RESEARCH PAPER:

Seasonal variation of plankton diversity in Tungabhadra river of India

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SUMMARY

The basic foods are the plankton-microscopic forms suspended in the water and drifting about at the mercy of the tides and winds. The most fundamental of these food organisms are the microscopic plant forms, phytoplankton, which convert inorganic substances into complex organic compounds through photosynthesis and subsequent processes of food elaboration. Hence, it becomes evident that the phytoplankton, its presence, and seasonal variations are of great importance. Studies on plankton of river Tungabhadra water, Karnataka was made to assess the pollution of water for three seasons from post monsoon 2009 to monsoon 2010. The qualitative and quantitative evaluation of the variation in river water showed high quantity of phytoplankton and zooplankton population throughout the study period and rotifers formed dominated group over other groups of organisms. The present study revealed that the water of river Tungabhadra was highly polluted by direct contamination of sewage and other industrial effluents.

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Planktons are very sensitive to the environment they live in any alteration in the environment which leads to the change in the plankton communities in terms of tolerance, abundance, diversity and dominance in the habitat. Therefore, plankton population observation may be used as a reliable tool for bio monitoring studies to assess the pollution status of aquatic bodies (Mathivanan *et al.,* 2007).

Phytoplankton community comprises of a heterogeneous group of tiny members of plant kingdom adapted to various aquatic environments. Their nature and distribution vary considerably with respect to seasons and water quality. Their dominance also leads to qualitative changes of aquatic system. Information pertaining to the nature, type and distribution of these organisms provide clue regarding the environmental conditions prevailing in their habitat.

Quantity and quality of phytoplankton is a good indicator of water quality. High relative abundance of chlorophyta is indicative of productive water (Muhammad Ali, 2003). Plankton constitutes the basic food source of any aquatic ecosystem, supporting fish and other aquatic animals. Zooplanktons are microscopic animals that eat other planktons. Zooplanktons support the economically important fish population. They are major mode of energy transfer between phytoplankton and fish. The study of zooplanktonic composition, abundance and seasonal variations are helpful in planning and successful fishery management (Kiran *et al.*, 2007).

The abundance and distribution of microorganisms in aquatic ecosystems result from a complex of environmental factors and trophic interactions among a multitude of biotic components. In lakes, as in the marine habitat, important fluxes of carbon nutrients and energy are mediated by the microbial food web (Pomeroy, 1974, Azam *et al.,* 1983), consisting of bacteria, picophytoplankton and protozoa (Nagata 1988; Weisse and Muller, 1990; Berninger *et al.,* 1991).

Study of plankton as an index of water quality with respect to industrial, municipal and domestic pollution has been reported earlier (Acharjee *et al.,* 1995; Jha *et al.*, 1997). Relative importance of different protozoan groups in the plankton varies with the available food resources, and thus with lake and season

(Finlay and Esteban, 1998).

Materials and Methods

Study area:

The Tungabhadra river is formed by the confluence of two rivers, the Tunga river and Bhadra river, which flow down the eastern slope of the Western Ghats in the state of Karnataka. Along with Nethravathi (west flowing river, joining the Arabian Sea near Mangalore), the Tunga and the Bhadra rise at Gangamoola, in Varaha Parvatha in the Western Ghats, at an elevation of 1198 mtrs. More than hundreds of tributaries, streams, creeks, rivulets and the like contribute to each of these two rivers. The journey of Tunga and the Bhadra is 147 km and 171 km, respectively, till they join at Kudli, at an elevation of about 610 metres near Holehonnur, about 15 km from Shimoga; areca granary of the country. From there, Tuungabhadra meanders through the plains to a distance of 531 km and joins with the Krishna at Gondimalla, near the famous Alampur in Mahaboobnagar District of Andhra Pradesh. river Tungabhadra is the largest tributary of the river Krishna, contributing an annual discharge of 14,700 million m^3 at its confluence point to the main river. Tungabhadra Sub basin (TBSB) stretches over an area of 48,827 sq. km in both the riparian states of Karnataka (38,790 sq. km) and Andhra Pradesh (9037 sq. km) and finally joins Krishna that flows into Bay of Bengal.

The TB sub basin is home for 78.78 lakh people out of which, 21.59 lakhs are living in the towns and cities along its banks. The TB river basin is dominated by vast agricultural, industrial and urban settlements. River Tunga, Bhadra and Tungabhadra are the main sources of drinking water supply for these urban local bodies. In addition, ground water is also harnessed to meet the demand. The river stretch from Holehonnur till Downstream of Siruguppa Town was selected for this study (Fig. 1 and Table 1).

