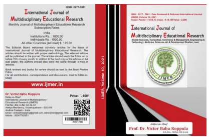
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NEW HYDROBIOLOGICAL STUDY OF KOYANA DAM, LIFE LINE OF MAHARASHTRA

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ABSTRACT

Some hydrobiological features of Koyana dam, situated in the Sahyadri range kokan were studied during May 2020 to October 2020. Water temperature showed abrupt fluctuations. The pH was generally acidic. Dissolved oxygen increased steadily with increasing rainfall and recorded highest in late August (12.7 mg^{-1}). The gross primary productivity had a highest value of 87.50 mg Cm^{-3}hr^{-1}. Chlorophyceae were identified among phytoplanktons. Zooplanktons were represented by Cladocerans & copepods. The study revealed higher concentration of nutrients at certain pockets of lae lake, which points to increasing human influences in the System, and the water cannot serve as a scarcity alternative for drinking purpose.

Keywords: Koyana Dam, Limno-Chemistry, Productivity, Planktons, Microbal Land.

INTRODUCTION

A large number of natural freshwater lakes exist in the Sahyadri range kokan, which are of great scientific and socio-economic value (Zutshi, 1985). For facilitation of commercial tourism, some reservoirs have even been artificially constructed. The Koyana dam is an artificially constructed reservoir in the town of Koyana (17^{0}24'N latitude and 73^{0}45'E longitude) in satara district of Maharashtra. A considerable amount of work has been carried out on different aspects of hydrobiology of the Himalayan lakes (Das et al., 1969; Zutshi et aL.,1972; Pant et al., 1985; Zutshi, 1989; Khulbe, 1992; Rawat et al., 1993; Jana, 1998; Jain et al., 1999). Some reports are available on the limnology of artificially constructed reservoirs in the Himalayas (Sehgal, 1989; Sugunan, 1995; Raina and Petr, 1999). Considerable hydrobiological investigations have been carried out on man-made water bodies in other parts of India (Abbasi et al., 1996; Shastri and Pendse, 2001). However, waterbodies in the Sahyadri range kokan have not been well documented. The present study was designed to obtain the present hydrobiological profile of the Koyana dam. The Koyana town suffers from an huge shortage of drinking water during the rainy months of May and June. This study also aimed to assess the suitability of the lake water as a substitute for drinking water in time of scarcity.

MATERIAL AND METHODS

The Koyana dam is spread over 115 km2 near the Koyananagar locality in the town of Koyana at an altitude of about 746 meters above mean sea level. The inauguration of this artificial lake in 1964 led to the growth of tourism industry surrounding the lake and the subsequent rapid urbanization of Koyana has had visible impacts of disturbance on the lake and its watershed. In the present investigation, three sampling stations (S-1, S-2 and S-3) were selected for the collection of fortnightly water samples during the period of May to October, 2019. Sampling station-1 (S-1), located at the eastern part of the lake receives the effluents through drains. Sampling station-2 (S-2) located at the northern region and sampling station-3 (S-3), located at the southwestern region receives the natural runoff through the hills. The water samples were collected from surface water at all the sites. Water temperature was recorded by centigrade thermometer. The pH of the water samples was estimated on spot. All the other physico-chemical analysis of the water was determined following Standard Methods (APHA,1998). The primary productivity was measured following the conventional ligtrt and dark bottle method (Gaarder and Gran, 1927). Only qualitative analysis of the phyoplanktons and zooplanktons were carried out. Correlation between the different physico-chemical parameters and plankton productivity were calculated following Karl Pearson's method (Palanichamy and Manoharan, 1990) and the corresponding significant test were performed to find out the level of significance.

RESULTS AND DISCUSSION

The results of the water quality and hydrobiological analysis are presented in Table-1. The water temperature ranged between 22^{0}C and 32^{0}C during the period of study. The variation in temperature was significant between the dry and rainy seasons. Similar fluctuation of temperature between seasons was also reported by Jain et al. (1999), Kamble B.S. et al (2017). Specific conductivity values were usually higher in S-1, which had a mean of 0.42 mmhos mgl^{-1}, than in other sites, which could be attributed to the greater ionic concentration of the inlet flow. The mean values of specific conductivity in S-2 and S-3 stood at 0.45 and 0.26 mmhos cm^{-1}, respectively. The water of the lake was generally acidic to neutral as can be observed from the pH values (Table-1). The rainwater however, played its part in neutralizing the acidic level and the highest pH value during our study was recorded in August (6.9). The acidic nature of Koyana range has also been reported by Zutshi et al. (1972) and Rawat et al. (1993).

