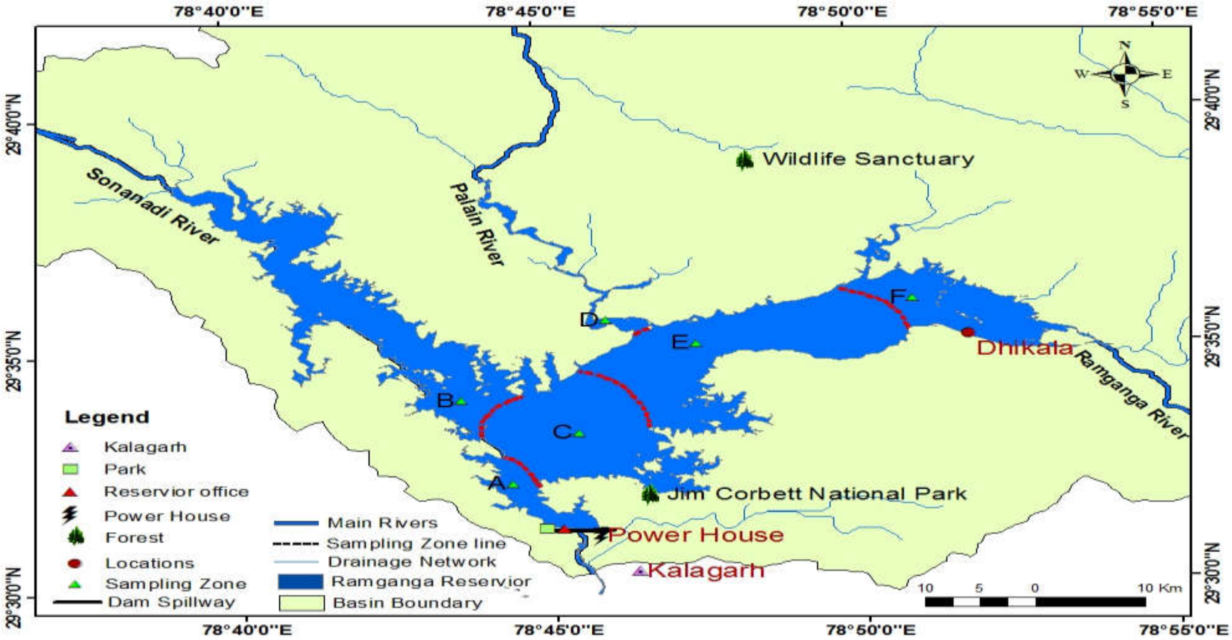

Fig. 1. Location map of Ram-Ganga reservoir showing the different sampling zone

METHODS

Six different sites were selected for the collection of water samples. The samples were collected in sterilized polythene bottles of one litter capacity. Monitoring was performed during September 2015 to August 2016 (seasonal monsoon, winter, and summer). For unstable parameters such as temperature, pH, and dissolved oxygen (DO) were measured at the sampling site. Samples were brought to the laboratory for analysis of other physico-chemical parameters like total dissolved solid, total alkalinity, total hardness, calcium, magnesium, chlorides, and biochemical oxygen demand (BOD). The parameters were compared according to the standard methods described in the literature (APHA,1998; WHO, 1998; Botkin and EA., 1995). The weighted arithmetic index method (Brown et al., 1972) was used for the calculation of water quality index (WQI) of the water body. Further, quality rating or sub-index (qn) was calculated by the following expression.

$$Q_{n} = 100[V_n - V_{10}] / [S_n - V_{10}]$$

Where:

qn=Quality rating for the *n*th water quality parameter,
Vn=Estimated value of the *n*th water quality parameters of collected sample,
Sn=Standard permissible value of the *n*th water quality parameter,
V_{10}=Ideal value of the *n*th water quality parameter in pure water.

(i.e. 0 for all other parameters except the parameter pH and Dissolved oxygen (7 and 14.6 mg/L respectively.) (Let there be *n* water quality parameters and quality rating or sub index (*q*n) corresponding to *n*th parameter is a number reflecting the relative of this parameter in polluted water with respect to its standard permissible value.) Unit weight was calculated by a value inversely proportional to the recommended standard value Sn of the corresponding parameter.

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

Where:

Wn=Unit weight for nth water quality parameter,
Sn=Standard permissible value of the nth water quality parameter,
K=Constant for proportionality.

The overall WQI was calculated by aggregating the quality rating with the unit weight linearly.

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

Where:

qn = Quality rating for the *nth* water quality parameter,
Wn=Unit weight for *nth* water quality parameter.

Table 1: Water Quality Index (WQI) and its status according to Chaterjee and Raziuddin(2002) and Thakor *et al.*(2011)

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 AND DISCUSSION

The analytical seasonally data of physico-chemical characteristics of water are presented in table (Table 3) and selected water quality parameters and WQI of the different season are presented in table 4,5,6 respectively. A comparison of the results obtained with BIS, (2012) and WHO standards (2004) was also done and found that all the values obtained were found to be well within the prescribed standard values. pH is the most important factor in water quality. The fluctuations in surface water pH indicate the buffering capacity of total alkalinity. During this study, pH values were ranged from 7.35 to 8.13 that indicate slightly alkaline nature of water body which was within the standard limit. i.e. 6.5-8.5 (central pollution control board, 2007; BIS 2012).

