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Water quality assessment of Almatti Reservoir of Bijapur (Karnataka State, India) with special reference to zooplankton

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Abstract The present investigation deals with the limnobiotic status of Almatti reservoir from February, 2003 to January, 2005. The study revealed that, the distribution and population density of zooplankton species depend upon the physico-chemical factors of the environment. Statistical analysis showed that there exists a significant relation between the biological and non-biological factors. The benthic fauna constituting the food of fish can be utilized for extensive culture operation so that the nutrients in the reservoir are not only properly cycled but also serve as a check on further eutrophication.

Keywords Physico-chemical factors · Seasonal variations · Zooplankton · Almatti reservoir · Correlation

Introduction

Water is one of the basic needs of the mankind and is vital to all forms of life, which exist in lentic and lotic habitats. All lentic habitats such as reservoirs, ponds, and lakes are extremely important because they are endowed with abundance of natural resource. Reservoirs are important to in pound surface water run off for the requirement of drinking, domestic, agricultural and industrial uses. The consideration of the physico-chemical factors in the study of limnology is basic in understanding the tropic dynamics of that water body. Each factor does play its individual role but at the same time the final effect is really the result of interaction of all the factors. In a broad sense, plankters are considered as an index of fertility and the landings of fish are directly proportional to the quantity of plankton (Chidambaram and Menon 1945). Of these, zooplankters provide the main food item of fishes and can be used as indicators of the tropic phase of a water body (Verma and Munshi 1987). The density and diversity of the zooplanktons are controlled by the several physico-chemical factors of water (Bais and Agarwal 1995).

Zooplankters are the microscopic, free-swimming animalcule components of an aquatic ecosystem, which are primary consumers on phytoplankton. Verma and Munshi (1987) have suggested that zooplankton provide the main food item of fishes and can be used as indicators of the trophic status of a water body. Zooplankton play an integral role in transforming energy to the consumers, hence, they form the next higher trophic level in the energy flow after phytoplankton. Therefore, in view of importance

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in studies related to their distribution, ecological requirement, mode of reproduction, the zooplankton have attracted the attention of several workers throughout the world. The density and diversity of the zooplankton are controlled by the several physico-chemical factors of water (Quasim 1979; Nair et al. 1983). The producers and consumers play an important role in the transformation of energy from one trophic level to the next higher trophic level ultimately leading to the fish production, which is the final product of aquatic environment. Such studies are made by George (1966) and Singh (2000). Studies have been made on the limnobiological status of natural and man-made water bodies in India mainly with an intension to assess the water quality (Sing 2000; Shastri and Pendse 2001).

The Almatti reservoir under study is one of the major perennial resource of the district and is located at about 63 kms away from Bijapur. It lies between 160° 19″ North latitude and 75° 53′ 15″ East longitude. The catchment area of the reservoir is 13,871 miles^2. The main purpose of reservoir is to provide irrigation and power generation. The present study was undertaken to investigate the seasonal dynamics of zooplankton in relation to physico-chemical factors. The results obtained are discussed in light of available literature along with the comments on recorded ecological correlations.

Materials and methods

Surface water samples were collected in clean polythene containers every month between February 2003 and January 2005. The collected samples were brought to the laboratory for the estimation of various physico-chemical parameters as per the procedures given in the standard methods (APHA 1991). Zooplankton the samples were collected monthly using plankton net made up of bolting nylon cloth (Mesh 25 μm) by sieving a known volume of water sample. Zooplankton.

Sample materials were collected from five sampling points and fixed in 4% formalin and preserved in 100-ml polythene bottles. The preserved samples were diluted to 40 ml with distilled water for their taxonomic study and numerical estimation. The organisms were observed under light microscope using "Sedgwick Rafter Cell" as per the procedure given in standard method protoc0ls (APHA 1991). Average of 5 to 10 counts for each sample were taken into account and results are expressed in number of organisms/ litre. All data were statistically analysed (simple correlation coefficient, standard deviation).

