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SEASONAL VARIATION OF PLANKTON IN THE BRACKISH WATER-FED CANAL AND THEIR ROLE IN FISH PRODUCTION

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ABSTRACT
The present study deals with the identification of planktonic organisms, diversity and their seasonal abundance in the entire length of the brackish water-fed canal. The canal carries huge amount of brackish water during the tidal inflow which can sustain the life of various aquatic forms including seeds of different fishes because of its good water quality and favourable environmental conditions. The sampling process has been done in every 15 days interval based on the tidal fluctuation. The recorded average plankton density was 0.59 ml 45 L^{-1} in 1st part of the canal and then 1.20 ml 45 L^{-1} in the middle part of the canal and 0.87ml 45 L^{-1} in last part which carries mostly in marine water . The dominated species includes; *Coscinodiscus sp* (Diatom), *Pandorina sp* (Chlorophyta), *Ulothrix sp* (Chlorophyta), *Spirogyra sp* (Chlorophyta), *Stigeoclonium sp* (Chlorophyta), *Closterium sp* (Chlorophyta), *Pleurosigma sp* (Diatom), *Ankistrodesmus sp* (Chlorophyta), *Uronema sp* (Chlorophyta), *Euglena sp*(Euglenozoa), *Guinardia sp* (Bacillariophyta), *Mysis sp*(Crustacea), *Moina sp* (Cladocerans), *Paramecium sp*,(Ciliophora) *Cyclops sp* (Copepods), *Daphnia sp* (Cladocerans), *Brachionus sp* (Rotifers), *Keratella sp* (Rotifers), *Platyias sp* (Rotifers), *Lecane sp* (Rotifers), etc. Moreover, Phytoplankton has been found more in terms of their density and diversity as compared to the zooplankton. The wild seed of *Penaeus monodon*, are also found in large quantity at the time of high tide. Therefore, fish production is moderately higher due to the abundance of various types of natural foods. The approximate fish production of this canal is about; shell fish: 160-165 kg/ha/year & fin fish: 250-270 kg/ha/year. If the canal is scientifically monitored i.e., restricted from illegal harvesting through public awareness, then the production can be achieved at a considerable range and it will meet the demand of protein, lipid and other essential minerals for growth and development of livelihood of local peoples & uplift the socioeconomic status of local fish farmers.

KEYWORDS: Water quality, plankton diversity and density, water productivity, fish production

INTRODUCTION
Brackish water Aquaculture has been identified by the Government of India as one of the high potential area for increasing fish and shell fish production and also to achieve maximum economic and social benefits. Brackish water aquaculture has rapidly transformed from a traditional activity practiced largely in the states of West Bengal and Kerala, to the status of a commercial enterprise in the country and this has largely been due to the scientific and technological interventions. India is the third largest producer of fish, second in inland fish production and fourth in farmed shrimp production. The sector provides livelihood to 11million people and contributes to over 1% to the GDP of the country. With the 1.2 million ha brackish water resources, besides 2.54 million ha of sodic soils and 8 million ha of inland saline soils, there is vast opportunity for the development of brackish water fish farming. With an annual average growth rate of 10%, it has already made a bench mark in the development area of the country. Brackish water Resources of India -Estuaries, Coast Line, Backwater, Mangroves, lagoons etc. India has a vast potential in the fisheries sector both in inland, brackish water and marine sector. India has potential fish production about 8.4 MT, present fish production is 6.4 MT, in which inland sector contributes 3.4 MT & marine sector contributes 3.0 MT. Phytoplankton in different sizes plays a vital role in productivity of an ecosystem. It has been reported that in many countries the failure of fishery was attributed to the reduced zooplankton especially copepod population (Stottrup, 2000). Mandal *et al*. (2010) opine that, production efficiency of phytoplankton in sewage fed fish pond is higher as compared to other fresh water pond. The whole experimental work has been carried out in the Negua Diversion Canal which situated in the district of Purba Medinipur, West Bengal. This district having diverse water body of brackish water resources including pond and canal. Thus it has great potentiality of the fin fish & shell fish species because of its presence of diversified plankton. This canal is started from the Kudi (Block- Egra) runs through different villages and finally meets in to the Bay of Bengal (Digha Mohana) & in its way it collects huge agricultural run-off and shows characteristic water quality which supports the growth of planktonic organisms. These organisms promote the development of numerous aquatic species of finfish and shell fishes.

