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ASSESSMENT OF PLANKTONIC DIVERSITY IN RIVER CHENAB AS AFFECTED BY SEWAGE OF MULTAN CITY

MUHAMMAD ISMAIL CHUGHTAI[1,2], KHALID MAHMOOD[1] AND ABDUL RASUL AWAN[1]

[1]*Nuclear Institute for Agriculture and Biology, P.O. Box 128, Faisalabad, Pakistan*
[2]*Institute of Pure and Applied Biology, Bahauddin Zakariya University, Multan, Pakistan*

Abstract

A study was carried out to investigate the monthly variations in planktonic life of river Chenab as affected by sewage of Multan City by analyzing frequency of occurrence, relative abundance and diversity index of plankton life. Density and diversity of plankton was used as a measure of water quality. Phytoplankton were abundant as compared to Zooplankton. Of the 86 Phytoplankton genera recorded, 13 were of Cyanophyta, 34 of Chlorophyta, 28 of Chrysophyta, 3 of Cryptophyta, 5 of Euglenophyta and 3 genera of Pyrrhophyta. Eighteen genera of Zooplankton were observed including 12 of Protozoan, 5 of Rotifers and one genus of Cladoceran. Total number of organisms was 1835, out of which 1733 were Phytoplankton and 102 were Zooplankton. Diversity index of Phytoplankton ranged from 3.34 to 6.79 and diversity index of Zooplankton ranged from 0.51 to 2.58. It may be concluded that the quality of Chenab water is marginally fit as the diversity index of Zooplankton was less than three throughout the study period.

Introduction

Pakistan's natural resources are increasingly under stress due to rapid population growth and environmentally unsustainable practices. Renewable freshwater resources are fast depleting pushing Pakistan into the category of water stressed countries (Anon., 2008). Less than half the urban sewage is drained off through sewers and covered drains, and only a small fraction of that is treated before being disposed off into water bodies (Anon., 2007).

Water quality includes all physical, chemical and biological characteristics of water (Boyd, 1981). Biological characteristics are related to density and diversity of organisms. Diversity is an important indicator of human interference with a natural ecosystem which often leads to reduce diversity. Few numbers of species are found in polluted water then clear water (Barnabe, 1990). Measurement of diversity in a given area over a period of time can be a fair measurement of the effects of pollution (Salam & Rizvi, 1999).

The quantity and quality of Phytoplankton is a good indicator of water quality. The high relative abundance of Chlorophyta indicates productive water (Boyd & Tucker, 1998). Zooplankton form an intermediate step in grazing food chain in aquatic bio-loop and an ecosystem (Rao, 1993). Today, many rivers of the world receive millions of liters of sewage, domestic waste, industrial and agricultural effluents (Boyd & Tucker, 1998).

The river Chenab originates from Jammu and Kashmir. After receiving several tributaries, it enters in Punjab near district Sialkot. In the Punjab, this river flows through Gujrat, Sargodha and Gujranwala districts. It receives river Jhelum at Trimmu in district Jhang and river Ravi at Sidhnai in district Khanewal. It then flows through districts of Multan and Muzaffargarh and joins river Sutluj in district Muzaffargarh (Salam & Siddique, 1997).

The river Chenab is important as it contains 33 fish species which have been identified (Ali *et al.,* 2005). The quality of Chenab water is deteriorating gradually by constantly pouring of wastes in river. The sewage of Multan City is being disposed off in river Chenab at Qasim Bela near Multan Cantt. So, it is essential to monitor the water quality continuously to determine the state of pollution in our rivers. Further this information can be communicated with general public and Government to develop policies for the conservation of freshwater resources. Keeping in view the importance of freshwater, the present study was conducted to investigate the monthly variations in biological parameters of Chenab water mixed with sewage of Multan City.

Materials and Methods

The present study was carried out on mixed water (sewage + Chenab water) at Qasim Bela (*longitude* 71° 25' 5" E and *latitude* 30° 12' 10" N), which is about 5 km away from Multan Cantt. The sewage of Multan City is being disposed off in river Chenab at Qasim Bela. The study site was suitable for limnological studies because the sewage of Multan city is properly mixed here, the depth and flow of water was maximum and water was available round the year. The samples were collected in 1.5 L plastic bottles on monthly basis for 10 months. The bottles were properly labeled.

