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Limnological and Correlation Studies of Sonala Dam, Sonala, Distt. Washim, (M.S.)

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ABSTRACT

Sonala dam is a perennial reservoir in Maharashtra, where limnological studies were conducted from Februay 2012 to January 2013. The reservoir is mainly used for drinking water supply to nearby villages and for irrigation. The nearby villages also use the water for bathing and washing purposes. The present investigation deals with the estimation of current status of physico-chemical characteristics of Sonala dam. Water samples were analysed from six sampling stations every month. The physico-chemical parameters varied seasonally. Physico-chemical factors like temperature, conductivity, pH, free carbon dioxide, biological oxygen demand and chloride recorded higher values during summer season. Similarly, during monsoon season turbidity, total dissolved solids, phosphate and nitrate; and in winter season dissolved oxygen were in maximum concentration. pH remained alkaline throughout the study period at all the sampling stations. The correlation matrix of physico-chemical factors have been computed and analysed. Correlation coefficient showed positive and negative relationship. Further, the statistical correlations have revealed DO and BOD exhibited an inverse relationship with each other. The observations revealed that the physico-chemical parameters of the water were within the permissible limits and can be safely used for domestic, irrigation and pisciculture.

I. INTRODUCTION

Fresh water is a natural resource of fundamental importance. India has vast fresh water resources in the form of both lentic and lotic ecosystems. The lentic ecosystems include ponds, lakes, tanks and reservoirs [21]. Reservoirs play a vital role for anthropogenic activities like domestic, agriculture and aquaculture. Dams are the most important water resource. Regrettably, dams are being polluted by injudicious disposal of sewage and human activities. The dams are always the victim of the negative impact of development. The nature plays major role to lower the water pollution but the process is very slow [19]. Analysis of water is important to preserve and protect the natural ecosystem. To assess the quality of water, analysis of physico-chemical parameters of water is essential for the best usage like irrigation, drinking, and other purposes. Different aspects of water are monitored to determine the quality of water. To employ scientific method for aquaculture, the study of different water parameters is very important for understanding of the metabolic events in aquatic ecosystem. The parameters influence each other as well as they govern the abundance and distribution of the flora and fauna. Pollution of water bodies first affects its physico-chemical quality and then systematically destroys the community disrupting the decline food web. Physico-chemical properties were influence by seasons and also anthropogenic activities like agriculture, urbanization, domestic sewage etc. in the catchment area resulted in deterioration of water quality [26]. The statistical correlation has been used to develop mathematical relationship for comparison of physico-chemical parameters [5].

There is a lack of baseline data on limnological characteristics of Sonala dam reservoir, Sonala, Distt. Washim. Therefore, the present study was undertaken to monitor the water quality of Sonala reservoir, to determine the seasonal changes in water quality parameters and to find the relationship between different physico-chemical parameters.

II. MATERIALS AND METHODS

Study area

Sonala Dam is a fresh water reservoir constructed in the year 1981. It is located at 77^0, 12', 30" Longitude and latitude of 20^0, 19', 00" in Sonala village of Washim district in Maharashtra (India). The reservoir is constructed on the River Adan a tributary of River Godavari. The Sonala dam is an earthen dam with 19.20 meter maximum height and 446.90 hector submergence with 132.50 square Km. of catchment area. The reservoir stores rain water received from adjoining catchment area. The reservoir is presently used for irrigation and drinking purpose for regional rural areas and is much influenced by anthropogenic activities.

Methods

The study was carried out for 12 months from February 2012 to January 2013 during different seasons at six sampling stations. The selection of six sampling stations was made on the basis of human and other domestic activities. The seasons defined as monsoon (June to September), winter (October to January) and summer (February to May). For physico-chemical analysis of water of Sonala dam, water samples were collected from six sampling stations every month in the forenoon (between 7:00 am to 9:00 am.). Unstable parameters like pH, temperature, Electrical Conductivity (EC) and Dissolved Oxygen (DO) were measured at the sites. To study other physico-chemical parameters, like free CO_2, chlorides, ammonia, nitrate, phosphate and Biochemical Oxygen Demand (BOD), water samples were collected in 5 liters plastic can, brought to the laboratory, analyzed and calculated as per standard formulas and methods. [3, 12, 18, 30].

Statistical analysis

The correlation between various physico-chemical parameters of water samples were analyzed statistically conducting Pearson correlation analysis.