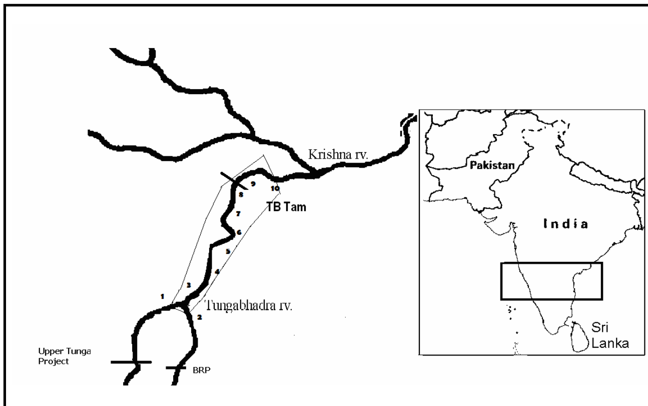

Fig. 1: Map of study area, Tungabhadra river

Methods:

Plankton and water samples were collected in three different seasons from ten sampling sites of the Tungabhadra river. Plankton sample was collected on each occasion with a 55 ìm mesh size standard plankton net. The net was then hauled in and the sample transferred to a 2l well labelled plastic container with screw cap and preserved with 4 per cent unbuffered formalin and stored

Table 1 : Selection of stations and their physico-chemical analysis

Sample No.	Sample locations	Latitude E	Longitude N	Alt (MSL)	Source of contamination
1.	Vaishnavahalli, Tunga river	75°38'40.37"E	13°58'26.46"N	564	Agricultural activities, sand mining
2.	Bhadra River, Hole Honnur	75°40'32.61"E	13°59'43.75"N	566	Domestic sewage
3.	S. Kodamaggi, Tungabhadra River	75°41'39.25"E	14° 2'36.28"N	555	Sand mining, agricultural activities
4.	DS, Honnali	75°38'35.45"E	14°15'58.28"N	541	Domestic sewage
5.	Sarathi	75°49'12.25"E	14°34'30.97"N	528	Industries, bathing, washing clothes, sand mining, agricultural activities
6.	Mylara	75°40'53.28"E	14°47'50.93"N	516	Floating population for temple, bathing, washing clothes, sand mining, agricultural activities
7.	Madalagatti	75°53'20.79"E	15° 6'39.42"N	502	Industries, bathing, washing clothes, sand mining, agricultural activities
8.	TB Dam	76°19'31.02"E	15°16'7.86"N	492	
9.	Shanapur	76°38'49.54"E	15°26'33.96"N	395	Industries, bathing, washing clothes, sand mining, agricultural activities
10.	Honnarahalli	76°56'35.11"E	15°45'33.69"N	366	Industries, bathing, washing clothes, sand mining, agricultural activities

in the laboratory prior to microscopic analysis in the laboratory.

Ten ml of the concentrated sample was investigated for plankton analyses, at different magnifications (50X, 100X and 400X) using Wild II Binocular Microscope with calibrated eye piece and the average recorded. A suitable plankton sample mount was then created. The drop count microscope analysis method was used to estimate the plankton flora and fauna. Since each sample drop from the dropper accounts to 0.1ml, the results on abundance / occurrence were multiplied accordingly to give the values as numbers of organisms per ml which is the standard unit of measurement. Organisms were observed for phytoplankton (cells, filaments, colonies) and zooplankton species (adults and juvenile stages alike). Final data were presented as number of organisms (cells, filaments, colonies and whole organism) per ml. Appropriate texts were used to aid identification of the species encountered (Olaniyan, 1975; Vanlandingham, 1982; Siver, 2003; and APHA, 1998).

Results and Discussion

The results obtained from the present investigation are summarized below:

Plankton population in river:

Plankton is part of aquatic life, which is composed of tiny organisms living and drifting in the direction of water current. It acts as the main source of food for most fauna, both in lotic and lentic water ecosystems. Zooplankton are microscopic animals that feed on plankton. Zooplankton occupy a central position between the autotrophs and other heterotrophs and form an important link in food web of the aquatic ecosystem. Zooplankton constitute the food source of organisms at higher trophic levels. Zooplankton and inturn fish production depend to large degree on the phytoplankton (Boney, 1975). Hence qualitative and quantitative assessments of plankton are of great importance. This investigation envisaged to help to assess the environmental condition of region and also health of river due to industrial activities including sand mining and other domestic activities in the region. The list of species in the river is summarized in Tables 2-5.