The water samples for plankton study were preserved by using 4% formalin solution (Battish, 1992) and examined under a microscope using 10X ocular and 10X and 40X objectives. The identification of Phytoplankton and Zooplankton were done up to generic level with the help of following literature (Ward & Whipple, 1959; Anon., 1978; Tonapi, 1980 and Battish, 1992).

Frequency of occurrence (%) and relative abundance (%) of each genus of Phytoplankton and Zooplankton was calculated for each month. Diversity index of plankton was calculated by using the following formula as described by Boyd (1981):

$$\text{Diversity Index } (\acute{H}) = \frac{S-1}{\text{In } N}$$

where:
S = The number of genera of Phyto- or Zooplankton
N = The total number of Phyto- or Zooplankton
In = Natural logarithm

Results and Discussion

The water quality of rivers and lakes should be maintained as they are most important gift of nature. The industrialization has caused significant changes in river water chemistry. They are being used by mankind over the period of centuries and few of them are now in natural conditions (Mason, 1998). Primary productivity is related to nutrient concentration, light and temperature. Light and temperature are exogenous factors which are called as driving variables while nutrient concentration is linked dynamically with growth (Rath, 1993).

Results indicated the occurrence of 105 genera in which 86 genera were of Phytoplankton and 18 genera of Zooplankton. Phytoplankton belong to Cyanophyta (13 genera), Chlorophyta (34 genera), Chrysophyta (28 genera), Cryptophyta (3 genera), Euglenophyta (5 genera) and Pyrrhophyta (3 genera) while Zooplankton including Protozoan (12 genera), Rotifers (5 genera) and Cladoceran (1 genus). The monthly distribution of Phytoplankton and Zooplankton is given in Tables 2 & 3.

Frequency of occurrence: Among the Phytoplankton, the members of Chlorophyta, Chrysophyta and Euglenophyta were present throughout the study period. The members of Cyanophyta and Cryptophyta were present in all months except November and July and October respectively. Minimum frequency of occurrence was found in Pyrrhophyta as they were present only in six months (Table 2). Among the Zooplankton, Protozoan was present in all months. Rotifers were present in six months except March, June, September and December while Cladoceran were present only in August as shown in Table 3.

Relative abundance: Phytoplankton were most abundant as compared to Zooplankton during the whole study period. Total number of organisms was 1835, out of which 1733 were Phytoplankton with relative abundance of 94.4% and 102 were Zooplankton with relative abundance of 5.6%. Chlorophyta and Chrysophyta were most abundant phyla as compared to others (Table 1).

Table 1. Monthly relative abundance (R.A) of Phyto and Zooplankton in Chenab water affected with sewage.

Parameters	Months									
	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
No. of Phytoplankton	126	73	171	129	83	196	281	398	120	161
No. of Zooplankton	05	15	08	9	10	20	7	21	07	01
Total No. of Organisms	131	88	179	138	93	216	288	419	127	162
R.A. (%) of Phytoplankton	96.2	82.9	95.5	93.5	89.3	90.7	97.6	95.0	94.5	99.3
R.A. (%) of Zooplankton	3.8	17.1	4.5	6.5	10.7	9.3	2.4	5.0	5.5	0.7

In March, among Phytoplankton, Chrysophyta was most abundant followed by Chlorophyta, Euglenophyta, Cyanophyta and Cryptophyta. Among genera, *Nitzschia* (Chrysophyta) was most abundant with relative abundance of 16.8%. Among Zooplankton, only Protozoa was present in which *Paramecium* was most abundant genus with relative abundance of 3.19%.

In April, among Phytoplankton, Chrysophyta was most abundant followed by Chlorophyta, Euglenophyta, Pyrrhophyta, Cryptophyta and Cyanophyta. Among genera, *Mallomonas* (Chrysophyta) was most abundant with relative abundance of 10.3%. Among Zooplankton, Protozoa was most abundant followed by Rotifers. Among genera, *Ascomorpha* (Rotifer) was most abundant with relative abundance of 4.55%.