Results

Monthly and seasonal variations and the population dynamics of zooplankters for 2 years of investigations are presented in Table 1 and Table 2. Four different groups such as cladocera, copepoda, ostracoda and rotifera represented the zooplankton community. Twenty-one species belong to 16 genera from the surface water of the reservoir, in which five genera belonged to cladocera (six species) four genera to copepoda (four species), one genera to ostracoda (one species) and six genera to rotifera (10 species) contributed to zooplankton richness in the reservoir. The total zooplankton density in Almatti reservoir ranged from 251 org/l to 492 org/l during 2003 and 253 org/l to 571 org/l in 2004.

Cladocera

Six species of cladocerans have been recorded and all were not present in every month. *Alona rectangula* and *Daphnia carinata* species formed the dominant among the cladocera group. It formed 20.6 and 22.04% of the cladoceran group in 2003 and 2004 respectively. In general cladocerans accounted the second dominant group among the zooplankton population and contributed 25.32 and 26.40% in 2003 and 2004 respectively and seasonally the maximum density of cladocerans were found in monsoon and minimum in summer during both the years of study (Table 2).

The physico-chemical parameters and four groups of zooplankters showed a simple correlation coefficient tests (r) and the degree of relationship. During 2004 cladocerans showed positive correlation of 1% level with humidity (r=0.8029) and 5% level correlation with rainfall (r=0.5373). While inverse correlation showed with different parameters such as total alkalinity, bicarbonate, electrical conductivity, total hardness, magnesium and rotifers (Table 4).

Table 1 Monthly variations of zooplankton groups (No/1) in Almatti reservoir from February 2003 to January 2005

Months	Zooplankton				
	Cladocera	Copepoda	Ostarcoda	Rotifera	Total zooplankton
Feb 2003	82	112	06	252	452
March	42	54	04	218	318
April	08	62	–	220	290
May	–	60	–	191	251
June	136	40	–	137	313
July	216	40	–	132	388
Aug	178	48	35	119	380
Sept	195	41	55	144	435
Oct	111	131	64	186	492
Nov	78	89	70	214	451
Dec	68	88	65	240	461
Jan 2004	46	52	52	200	350
Feb	96	118	08	225	447
March	56	74	06	239	375
April	15	64	–	251	330
May	–	60	–	193	253
June	176	34	–	171	381
July	246	30	–	154	430
Aug	206	44	38	136	424
Sept	223	54	62	180	519
Oct	133	141	68	209	551
Nov	96	120	78	254	548
Dec	107	118	54	292	571
Jan 2005	61	81	46	341	529
Total	2,575	1,755	711	4,898	9,939

Copepoda

The copepoda group is represented by *Mesocyclops hyalinus*, *Tropocyclops prasinus*, *Paracyclops fimbriatus*, and *Nauplius larvae*. Copepoda population was recorded throughout the study period and was found abundant in winter season and less during monsoon seasons. The annual cyclic fluctuations in the members of copepoda density during 2 years are presented in Table 3 and Fig. 1. This group constituted 17.83 and 17.50% of the total zooplankton population in 2003 and 2004 respectively. Copepods were present in moderately good numbers throughout the year. The highest number was recorded in February 112 org/l in 2003 and 118 org/l during 2004 thereafter declined gradually upto July then further it was increased till October (Table 1).

Table 2 Seasonal variations in zooplankton groups (No/1) of Almatti reservoir from February 2003 to January 2005

Zooplankton	Seasons					
	Feb. 2003 to Jan. 2004			Feb. 2004 to Jan. 2005		
	Summer	Monsoon	Winter	Summer	Monsoon	Winter
Cladocera	33.00±37.39	181.25±33.93	75.75±27.03	41.75±29.47	212.75±29.47	99.25±29.84
Copepoda	72.00±26.88	42.25±3.86	90.00±32.30	79.00±26.65	40.50±10.75	115.00±24.93
Ostracoda	2.50±3.00	22.50±27.23	62.75±7.63	3.50±4.12	25.00±30.48	61.50±14.27
Rotifera	220.25±24.95	133.00±10.55	210.00±23.03	227.00±25.03	160.25±19.43	274.00±56.08
Total	327.75±87.27	370.00±50.24	438.50±61.52	351.25±81.31	438.50±57.93	549.75±17.19