Seasonal variation in the species diversity index (H), richness index (s) and dominance index (d) have been calculated and presented in Table 9 for all the ten stations. The diversity index in Tungabhadra river ranged from 0.0 to 0.82 for the different selected stations. When the indices were seasonally examined it could be seen richness index recorded maximum during the monsoon and minimum during summer at all the selected stations. The dominance index for different seasons observed between 0.18 (monsoon) and 1.40 (post monsoon) at station L_4 and station L_{10}, respectively. High diversity index was associated with high evenness index, reflecting the multi dominance pattern in cluster (Balloch *et al.,* 1976). Richness index showed a different trend, which decreased with increasing diversity index.

Table 2 : Plankon presence during postmonsoon

Sr. No.	Species	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}
1.	*Cocconeis placentula*	-	-	-	-	-	-	-	-	-	-
2.	*Fragillaria construens*	+	-	-	-	+	-	-	-	-	-
3.	*Gomphonema gracile*	-	-	+	+	-	-	-	-	+	-
4.	*Merismopedia tenuissima*	+	-	-	-	+	-	-	-	-	-
5.	*Microcystis aeruginosa*	-	-	-	-	-	-	-	-	-	-
6.	*Mouzetia* species	-	-	-	-	-	-	-	-	-	+
7.	*Navicula similis*	-	-	-	-	-	-	-	-	+	-
8.	*Oscillatoria subbrens*	+	-	+	+	+	-	-	-	-	-
9.	*Pediastrum duplex*	-	-	-	-	-	-	-	-	-	-
10.	*Pediastrum simplex*	-	-	-	-	-	-	-	-	-	-
11.	*Brachionus* sp.	-	-	-	-	-	-	-	-	-	-
12.	*Spirogyra crassa*	+	-	+	-	+	-	-	-	-	-
13.	*Spirogyra* species	-	+	-	-	-	-	-	-	-	-
14.	*Stauroneis phoenicenteron*	-	-	-	-	-	-	-	-	-	-
15.	*Surirella robusta*	-	-	+	+	-	-	-	-	-	-
16.	*Surirella splendida*	+	-	-	-	+	-	-	-	-	-
17.	*Synedra ulna*	+	-	+	+	+	-	+	-	+	+
18.	*Ulothrix* species	-	-	-	-	-	+	+	-	-	+

Table 3: Plankon presence during summer

Sr. No.	Species	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}
1.	*Cocconeis placentula*	-	-	-	-	-	-	-	-	-	-
2.	*Fragillaria construens*	-	-	-	+	-	-	-	-	-	-
3.	*Gomphonema gracile*	-	-	-	-	-	-	-	-	-	-
4.	*Merismopedia tenuissima*	-	-	-	-	-	-	-	-	-	-
5.	*Microcystis aeruginosa*	-	-	-	-	-	-	-	-	-	-
6.	*Mouzetia* species	-	-	-	-	-		+	+	+	+
7.	*Navicula similis*	-	-	-	-	-	-	-	-	-	-
8.	*Oscillatoria subbrens*	-	-	-	-	-	-	-	-	-	-
9.	*Pediastrum duplex*	-	-	-	-	-	-	-	-	-	-
10.	*Pediastrum simplex*	-	-	-	-	-	-	-	-	-	-
11.	*Brachionus* sp.	-	-	-	-	-	-	-	-	-	-
12.	*Spirogyra crassa*	-	-	-	-	+	-	-	-	-	-
13.	*Spirogyra* species	-	-	-	-	-	-	-	-	-	-
14.	*Stauroneis phoenicenteron*	-	-	-	-	-	-	-	-	-	-
15.	*Surirella robusta*	-	-	-	-	-	-	-	-	-	-
16.	*Surirella splendida*	-	-	-	-	-	-	-	-	-	-
17.	*Synedra ulna*	+	+	-	-	+	-	-	-	-	-
18.	*Ulothrix* species	-	-	-	-	-	-	-	-	-	-