MATERIALS & METHODS
The experimental work has been carried out in the Negua Diversion Canal which situated in the district of Purba Medinipur 22°57'10"N. 21°36'35"N. (Latitude) 88°12'40"E 86°33'50"E (Longitude); West Bengal (figure-1).

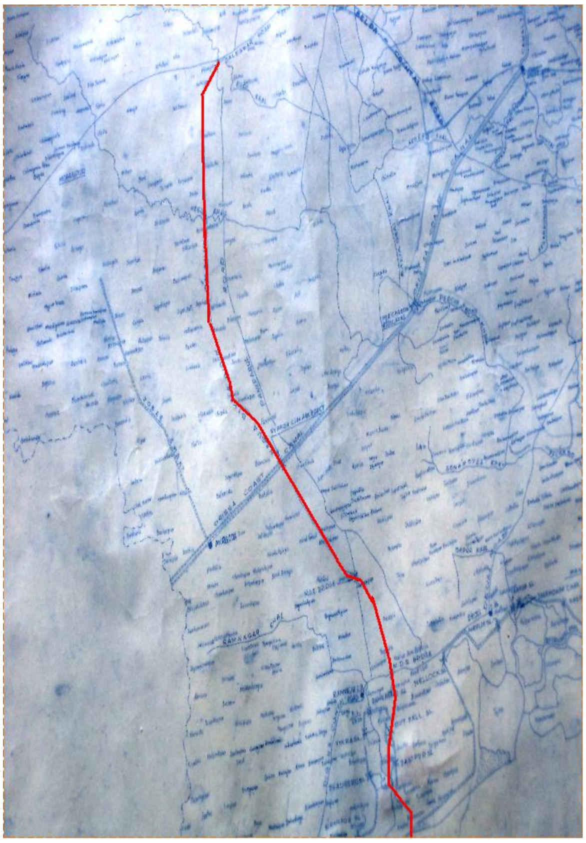

FIGURE1- Red/Bold line denote the Negua Diversion Canal

This Purba Medinipur district is rich in natural resources especially brackish water resource which supports the life of different flora and fauna. The Negua Diversion Canal is the part of Dubda basin project and it was started in the year 1972. On its way the canal shows characteristics freshwater from the origin *i.e.* Kudi up to Siphon, Paniparul, and then brackish water after siphon *i.e.* the middle part of canal and followed by last part i.e., in Mohana or the end of the canal which carries characteristics marine water. The total length of the canal is about 30.3 KM and width varies from 110-140 M depending upon the seasonal changes & tidal fluctuation of water from the Bay of Bengal.

The experimental work has been designed through the following steps:

- Demographic survey of the experimental area.
- Identification of plankton and their densities and diversity in every 15 days interval.
- Available fishes are recorded in every month.
- Estimate total fish production.

Plankton were collected by plankton net (80 Bolt silk cloth) from the different places of Negua Diversion Canal by random sampling method in every 15 days interval. The sample water has been collected just below the surface layer and the total volume was passed through the plankton net (45 liters for each case). Then the collected plankton were observed under compound microscope and phytoplankton and zooplankton were counted on a Sedgwick-Rafter cell at 45x and 100x magnification and identified as methods developed by Taylor (1976), Anand et al. (1986) and Santhanam *et al*. (1987), Davis (1955), Kasturirangan (1963), Newell and Newell (1986), Deboyd Smith (1977), Wimpenny (1966), Todd and Laverack (1991) and Perumal *et al*. (1998). Fish production is also regularly monitored through physical verification and the local market survey. Statistical calculation has been done with the help of available statistical software like SPSS.