Fig. 1. A View of Ram-Ganga reservoir during Monsoon season

Fig. 2. A View of Ram-Ganga reservoir during Winter season

Fig. 3. A View of Ram-Ganga reservoir during Summer season

Table 2. Morphometrics and hydrological data of Ram-Ganga reservoir

Morphometrics Data		Hydrological Data	
Parameter	Value	Parameter	Value
Type	Earth and boulder fill	Mean Annual Rainfall(mm)	1552
Max dam height(m)	128	Mean Annual Runoff(m.cum.)	2683
Length of Dam(m)	715	Designed flood(cum./Sec)	12121
Full storage level(m)	365.30	Max probable flood(cum./Sec)	10392
Dead storage level(m)	317	Diversion flood(cum./Sec)	9705
Catchment Area(Km^2)	3,314		
Surface Area(Km^2)	55		
Basin Area(Km^2)	78		

Table 3. Average with standard error values of physico-chemical parameters of water samples collected at Ram-Ganga reservoir

S. No.	Parameters	Year 2015-16		
		Monsoon	Winter	Summer
1	pH	8.13±0.69	7.35±0.14	8.00±0.03
2	TDS	123.52±26	79.64±0.21	93.84±6.98
3	DO	8.42±0.18	9.66±0.04	9.26±0.22
4	BOD	1.53±0.22	1.32±0.16	1.51±1.8
5	Alkalinity	99.22±0.59	145.82±1.01	125.86±9.95
6	Total hardness	165.56±0.83	146.32±0.44	161.53±7.69
7	Calcium	56.8±0.37	30.28±1.02	49.89±0.76
8	Magnesium	17.89±6.12	19.24±1.03	12.62±0.61
9	Chloride	48.16±1.86	31.62±0.36	40.73±0.24

Table 4. Calculation of WQI of water samples in monsoon season of Ram-Ganga reservoir

S. No.	Parameters	Observed value (Vn)	Standard Value(Sn)	Ideal value (V_{10})	Unit Weight (Wn)	Quality Rating (Qn)	WnQn
1	pH	8.13	7.5	7	0.219	226	49.49
2	TDS(mg/l)	123.52	500	0	0.0037	24.70	0.091
3	DO(mg/l)	8.42	5	14.6	0.3723	64.37	23.96
4	BOD(mg/l)	1.53	5	0	0.3723	30.6	11.39
5	Alkalinity(mg/l)	99.22	120	0	0.0155	82.68	1.281
6	Total hardness(mg/l)	165.56	300	0	0.0062	55.18	0.342
7	Calcium(mg/l)	56.8	75	0	0.025	75.73	1.893
8	Magnesium(mg/l)	17.89	30	0	0.061	59.63	3.637
9	Chloride(mg/l)	48.16	250	0	0.0074	19.26	0.142
					ΣWn=1.082	ΣQn=638.15	ΣWnQn=92.23
WQI=92.23							

Table 5. Calculation of WQI of water samples in winter season of Ram-Ganga reservoir

S. No.	Parameters	Observed value (Vn)	Standard Value(Sn)	Ideal value (V_{10})	Unit Weight (Wn)	Quality Rating (Qn)	WnQn
1	pH	7.35	7.5	7	0.219	70	15.33
2	TDS(mg/l)	79.64	500	0	0.0037	15.92	0.058
3	DO(mg/l)	9.66	5	14.6	0.3723	51.66	19.23
4	BOD(mg/l)	1.32	5	0	0.3723	26.4	9.83
5	Alkalinity(mg/l)	145.82	120	0	0.0155	121.51	1.88
6	Total hardness(mg/l)	146.32	300	0	0.0062	48.77	0.302
7	Calcium(mg/l)	30.28	75	0	0.025	40.37	1.01
8	Magnesium(mg/l)	19.24	30	0	0.061	64.13	3.912
9	Chloride(mg/l)	31.62	250	0	0.0074	12.64	0.093
					ΣWn=1.082	ΣQn=451.4	ΣWnQn=51.64
WQI=51.64							

Table 6. Calculation of WQI of water samples in summer season of Ram-Ganga reservoir

S. No.	Parameters	Observed value (Vn)	Standard Value(Sn)	Ideal value (V_{10})	Unit Weight (Wn)	Quality Rating (Qn)	WnQn
1	Ph	8.00	7.5	7	0.219	200	43.8
2	TDS(mg/l)	93.84	500	0	0.0037	18.77	0.069
3	DO(mg/l)	9.26	5	14.6	0.3723	55.62	20.71
4	BOD(mg/l)	1.51	5	0	0.3723	30.2	11.24
5	Alkalinity(mg/l)	125.86	120	0	0.0155	104.88	1.625
6	Total hardness(mg/l)	161.53	300	0	0.0062	53.84	0.334
7	Calcium(mg/l)	49.89	75	0	0.025	66.52	1.663
8	Magnesium(mg/l)	12.62	30	0	0.061	42.07	2.566
9	Chloride(mg/l)	40.73	250	0	0.0074	16.29	0.120
					ΣWn=1.082	ΣQn=588.19	ΣWnQn=82.13
WQI=82.13							

Total dissolved solid (TDS) is determined by measuring the number of solid materials dissolved in the water (surface, ground).TDS indicate the general nature of salinity of water such as higher value will have a salty taste. Dissolved solid is a very important criterion for irrigation water due to their gradual accumulation results in salinization of soil, thus, rendering the agriculture land non-productive. The total dissolved solid in the sampled water ranged from the 79.64 mg/L to 123.52 mg/L.

