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RESEARCH ARTICLE

Zooplankton diversity influenced by hydro biological parameters in some ponds of south eastern part of Bankura town of WB, India

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Abstract

The Bankura district of West Bengal is with full of static water bodies like pond, reservoir, water tank etc. Most of these water bodies are being used by the local residents for their daily purposes. The unaware use of water causes some changes in physico-chemical parameters of some ponds of Bankura town. This project work reveals the fact that, how these changes in parameter influences the Zooplankton diversity. Among Zooplankton mainly the Rotifers play an important role (as bio-indicator) to know the water quality of studied perennial water bodies.

INTRODUCTION

Life without water is impossible because it contains life in every possible form. Water is consumed in greatest quantity throughout the world for drinking, bathing, washing, irrigation and also for aquaculture purpose. Rivers, ponds, lakes and underground stores are the major sources of water. Functional parameters of an ecosystem attributes to the ecological significance and resulting from the interactions between its physical, chemical and biological components. These interactions result in the creation of a variety of niches which are inhabited by various organisms thus providing a habitat for plants, animals and micro organisms in an ecosystem and thus determine the tropic dynamics of the aquatic body.

The study of fresh water fauna specially Zooplankton even in a particular area is extensive and complicated phenomenon due to environmental, physical, geographical, biological and chemical variations involving ecological extrinsic and intrinsic factors. Distribution of Zooplankton and their variation at different zones of water body is known to be influenced by physico-chemical parameters of water.

During the last several decades, the water quality of the Indian water bodies has been deteriorating due to continuous discharge of industrial wastes and domestic sewage (Krishnan *et. al.*, 2007). Freshwater ecosystems are affected by physico-chemical elements both directly and indirectly in various ways. It is necessary to know the physico-chemical properties of aquatic bodies to study the rearing practice of the fishes in them (Jhingran, 1991). The ecological studies on south-eastern part of Bankura town of Bankura district of West Bengal (WB), India (**Figure 1**) has been investigated to know the physico-chemical and biological parameters which includes diversity and distribution of Zooplankton for a period of six month and the collected data are being discussed with an emphasis on their significance and interrelationship among them. The physico-chemical parameters studied are atmospheric temperature, water temperature, pH, alkalinity, total hardness, chloride ion, dissolved Oxygen, free Carbon dioxide, Bi-carbonate, organic carbon of soil, organic soil, Phosphate-P, Ammonium-N, Nitrite-N ,Conductivity, TDS (Total Dissolved Solids) and the Zooplankton as biological parameter.

Materials and Methods

Sampling Program and Procedure

The total study was carried out consecutively for six months from April to September, 2014 at six different perennial ponds located at south eastern part of Bankura town (from **Figure 3-8**). The main goal of present study is to investigate the physico-chemical and biological characteristics of these ponds. The water samples were collected from these six ponds. From the **Figure 2** collected from satellite map it is quite clear that the six sites (S-13, S-14, S-15, S-16, S-17 and S-18) of water collection were divided into three parts along with duplicate pond sites in each three parts. S-13 and S-14 are the two ponds of Police line, Bankura. The S-13 is college tank pond and the S-14 pond is Police tank. S-15 pond is used by the common people for daily purposes such as bathing, washing and fishing; the names of S-15 and S-16 ponds are Shit Pukur and Chintar Pukur respectively and these two ponds S-15, S-16 are situated at the Kundu Para of the township. The last two ponds namely S-17 known as Boro Pukur of Pathak Para and S-18 known as Aparupa Pukur of Pathak Para have been taken under consideration. The main three different water collecting sites are from south eastern part of Bankura, situated in the middle of thickly populated part of Bankura town; which is inside of the township and the pathak para that is highly populated area of Bankura.

Collection of samples for measuring the Dissolved Oxygen (DO) was taken in between from 6 A.M. to 8 A.M. from the surface of the pond water. The hydrogen ion concentration (pH), DO, free Carbon dioxide (CO_2), Organic carbon content of soil, Ammonium-N concentration, Phosphate-P concentration, Nitrite-N concentration, Alkalinity, Hardness, Conductivity, Total Dissolved Solids (TDS) and presence of Chloride ion were determined by following standard methods (APHA, 2005). The values were compared with standard values of BIS [Bureau of Indian Standards] (2003), Khanna and Bhutiani (2008). A Celsius thermometer (scale ranging from 0°C to 100°C) was used to measure air and surface water temperature. Digital Electrode pH meter (Systronics, Model No. SYS–335) was used for measuring the pH of sample water. The chemicals used for analysis of all the parameters were all of analytical AR grade.

We collected the Zooplankton with a modified Heron Tranter net, a round metallic frame of 0.625 sq. m. area. The filtering cone was made up of Nylon bolting silk plankton net (No. 25 mesh size 50 μ) was used for collection of Zooplankton. Collected samples were transferred to the labelled vials which contain 5% formalin. Sedgwick Rafter Counter was used for Quantitative analysis and identification by taking 1 ml sample on counter. The Plankton was observed & documented using Magnus Trinocular Microscope (Model-MLX TR) attached with Nikon Coolpix Camera. Detailed taxonomic identification was earned out with Tonapi (1980), Needham and Needham (1962), APHA (2005), Kodarkar (1992) and Hosmani (2008). Chemicals used were highest purity available.