Table 4 : Plankon presence during monsoon

Sr. No.	Species	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}
1.	*Cocconeis placentula*	-	-	-	-	-	+	-	-	-	-
2.	*Fragillaria construens*	+	-	-	+	+	-	-	-	-	-
3.	*Gomphonema gracile*	-	-	-	+	-	-	-	-	-	-
4.	*Merismopedia tenuissima*	-	-	-	+	-	-	-	-	-	-
5.	*Microcystis aeruginosa*	-	-	-	+	-	-	-	-	-	-
6.	*Mouzetia* species	-	-	-	-	-	-	-	-	-	-
7.	*Navicula similis*	-	-	-	-	-	-	-	-	-	-
8.	*Oscillatoria subbrens*	-	-	-	-	-	-	-	-	-	-
9.	*Pediastrum duplex*	-	-	-	-	+	-	-	-	-	-
10.	*Pediastrum simplex*	-	-	-	-	+	-	-	-	-	-
11.	*Brachionus* sp.	-	+	-	-	-	-	-	+	-	-
12.	*Spirogyra crassa*	-	+	-	-	-	-	-	-	-	-
13.	*Spirogyra* species	-	-	-	+	-	-	-	-	-	-
14.	*Stauroneis phoenicenteron*	-	-	-	-	-	+	-	-	-	-
15.	*Surirella robusta*	-	-	-	+	-	-	-	-	-	-
16.	*Surirella splendida*	-	-	-		-	-	-	-	-	-
17.	*Synedra ulna*	+	-	+	+	+	+		+	-	-
18.	*Ulothrix* species	-	-	-	+	-	+	+	+	-	-

Diversity indices are good indicators of pollution in aquatic ecosystem (Mason, 1998). Diversity index greater than 3 indicates clean water, values in the range of 1 - 3 are characteristics of moderately polluted conditions and values less than 1 characterizing heavily polluted condition (Mason, 1998). Margalef (1968) recorded that higher diversity is a clear indication of longer food chains. The results were showing competition under optimum condition because no adverse environmental factors were noticed in this bionetwork. When stress occurs in a community dominated by a few species, a large number of dominated species is eliminated and evenness increases.

Highest planktonic abundance was recorded in lentic zone due to reduced water current and higher transparency. Green algae were the dominant group in lacustrine zones, while diatoms were encountered more in lotic community. Least plankton abundance and species

Table 5 : Family wise classification of plankton in the study area

Sr. No.	Species	Family	Indicator
1.	*Cocconeis placentula*	Cocconeidaceae	
2.	*Fragillaria construens*	Fragilariaceae	Non polluted habitat
3.	*Gomphonema gracile*	Noctuoidea	
4.	*Merismopedia tenuissima*	Merismopediaceae	Polluted habitat
5.	*Microcystis aeruginosa*	Microcystaceae	Polluted habitat
6.	*Mouzetia* species	Sterculiaceae	Non polluted habitat
7.	*Navicula similis*	Biraphideae, sub class- Naviculoideae	
8.	*Oscillatoria subbrens*	Oscillatoriaceae	
9.	*Pediastrum duplex*	Hydrodictyaceae	Non polluted habitat
10.	*Pediastrum simplex*	Hydrodictyaceae	Mostly polluted habitat
11.	*Brachionus* sp.	Hydrochnidae	Mostly polluted habitat
12.	*Spirogyra crassa*	Zygnemataceae	Polluted habitat
13.	*Spirogyra* species	Zygnemataceae	
14.	*Stauroneis phoenicenteron*	Stauroneidaceae	
15.	*Surirella robusta*	Surirellaceae	
16.	*Surirella splendida*	Surirellaceae	
17.	*Synedra ulna*	Fragilariaceae	Polluted habitat
18.	*Ulothrix* species	Zygnemataceae	Non polluted habitat

Table 6 : Diversity index of plankton in TB river

Sample station	Shanon-weiner index			Simpson index			Hmax		
	Post monsoon	Summer	Monsoon	Post monsoon	Summer	Monsoon	Post monsoon	Summer	Monsoon
L1	0.77	0.00	0.30	1.13	1.00	0.50	4.15	3.45	4.05
L2	0.00	0.00	0.28	1.00	1.00	0.56	3.75	3.45	3.53
L3	0.65	0.00	0.00	1.24	0	1.00	4.15	0	3.92
L4	0.60	0.00	0.82	1.21	1.00	0.18	3.92	3.45	4.21
L5	0.77	0.26	0.49	1.13	0.59	0.38	4.15	3.89	4.23
L6	0.00	0.00	0.42	1.00	0	0.50	3.05	0	4.09
L7	0.30	0.00	0.00	1.25	1.00	1.00	3.35	3.53	4.05
L8	0.00	0.00	0.30	0	1.00	0.62	0	3.53	4.16
L9	0.44	0.00	0.00	1.28	1.00	0	3.53	3.53	0
L10	0.41	0.00	0.00	1.40	1.00	0	3.45	3.53	0