RESULTS

The experimental results were categorized in to three parts based on the concentration of salts in water. The first part contain mostly of freshwater, middle part carries brackish water and marine water in the last part. The identified plankton & their density has been recorded in every 15 days interval and tabulated in the table-1 and table -2 respectively.

TABLE -1: Variation of plankton abundance in every 15 days interval

Date and Time of sample collection	Beginning of the canal(Freshwater)	Middle course of canal(Brackishwater)	In the confluence with the sea (Marine water)
1st to15th January, 2011	*Spirogyra sp*	Filamentous algae	*Ulothrix* sp
(7.00 am - 7.30 am)	*Stigeoclonium sp*	*Mysis sp*	*Pandorina sp*
	Pandorina sp	Leech	*Diaptom sp*
	Lacane sp	Aquatic insect	Insect larvae
	Uronema sp	*Cyclops sp*	Nematode worms
	Cyclops sp	Megalopa larva	Filamentous algae
	Brachionus sp	*Nauplius sp*	Leech
	Keratella sp		
16th to 31st January, 2011	*Stigeoclonium sp*	Filamentous algae	Filamentous algae
(7.00 am - 7.30 am)	*Spirogyra sp*	*Spirogyra sp*	*Ulothrix* sp
	Uronema sp	Water mite	Insect embryo
	Pandorina sp	*Mysis sp*	*Cyclops sp*
	Lacane sp	Leech	Megalopa larva
	Cyclops sp	Aquatic insect	*Diaptom sp*
	Brachionus sp	*Cyclops sp*	Insect larvae
	Keratella sp	Megalopa larva	Nematode worms
	Aquatic insect	Beetle	
		Nauplius sp	
1st to15th February, 2011	*Stigeoclonium sp*	Filamentous algae	Filamentous algae
(6.30 am - 7.00 am)	*Closterium sp*	*Spirogyra sp*	*Ulothrix* sp