Results and Discussion

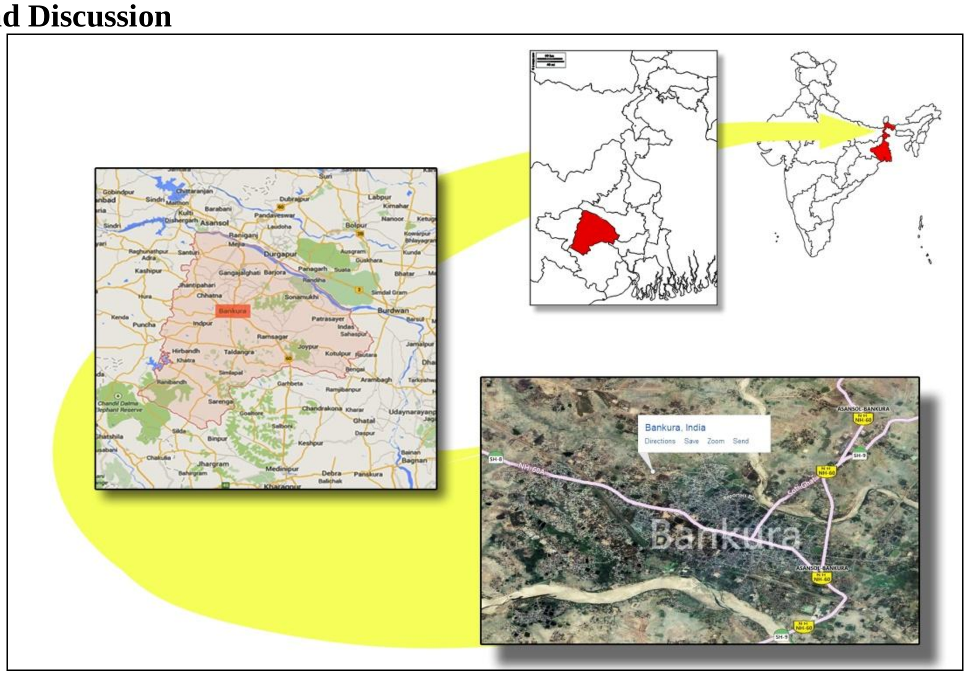

Figure 1: Map of study area

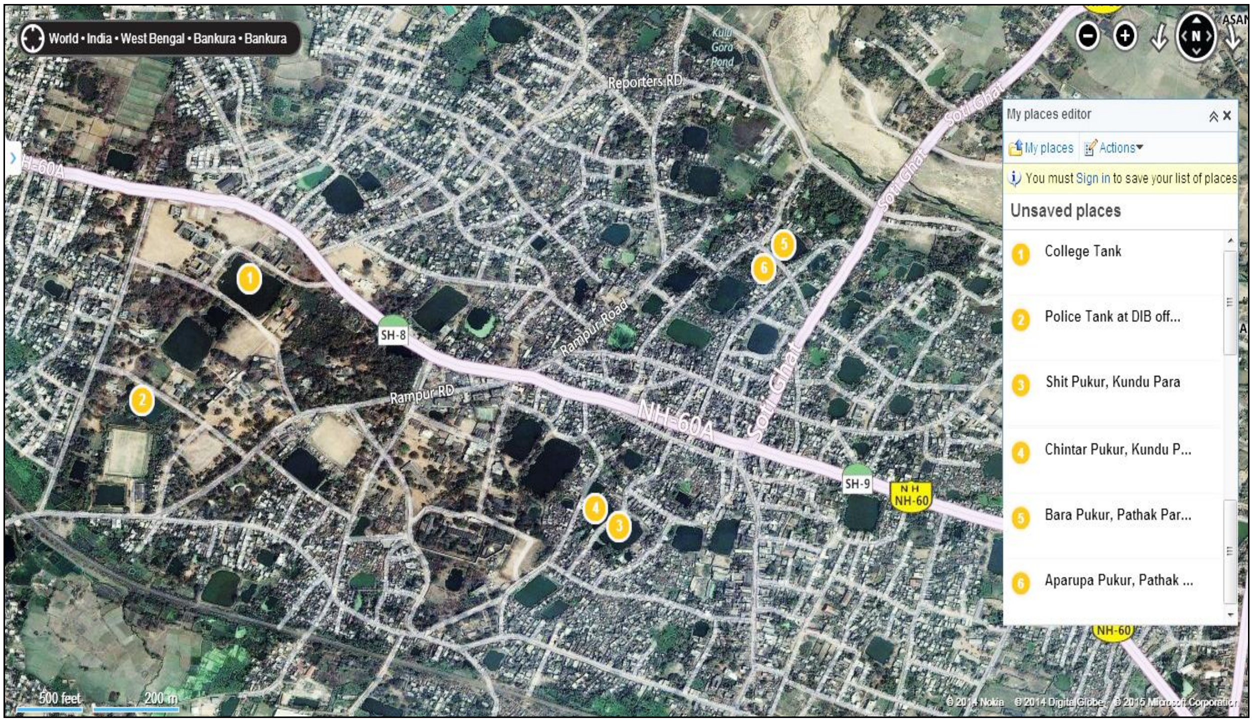

Figure 2: Sattelite view of the selected ponds at the study area

Figure 3: S-13 (College Tank, Near Bankura Christian College); satellite view; during sampling

Figure 4: S-14 (Police Tank at DIB Office Campus, Bankura); satellite view; during sampling

Figure 5: S-15 (Shit Pukur, Kundu Para, Bankura); satellite view; during sampling

Figure 6: S-16 (Chintar Pukur, Kundu Para, Bankura); satellite view; photograph during sampling

Figure 7: S-17 (Boro Pukur, Pathak Para, Bankura); satellite view; photograph during sampling

Figure 8: S-18 (Aparupa Pukur, Pathak Para, Bankura); satellite view; photograph during sampling

The physico-chemical parameters of six different ponds of south eastern part of Bankura town from September to October, 2014 are being summarized in Table–1. The values of different hydro biological parameters are Mean ± S.E. where N=6. Some observable variations in hydro biological parameters were observed for all these six ponds are located at Bankura.