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Table-1: Summary of the hydrobiological features of the Koyana dam.

Parameter	S-1			S-2			S-3		
Water temperature(^{0}C)	22.0-32.0	25.1	±2.71	22.0-32.0	25.1	±2.71	22.0-32.0	25.1	±2.71
Hydrogen ion concentration(pH)	6.1-6.9	6.32	±0.45	6.3-6.8	6.34	±0.30	6.3-6.9	6.46	±0.42
Specific conductivity (mmhos cml^{-1})	0.21-0.85	0.42	±0.16	0.10-0.88	0.45	±0.2	0.10-0.72	0.26	±0.20
Dissolved oxygen (mgl^{-1})	5.0-12.0	7.34	±2.66	5.5-11.5	7.39	±1.93	5.7-12.7	7.77	±2.09
Free carbon dioxide(mgl^{-1})	5.3-6.5	5.63	±0.83	5.6-6.0	5.90	±0.32	5.1-5.9	5.39	±0.42
Total alkalinity (mgl^{-1})	28.0-46.1	38.09	±4.25	28.0-46.0	36.11	±3.28	25.1-37.0	32.49	±2.85
Total hardness (mgl^{-1})	10.4-26.0	16.24	±4.20	10.2-24.0	15.44	±3.83	8.8-20.0	13.10	±2.93
Chloride ion (mgl^{-1})	16.8-26.8	22.02	±2.98	16.2-24.8	19.59	±2.54	12.2-20.8	16.14	±2.96
Phosphate-P(mgl^{-1})	0.03-0.15	0.07	±0.04	0.02-0.11	0.05	±0.03	0.03-0.09	0.03	±0.02
Ammonium-N (mgl^{-1})	0.012-0.070	0.046	±0.023	0.009-0.052	0.033	±0.018	0.008-0.036	0.022	±0.015
Nitrite-N(mgl^{-1})	0.008-0.030	0.018	±0.011	0.007-0.024	0.013	±0.005	0.002-0.019	0.008	±0.003
Nitrate-N(mgl^{-1})	0.07-0.35	0.19	±0.07	0.04-0.29	0.16	±0.010	0.04-0.16	0.009	±0.08
Primary productivity Gross Primary Productivity (GPP) (mg C^{-3} hr^{-1})	25.8-68.1	46.24	±14.26	37.5-87.5	55.25	±16.04	41.26-87.6	62.51	±16.84
Net Primary Productivity (NPP) (mg C^{-3} hr^{-1})	20.26-58.28	32.23	±12.07	30.75-62.75	42.25	±10.39	30.75-60.0	43.49	±12.70

SD= Standard Deviation, (n= 11 for and NPP, and for all other parameters, n=13).

A positive correlation was observed between water temperature and dissolved oxygen (DO) (Table-2). The DO varied between 5.2-12.6 mgl^{-1} in lake water, also varied by Kamble B.S. et. al. (2020). The values showed an increasing tendency from early June onwords, reached the peak at the end of September and decreased thereafter. Higher DO values during the monsoon may be due to turbulence and oxygenation resulting from high rainfall and mixing results in an increased pH value and vice-versa, possibly due to comparatively high photosynthetic activity during this period. The free CO_2 also recorded a significantly positive correlation with total alkalinity (Table-2).

Table-2: Pearson's correlation coefficients for physico-chemical characteristics and plankton productivity of the Koyana dam (n=11, d.f.=9 for gross primary productivity, and for all other parameters, n=13, d.f.=11).