In May, among Phytoplankton, Chrysophyta was most abundant followed by Chlorophyta, Cyanophyta, Cryptophyta and Euglenophyta. Among genera, *Closterium* (Chlorophyta) was most abundant with relative abundance of 19.6%. Among Zooplankton, Protozoa was most abundant followed by Rotifers. Among genera, *Hemiophrys* (Protozoa) was most abundant with relative abundance of 2.79%.

In June, among Phytoplankton, Chrysophyta was most abundant followed by Chlorophyta, Euglenophyta, Cyanophyta, Cryptophyta and Pyrrhophyta. Among genera, *Navicula* (Chrysophyta) was most abundant with relative abundance of 13.8%. Among Zooplankton, only Protozoa was present in which *Amoeba* and *Hemiophrys* were most abundant genera with relative abundance of 2.9%.

In July, among Phytoplankton, Chrysophyta was most abundant followed by Chlorophyta, Cyanophyta, Euglenophyta and Pyrrhophyta. Among genera, *Melosira* (Chrysophyta) was most abundant with relative abundance of 27.9%. Among Zooplankton, Protozoa was most abundant followed by Rotifers. Among genera, *Paramecium* (Protozoa) was most abundant with relative abundance of 4.3%.

In August, among Phytoplankton, Chrysophyta was most abundant followed by Chlorophyta, Euglenophyta, Cyanophyta, Cryptophyta and Pyrrhophyta. Among genera, *Chlorella* (Chlorophyta) was most abundant with relative abundance of 22.2%. Among Zooplankton, Rotifers was most abundant followed by Protozoa and Cladocera. Among genera, *Colurella* (Rotifer) was most abundant with relative abundance of 5.56%.

In September, among Phytoplankton, Chlorophyta was most abundant followed by Chrysophyta, Cyanophyta, Euglenophyta, Cryptophyta and Pyrrhophyta. Among genera, *Navicula* (Chrysophyta) was most abundant with relative abundance of 24.3%. Among Zooplankton, only Protozoa was present in which *Paramecium* was most abundant genus with relative abundance of 2.43%.

In October, among Phytoplankton, Chlorophyta was most abundant followed by Chrysophyta, Cyanophyta, Euglenophyta and Pyrrhophyta. Among genera, *Nitzschia* (Chrysophyta) was most abundant with relative abundance of 17.4%. Among Zooplankton, Protozoa was most abundant followed by Rotifers. Among genera, *Hemiophrys* (Protozoa) was most abundant with relative abundance of 4.06%.

In November, among Phytoplankton, Chlorophyta was most abundant followed by Chrysophyta, Cryptophyta and Euglenophyta. Among genera, *Closterium* (Chlorophyta) was most abundant with relative abundance of 48.1%. Among Zooplankton, Protozoa was most abundant followed by Rotifers. Among genera, *Cyphoderia* and *Tintinnopsis* were most abundant genera with relative abundance of 1.57%.

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Table 2. Relative abundance (%) of Phytoplankton in mixed water (Chenab water + sewage of Multan City).