Table 3 Yearly variations in zooplankton groups (No/1) from February 2003 to January 2005

Twelve	Cladocera	Copepoda	Ostracoda	Rotifera	Total zooplankton
2003–2004					
Total	1,160	817	351	2,253	4,851
Average	96.66	68.08	29.25	187.75	–
Percentage	25.32	17.83	7.66	49.18	100
2004–2005					
Total	1,415	938	360	2,645	5,358
Average	117.91	78.16	30	220.41	–
Percentage	26.40	17.50	6.71	49.36	100

Copepoda group was positively correlated with rotifers (r=0.6079) at 5% level. A negative relationship was noticed with chloride (r=−0.5055) at 5% level in 2003. During 2004 they were strongly correlated with rotifera (r=0.5076) and ostracoda (r=0.5790). But the negative correlationship was noticed with the onset of rainfall and humidity (Table 4).

Ostracoda

Chief component of the ostracoda population was *Cypris* species which include *Cypris subglobasa* and *Stenocypris sps*. Both species contributed only 7.66 and 6.71% of the total zooplankton community (Table 3). This group was also found abundantly in winter season followed by monsoon season during both the years of study period. The monthly distribution and seasonal fluctuations in the members of ostracoda density during 2 years are presented in Tables 1 and 2. The density of the species fluctuated between 4 org/l (March) and 70 org/l (Nov.) in 2003 whereas in 2004 the number ranged from 6 org/l (March) to 78 org/l (Nov.) The species of this group appeared in February and March, but disappeared from April to July and reappeared in August with progressive increase in the density.

Ostracod group was positively correlated with dissolved oxygen (r=0.5710) and nitrate (r=0.6518) at 5% level but it was negatively correlated with many parameters such as air, temperature (r=−0.6861), total alkalinity (r=−0.6077), magnesium (r=0.6703) and chloride (r=−0.5956) at 5% level. But inverse correlation at 1% showed with total hardness (r=−0.7438), sulphate (r=−0.8854), bicarbonate (r=−0.8054), Total dissolved solids (r=−0.7411) and Electrical conductivity (r=−0.7102) in 2003. During 2004, negative correlation was noticed with sulphate (r=−0.5386) and 5% level correlation with copepod group (r=0.5790) (Table 4).

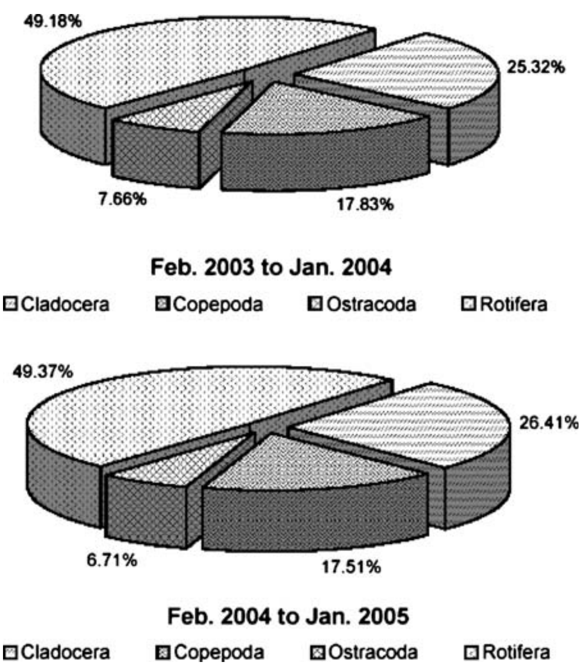

Fig. 1 Percent occurrence of zooplankton in Almatti reservoir

Rotifera

The rotifera was the most dominant group and contributed 49.18 and 49.36% of the total zooplankton population during first and second year respectively (Tables 1 and 2; Fig. 1). The maximum numerical abundance recorded in February was 252 org/l during 2003 and 341 org/l in 2004 (Jan.) Minimum abundance recorded was 119 org/l and 136 org/l in Aug during 2003 and 2004 respectively.