Table 7 : Areas affected with salinity, alkalinity and water logging in the TBSB

District/Taluk	Area affected (Area in hectares)			
	Salinity	Alkalinity	Water logging	Total
Koppal	6,916.51	1,028.88	4014.59	11,959.98
Raichur	25,931.57	4,546.76	23,838.88	54,317.21
Bellary	19,170.51	2,770.2	7,997.39	29,938.1
Total	52,018.59	8,345.84	35,850.86	96,215.29
Bhadra Command Area	3,826	1,643	29,219	

Source: Tungabhadra Command Area Development Authority and Bhadra Command Area Development Authority

diversity were recorded downstream (Ayoade, 2009). These changes are attributable to the construction of dam that brought about significant changes in the abiotic and biotic factors.

Studies on plankton of river Cauvery water, Mettur, Salem District, Tamil Nadu was made to assess the pollution of water from January 2003 to December 2003. The qualitative and quantitative evaluation of the variation in river water showed high quantity of phytoplankton and zooplankton population throughout the study period and rotifers formed dominated group over other groups of organisms. The present study revealed that the water of river Cauvery was highly polluted by direct contamination of sewage and other industrial effluents (Mathivanan *et al.*, 2007).

In Lake Neumuhler (Mathes and Arndt, 1995), ciliates dominated the biomass in late spring, summer and autumn, the smaller flagellates were important in late summer and in winter, whereas the larger flagellates dominated in early spring. The seasonal and vertical abundances of ciliates and flagellates are described over a two year period in Lake Kinneret, Israel. Ciliate numbers ranged from 3 to 47 cells per ml (Hadas and Berman, 1998).

In the present study in the Tungabhadra river, plankton species were showing maximum diversity and species richness during the pre monsoon and the post monsoon when conditions were relatively stable. Results obtained also indicated low diversity and low species richness during the monsoon period which may be due to environmental stress as per Hawkes (1979) opinion that low diversity is reflection of environmental stresses. According to Whittaker (1965), the value of dominance index is always higher where the community is dominated by a fewer number of species and when the dominance is shared by a large number of species. This is agreed with the present study. Higher value of dominance index in the Tungabhadra river was registered during the monsoon periods. The present investigation also indicates that, whenever dominance index of zooplankton species was higher, the evenness index was lower and *vice versa* (Walting *et al.,* 1979).

Zooplankton community analysis and saprobiological characteristics of the Tungabhadra river using diversity index was carried out during December 2004 to November 2005 by Suresh *et al.* (2009), to enrich knowledge on bioindicators in understanding the point and non point sources of pollution and also its stress on the aquatic life. They reported lower diversity values in the Tungabhadra river. In the present study also the same results were found.

In the present investigation, the phytoplankton fluctuates seasonally and its productivity was high during monsoon and low during summer. The phytoplankton comprised of the major portion in the river. The basic process of phytoplankton production was dependent upon temperature, turbidity and nutrients. In the present study, the low productivity of phytoplankton might be due to the grazing effect by zooplankton and fishes.

The zooplankton population also fluctuated seasonally, and the productivity was high during monsoon and low during summer. The predominance of rotifers and copepodes over the other groups of zooplankton were observed in the present study. Thus, the influence of nutrients of water on the zooplankton population has been reduced in downstream sampling stations. In the present investigation, this observation clearly revealed that zooplankton represents a sensitive indicator of pollution compared to that of phytoplankton.

Sources of pollution:

Pollution from agriculture:

Runoff from agricultural fields has resulted in water logging and salinization in the basin affecting the irrigated areas and water quality. Total area affected by salinity, alkalinity and water logging in the Tungabhadra command area was 52000, 8345 and 35850 ha respectively. These problems were prevalent mainly in the downstream of the basin – in Koppal, Raichur and Bellary districts (Table 7). Raichur district ranked first in salinity problem with the total area being affected as 26,000 ha and the worst affected taluks being Manvi and Sindhanur. Bellary district has been affected with an area of 19,170 ha and Siraguppa and Bellary were the worst affected taluks. Similar to salinity, alkalinity and water logging are also high in Raichur and Bellary districts followed by Koppal. Total area affected by alkalinity was 4,546 ha and 2,770 ha, respectively in Raichur and Bellary districts and the area affected by water logging was 23,838 and 7,997 ha, respectively.