III. RESULTS AND DISCUSSION

Physico-chemical parameters (Mean ± S.E) of Sonala Dam obtained during the present investigation (February 2012 to January 2013), is presented in Table 1. The statistical analysis of Pearson's correlation coefficient is presented in Table 2.

Water temperature

In present investigation, the temperature of Sonala dam water ranged from 20.42 ^{0}C to 26.2 ^{0}C. Low water temperature was recorded during the winter season and the higher water temperature recorded during the summer season. High water temperature during the summer season was observed due to low water level, high temperature and clear atmosphere. Similar findings were recorded [17, 23]. Low temperature during winter season might be due to high water level, lesser solar radiation and low atmospheric temperature [4]. Water temperature showed significant positive correlation with conductivity ($r= 0.667$), TDS ($r= 0.701$) and BOD ($r= 0.781$) at $p<0.01$, however showed significant negative correlation with dissolved oxygen ($r= -0.923$ at $p<0.01$) and ammonia ($r= -0.655$ at $p< 0.05$).

Electrical conductivity

During the study period conductivity ranged from 440 µmhos/cm to 618µmhos/cm. Conductivity of dam water was seen maximum during summer and decreased during winter season [25]. Higher values of conductivity during summer months may be due to the increased concentrations of salts in reduced quantity of water in reservoir. However, during the

winter season and rainy season there was more inflow of water, which diluted the pollutants to some extent and lowered the ionic contents of the water. Pearson's correlation coefficient of conductivity showed significant positive correlation with CO_2 (r= 0.848) , PO_4 (r= 0.837) and BOD (r= 0.930) at $p < 0.01$.

Turbidity

The turbidity value of the Sonala dam was recorded between 18.8 to 26.71 NTU. The maximum turbidity during monsoon season and minimum during winter season was observed [10]. Maximum values of turbidity in dam water during monsoon may be due to increase of suspended particulate matter in water and influence of flow of surface runoff from the catchment areas [1, 27]. Lower turbidity was observed during the winter months due to increased water level of reservoir which diluted the pollutants in water [14]. Turbidity showed high significant positive relationship ($p<0.01$ level) with total dissolved solids (r=0.828) and nitrate (r= 0.739) whereas chloride (r= –0.832) and ammonia(r= –832) showed negative relationship ($p<0.01$ level) and ($p<0.05$ level) respective.

Total Dissolved Solids (TDS)

The data obtained from the present study revealed that the TDS value ranged between 235.71 to 432.6 mg/L. Maximum value was observed during monsoon season and minimum during the winter season [28]. The low values of total dissolved solids during winter months might be due to settling of suspended particles and trapping of dissolved solids by organisms. Total dissolved solids showed significant positive correlation with water temperature (r= 0.701) at 0.05 level and nitrate (r= 0.834) at $p< 0.01$ level, whereas pH(r= –0.680), ammonia (r= –0.842), dissolved oxygen (r= –0.607) and chloride (r= –0.595) showed negative relationship ($p<0.05$ level) [24].

pH

The results from present, investigation indicated that, the average pH value observed ranged 7.23 to 7.60. The pH showed seasonal change and fluctuation in values, which were mainly due to photosynthetic activity of phytoplankton and other higher aquatic plants [17]. Decrease in pH values during winter season is mainly related to the high bicarbonate content, while the uptake of CO_2 by phytoplankton decreased as a result of increase in concentration of bicarbonate [15]. Minimum in winter season could also be due to short day length and decreased photosynthetic activity [25]. pH remained alkaline throughout the study period at all the sampling stations. During the study period, pH showed significant positive correlation with ammonia (r= 0.834) at $p<0.01$, whereas significant negative correlation with nitrate (r= -0.620) at $p<0.05$.

Free Carbon dioxide (CO_2)

In the present investigation, CO_2 ranged from 14.62 to 33.52 mg/L. Maximum value was recorded during the summer season and minimum during winter season. The maximum concentration of CO_2 in the water during summer season may be attributed to microbial degradation of organic matter and respiratory activities of aquatic flora and fauna [20]. During the study period CO_2 showed significant positive correlation with chloride (r= 0.860), phosphate (r=0.962) and biological oxygen demand (r=0.809) at ($p<0.01$ level

Chloride

Chloride is an anion in water. It occurs in fresh water in the form of salt of sodium, potassium and calcium. In the present investigation, the values of chloride ranged from 52.64 to 89.65 mg/L. The maximum value was obtained during the summer season and minimum value was recorded during the rainy season [11]. This may be due to the concentration of sewage and increased intensity of human activities associated with dam water. During the rainy season indicated low concentration of chloride may be due to dilution of pollutants in more quantity of water [23].Statistically, chloride showed significant positive correlation with phosphate(r=0.845) and CO_2(r=0.860) at $p<0.01$ level, whereas significant negative correlation with nitrate (r= -0.764) at $p<0.01$ level.