Table 4 Simple correlation coefficient test between zooplankton groups and other parameters of Almatti reservoir from February 2003 to January 2005

Parameters	2003–2004	2004–2005
Cladocera vs rainfall	0.7999[a]	0.5373[b]
Cladocera vs humidity	0.9242[a]	0.8029
Cladocera vs total alkalinity	−0.6215[b]	−0.7634
Cladocera vs phosphate	0.6705[b]	–
Cladocera vs bicarbonate	−0.5106[b]	−0.9050[a]
Cladocera vs total dissolved solids	−0.6294[b]	–
Copepoda vs chloride	−0.5055[b]	–
Ostracoda vs air temp	−0.6861[b]	–
Ostracoda vs dissolved oxygen	0.5710[b]	–
Ostracoda vs total alkalinity	0.6077[b]	–
Ostracoda vs total hardness	−0.7438[a]	–
Ostracoda vs magnesium	−0.6703[b]	–
Ostracoda vs chloride	−0.5956[b]	–
Ostracoda vs nitrate	0.6518[b]	–
Ostracoda vs sulphate	−0.8854[a]	−0.5386[b]
Ostracoda vs bicarbonate	−0.8054	–
Ostracoda vs total dissolved solids	−0.7411	–
Ostracoda vs electrical conductivity	−0.7102[a]	−0.6177[b]
Rotifera vs rainfall	−0.7793[a]	−0.6964[b]
Rotifera vs humidity	0.8219[a]	−0.7140[a]
Rotifera vs total alkalinity	0.6022[b]	–
Rotifera vs calcium	0.5069[b]	–
Rotifera vs Phosphate	−0.5507[b]	–
Cladocera vs electrical conductivity	–	−0.6862[b]
Cladocera vs total hardness	–	0.7518[a]
Cladocera vs magnesium	0.6487[b]	
Copepoda vs rainfall	–	−0.5750[b]
Copepoda vs humidity	–	−0.5368[b]
Rotifera vs water temp	–	0.5489[b]
Ostracoda vs Cyanophyceae	0.8900[a]	0.9610[a]
Cladocera vs Bacillariophyceae	−0.7825[a]	−0.8288[a]
Cladocera vs Dinophyceae	0.9278[a]	−0.9635[a]
Copepoda vs Chlorophyceae	0.5629[b]	0.7388[a]
Rotifera vs Chlorophyceae	0.7597[a]	0.7339[a]
Rotifera vs Bacillariophyceae	0.8975[a]	0.7722[a]
Rotifera vs Desmids	0.6739[b]	0.7588[a]
Rotifera vs Dinophyceae	0.8217[a]	0.6185
Copepoda vs Cyanophyceae	–	0.6759[b]
Copepoda vs Bacillariophyceae	–	0.5657[b]
Copepoda vs Desmids	–	0.5567[b]
Cladocera vs Rotifera	−0.7650[a]	−0.5771[b]
Copepoda vs Rotifera	0.6079[b]	0.5076[b]
Copepoda vs Ostracoda	–	0.5790[b]

[a] Significant at 1%

[b] Significant at 5%

Data on seasonal mean numerical abundance showed the highest incidence of rotifers occurrence was recorded in summer in 2003 whereas in 2004 the population density was fluctuated and the maximum abundance was found in winter (Table 2). The rotifera was represented by 6 genera. The most dominant being *Brachionus*, represented by 4 species viz., *Brachionus diversicornis, B. candatus, B. calyciflorus* and *B. rubens*. The others were *Asplanchana priodonta, Tricocera cylinderica, Lecane ploenensis, Keratella tropica, K. cochlearis* and *Notholca* sps.

