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**RESEARCH ARTICLE**

**MICRO-FAUNAL DISTRIBUTION WITH EFFECTIVE VARIATION OF PHYSICO-CHEMICAL
 PARAMETERS IN TWO DIFFERENT ZONES OF FRESHWATER ECOSYSTEM IN BANKURA
 DISTRICT 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 local residents for their daily purposes and some are also used for economic purposes such as fish culture. The unaware use of water causes some changes in physico-chemical parameters of some ponds of Bankura town. But the Ramsagar zone, which is famous for fish culture; the ponds, as well as the physico-chemical factors of those pond water are well maintained. The sampling was done both in Bankura town zone and Ramsagar zone ponds simultaneously (September, 2015 to February, 2016). After evaluating all the values of the water of those ponds (both from Ramsagar zone and Bankura town zone) it is revealed that, there are extreme changes of values between both the studied areas and zooplankton plays an important role (as bio-indicator) to know the water quality of studied perennial water bodies.

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Introduction:-

Water is one of the basic need as well as origin of life and the freshwater is most important to human beings and other organisms of the environment for sustenance of life and maintaining the unique ecosystem as nature. Ponds are useful in many ways, including the common source of open freshwater in land. It is one of the methods of artificial infiltration of underground water (Smitha and Sajitha, 2015). Here, the freshwater zooplankton is an important component in an aquatic ecosystem and plays a critical role for maintaining ecological chain of the ecosystem as they maintaining the link between the producer and primary consumer. They are not only the primary food for many organisms, such as fish, crustaceans and shellfish but also be used as indicators of trophic status of water bodies. Their distribution and the level of abundance can be used to estimate the fishery potential of a water body (Hutchinson, 1967). The knowledge of their abundance, species diversity and special distribution is important in understanding trophodynamic and trophic progression of water bodies.

For the fish culture there at the water bodies the farmer manicured the physico-chemical factors as per conventional method. Thus we can maintain the biological factors for culture purpose. But, if we look at the non-manicured water bodies, the physico-chemical factors are abruptly disturbed and for particular factor, the biological factors are affected in certain cases. In this study we have selected the water bodies of two regions in Bankura district of West

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Bengal, India. One is Ramsagar Zone, which is famous for the fish culture and here the ponds are well maintained as well as the physico-chemical factors; the second one is Bankura zone, where some non-manicured ponds are selected and no special care was taken there. Thus, we measured out the relationship between the biological factors and also the environmental effects on those factors, specially the zooplanktons (evidently by comparison) of both the zonal water bodies.

The physico-chemical parameters studied were the atmospheric temperature, water temperature, pH, alkalinity, dissolved oxygen, free carbon dioxide, bi-carbonate, organic carbon of soil, organic matter, primary productivity, phosphate-P, ammonium-N, nitrite-N, total hardness, chloride ion, electrical conductivity and the zooplankton as biological parameter.