	Spirogyra sp	*Mysis sp*	Insect embryo
	Uronema sp	Leech	*Diaptom sp*
	Cyclops sp	Aquatic insect	Insect larvae
	Brachionus sp	*Cyclops sp*	Nematode worms
	Keratella sp	Megalopa larva	*Cyclops sp*
	Lacane sp	*Nauplius sp*	Megalopa larva
16^{th} to 29^{th} February, 2011	*Stigeoclonium sp*	Filamentous algae	*Ulothrix* sp
(6.30 am - 7.00 am)	*Spirogyra sp*	*Spirogyra sp*	Filamentous algae
	Ankistrodesmus sp	*Paramecium sp*	*Diaptom sp*
	Guinardia sp	*Mysis sp*	Insect larvae
	Coscinodiscus sp	Leech	Nematode worms
	Closterium sp	Aquatic insect	Insect embryo
	Cyclops sp	*Cyclops sp*	*Cyclops sp*
	Brachionus sp	Megalopa larva	Megalopa larva
	Keratella sp	*Nauplius sp*	*Paramecium sp*
	Lacane sp		
1^{st} to15^{th} March, 2011	*Stigeoclonium sp*	Filamentous algae	Filamentous algae
(6.00 am - 6.30 am)	*Spirogyra sp*	*Spirogyra sp*	*Ulothrix* sp
	Ankistrodesmus sp	*Paramecium sp*	*Diaptom sp*
	Coscinodiscus sp	*Mysis sp*	Insect larvae
	Guinardia sp	Leech	Nematode worms
	Closterium sp	Aquatic insect	Insect embryo
	Cyclops sp	*Cyclops sp*	*Cyclops sp*
	Brachionus sp	Megalopa larva	Megalopa larva
	Keratella sp	*Nauplius sp*	*Paramecium sp*
	Daphnia sp		
16^{th} to 31^{st} March, 2011	*Stigeoclonium sp*	*Spirogyra sp*	Filamentous algae
(6.00 am - 6.30 am)	*Spirogyra sp*	Filamentous algae	*Ulothrix* sp
	Closterium sp	*Paramecium sp*	*Diaptom sp*
	Ankistrodesmus sp	*Mysis sp*	Insect larvae
	Coscinodiscus sp	Aquatic insect	Nematode worms
	Guinardia sp	*Cyclops sp*	Insect embryo
	Cyclops sp	Megalopa larva	*Cyclops sp*
	Brachionus sp	*Nauplius sp*	Megalopa larva
	Keratella sp		
	Lacane sp		
1^{st} to15^{th} April, 2011	*Stigeoclonium sp*	Filamentous algae	Filamentous algae
(5.30 am - 6.00 am)	*Spirogyra sp*	*Spirogyra sp*	*Ulothrix* sp
	Closterium sp	*Paramecium sp*	*Diaptom sp*
	Ankistrodesmus sp	*Mysis sp*	Insect larvae
	Coscinodiscus sp	Aquatic insect	Nematode worms
	Cyclops sp	*Cyclops sp*	Insect embryo
	Brachionus sp	Megalopa larva	*Cyclops sp*
	Keratella sp	*Nauplius sp*	Megalopa larva
	Daphnia sp		
16^{th} to 30^{th} April, 2011	*Spirogyra sp*	*Spirogyra sp*	Filamentous algae
(5.30 am - 6.00 am)	*Closterium sp*	*Mysis sp*	*Diaptom sp*
	Pandorina sp	Aquatic insect	Insect larvae
	Stigeoclonium sp	*Cyclops sp*	Nematode worms
	Uronema sp	Megalopa larva	Insect embryo
	Cyclops sp	*Nauplius sp*	*Cyclops sp*
	Brachionus sp		Megalopa larva
	Keratella sp		
	Lacane sp		
1^{st} to15^{th} May, 2011	*Stigeoclonium sp*	Filamentous algae	*Ulothrix* sp
(5.30 am - 6.00 am)	*Ankistrodesmus sp*	*Spirogyra sp*	Filamentous algae
	Coscinodiscus sp	*Paramecium sp*	*Diaptom sp*
	Spirogyra sp	*Mysis sp*	Insect larvae
	Closterium sp	Aquatic insect	Nematode worms
	Pandorina sp	*Cyclops sp*	Insect embryo
	Brachionus sp	Megalopa larva	*Cyclops sp*
	Keratella sp	*Nauplius sp*	Megalopa larva
	Lacane sp		
	Cyclops sp		
	Daphnia sp		
16^{th} to 31^{st} May, 2011	*Spirogyra sp*	*Spirogyra sp*	Filamentous algae
(5.30 am - 6.00 am)	*Closterium sp*	Filamentous algae	*Ulothrix* sp
	Pandorina sp	*Paramecium sp*	*Diaptom sp*
	Uronema sp	*Mysis sp*	Insect larvae

	Stigeoclonium sp *Brachionus sp* *Keratella sp* *Lacane sp* *Cyclops sp*	Aquatic insect *Cyclops sp* Megalopa larva *Nauplius sp*	Insect embryo *Cyclops sp*
1st to15th June, , 2011 (5.00 am - 5.30 am)	*Stigeoclonium sp* *Spirogyra sp* *Coscinodiscus sp* *Ankistrodesmus sp* *Closterium sp* *Cyclops sp* *Brachionus sp* *Keratella sp* *Daphnia sp*	Filamentous algae *Spirogyra sp* *Pandorina sp* *Mysis sp* Aquatic insect *Cyclops sp* Megalopa larva *Nauplius sp*	Filamentous algae *Ulothrix* sp *Diaptom sp* Insect larvae Insect embryo *Cyclops sp* Megalopa larva *Paramecium sp*
16th to 30th June, 2011 (5.00 am - 5.30 am)	*Ankistrodesmus sp* *Closterium sp* *Stigeoclonium sp* *Spirogyra sp* *Uronema sp* *Cyclops sp* *Brachionus sp* *Keratella sp* *Lacane sp* *Daphnia sp*	Filamentous algae *Spirogyra sp* *Pandorina sp* Insect larvae Aquatic insect *Cyclops sp* Megalopa larva *Nauplius sp*	Filamentous algae *Ulothrix* sp *Diaptom sp* Insect larvae Insect embryo *Cyclops sp* Megalopa larva *Paramecium sp*