Dissolved oxygen

Dissolved oxygen, an important abiotic factor regulates the life of animals in water. In the present investigation, dissolved oxygen was in the range of 6.33 to 9.54 mg/L. The minimum values were recorded during the monsoon season and the maximum value was recorded during the winter season. Dissolved oxygen showed high significant positive relationship ($p<0.05$ level) with ammonia ($r=0.674$), whereas biological oxygen demand ($r= -0.907$) at $p<0.01$ level and phosphate ($r= –0.602$) at $p<0.05$ level showed negative relationship. During winter months higher value of DO was observed due to decreased solar intensity and reduced temperature of water, which reduced the microbial activities and their consumption of DO from water [8]. On the other hand higher solubility of oxygen at low temperature of water is responsible to maintain the more DO values in dam water [21].

Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand is an important parameter which is used as an index of organic pollution in water. Presence of oxidizable organic matter in water results in increased BOD, as more the amount of oxygen is required to degrade it biologically. The biochemical oxygen demand (BOD) reported from Sonala dam ranged from 6.0 to 10.3 mg/L. The maximum demand of oxygen in the water was recorded during summer season and the minimum demand was recorded during the winter season. Higher values during the summer season were due to increased metabolic activities of various aerobic and anaerobic micro-organisms on bottom sediments and organic matter, which increased BOD. It is evident from the minimum value of BOD harvested during the winter season that, decreased in values of BOD, may be caused due to reduction of microbial activities at low temperature. However, the comparatively more water and dilution effect is also responsible to reduce the BOD values during winter days [6, 9]. Statistically, BOD showed significant positive correlation with phosphate ($r=0.855$), conductivity ($r=0.930$), CO2 ($r=0.809$) at $p<0.01$ level and temperature ($r= 0.781$) at $p<0.05$ level.

Ammonia

Ammonia is an end product of decomposition of nitrogenous organic matter; it is also the excretory product of aquatic fauna. During the present study, the value of ammonia ranged from 0.63 to 2.04 mg/L. Ammonia showed high significant positive relationship ($p<0.01$ level) with pH ($r=0.717$) and DO ($r= 0.674$) at $p<0.05$ level. Ammonia showed high significant negative relationship with nitrate ($r= -0.864$) at $p<0.01$ level and temperature ($r= -0.655$), turbidity ($r= -0.580$) and TDS($r= -0.842$) at $p< 0.05$ level.

Phosphate

Phosphate is a key nutrient that resulted in an enrichment of natural water owing to its immense importance towards biological productivity. In the present investigation, the phosphate was in the range of 0.13 to 0.25 mg/L. The concentration of phosphate was maximum during monsoon and minimum during the winter season. These domestic activities in the vicinity of the dam resulted in the increase in the percentage of phosphate in water. Agricultural practices in the basin of river and the use of cow dung as manure by farmers, during summer season polluted the water and constituted the major source of phosphate [13]. During the winter season relatively low level of phosphate

Table 1. Average with standard error values of physico-chemical parameters at Sonala Dam (2012-13)

S.No	Parameters	Year 2012 -2013		
		Summer	Monsoon	Winter
1	Temperature (^{0} C)	26.21±1.6	25.83±.84	20.42±0.66
2.	Conductivity (µmhos/cm0	618±7.9	499±17.7	440±10.03
3	Turbidity (NTU)	19.41±1.2	26.71±1.63	18.8±2.26
4	Total dissolved solids (mg/L)	337.62±36.76	432.6±40.29	235.71±35.62
5	pH	7.60±0.04	7.45±0.06	7.23±0.06
6	Carbon dioxide (mg/L)	33.52±1.54	14.62±2.14	18.39±0.20
7	Chloride (mg/L)	89.65±1.8	52.64±5.65	75.50±5.25
8	Dissolved Oxygen (mg/L)	7.13±0.84	6.33±0.46	9.54±0.52
9	Biochemical Oxygen Demand (mg/L)	10.3±0.53	7.43±0.30	6.0±0.44
10	Ammonia (mg/L)	2.04±0.025	1.30±0.046	0.63±0.19
11	Phosphate (mg/L)	0.16±0.015	0.25±.002	0.13±0.007
12	Nitrate (mg/L)	1.19±0.02	4.01±	0.05±0.006