Table-1: Summary of physico-chemical and biological parameters (Mean ± S.E., N=6) of different pond water of south eastern part of Bankura town during January to June, 2014.

	S-13	**S-14**	**S-15**	**S-16**	**S-17**	**S-18**	**BIS standard**
Place	College Tank, Near Bankura Christian College	Police Tank at DIB Office Campus, Bankura	Shit Pukur, Kundu Para, Bankura	Chintar Pukur, Kundu Para, Bankura	Boro Pukur, Pathak Para, Bankura	Aparupa Pukur, Pathak Para, Bankura	
Latitude	23°14′14.1″N	23°14′03.6″N	23°13′52.4″N	23°13′54″ N	23°14′18.1″ N	23°14′15.9″N	--
Longitude	87°03′35.2″E	87°03′26.5″E	87°04′06.8″E	87°04′04.9″ E	87°04′20.8″E	87°04′19.1″E	--
Shape of pond	Almost rectangular	Almost rectangular	Almost rectangular	Almost rectangular	Almost square	Almost rectangular	--
Air Temp. (^{0}C)	34 ± 3.2	33.8 ± 3.8	34.3 ± 3.4	35.1 ± 2.9	34.5 ± 3.5	35.6 ± 2.8	--
Water Temp. (^{0}C)	20.2 ± 2.1	21.3 ± 2.0	20.4 ± 1.9	22.1 ± 2.3	23.0 ± 2.1	20.2 ± 1.9	--
pH	7.45 ± 0.53	7.89 ± 0.62	8.02 ± 0.79	7.89 ± 0.72	7.80 ± 0.70	7.73 ± 0.62	6.5 – 8.5
DO (mg/L)	0.8 ± 0.04	0.90 ± 0.43	0.6 ± 0.02	0.46 ± 0.02	0.42 ± 0.03	0.60 ± 0.01	Upto 6.0
Free CO_2 (mg/L)	12.66 ± 0.38	14.6 ± 0.23	34.6 ± 0.29	33.2 ± 0.19	47.0 ± 1.00	57 ± 3.02	--
Chloride ions (mg/L)	23.34 ± 0.49	18.0 ± 0.21	48.0 ± 0.09	30.0 ± 0.36	40.0 ± 0.93	44.2 ± 0.15	Upto 250
Alkalinity (mg/L)	238 ± 6.21	58.6± 3.95	10.9 ± 0.09	10.2± 0.56	238.01 ± 5.6	234.2 ± 3.5	50 – 200
Total hardness (mg/L)	114 ± 4.59	150.6 ± 7.3	128.6 ± 5.6	120.0 ± 5.6	186.25 ± 9.5	174.3 ± 6.9	Upto 300
Bi-carbonate (mg/L)	7.3±0.03	8.2±0.05	10.9 ±0.10	10.2±0.11	238±7.9	234±7.2	--
Organic Carbon of Soil (in %)	0.975±0.002	1.755±0.004	0.449±0.001	0.195±0.0002	0.039±0.002	0.019±0.001	--
Organic Matter (in %)	1.667±0.3	3.01±0.2	0.771±0.04	0.335±0.3	0.067±0.003	0.032±0.004	--
GP (mg/O_2/L/Day)	0.4±0.05	0.4±0.05	1.2±0.6	1.18±0.7	0.46±0.05	0.30±0.03	--
GPP (mgC/M^3/Hr)	150±5.6	150±4.3	450±7.1	442.5±6.8	86.25±3.8	243.75±4.1	--
NPP (mg C/M^3/Hr)	112.5±4.0	37.5±1.5	326.25±5.5	375.00±5.1	48.75±1.9	187.5±4.2	--
CR (mgC/M^3/Hr)	37.5±2.2	112.5±3.9	247.5±4.7	67.5±2.7	37.5±2.3	56.25±3.4	--
Phosphate-P (mg/L)	15±1.1	20±1.4	775±12.6	500±10.7	147.39±4.1	170.92±4.3	--
Ammonium-N (mg/L)	0.000012	0.00002	0.000010	0.0000096	0.0000011	0.000014	--
Nitrite-N (mg/L)	0.00018	0.00087	0.00029	0.00065	0.00021	0.00090	--
Conductivity (µS/cm)	750±6.9	690±5.1	1200±8.3	1000±8.1	800±7.8	900±8.0	--
TDS (ppm)	502±7.8	462±6.9	804±8.1	670±5.3	536±4.7	603±5.8	Upto 500

Water temperature varies seasonally from 20.2 ºC to 23.0ºC. The air temperature ranges minimum from 33.8 to maximum to 35.6 ^{0}C (**Table-1**). Similar types of variation in water temperature were observed by Sen *et. al.*, 2011; Srivastava and Srivastava, 2011; Majumder and Dutta, 2014. There is an agreement with the opinion put forward by Lewis (1987) who maintained that Lower and higher water temperatures might produce a large difference in the primary productivity between temperate and tropical aquatic ecosystems and result observed by Chattopadhyay and Banerjee (2008).