TABLE 2: Density of plankton in every 15 days interval (ml $45L^{-1}$)

Date and Time	1st part of the canal (Freshwater)	Middle part of the canal (Brackish-water)	Last part of the canal (Marine-water)
1st to15th January, 2011 (7.00 am - 7.30 am)	0.48 ± 0.15	0.95 ± 0.21	0.81 ± 0.41
16th to 31st January, 2011 (7.00 am - 7.30 am)	0.57 ± 0.17	1.11 ± 0.35	0.91 ± 0.52
1st to15th February, 2011 (6.30 am - 7.00 am)	0.66 ± 0.29	1.15 ± 0.43	0.99 ± 0.24
16th to 29th February, 2011 (6.30 am - 7.00 am)	0.54 ± 0.11	1.27 ± 0.77	0.88 ± 0.28
1st to15th March, 2011 (6.00 am - 6.30 am)	0.69 ± 0.49	1.43 ± 0.71	1.03 ± 0.52
16th to 31st March, 2011 (6.00 am - 6.30 am)	0.63 ± 0.33	1.53 ± 0.21	0.98 ± 0.41
1st to15th April, 2011 (5.30 am - 6.00 am)	0.57 ± 0.18	1.35 ± 0.53	0.87 ± 0.23
16th to 30th April, 2011 (5.30 am - 6.00 am)	0.55 ± 0.14	1.25 ± 0.44	0.78 ± 0.26
1st to15th May, 2011 (5.30 am - 6.00 am)	0.58 ± 0.22	1.18 ± 0.26	0.86 ± 0.40
16th to 31st May, 2011 (5.30 am - 6.00 am)	0.67± 0.19	1.12 ± 0.21	0.86 ± 0.23
1st to15th June, 2011 (5.00 am - 5.30 am)	0.62 ± 0.14	1.09 ± 0.55	0.81 ± 0.29
16th to 30th June, 2011 (5.00 am - 5.30 am)	0.56 ± 0.16	1.03 ± 0.20	0.75 ± 0.43

[Each data is mean of 5 separate determinations ± Standard Error of Mean]

The experimental results were counted from the month of January to June, 2011. Variation of plankton in the entire length of the canal is presented in table -1 and it indicate that brackish water shows greater abundance of both types plankton as compared to the marine water and freshwater. The important dominated Genus includes: *Cyclops, Daphnia, Mysis, Brachionus, Keratella, Stigeoclonium, Spirogyra, Closterium, Uronema, Ankistrodesmus, and Ulothrix etc.* Plankton density has been recorded in every 15 days interval and tabulated in the table-2. The density deviation has also represented in figure-2. It showed that, in winter months plankton density was very low in the first part of the canal which mostly carries fresh water (0.48 ml $45L^{-1}$) followed by last part (0.81 ml $45L^{-1}$) but higher in the middle part of the canal (0.95 ml $45L^{-1}$) which carries brackish-water. This density gradually increases through changes of environmental temperature. The maximum density was observed during the 1st week of March, 2011 in the middle part of the canal (1.53 ml $45L^{-1}$) & it represented in figure-2. In an average plankton density was comparatively higher in brackish water (Middle part) followed by marine water (Last part) and then fresh water (1st part) due to the nutritional enrichment from agricultural run-off. Because of this, fish production was higher in middle part of the canal as compared to other two parts. The dominated fish species includes: *Penaeus* *monodon, Fenneropenaeus indicus, Metapenaeus dobsoni,Metapenaeus monoceros,Mugil cephalus, Eleotris pisonis, Mystus sp, Stolothrissa tanganicae, Lates calcarifer, Synaptura panoides, Hemibagrus gracilis, Periophthalmus modestus.*