Rotifers, the dominant group of zooplankton showed positive correlation at 5% level with total alkalinity (r=0.6022), calcium (r=0.5069) and copepods (r=0.6079), but negative correlation with rainfall (r=−0.7650), humidity (r=−0.8219) and cladocera (r=−0.7650) at 1% level and 5% level inverse correlation noticed with phosphate (r=−0.5507) in 2003, whereas during 2004 it was inversely correlated with the rainfall, humidity, water temperature and cladocerans (Table 4).

Discussion

In aquatic ecosystems zooplankters plays a critical role not only in converting plant food to animal food but also they themselves serve as source of food for higher organisms. zooplankters provide the main food for fishes and can be used as indicators of the trophic status of water bodies (Verma and Munshi 1987). Zooplankton biomass can serve as an index to the fertility of the area and is also an indirect measure of the exploitable fishery of a region. In the temperate lakes and reservoirs the plankton production often takes the form of a bimodal curve with production and autumn peaks (Welch 1952). This fluctuation is mainly influenced by the variation in the temperature along with many other factors. Among the several factors temperature seems to exhibit the greatest influence on the periodicity of zooplankton (Battish and Kumari 1986). According to Silva and Davias (1986) the amount of dissolved solutes play an important role directly or indirectly to control the growth of zooplankton. Both conductivity and TDS values were maximum during summer in Almatti reservoir, which may promote a high zooplankton growth. This is also in agreement with Hujare (2005) on Talsande and Vadagaon reservoirs of Kolhapur district in India. Jackson (1961) has reported that the increase alkalinity of water increases the zooplankton population. Byars (1960) reported that the zooplankters prefer the alkaline nature of water. In the present study some of the zooplankton groups increase with rise in alkalinity of water.

Cladocera

Seasonal fluctuations in cladocerans in different water bodies have been reported (Nayar 1971; Rao et al. 1981; Mathew 1985 and Kaushik and Sharma 1994). Murugan et al. (1998) have reported that cladoceran species like *D. carinata* are preferred as live food for early stages of culture fishes. The high levels of proteins, free amino acid, fat and carbohydrate contents were reported for cladoceran species like *D. carinata*. The cladoceran species like *Daphnia, Moina* constitute important links in limnetic as well as benthic food chains. Most of the cladocerans are filter feeders and consume microscopic algae and particulate organic matter in detritus thereby playing an important role in recycling of matter and energy. Mahajan (1981) has reported that cladoceran species such as *Diaphanosoma, Chydorus* and *Sphaericus* are indicators of eutrophication. However, the other parameters of the present study showed that the reservoir is of a better quality although there is a need in continuous monitoring to maintain the quality of drinking water and at the same time the Government should take necessary steps to beautify the water of the reservoir before reaching eutrophic condition.

Cladocerans were maximum from June to October when rotifer number was minimum indicating an inverse relationship. Similar observations were made by Mathew (1985) in tropical lake. It has been reported that the density and biomass of cladocerans was primarily determined by food supply (Wright 1954; Singh 2000). In the present study, similar observations were made where the cladocerans were abundant when the food supply (phytoplankton) was maximum. During summer months the low density could be due to more dense growth of rotifers thus avoiding competition and negatively correlated with rotifer population. Quadri and Yousuf (1980) found that the temperature is the primary factor affecting the occurrence and distribution of cladocerans. Other factors, which appear to influence the cladoceran distribution, are rainfall, humidity and phosphate. However, the group also showed an inverse relationship with alkalinity electrical conductivity, total hardness, magnesium, bicarbonate and total dissolved solids.

Copepoda

Chauhan (1993) has recorded maximum copepods in summer and minimum during winter. According to Das et al. (1996) copepods favour more stable environment and generally regarded as pollution sensitive taxa as they disappear in polluted waters. On the contrary to this, the change in the number of copepods with seasonal occurrence in different water bodies located in different regions of India has been reported (Patil and Goudar 1985; Mathew 1985; Vijaykumar et al. 1991 and Kaushik and Sharma, 1994).