Phytoplankton	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Phytoplankton	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cyanophyta	**2.29**	**1.14**	**4.47**	**3.61**	**7.53**	**1.39**	**2.43**	**2.15**	-	**1.23**	*Lauterbomiella*	-	-	-	-	-	-	-	-	0.79	-
Oscillatoria	0.76	-	-	-	-	-	-	-	-	-	*Microspora*	-	-	-	-	-	-	-	-	-	1.85
Anabaenopsis	-	1.14	-	-	-	-	-	-	-	-	*Tetraedron*	-	-	-	-	-	-	-	-	-	0.62
Lyngbya	1.53	-	1.68	-	-	0.93	-	-	-	-	**Chrysophyta**	**54.9**	**39.3**	**53.1**	**43.5**	**48.3**	**45.4**	**40.9**	**28.1**	**22.1**	**11.0**
Coelosphaerium	-	-	2.23	-	-	-	-	-	-	-	*Tabellaria*	-	9.09	2.23	2.17	-	0.93	1.05	-	-	3.08
Gloeocapsa	-	-	-	0.72	-	-	-	-	-	-	*Cocconeis*	-	2.27	0.56	0.72	-	0.46	0.35	-	-	-
Dactylococcopsis	-	-	-	0.72	-	-	-	0.72	-	-	*Melosira*	2.29	3.41	1.68	4.35	27.9	2.78	-	0.48	3.15	0.62
Anabaena	-	-	-	-	2.15	-	-	-	-	-	*Navicula*	11.4	-	5.59	13.8	-	18.1	24.3	6.68	-	-
Aphanizomenon	-	-	-	-	1.08	-	-	-	-	-	*Cyclotella*	2.29	-	8.38	7.97	13.9	8.80	-	-	11.0	3.08
Microcystis	-	-	-	2.17	4.30	-	2.43	0.24	-	0.62	*Mallomonas*	0.76	10.3	3.98	2.90	-	-	2.78	-	-	-
Gloeotrichia	-	-	0.56	-	-	-	-	-	-	-	*Stephanodiscus*	3.05	4.55	12.3	10.9	-	9.72	7.29	1.19	2.36	1.23
Merismopedia	-	-	-	-	-	0.46	-	-	-	-	*Fragilaria*	1.53	-	1.12	0.72	-	0.93	-	0.48	0.79	-
Pharmedium	-	-	-	-	-	-	-	1.19	-	-	*Synedra*	0.76	-	-	-	-	1.85	-	-	-	-
Raphidiopsis	-	-	-	-	-	-	-	-	-	0.62	*Nitzschia*	16.8	-	17.3	-	-	-	4.86	17.4	3.15	1.23
Chlorophyta	**25.9**	**29.6**	**31.2**	**37.7**	**24.8**	**37.9**	**51.5**	**63.9**	**64.4**	**77.1**	*Cymbella*	-	-	-	-	-	-	-	0.48	-	-
Oocystis	2.29	3.41	2.23	3.62	-	7.87	0.69	0.72	1.57	4.94	*Meridion*	3.82	-	-	-	-	-	-	-	-	-
Gonatozygon	1.53	7.95	1.58	-	-	-	1.74	-	-	3.70	*Surirella*	6.87	-	-	-	4.30	-	-	-	-	-
Closterium	7.63	-	19.6	7.25	-	2.78	17.4	14.6	48.0	54.9	*Gomphonema*	1.53	4.55	-	-	-	-	-	-	-	-
Chlorella	4.50	4.55	-	7.25	-	22.2	10.8	12.6	-	4.32	*Gyrosigma*	0.76	-	-	-	-	-	-	-	-	-
Netrium	-	1.14	0.56	-	-	-	-	0.72	0.79	-	*Pinnularia*	1.53	-	-	-	-	0.93	-	1.19	-	-
Cosmarium	-	-	1.12	1.45	-	-	0.35	-	0.79	-	*Epithemia*	0.76	-	-	-	-	-	-	-	0.79	-
Treubaria	-	-	1.12	-	-	0.46	-	-	2.36	-	*Stauroneis*	0.76	-	-	-	-	-	-	0.24	-	-
Asterococcus	2.29	-	2.79	2.17	-	-	3.12	7.88	2.36	1.85	*Coscinodiscus*	-	2.27	-	-	-	-	-	-	-	-
Chodatella	-	-	-	-	1.08	-	-	-	0.79	-	*Diploneis*	-	1.14	-	-	-	-	-	-	-	-
Tetrastrum	-	-	-	-	-	1.39	-	-	-	0.62	*Cymatopleura*	-	1.14	-	-	-	-	-	-	-	-
Staurastrum	-	-	-	0.72	-	-	1.39	-	-	1.23	*Dinobryon*	-	0.56	-	-	-	-	-	-	-	0.62
Coelastrum	-	-	-	5.09	4.30	-	2.08	8.59	-	-	*Uroglenopsis*	-	-	-	0.72	-	-	-	-	0.79	-
Closteriopsis	0.76	-	-	-	-	-	-	-	-	-	*Centritractus*	-	-	-	0.72	-	0.93	-	-	-	-
Oedogonium	2.29	-	-	2.90	-	-	-	-	2.36	-	*Tribonema*	-	-	-	-	1.08	-	-	-	-	0.62
Rhizoclonium	3.05	-	-	-	-	-	-	-	-	-	*Prymnesium*	-	-	-	-	1.08	-	-	-	-	-
Spirotaenia	1.53	-	-	-	4.30	-	-	-	-	1.23	*Ophiocytium*	-	-	-	-	-	-	0.35	-	-	-
Chlamydomonas	-	6.82	-	-	7.53	-	-	-	-	-	*Eunotia*	-	-	-	-	-	-	-	-	-	0.62
Chlorogonium	-	2.27	-	0.72	5.38	-	-	-	-	-	**Englenophyta**	**12.2**	**5.68**	**2.79**	**5.07**	**6.45**	**5.09**	**1.38**	**0.72**	**3.14**	**6.17**
Sphaerocystis	-	1.14	-	-	1.08	-	10.8	-	-	-	*Euglena*	9.92	3.41	2.23	2.90	5.38	2.31	-	0.72	1.57	1.85
Coelastrus	-	1.14	-	-	-	-	-	-	-	-	*Euglenopsis*	1.53	2.27	-	1.45	1.08	1.85	-	-	1.57	3.08
Scenedesmus	-	1.14	2.23	1.45	1.18	-	1.74	10.7	3.94	0.62	*Phacus*	-	-	-	0.72	-	-	0.69	-	-	1.23
Platymonas	-	-	-	0.72	-	-	-	-	-	-	*Lepocinclis*	0.76	-	-	-	-	0.93	0.69	-	-	-
Actidesmium	-	-	-	0.72	-	-	-	-	-	-	*Trachelomonas*	-	-	0.56	-	-	-	-	-	-	-
Echinosphaerella	-	-	-	0.72	-	1.85	-	-	-	-	**Pyrrhophyta**	-	**4.50**	-	**0.72**	**1.08**	**0.46**	**0.35**	-	-	**2.47**
Tetmemorus	-	-	-	0.72	-	-	-	-	0.79	-	*Peridinium*	-	4.50	-	-	-	-	0.35	-	-	2.47
Tetrastrus	-	-	-	1.45	-	-	-	-	-	-	*Chilomonas*	-	-	-	-	1.08	-	-	-	-	-
Planktosphaeria	-	-	-	0.72	-	0.93	1.05	-	-	1.23	*Glenodinium*	-	-	-	0.72	-	0.46	-	-	-	-
Pediastrum	-	-	-	-	1.08	-	-	7.88	-	-	**Cryptophyta**	**0.76**	**3.41**	**3.35**	**1.45**	-	**0.46**	**1.04**	-	**4.72**	**1.23**
Quadrigula	-	-	-	-	-	0.46	-	-	-	-	*Cryptomonas*	-	2.27	1.12	-	-	-	0.35	-	1.57	1.23
Tetradesmus	-	-	-	-	-	-	0.35	-	-	-	*Protochrysis*	-	-	-	-	-	-	-	-	0.79	-
Crucigenia	-	-	-	-	-	-	-	0.24	-	-	*Nephroselmis*	0.76	1.14	2.23	1.45	-	0.46	0.69	-	2.36	-