pH is a critical factor which determines many biological factors and various chemical factors. Aquatic organisms are affected by pH because most of their metabolic activities are pH dependent as per reported by Wang *et. al.*, 2002. The average pH values of the water of the study area (six ponds) during the three month period vary from minimum 7.45 to maximum of 8.02 (**Table-1**). Result has been supported by the finding of Chaurasia and Pandey (2007). The lowest pH value was found in S-13(College Tank). In the present investigation pH ranges between 7.45–8.02 shows slightly acidic to slightly alkaline condition of the pond water. Mary (1989) reported that pH of polluted water fluctuates in the range of 8 to 9. A common factor causing pH level to rise over 9.0 is intense photosynthetic activity resulting from algal growth in enriched waters causing eutrophic condition (Garcia and Paez, 2007). The BIS (2003) limits the pH of drinking water between 6.5–8.5. pH of these is under acceptable range, with proper treatment it can be used for fishing and drinking.

Dissolved Oxygen is very crucial factor, it plays critical role in sustaining fauna. Among all the ponds S-14 shows the highest level of dissolved oxygen. Air is in contact with water surface, diffusion of the gas plays the major role maintaining the dissolved oxygen levels (Parikh and Mankodi, 2012). Moreover, photosynthetic activity caused by the small photosynthetic organism or plant like algae adds a little amount of oxygen to the pond. With a balance in the natural ecosystem, the pond which has aquatic plants will have slightly more DO in comparison to the pond having scarce aquatic flora. Aquatic vegetation is a crucial factor in determining the productivity of pond ecosystem. If this growth remains unchecked, it leads to formation of a mat of floating algae which eventually covers the whole surface of the water body and create algal bloom. This does not allow the surface diffusion of gases leading to depleted oxygen levels in the water causing death and decay of aquatic organisms in anoxic condition. Thus the increased algal bloom the level of dissolved oxygen may decrease in the water body; reported by Obenour *et. al.*, 2014. DO level of S-17 pond found to be very low, reason behind this could be the heavy usage by the local people and pollutant discharge. Amongst all DO level is high S-14(0.90mg/L) due to presence of high phytoplankton population. Rotifers respire by their whole body since they do not have respiratory organs. But they somehow tolerated the low DO condition of S-16, and showed the highest population amongst the ponds under study. *Paramoecium sp*., *Euglena sp*., *Chlamydomonas sp*., *Keratella cochlearis*, *B. urceolaris* and *Monostyla bulla* were found in water where good sunlight falls up to the depth. Likens and more algal bodies were observed in the water reservoir where more numbers of hydrophytes were found. Similar observation found by Pattnaik B. Sai Ram (2014). Strychnine a chemical produced when few aquatic plants are decomposed in anaerobic condition, which is very harmful to the aquatic life such as fish, and any animal who consumes the water (Sharma, 2009).The concentration of dissolved oxygen directly depends on the area exposed to the air and the inversely proportional to the temperature of the water; phytoplankton and zooplankton population too affects the dissolved oxygen level. Similar types of finding were proposed by Ahmad and Krishnamurthy, 1990; Singh and Singh, 1993.

Carbon dioxide dissolved in water plays a crucial role in maintaining the aquatic life. Sources of Carbon dioxide are mainly respiration of aquatic organisms and mixing with the air on the surface. Due to its high solubility it mixes with air very easily, and after that it can form carbonic acids and carbonate which alters the pH of the water. In our study S-18 showed the highest value (57mg/L) and S-13 showed the lowest value (12.66mg/L). Reason behind this could be S-18 pond showed very high population of daily users. But free CO2 levels rarely limit the growth of phytoplankton (Cole, 1975).

The ability to neutralize the large amount of strong acids is defined by the alkalinity. CO_2 which dissolved in water eventually forms carbonate and bicarbonate, removes hydrogen ions and thereby decreases the pH of the water. In our study results showed very high fluctuations; in S-13 (238mg/L), S-17 (238.01mg/L) & S-18 (234.2mg/L) crossed the maximum limit defined by the BIS (maximum limit 200 mg/L). And the alkalinity levels of S-15 (10.9 mg/L) & S-16 (10.2 mg/L), which is far beyond the lower limit (lower limit 50mg/L) defined by BIS. Only the range in S-14 (58.6mg/L) pond stays in the normal range. Deviations from range may be due to the heavy usage by the local people for washing and cleaning purposes. Similar types of results were seen by the Harney *et. al.* (2011), when detergent is added to the system alkalinity level increased.

Chloride in water is basically distributed as NaCl, KCl, $CaCl_2$. Main sources of chloride in water are leeching from rocks, pollution, and animal sources. In our study the range is in between 18 – 48 mg/L; which is very minimal. Lowest of them is S-14 (18.0 mg/L). Majumder and Dutta (2014) also found this range of chloride value at Dwarakeshwar river of Bankura. The higher concentration of chloride is considered to be an indicator of higher pollution due to higher organic waste of animal origin. Venkatesharaju *et. al.* (2010) noticed that higher level of chloride in summer due to high temperature and low water level. The chloride content was at its peak in summer and lowers down during winter season during the course of investigation. This one may be result of water dry up in summer season and concentrate the Chloride ions. Beside this, the higher concentration of Chloride is considered to be an indicator of higher pollution due to higher organic waste of animal origin, Mishra *et.al.*(2008). The chloride content in the body regulates badly the process of osmoregulation. *L. ovalis*, *Heliodiaptomous*, *Cypris*, *Heterocypris* and *P. vulgaris* were found in ponds having low chloride contents. *Lecane luna* could tolerate chloride content up to 25-60 mg/L. *Hexarthra fennica*, *Cypris sp*. and *B. plicatilis* had shown high chloride toleration capacity.