Parameter	Temperature	pH	Conductivity	DO	Free CO_2	Alkalinity	Hardness	Chloride	NH_4-N	NO_2-N	NO_3-N	PO_4-P	GPP
Temperature	-	0.21	0.14	0.216	0.33	0.552	0.301	0.26	1.161	0.281	0.285	0.101	0.211
pH	NS	-	0.276	0.59	0.666	0.642	0.229	0.58	0.368	0.322	0.216	0.264	0.217
Conductivity	NS	NS	-	0.183	0.307	0.124	0.16	0.42	0.234	0.11	0.21	0.058	0.253
DO	NS	0.05	NS	-	0.618	0.542	0.415	0.331	0.396	0.402	0.307	0.286	0.421

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Free CO_2	NS	0.05	NS	0.04	-	0.581	0.261	0.327	0.298	0.244	0.234	0.312	0.263
Alkalinity	0.05	0.01	NS	0.04	0.05	-	0.518	0.535	0.313	0.311	0.21	0.278	0.462
Hardness	NS	NS	NS	NS	0.04	0.04	-	0.37	0.261	0.299	0.217	0.25	0.24
Chloride	NS	NS	0.05	NS	0.03	0.03	NS	-	0.301	0.398	0.406	0.026	0.272
NH_4-N	NS	NS	NS	NS	NS	NS	NS	NS	-	0.317	0.232	0.232	0.28
NO_2-N	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	0.211	0.151	0.403
NO_3-N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	0.211	0.406
PO_4-P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	0.203
GPP	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-

NS = not significant, lower matrix = Probability values, Upper matrix = Correlation coefficients

The total alkalinity here refers to bicarbonate alkalinity, as carbonate was absent in the lake water. Low alkalinity values were observed during the rainy season and relatively more during the pre- and post-monsoon period. At S-1, the total alkalinity recorded 28 mgl^{-1} at the end of September against a total average of 46.1 mgl^{-1}. Adebisi (1980) showed alkalinity to be inversely related to water level. Lower alkalinity in the rainy seasons was also reported by Dhanapakiam et al. (1999), Shastri and Pendse (2001). The total alkalinity showed a strong negative correlation with pH and DO but a strong positive correlation with chloride (Table-2). The total hardness of the up of the well aerated run of stream coming from the surrounding hills. The free CO_2 content showed no remarkable fluctuation (Table-1). Correlation studies showed highly negative relation between pH and free carbon dioxide [r= (-) 0.66]. Again, the free carbon dioxide recorded a highly significant negative relation with dissolved oxygen [r= (-) 0.618]. Therefore, it may be possible that high dissolved oxygen concentration surface water varied from 5-12 mgl^{-1}, the value fluctuating positively in accordance to the total alkalinity (G = 0.614). According to Kannan (1991), water with a hardness value less than 60 mgl^{-1} is soft. Hence, the lake water can be regarded as soft. Sehgal (1989) and Sugunan (1995) reported low level of total hardness in the pong reservoir.

Chloride concentration varied from 12.2-26.8 mgl^{-1} in the lake water. Chloride concentration indicates the presence of organic waste, primarily of animal origin (Thresh et al.,1949). Munawar (1970) further suggested that higher concentration of chloride in the water is an index of pollution of animal origin and there is a direct relation between chloride concentration and pollution level. Low concentration of chloride ion in the lake water, particularly in the monsoon indicates, there is low amount of organic waste of animal origin during the rainy season. Ground condition in Koyana revealed that the municipality drains carried more of fresh rainwater than sewage effluents into the lake during the monsoon. Sehgal (1989) recorded very low level of chloride in the Pong reservoir. Shastri and Pendse (2001) also reported lower values of chloride during rainy season.

The Ammonium-N values ranged from 0.008-0.070 mgl^{-1} in the lake water. The low NH4-N concentrations may be due to the fact, that aquatic autotrophs rapidly utilize ammonium ions preferring these to nitrates; accordingly, NH_4-N does not reach a harmful concentration. The NH_4-N is negatively correlated to dissolved oxygen (Table-2). Jana and Barat (1984) observed similar relation between DO and NH_4-N. At S-1, the NH_4-N values recorded higher throughout the period of study, indicating sewage contamination & S, ammonical nitrogen owes itself mostly to animal excreta. The Nitrite-N concentrations were found out to be quite low. The maximum concentration of NO_2-N (0.032 mgl^{-1}) was recorded in early May at S-1. The minimum value was recorded at S-3 (0.002 mgl^{-1}) in September. The much lugher mean value of NO_2-N in S-1 (0.018 mgl^{-1}) in comparison to that of S-3 (0.008 mgl^{-1}) points to the higher concentration of effluents in S-1. Higher values of NO_2-N at S-1 may also be due to oxidation of ammonia. Similar observations have been reported by Kapila and Patel (1999). Lower values of the nutrient during the rainy season could be attributed to a dilution effect.