Table 3. Relative abundance (%) of Zooplankton in river Chenab water.

Zooplankton	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Protozoan	**3.95**	**8.41**	**4.78**	**7.59**	**9.68**	**1.84**	**2.43**	**4.65**	**4.72**	**0.70**
Holophrya	0.76	-	-	-	2.15	-	-	-	-	-
Didinium	-	1.14	-	-	-	-	-	-	-	-
Euglypha	-	2.79	-	-	1.08	-	-	-	-	-
Tintinnopsis	-	2.27	0.56	-	-	-	-	-	1.57	-
Hemiophrys	-	-	2.79	2.90	-	-	-	4.17	-	-
Amoeba	-	-	-	2.90	-	1.38	-	-	-	-
Centropyxis	-	-	1.43	0.72	-	-	-	-	0.79	-
Pseudodifflugia	-	-	-	-	2.15	0.46	-	-	-	-
Paramecium	3.19	1.14	-	-	4.30	-	2.43	0.24	-	-
Arcella	-	-	-	-	-	-	-	0.24	-	0.70
Difflugia	-	1.14	-	1.07	-	-	-	-	0.79	-
Cyphoderia	-	-	-	-	-	-	-	-	1.57	-
Rotifers	**-**	**7.95**	**1.73**	**-**	**1.08**	**6.02**	**-**	**0.48**	**0.92**	**-**
Asplanchna	-	2.27	-	-	-	-	-	-	-	-
Ascomorpha	-	4.55	-	-	-	-	-	-	-	-
Epiphanes	-	1.14	1.73	-	-	-	-	-	-	-
Colurella	-	-	-	-	1.08	5.56	-	0.48	-	-
Dicranophorus	-	-	-	-	-	0.46	-	-	0.92	-
Cladocerans	**-**	**-**	**-**	**-**	**-**	**1.43**	**-**	**-**	**-**	**-**
Daphnia	-	-	-	-	-	1.43	-	-	-	-