Hardness of water is another important factor which decides many parameters, but it is not the indicator of the pollution. Characterization of water according to the hardness of water is as follows: 0 – 75 mg/L = soft, 75 – 150 mg/L= moderately hard, 150 – 300 mg/L= hard, above 300 mg/L= very hard. In the present study, total hardness level varied from 114 mg/l (S-13) to 186.25 mg/L (S-17). This may be due to the presence of high content of Calcium and Magnesium ions in addition to Sulphate and Nitrate ions (Angadi *et. al.,* 2005). Kaur and Sharma (2001) reported that generally during summer maximum hardness is seen. Increase in hardness value can be attributed to the decrease in water volume and increased rate of evaporation, as a result of high loading of organic substances, detergents and other pollutants (Rajgopal *et. al.*, 2010). Most of the ponds were sufficiently large and S-16 showed lowest level of hardness, this was observed to be eutrophic too.

Organic carbon of soil is the amount of organic carbon hold by soil particles. Organic carbon (OC) enters the soil through the decomposition of plant and animal residues, root exudates, living and dead microorganisms, and soil biota; it cycles throughout the carbon cycle. It has a vital impact on flora and fauna; it also decides the water holding capacity of the soil. At low organic carbon contents, the sensitivity of the water retaintion to changes in organic matter content was highest in sandy soils. Increase in organic matter content led to increase of water retaintion in sandy soils, and to a decrease in fine-textured soils. At high organic carbon values, all soils showed an increase in water retaintion (W.J. Rawls, Y.A. Pachepsky, J.C. Ritchie, T.M. Sobecki, H. Bloodworth). Organic carbon content varies between 0.5% to 2.5% in India (Roland Hiederer and Martin Kochy). In our study Organic carbon content of soil varies between 0.019 % (S-18) to 1.755 % (S-14). Two ponds S-17 and S-18 showed lower level, and S-14 showed very high level may be due to high eutrophication.

Organic matter constitutes 55% carbon content and it determines the water holding capacity. Organic matter is highest in S-13(1.667%) but it is lowest in S-14(0.032%).

Ammonium-N is the most reactive form of N in aquatic systems. Because it is positively charged, it readily adheres to soil and sediments. In addition to decomposition, ammonium levels can be increased by dissimilatory reduction, a process of microbes converting nitrate to ammonium when oxygen is not present. The reverse process also occurs—microbes can convert ammonium to nitrate through nitrification. Normal acceptable range found in groundwater is 0.32mg/L to 0.71mg/L. In our study we found that the ammonium-N levels are very low. Amongst them, S-14 has the highest value (0.00002mg/L) due excessive algal bloom.

The natural sources of Phosphate are the geological deposits which contain phosphorous in soluble as well as insoluble form. These phosphate releases due to natural processes of weathering and erosion which ultimately enters into the ecosystem and the aquatic plants utilizes them for growth and development. Urban ponds receive excess of nutrients from house hold sewage, waste water from nearby shops and lorries, street runoff etc. (Goswami & Mankodi, 2012). This ultimately results into Eutrophication of the pond and as this is caused by human activities and not by natural processes,it is called “Cultural Eutrophication” (Welch & Lindell,1980). Soluble reactive phosphorus, typically in the form of orthophosphate (PO_4^{+3}), can be a nutrient for aquatic plants, such as algae, which can be either a health risk to aquatic life or an aesthetic nuisance to those living near or using the waterways. In the case of blue-green algae, toxic by-products can be produced, which create health issues if a lake or reservoir would be used as a source of drinking water. Levels above 0.1 mg/L PO4-P can stimulate plant growth above its natural rate (Water Quality with Vernier, Phosphates,). In our study we found then that all of the ponds have considerably higher range of phosphate but the maximum was found in S-15 (775mg/L) and minimum was found in S-13(15mg/L). S-15 pond is located in very dense area and used more frequently by nearby people; S-13 was considerably less used.

Nitrate and nitrite are naturally occurring ions that are part of the nitrogen cycle. The nitrate ion (NO_3^-) is the stable form of combined nitrogen for oxygenated systems. Although chemically nonreactive, it can be reduced by microbial action. The nitrite ion (NO_2^-) contains nitrogen in a relatively unstable oxidation state. Chemical and biological processes can further reduce nitrite to various compounds or oxidize it to nitrate (ICAIR Life Systems, Inc., 1987). Nitrite can also form in groundwater and surface water due to pouring of the agricultural waste such as excess fertilizers containing inorganic nitrogen compounds and it can also form due to oxidation of animal waste (WHO/SDE/WSH/07.01/16/Rev/1 English only Nitrate and nitrite in drinking-water). Normal range of nitrite in water is 1mg/L. In our study we found that all the ponds despite of being located in heavily populated area, contains very low amount of nitrite in water. Concentration varied from 0.00018mg/L (S-13) to 0.00090 mg/L (S-18).