Irregular occurrence of copepod peaks indicated no distinct correlation with the temperature of water, which is in agreement with the findings of Mathew (1985). Wetanabele (1983) has reported that the copepods are excellent food for zooplanktivorous fish and their nutritional value was also very high. Thus abundant population density of copepods in Almatti reservoir is favourable for pisciculture practices. In the present study copepods showed direct correlation with the rotifer population and with ostracods during the study period, indicating their differential food preference in the reservoir and these groups also showed positive correlation with some algal groups during 2004 whereas copepods showed inverse relationship with rainfall, humidity, water temperature and chloride.

Ostracoda

The reservoir reported poor number of ostracods. The ostracods grow well in hard water (Harshey et al. 1987). This group was represented only by *Cypris* species, which was abundant in post monsoon and in winter months and very few number in summer season indicating their preference towards low temperature of the reservoir. Hujare (2005) has reported on Talsande and Attigre reservoir that ostracods did not show any seasonal trend in their occurrence. Kaushik and Sharma (1994) reported that ostracods occur in greater number when the temperature of the reservoir is 20°C. Hence, our present observation is also in confirmity with their findings. Ostracods showed a direct correlation with DO and nitrate as well as with some plankton groups but was inversely correlated to air temperature, total alkalinity, total hardness, magnesium, chloride, sulphate, bicarbonate, total dissolved solids and electrical conductivity.

Rotifers

During the investigation rotifer group was represented by 10 species. Rotifers such as *Brachionus* species and *Karatella* sps. were the dominant forms of rotifers and was recorded throughout the study period. Dadhich and Saxena (1999) have reported abundant population of *Brachionus* in both eutrophic and mesotrophic lakes. The genus *Keratella* contributed significant fraction of rotifer population in the Almatti reservoir. The *Keratella tropica* was numerically superior to *Keratella cochlearis* The *Keratella* genus is recorded as indicators of pollution by various workers. Goel and Chavan (1991) has reported occurrence of *Keratella* in polluted freshwater tank at Kolhapur. According to Bath and Kaur (1998) the *Keratellaq tropica* is warm stenothermal species and *K. cochlearis* is eurythermal species. However, during the present investigation these two species were found throughout the study but was found maximum in summer. According to Goel and Chavan (1991) the species of *Keratella* and *Brachionus* are the pollution tolerant species and indicate accumulation of organic matter. However, the Almatti resevoir water is not polluted but *Brachious and Keratells sps* rotifers were observed during the study in both the years indicated the presence of organic matter. More work is still required to designate regional indicator species from different parts of India.

On the other hand during the year 2003 maximum number of these rotifers were seen during summer indicating the influence of temperature supported by positive correlation between temperature and rotifer population. This observation is in concurrence with the work of Kaushik and Sharma (1994), Sinha and Sinha (1983) and Singh (2000). Throughout the study period it has been observed that the high temperature, duration of the day, intensity of sunlight during summer and accelerating phytoplankton are some of the limiting factors for the growth and abundance of rotifers. Ahmed and Krishnamurthy (1990), Alireza (1995) and Hujare (2005) support these findings.

Rotifers are considered as ideal indicators of water quality assessment (Berzens and Pejler 1989). It is presumed that rotifers utilize the nutrients and phytoplankton more rapidly to build up their population. This may be the reason for the worldwide distribution of rotifers (Pennak 1978). Rotifers also showed positive correlation with physical parameters like total alkalinity and calcium, and showed inverse relationship with rainfall, humidity, phosphate and cladoceran groups.

Conclusions

Zooplankton community was represented by four groups viz., cladosera, copepoda, ostracoda and rotifera. Cladoserans were found maximum in monsoon and minimum in summer season. The copepods were found maximum in winter and minimum in monsoon season. Ostracods were found maximum number in winter, whereas rotifers were abundantly found in summer season during both the years of the study. The availability of zooplankters are correlated with physical and chemical parameters of the reservoir. Thus the reservoir plays a very important role in maintaining the biodiversity. Further, the present study indicates that the Almatti reservoir water is a suitable source for the supply of water for drinking, irrigation and fish culture.

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