The lowest TDS reported during winter was 79.64 ml/L and highest TDS reported during monsoon was 123.52 mg/L due to high run-offs from sediment and catchments watershed. Dissolved oxygen is an important indicator of water quality, ecological status, productivity and health of a reservoir. Dissolved oxygen in water comes from the atmosphere due to their air action. Algae and aquatic plants also release oxygen into water through photosynthesis (ICMR, 1975).The higher value of dissolved oxygen indicates good aquatic life.

The amount of dissolved oxygen varied from 8.42 mg/L to 9.66 mg/L. The lowest dissolved oxygen recorded during monsoon season was 8.42 mg/L and the highest amount recorded during winter season was 9.66 mg/L due to low temperature. Biological oxygen demand is a parameter to assess the organic load in a water body (ICMR, 1975). BOD is the measure of the extent of pollution in the water body. The BOD reported from water samples was recorded from 1.32 mg/L to 1.52 mg/L. The lowest demand was recorded during winter season 1.32mg/L. The highest demand for oxygen in the water was recorded during monsoon season was 1.53 mg/L due to the possible addition of a high amount of waste along with rain water from the surrounding. The total alkalinity of the reservoir is a reflection of its carbonates and bicarbonate profile (Wetzel, 2011) with the likelihood of silicates and phosphate contributing to it. This is so; because phenolphthalein alkalinity was absent in the reservoir (Campbell and Wildberger, 2001). Alkalinity is a measure of the capacity of water to neutralize a strong acid (Wetzal, 1983). The alkalinity in the water samples ranged from 99.22 mg/L to 145.82 mg/L. The highest alkalinity recorded during winter was 145.82 mg/L due to a high nutrient in water and lowest recorded during monsoon was 99.22 mg/L. due to dilution of water by addition to reservoir water. The total hardness is also an important parameter of water quality whether to be used for the domestic, industrial or agricultural process. The total hardness of water is not a specific constituent but is a variable and complex mixture of cations and anions. The total hardness is due to the presence of calcium and magnesium ions (Boyd, 1979). The observed value of total hardness recorded from 146.32 mg/L to 165.56 mg/L. The highest amount of total hardness in the water was recorded during 165.56 mg/L due to the presence of high content of calcium and magnesium and the lowest amount of total hardness was recorded during the winter season due to the low concentration of calcium and magnesium. The quantities of calcium in natural water depend upon the type of rocks. .The analysis of calcium revealed a ranged between 30.28 mg/L to 56.8 mg/L. The highest amount of calcium recoded in water samples during monsoon was 56.8 mg/L by the addition of waste along with rain water and responsible for the increase in the amount of calcium (Verma et al., 2010). The lowest amount of calcium in water was during the winter season due to Calcium is most abundant ions in fresh water and is important is shell construction, bone building and plant precipitation of lime (Solanki, 2012).

The concentration of magnesium was minimum than the concentration of calcium possibly due to the lesser occurrence of magnesium minerals in bottom strata of the reservoir. Magnesium is essential for chlorophyll growth and acts as a limiting factor for the growth of phytoplankton (Solanki, 2012).The amount of magnesium recorded in the water ranged between 12.62 mg/L to 19.24 mg/L. The highest amount of magnesium in water sample was recorded during winter and the lowest value was recorded during summer due to the magnesium essentiality for chlorophyll bearing plant for photosynthesis (Pawar and Pulle, 2005). The chloride in water originates from natural sources, sewage and industrial effluents, urban runoff containing de-icing salt and saline intrusion (Solanki, 2012). Chloride concentration in the reservoir was noticed between 31.62 mg/L to 48.16 mg/L. The highest chloride reported in Monsoon season due to rainfall and lowest value of chloride recorded during the winter season due to frequent run-off and evaporation of water.

Conclusion

From the results obtained, it was found that the water quality index and concentration of different physico-chemical parameters are higher during monsoon season due to the heavy rainfall and the sedimentation rate increases. In all, the range of physico-chemical properties of Ram-Ganga reservoir is comparable in seasonally. The values found in WQI is 51.64, 82.13 and 92.23 in winter, summer and rainy season respectively. The observation in this study indicates the higher values of some parameters of the reservoir water. They minimize the suitability of the water for drinking purpose without prior treatment. Higher values of water quality index clearly show that the status of the water body is entropic and not totally safe for human drinking purpose. It is also observed that the pollution load is relatively higher in monsoon season and summer season when compared to the summer season.

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