The primary productivity of a water body is the manipulation of its biological production. It forms the basis of the ecosystem functioning, (Odum, 1971). Primary productivity at each level can be distinguished further into gross primary production i.e the total amount of organic matters produced and net primary production or the amount of organic matter produced of a particular level (Yeragi and Shaikh, 2003). Photosynthetic fixation of carbon in the inland aquatic system occurs in various plant communities such as phytoplankton, periphytic algae, benthic algae, and macrophytes. Production by the phytoplankton, the primary synthesis, is the most important phenomenon and

reflects the nature and the degree of productivity in the aquatic ecosystem. The rate of photosynthesis was measured by estimating oxygen (O_2) in light and dark bottle
method of Gaarder and Gran (1927). Gross Productivity (GP), Gross Primary Productivity (GPP), Net Primary Productivity (NPP) and Community Respiration (CR) were measured using the dissolved oxygen values of light and dark bottle. S-15 pond under study showed highest value of GP, GPP, NPP and CR; at the same time S-17 showed the least. High level of GPP in S-15 pond indicates the presence of the high population of phytoplankton (high photosynthetic activity) and the CR in the same pond found to be high too, that indicates high population of consumers. Community respiration is due to heterotrophic organisms. In S-16 although it S-18 pond it showed very low level of GP and but it showed low level of CR, although it showed a very high population of Zooplanktons.

Conductivity is a measure of water's ability to pass electrical flow. This ability is directly related to the concentration of ions in the water. These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulphides and carbonate compounds. Compounds that dissolve into ions are also known as electrolytes.

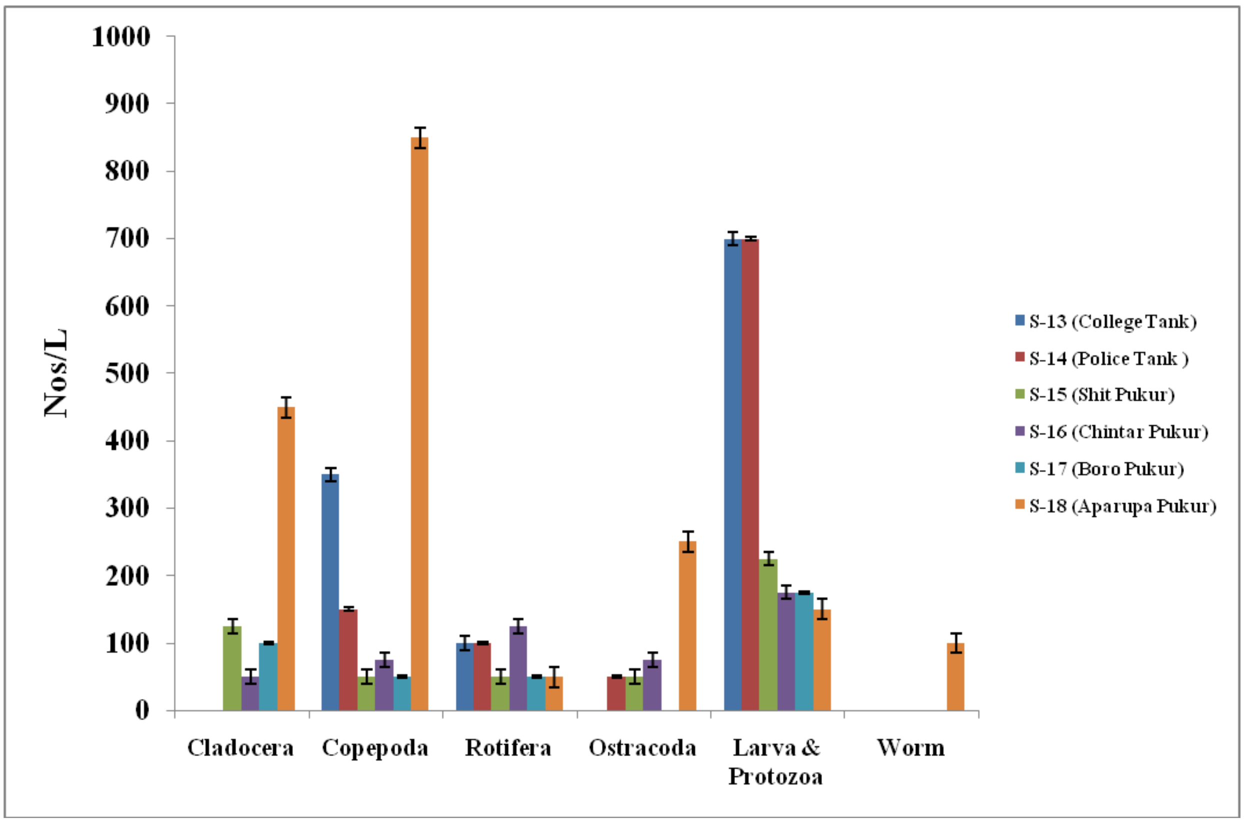

Figure 9: Graphical representation of some biological parameters of pond water of south eastern part of Bankura town during April to September, 2014