has been reported. This may be attributed to the abundance of phytoplankton in the water. Assimilation of phosphates by phytoplankton population reproduction for their growth and is responsible to decrease the levels of phosphates in the months of winter [7, 8]. Phosphate showed positive correlation with conductivity (r=0.837), CO2 (r= 0.962), chloride (r=0.845) and BOD (r= 0.855) at $p<0.01$ level, whereas showed significant negative relationship with DO (r= -0.602) at $p<0.05$ level.

Nitrate

Nitrate is an important nutrient that results in enrichment of natural water. Large quantity of nitrate leads to eutrophication. Nitrate is an indication of nitrogen richness in an aquatic system primarily attributed to animal origin [29]. In the present investigation, nitrate ranged from 0.05 to 4.01mg/L. During the study period maximum values of nitrate were observed during the monsoon season, this may be due to the influx of runoff water from the agricultural fields and more quantity of sewage and wastes brought by water from catchment area increased the level of nitrates in dam water [27]. Nitrate showed high significant positive relationship ($p<0.01$ level) with TDS (r=0.834) and turbidity (r=0.739), whereas showed significant negative relationship with pH (r= -0.620) at $p<0.05$ level.

IV. CONCLUSION

Fluctuations in various physico-chemical parameters were monitored during monsoon, winter and summer seasons. The study of correlation coefficient between various physico-chemical factors indicated that water temperature varied with the variation of atmospheric temperature. The present study shows that, the water of Sonala dam exhibits high concentration of turbidity and total dissolved solids, which may be attributed to large flow of surface, run off from catchment areas and increase of suspended particulate matter in water. The pH of water tends towards alkaline nature. High value of ammonia was recorded, may be due to the death and subsequent decomposition of phytoplankton and excretion of ammonia by planktonic organisms. Maximum BOD was recorded in summer season. The values of BOD showed inverse trend with the values of dissolved oxygen. High values of BOD were due to the metabolic activities of various aerobic and anerobic micro-organisms on bottom sediments and organic matter. High concentration of chloride during summer season may be due to sewage and human activities performed. Phosphate and nitrate values were higher during monsoon season and lower during winter season. Higher values during monsoon season may be due to the use of chemical fertilizers in crop fields of catchment areas and surface runoff. The correlation coefficient indicates positive and negative correlation of physico-chemical parameters with each other.

The selected dam, reservoir was found to be affected by anthropogenic activities, yet the overall dam is not considered as more polluted in nature. Not much pollution was observed, though results of some of the parameters, values were reported slightly above the permissible standards of WHO. The reason may be uncontrolled use of dam water for waste disposal and anthropogenic activities. The data harvested from the present study exhibits that the degree of contamination of the lake water is greater in summer months. It may be concluded that, on an average the water reservoir of Sonala dam is not significantly polluted. Comprehensive monitoring and proper management could be enough to make the water less polluted. This study may be helpful in sustainable management of the reservoir.

Table 2. Matrix showing correlation & significance level of physico-chemical & biotic parameters of water from Sonala dam during 2012-2013

	Wt	CON	TUR	TDS	pH	CO_2	Chlo	DO	BOD	NH3	PO_4	NO_3
Wt	1											
CON	0.667*	1										
TUR	0.392	-0.245	1									
TDS	0.701*	0.229	0.828**	1								
pH	-0.506	-0.29	-0.438	-0.680*	1							
CO_2	0.426	0.848**	-0.525	-0.15	0.044	1						
Chlo	0.012	0.556	-0.832**	-0.595*	0.419	0.860**	1					
DO	-0.923**	-0.823**	-0.157	-0.607*	0.536	-0.56	-0.168	1				
BOD	0.781**	0.930**	-0.118	0.355	-0.248	0.809**	0.487	-0.907**	1			
NH3	-0.655*	-0.345	-0.580*	-0.842**	0.717**	0.159	0.535	0.674*	-0.383	1		
PO_4	0.455	0.837**	-0.509	-0.093	0.102	0.962**	0.845**	-0.602*	0.855**	0.114	1	
NO_3	0.392	0.022	0.739**	0.834**	-0.620*	-0.47	-0.764**	-0.357	0.078	-0.864**	-0.38	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

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