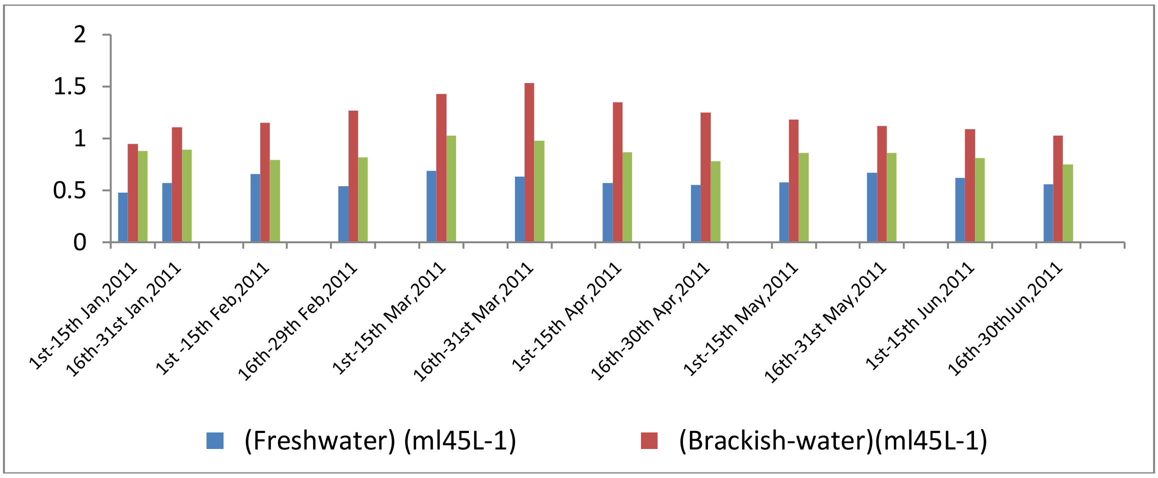

FIGURE-2: Density variation of plankton from January, 2011 to June, 2011

Therefore, besides plankton, the canal is a good resource of wild seed of *P.monodon*, which is of commercial importance. As plankton have enriched then different fish species are available throughout the canal, these includes: *Ilophis brunneus*, *Gobiosoma hilebrandi*, *Scatophagus argus*, *Sillago sihama*, *Trapon jarbua* , *Eubleekeria splendens Glossogobius giuris* ,*Gobiomorus dormitor*, *Mugil cephalus*, *Eleotris pisonis*, *Mystus sp*, *Stolothrissa tanganicae*, *Lates calcarifer*, *Synaptura panoides*, *Hemibagrus gracilis*, *Periophthalmus modestus*, *Alosa pseudoharengus* ,*Pomadasys hasta*, *etc*. In addition to that, some of the economically important shell fish species are also found in the canal like- *Penaeus monodon*, *Fenneropenaeus indicus*, *Metapenaeus dobsoni*, *Metapenaeus monoceros*, *Scylla serrata*, *Portunus pelagicus*, *Carcinoscorpius sp*, *Squilla mantis etc*. In general fish are harvested by the local fish farmers using locally available gears for livelihood.