Materials and Methods:-

Sampling program and procedure:-

The total study was carried out consecutively for six months from September, 2015 to February, 2016 at twelve different perennial ponds located at two different zone of Bankura district (from Figure 3-14). The main goal of present study is to investigate the different physico-chemical characteristics; how effectively leads to change the biological characteristics specially zooplankton of this two zonal ponds. The water samples were collected from these twelve ponds. From Figure 2 (collected from satellite map) it is quite clear that the ponds of Ramsagar zone are closely distributed in surrounding Fishery firm and those ponds are used for fish culture. Thus the ponds are manicured to maintain a standardized comfortable environment for fish culture by local farmers. The first zone of our study is the Ramsagar zone, about 30 Km. away from Bankura town. This zone is very much popular for fishery and the ponds are well maintained; bathing and washing purposes are limited in those ponds. Pond R-1 (Hatibari 1) is large and situated far from locality beside a poultry farm house and the color of water is greenish. Pond R-2 (Hatibari 2) is just beside the R-1, same size to R-1, well manicured and water color is greenish. Pond R-3 (Sima bandh) is also well maintained, no weeds, regularly manicured, water color not so greenish. All three ponds are used for fish culture strictly and maintained by fish farmers. Pond R-4 (Hatibari 3) is not so large; it is used for regular purpose and seasonal fish culture. Pond R-5 (Hadgora pukur) is large, water color is greenish-red, well maintained and situated in the locality. Pond R-6 (Rakshit Pukur) is also large, water color greenish and situated in the locality. Both the ponds are used for local activity and some extend of seasonal fish culture. Beside the first zone, the second zone that is situated in Bankura town and the studied ponds are distributed throughout the south-eastern part of Bankura town. Here the six sites (S-1, S-2, S-3, S-4, S-5 and S-6) of water collection were divided into three parts along with two nearer pond sites. S-1 and S-2 are the two ponds of Police line area, Bankura. The S-1 is within the Bankura Police line and the S-2 pond is Tamblibandh pond which is situated next to the Police line pond. S-3 pond is used by the common people for daily purposes such as bathing, washing and fishing also; the names of S-3 and S-4 ponds are beside Shit Pukur lane, Kundupara and they situated side by side in the township area. The last two ponds namely S-5 known as Rathtala area pond and S-6 known as Dol mandir area pond, has been taken under consideration and situated towards northern part of the Bankura town; which is inside of the township and both the ponds (S-3 and S-4) are surrounded by highly populated area of Bankura. Collection of samples for measuring the dissolved oxygen (DO) was taken in between from 6 to 8 A.M. from the surface of the pond water. The negative logarithm of hydrogen ion concentration (pH), DO, free carbon dioxide (CO₂), organic carbon content of soil, ammonium-N concentration, phosphate-P concentration, nitrite-N concentration, alkalinity, organic matter, bi-carbonate, hardness, electrical 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. The 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.

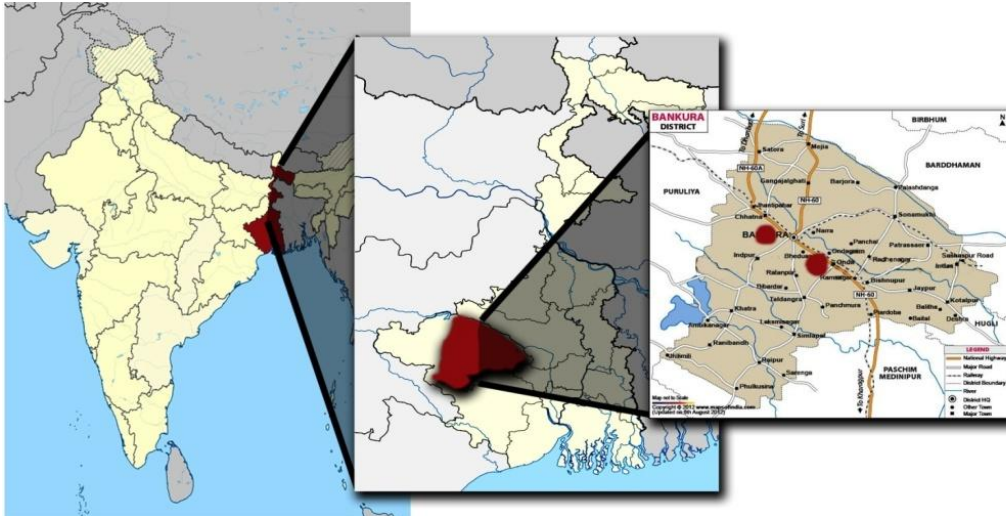


Fig. 1:- Showing distribution of two study zone (1. Ramsagar zone and 2. Bankura town zone)