In December, among Phytoplankton, Chlorophyta was most abundant followed by Chrysophyta, Euglenophyta, Pyrrhophyta, Cyanophyta and Cryptophyta. Among genera, *Clasterium* (Chlorophyta) was most abundant with relative abundance of 54.9%. Among Zooplankton, only Protozoa was present in which *Arcella* was most abundant genus with relative abundance of 0.62%.

Phytoplankton were most abundant as compared to Zooplankton in the present study. Among Phytoplankton, Chrysophyta was the most abundant phylum, maximum in March and minimum in December. Chrysophyta gradually decreased showing direct relation with seasonal changes. Chrysophyta showed a negative relation with Chlorophyta. Cyanophyta was maximum in July and then decreased showing inverse relation with Chlorophyta (Shephered & Bromage, 1992).

Over abundance of Phytoplankton causes an imbalance in dissolved oxygen that may cause daily net deficit in dissolved oxygen availability. Some blue green algae are poor oxygentors because much of the oxygen produced by Phytoplankton in surface scum is lost to the atmosphere rather than dissolved in the water (Boyd, 1998).

Among Zooplankton, Protozoa was most abundant phylum. Beside the Protozoan, Rotifers and Cladocerans were also observed.

Diversity indices: Diversity index of Phytoplankton ranged from 3.34 to 6.79. It was maximum in June and minimum in October. It shows increasing trend in March, then decreasing from April to May, again increasing in June then decreasing from July to October and then increasing in November and December. Diversity index of Zooplankton ranged from 0.51 to 2.58. It shows increasing trend in April, then decreasing from May to June, again increasing in July then decreasing from August to September and then increasing in October (Table 4).

Diversity indices are good indicator of pollution in aquatic ecosystem. In the present study, diversity index Phytoplankton ranged from 3.34 to 6.79 and Zooplankton ranged from 0.51 to 2.58. Diversity index value greater than 3 indicates clean water. Values in the range of 1 to 3 are characteristics of moderately polluted conditions and values less than 1 characterize heavily polluted condition (Mason, 1998). Salam & Rizvi (1999) have carried out the biological parameters of Chenab River at Muzaffargarh and concluded that water is clear with no sewage problem having diversity index of Phytoplankton ranged from 6.36 to 9.79 and Zooplankton ranged from 1.44 to 4.44.

Table 4. Diversity indices of Zooplankton in Chenab water affected with sewage.

Months	Phytoplankton				Zooplankton			
	S	N	In N	Diversity index	S	N	In N	Diversity index
March	30	126	4.84	5.99	2	05	1.61	0.62
April	24	73	4.29	5.36	8	15	2.71	2.58
May	25	171	5.14	4.67	3	08	2.08	0.96
June	34	129	4.86	6.79	3	09	2.20	0.91
July	19	83	4.42	4.07	5	10	2.30	1.74
August	25	196	5.25	4.57	5	20	3.00	1.33
September	25	281	5.64	4.26	2	07	1.95	0.51
October	21	398	5.99	3.34	4	21	3.04	0.99
November	23	120	4.79	4.59	5	07	1.95	2.05
December	27	161	5.08	5.12	2	02	0.69	1.45

S= Number of genera, N= Total number of individuals, In = Natural logarithm

Conclusion

Based on diversity index, it may be concluded that the quality of Chenab water is marginally fit as the diversity index of Phytoplankton was more than three while of Zooplankton it was less than three throughout the study period. The main source of pollution is sewage water that should be properly treated before disposal to save the freshwater resources. The addition of sewage causes oxygen deficiency which ultimately affects the Zooplankton life. So, it is essential to monitor the water quality continuously to determine the level of pollution in order to save the aquatic life.

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