DISCUSSION

The plankton density and diversity is depended on the physico-chemical properties of water and productivity of the canal. Phytoplankton initiates the food chain, by serving as food to primary consumers like zooplankton, shellfish and finfish (Sridhar et al., 2006; Mathivanan et al., 2007; Tas and Gonulol, 2007; Saravanakumar et al., 2008). The pelagic algal communities make important contributions to the smooth functioning of estuarine ecosystem (Kawabata et al., 1993). Phytoplankton species distribution shows wide spatio-temporal variations due to the differential effect of hydrographical factors on individual species and they serve as good indicators of water quality including pollution (Gouda and Panigrahy, 1996). The salinity acts as a limiting factor in the distribution of living organisms and its variation caused by dilution and evaporation is most likely to influence the fauna in the coastal ecosystem (Balasubramanian and Kannan, 2005; Sridhar et al., 2006). Plankton plays an important role in fish production in the pits of ' khadan'of china clay mines (Mandal et.al.,2008) The phytoplankton counts were high during southwest monsoon season as reported in some of the previous studies in Bay of Bengal (Marichamy et al., 1985). Similar observations were earlier reported by Patterson Edward and Ayyakkannu (1991); Gouda and Panigrahy (1996) and Rajasegar et al. (2000). Ei-Gindy and Dorghan in 1992 stated that phytoplankton and their growth depend on several environmental factors, which are variable in different seasons and regions. From this investigation it showed that, plankton density and diversity is higher in the middle part of the canal which carries mostly in brackish-water because of high nutritional value. Plankton density is moderately higher in marine water (last part of the canal) as compared to freshwater. Plankton density directly influenced the fish production. It is estimated that, the approximate fish production of this canal is about; shell fish: 160-165 kg/ha/year & fin fish: 250-270 kg/ha/year. Therefore, local people can obtain fish round the year in the local market at very cheapest cost and also uplift the socioeconomic status of local fish farmers. So as to ensure fish production throughout the year, local peoples should be aware about the breeding season of different fishes and they must keep away from harvesting through organizing different training program.

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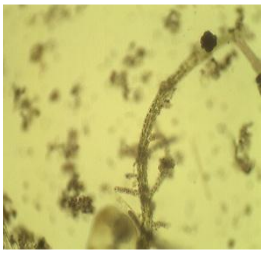
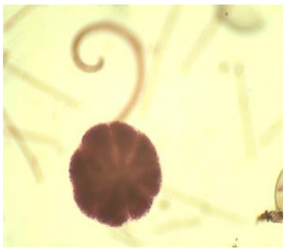
The following are the identified phytoplankton and zooplankton:

Phytoplankton


Stigeoclonium sp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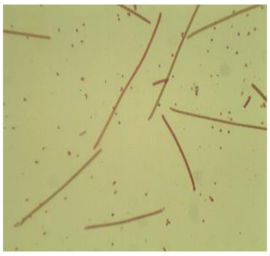
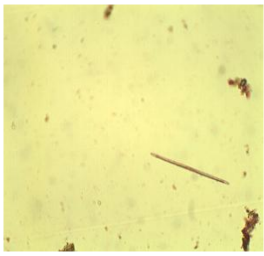
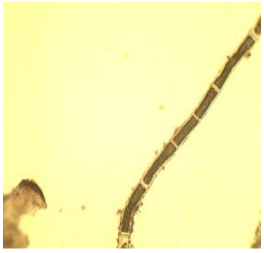
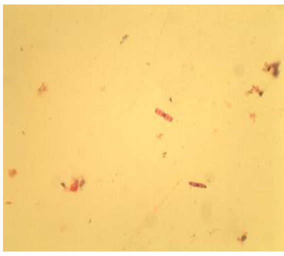
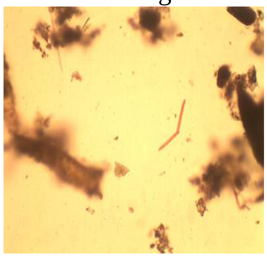