Application of chemicals and pesticides in the agriculture area, especially on paddy crop, was another source of water pollution. There were no systematic studies about these non-point pollution sources. There was in year 2006 incident of spraying of pesticides intensively for the paddy crops that affected the water in the river, which also caused lot of foul smell and people were cautioned not to drink the water for some time. Sand mining from the riverbed using mechanized boats though they were not permitted was also causing degradation of the river and is affecting the water quality.

Industrial pollution:

Observation in the field revealed that the inflow of effluents from major industries have affected the nearby villages in the basin (Table 8). For instance, Harihara Polyfibres had affected around 45 surrounding villages. Discussions revealed that washer-men and fishermen who spent long hours in the river had experienced skin diseases and other ailments. Free skin disease detection and

Table 8: Major impacts of industrial pollution

Impacts	Location affected
Health impacts	65 Villages in the mid reach of the basin (downstream of HPF)
	35 Villages and one town in the upstream of the river (downstream of VISL and MPM)
Fish kills	In the mid-reach of the river (Downstream of HPF)

treatment camps held at villages located at a distance of 20 km from HPF effluent discharge point revealed that around 13 fishermen were suffering from skin diseases 'superficial folliculitis', which is an inflammation of the hair follicles.

In the upper reach of the basin, the villages located in the surroundings of VISL and MPM were also facing pollution problems. Around 11 villages located in the stretch between Bhadravathi town and Kudli which was the confluence point of river Tunga and Bhadra, were affected (Table 5). The river Bhadra was highly polluted at Holehonnur town as the effluents from MPM and VSIL joins the river. The residents of Holehonnur town are supplied with poor quality drinking water and there were protests by the public for safe drinking water.

On the contrary, the water quality monitoring results of pollution control boards have indicated that the industries are meeting the discharge standards. But the discussion with the people living in the surrounding of these industries highlight the discharge of effluents without treatment. There were lot of agitations between the industries and local people to stop the effluents discharge. As a result of this, Tungabhadra Environment Monitoring Committee was formed to curb and monitor the pollution from Harihar Polyfibres.

Dynamite operation:

Stretches of the river face threat by some groups of people who illegally blast dynamite. The purpose was to catch fish at one go (20-30 kgs). Dynamite blast kills all the fish, particularly the small ones and the eggs. The blast occurs 2-3 times in a week in 10 locations across the river. Only partial fish can be collected in the process, remaining fish decomposes giving bad stench and pollute the river and ecosystems. Although there have been many conflicts with these groups and also complaints to the concerned department, problem remains.

Urban waste water:

Majority (around 20 out of 27) of the ULBs did not have underground drainage system and treatment facilities to collect and treat the municipal sewage. In rest of ULBs, though UGD is present, it is partial. Eleven towns across the basin discharge waste water into the river. Rest discharge waste water into agricultural fields, open tanks or low lying areas. Details on wastewater disposal by some of the ULBs are given in Table 9.

Table 9 : Prevalence of UGD and treatment plants

Towns	UGD system	Treatment plant	Waste water disposal
Partial	7 towns	1	7 into the river
Not available	20 towns	21	20 into agricultural fields/valleys

Mining and pollution:

Two major iron mining areas, *i.e.,* Kudremukh and Hospet, exist in the river basin. Mining industries are affecting the water. There were no proper mining standards for iron ore extraction, which was open cast mining. Earlier mining was restricted to mine heads, but now it is done at the foothill level also. Apart from the impact on water quality due to the silt from mines, there was also the issue of air pollution (due to the transportation of ore in open trucks and truck movement). Agriculture in the region was also affected because of mining related dust pollution as the dust gets deposited on crops.

Conclusion:

In general, in all the stations, richness of zooplankton were comparatively low in pre-monsoon and post-monsoon periods (Table 6). During these periods, the phytoplankton abundance also was low due to rain. The rain water causes strong currents which wash away the phytoplankton (Ramanujan, 1994). The depletion of phytoplankton naturally affects the population of zooplankton. Whenever the dominance index was higher, the evenness index was lower and *vice versa,* the present study confirms the earlier findings (Watling *et al.,* 1979).

It is concluded from this study that the plankton population of Tungabhadra river is highly influenced by the discharge from different industrial effluents. The shift in the planktonic community structure and dominance of pollution tolerant forms at discharge zone indicated deterioration of water quality in this stretch of the river. The zooplankton population dynamics might have been influenced by sand mining and other human activities in some selected stations of Tungabhadra river. Zooplankton depletion will adversely affect normal food web pattern of the river water and intern this leads destruction of environmental conditions of the river. So, the conservation and maintenance of the river is very essential for future generations.

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