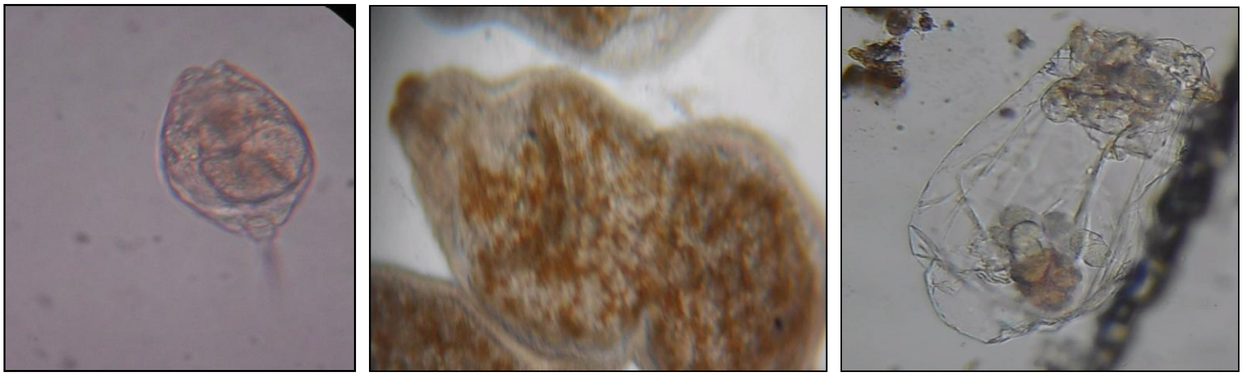

Figure 10: Zooplanktons and worms are frequently observed in the pond sites

Table-2: Abundance of Zooplankton of study sites

		Counting in study site (as per Nos./L)					
Sl. No.	**Genera**	**S-13**	**S-14**	**S-15**	**S-16**	**S-17**	**S-18**
	Cladocera						
1.	*Daphnia sp.*	0	0	100	40	75	275
2.	*Bosmina sp.*	0	-	-	-	-	50
3.	*Moina sp.*	0	0	25	-	25	100
4.	*Ceriodaphnia sp.*	0	-	-	10	-	25
	Total	**0**	**0**	**125±6**	**50±3**	**100±5**	**450±27**
	Copepoda						
5.	*Cyclops sp.*	250	112	42	50	40	625
6.	*Mesocyclops sp.*	75	38	8	20	10	200
7.	*Diaptomus sp.*	25	-	-	5	-	25
	Total	**350±18**	**150±8**	**50±3**	**75±4**	**50±3**	**850±43**
	Rotifera						
8.	*Brachionus bidentata*	52	42	25	75	25	25
9.	*Brachionus diversicornis*	22	28	25	50	-	-
10.	*Brachionus quadridentata*	18	25	-	-		25
11.	*Keratella tropica*	8	-	-	-	25	
12.	*Asplanchna sp.*	-	5	-	-	-	-
	Total	100±5	**100±5**	**50±3**	**125±6**	**50±3**	**50±3**
	Ostracoda						
13.	*Cypris sp.*	-	25	25	50	-	175
14.	*Stenocypris sp.*	-	25	25	25	-	75
	Total	**0**	**50±3**	**50±3**	**75±4**	**0**	**250±15**
	Larva And Protozoa						
15.	Nauplius larva	325	350	150	100	75	125
16.	Zoea	75	50	-	-	25	25
17.	*Paramoecium sp.*	175	50	75	50	50	50
18.	*Euglena sp.*	125	250	-	25	-	50
	Total	**700±35**	**700±35**	**225±12**	**175±9**	**150±8**	**250±15**
19.	**Worm**	**-**	**-**	**0**	**0**	**0**	**100±5**
	Grand Total	1150	1000	500	500	350	1950

Table-3: Diversity index, richness and evenness in study sites

Study site	Diversity Index	Species Richness	Species Evenness
S-13	1.262	3.060	0.412
S-14	1.322	3.000	0.445
S-15	2.870	2.698	1.064
S-16	2.468	2.698	0.914
S-17	6.235	2.544	2.451
S-18	1.764	3.290	0.536

The more ions that are present, the higher the conductivity of water. The amount of mineral and salt impurities in the water is called total dissolved solids (TDS). TDS is measured in parts per million (ppm). TDS tell how many units of impurities there are for one million units of water. Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 μS/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macro-invertebrates (5.9 Conductivity - http://water.epa.gov/type/rsl/monitoring/vms59.cfm). The conversion factor depends on the chemical composition of the TDS and can vary between 0.54–0.96. A value of 0.67 is commonly used as an approximation if the actual factor is not known [(TDS) ppm = Conductivity μS/cm x 0.67]. In our study conductivity varied (S-13 to S-18) between 690–1200 μS/cm, which is under acceptable limit. Conductivity of the S-15 pond found to be very high (1200 µS/cm), this may due to heavy usage by local people for daily purposes. Lowest of them is the S-14 pond, this pond is less used thus lower value. Total Dissolved Solid (TDS) values for the ponds (S-13 to S-18) exceeded the maximum limit. Thus it indicates the water is not usable for drinking or other purposes. The TDS values ranges from 462 – 804 ppm. S-15 pond has the maximum TDS value (804ppm) and S-14 pond has the minimum TDS value (462ppm).

Zooplanktons are organisms that have animal-like traits. The biggest are only five millimetres long and the smallest are just one thousandth of this size. They float, drift or weakly swim in the water. In fact, the name plankton comes from the Greek word 'planktos' which means 'wanderer' or 'drifter'. In lentic system zooplanktons are represented by taxonomic group of Rotifera, Cladocera, Copepoda and Ostracoda. Rotifera is the second most abundant group of Zooplankton.