Ulothrix sp


Filamentous algae


Spirogyra sp


Thread algae

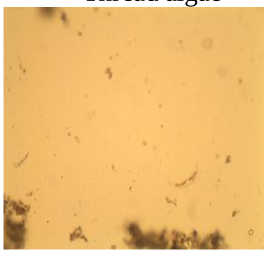

Coscinodiscus sp

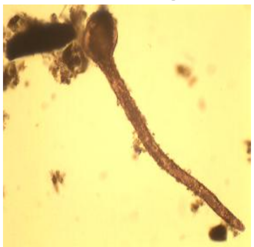

Thread algae

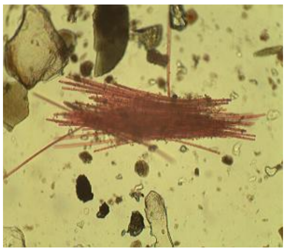

Thread algae

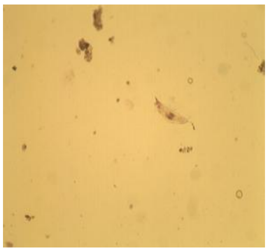

Closterium sp

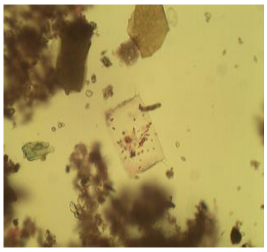

Pleurosigma sp


Ankistrodesmus sp


Uronema sp

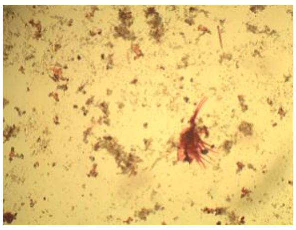

Filamentous algae


Euglena sp


Guinardia sp

Zooplankton:

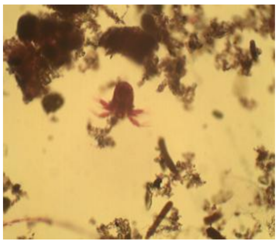

Megalopa Larva

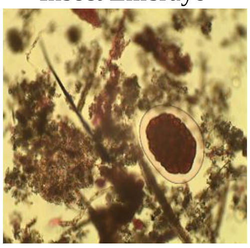

Zoea Larva


Insect Embrayo

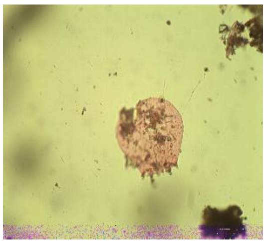

Diaptom sp


Leech

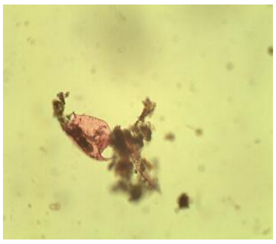

Mite


Insect Egg

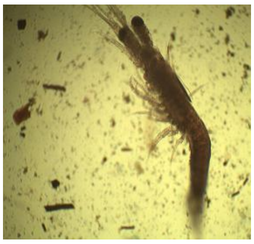

Brachionus sp



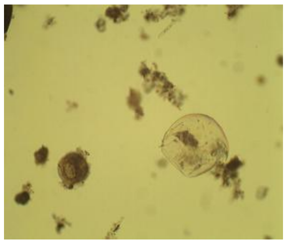
Brachionus sp



Keratella Sp

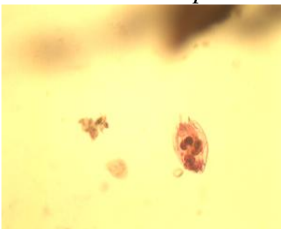


Mysis sp



Moina sp

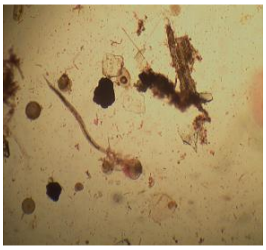
Developmental stage of Mollusca



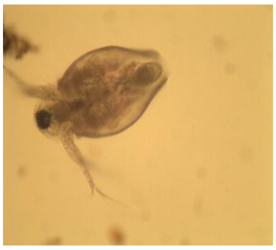
Brachionus sp

Cyclops sp

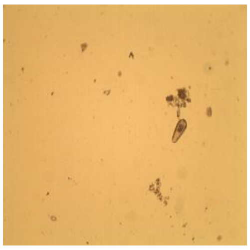
Larvae of prawn



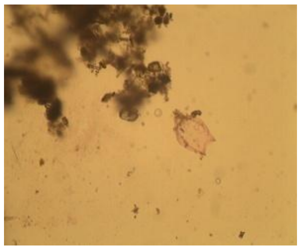
Nematode worm



Daphnia sp



Paramecium sp



Keratella sp

The above picture was captured through MOTIC B SERIES with MOTIC IMAGES PLUS 2.0.