The Nitrate-N is one of the most oxidisable forms of nitrogen and is an essential plant nutrient. Due to its higher mobility, its concentration in fresh water, apart from autochthonous production and utilization by plants, is also regulated by waste loading, agricultural runoff and ground water inputs. Thus, NO_3-N concentration is associated with rainwater runflow sewage and sullage discharge. The NO_3-N ranged from 0.04-0.35 mgl^{-1} in the lake water. Sugunan (1995) reported much lower level of NO_3-N in the Govind Sagar reservoir. The highest concentrations of the nutrient were recorded after the onset of rains, probably by the transport of nutrients from the watershed areas with the runoff water. In S-1, the NO_2N recorded relatively higher throughout the period of study. These points to the sewage contamination via the drains. Alderfer and Lovelace (1977) remarked that inorganic nitrogen above 0.03

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mgl^{-1} stimulates algal growth to such an extent that the water may not be suitable for human consumption. From this aspect, the lake water is not healthy for drinking purpose. Pant et al. (1955) reported on the rising level of nitrogen in lake Nainital due to increasing human influences.

Throughout the investigation period, the Phosphate-P concentration was found out to be low. The maximum value of 0.15 mgl^{-1} was obtained from S-l in July. The minimum value (0.02 mgl^{-1}) was recorded at S-2 in October. Phosphate is considered amongst the primary limiting nutrients in ponds and lakes (Schindler,1971). Low values of phosphate have been reported from various region. Higher values of this nutrient at S-1 compared to the other sites may be due to discharge of domestic sewage into the water. Similar increase in PO_4-P at the point of sewage discharge was reported by Kapila and Patel (1999).

The overall mean of gross Primary productivity in S-3 (62.51 mg cm^{-3}hr^{-1}) was higher than S-1 (46.24 mg cm^{-3}hr^{-1}). The productivity of the Koyana dam seems to be higher. Both gross primary productivity and net primary productivity were found out to be low on cloudy days. Romaire and Boyd (1979) also showed that cloudy days cause a decrease in photosynthetic rates. The net primary productivity was found out to be 46.24 mg C^{-3} hr^{-1}, 55.25 mg C^{-3} hr^{-1} and 62.50 mg C^{-3} hr^{-1} of the gross primary productivity in the S-1, S-2 and S-3, respectively. The gross primary productivity showed a positive correlation with dissolved oxygen (t=0.401) and Nitrate nitrogen (r=0.402). Datta et al. (1984) also established a positive correlation between Nitrate nitrogen and gross production.

An attempt was made to study the prominent groups of phytoplanktons and zooplanktons present in the lake water. Among the phytoplanktons, Chlorophyceae and Cyanophyceae were the prominent groups as Spirogltra, Closterium, Phormidium, Scenedesmus, Stigeoclonium, Ulothrix and Oscillatoria could be identified, which clearly indicate that the lake water is polluted. Cladocerans and Copepods mostly represented the zooplankton community. Cyclops was the most abundant zooplankton. Others among copepods were Phyllodiaptomus. Among the cladocerans, Moina, Daphnia and Bosmino were recorded.

CONCLUSION

In the present investigation, certain pockets of Koyana dam lake (S-1) appeared to be more disturbed by external influences compared to the other zones. S-3 seemed to be least polluted. The contaminants that the lake received were clearly manifested in the results, although the values were diluted due to heavy rainfall in the monsoons. Based on the immunological investigations, and planktons identified, the water does not seem fit for domestic use and cannot serve as a scarcity alternative for drinking water. The results obtained in the present study shall be helpful in the future management of the Koyana dam and proper development of Koyana nagar as a whole.

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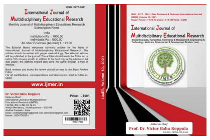
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