Rotifers are the most important soft-bodied metazoans (invertebrates) having a very short life cycle among the plankton. The rotifera group is generally represented by 6 genera. The most dominant being *Brachionus sp.*, represented by 3 species viz., *B. diversicornis, Brachionus bidentata, and B. qudridentata.* The others were, *Keratella tropica, Asplanchna sp.* and *Filinia sp*. *Lecane sp*. Rotifers are the most responsive to the environmental changes. They appear to be more sensitive indicators of changes in water quality (Gannon and Stemberger, 1978). Presence of *Brachionus sp.* is the indication that the pond is organically polluted reported by Goel 1991. This is also agreed by Ahmed *et. al.*, 2012; Dutta and Patra, 2013. The species of B. calyciflorus considered to be a good indicator of eutrophication, reported by Manickam *et. al.*, 2012. Information on the acute toxicity tests of lead (Pb) on *Brachionus sp.* is available in literature (Snell & Janssen, 1998). Studies carried out by Yi-Lomg Xi, Xiao-ping and Zhao-Xia Chu (2006) had shown that DDT, Dicophol, Estradiol and other pesticides do had a direct impact on growth, fecundity and survival of rotifers. Overall study indicates that the rotifer population is lower than expected (Fig. 9). Dhanapathi (2000) found that they increase in large quantity rapidly under favourable environmental conditions.

Cladocerans are a crucial group among zooplankton and form the most useful and nutritive group of crustaceans for higher members of fishes in the food chain. Among Zooplankton, cladocera was the dominant group. This group is represented by *Daphnia sp*., *Moina sp*., *Ceriodaphnia sp*. and *Bosmina sp*. This group feeds on smaller zooplankton, bacterioplankton and algae; reported by Murugan (1998) and they are highly responsive against pollutants, this group even reacts against the low concentration of contaminants. Cladocerans are important food source for fry, fingerlings and adult of many economically important fish species. S-18 pond showed very high population of the cladocera, where in S-13 & S-14 cladocera were absent.

Copepoda comprises of the third most abundant group of Zooplankton & this group is represented by *Cyclops sp*., and *Diaptomus sp*, *Mesocyclops sp*. Copepods have the toughest exoskeleton and the longest and the strongest appendages which help them to swim faster than any other zooplankton. Feeding habits differ in three orders of copepods. Cyclopoid copepods are commonly carnivorous (live on other zooplankton and fish larvae) though they also feed on algae, bacteria and detritus. The calanoid copepods are generally omnivorous (feed on ciliates, rotifers, algae, bacteria and detritus) however their food intake is dependent on their age, sex, season and food availability. The third group harpacticoid copepods are primarily benthic. Thus, their physical structures and versatile feeding habits ultimately assist them to hold up harsher environmental conditions as compared to cladocera (Kalff, 2002). Again S-18 pond showed a very high population of Copepoda, followed by S-13 pond. Copepoda domination may also be due to their feeding on diatoms, Rotifera and Cladocera, (Hutchinson, 1967) and high reproduction capacity.

The Cladocerans and copepods are widely referred to as tolerant species, present in all kinds of waters (Verma and Dalela, 1975) and in the present study cladocerans are maximum in S-18 and pond is polluted. Cladocerans are also reported to be the indicators of eutrophic nature of water bodies (Sharma, 2001).

Ostracoda comprises of the least abundant group of Zooplankton and this group is represented by *Cypris sp*., and *Heterocypris sp.* Ostracodans are mainly bottom dwellers of lakes and live on detritus and dead phytoplanktons. These organisms are food of fish and benthic macroinvertebrates (Chakrapani *et. al*., 1996.) During our study they show least abundance in number.

Larva and Protozoa showed very dense population in S-13 and S-14 pond, and moderately in S-15, S-16, S-17, S-18.

Highest species diversity was observed in S-17, which is used for fishing purposes (**Table-3**). High diversity of zooplankton in S-17 indicates the fact that this water body is least polluted and suggested for prevalence of proper biogeochemical cycles. Therefore, it is considered to be a suitable one for natural fin-fish and shell-fish (pisciculture) culture practices. Species Richness is high in S-18, that show maximum number species which distributed upon favourable environment condition. According to Guy (1992) the study of Zooplankton is necessary in fisheries; aquaculture and paleolimnological research as it provide food for fish in freshwater lakes and play a major role in fish production. Rotifers are globally recognized as pollution indicator organisms in the aquatic environment (Kamble and Meshram, 2005). According to Guy (1992), phytoplankton abundance fluctuates with changes in environmental factors and grazing by Zooplankton. Zooplankton distribution is non homogenous. Some are mainly found in the littoral waters while others are in selected limnetic waters.

Conclusion

Management of water body like pond essentially requires an understanding of physico-chemical and biological conditions. The aquatic environment is an area controlled by the changes in factors such as light, heat, humidity and contamination of various effluents in the water body. It can also be said the overall productivity of a water body is directly regulated by physico-chemical as well as by biological parameters. From the above investigation, it may be concluded that the values of different physico-chemical parameters at all the six sites during the six months are in the range prescribed by BIS (2003). The most important finding of this work is having a moderate number of Zooplankton diversity in the six studied water bodies of south eastern part of Bankura town. As rotifers are suppose to act as bio-indicators for fish culture; so it can easily be said that besides being used by the local residents the water of these ponds may easily be used for fishing purpose with a little management. The study is quite useful in further investigation and in improvement of quality and quantity of the Zooplankton community. Biodiversity is rightly considered as an index of sound health of habitat and strong base for better evolution.

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