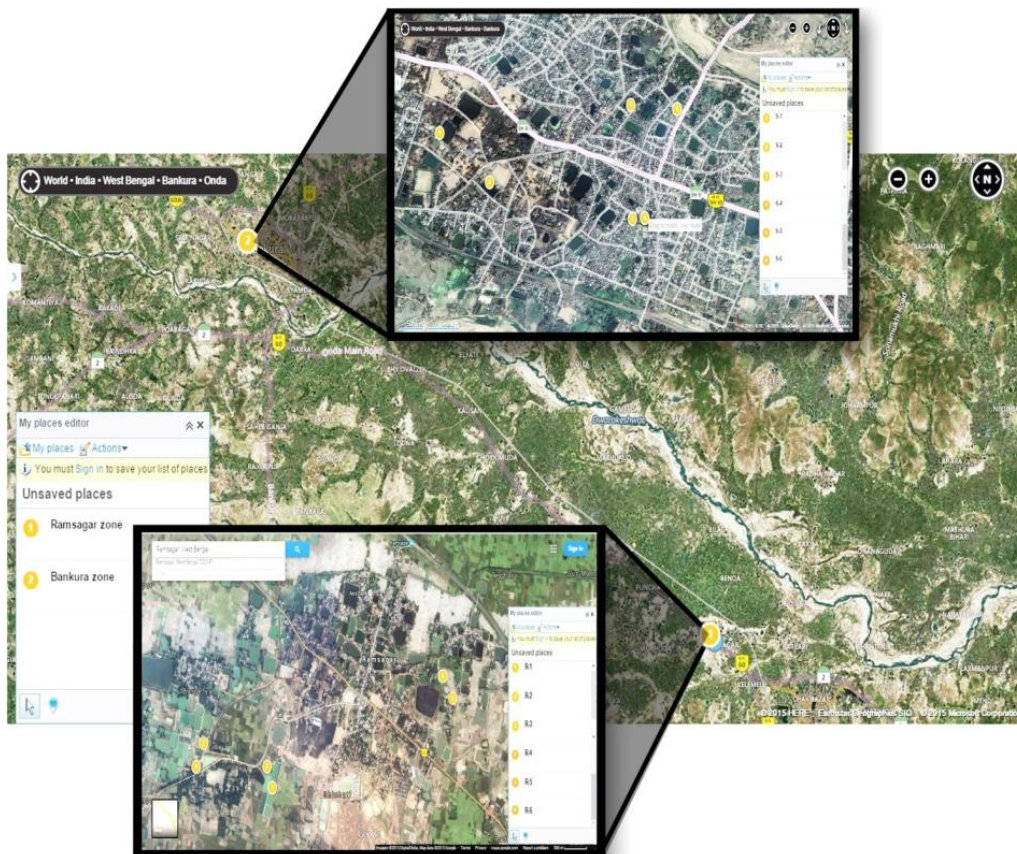


Fig. 2:- Satellite map of study area (1. Ramsagar zone and 2. Bankura town zone)

The zooplanktons were collected 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 50μ) was used for collection of zooplankton. Collected samples were transferred to the labeled vials which contain 5% formalin solution. Sedgwick Rafter Counter was used for quantitative analysis by taking 1 ml. of sample on the counter. The Plankton was observed & documented using Magnus Trinocular Microscope (Model-MLX TR) attached with Nikon Coolpix Camera. Detailed taxonomic identification was done following Needham and Needham (1962), Tonapi (1980), Hosmani (2008) and APHA (2005). Chemicals used (during the experiments) were with highest purity available.



Fig. 3:- R-1 (Hatibari-1); Satellite view; Photograph during sample collection.



Fig. 4:- R-2 (Hatibari-2); Satellite view; Photograph during sample collection.

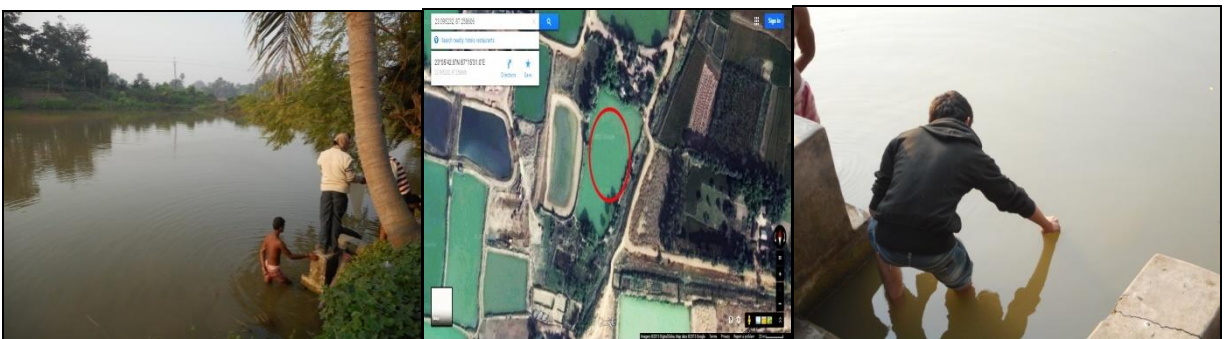


Fig. 5:- R-3 (Sima bandh); Satellite view; Photograph during sample collection.

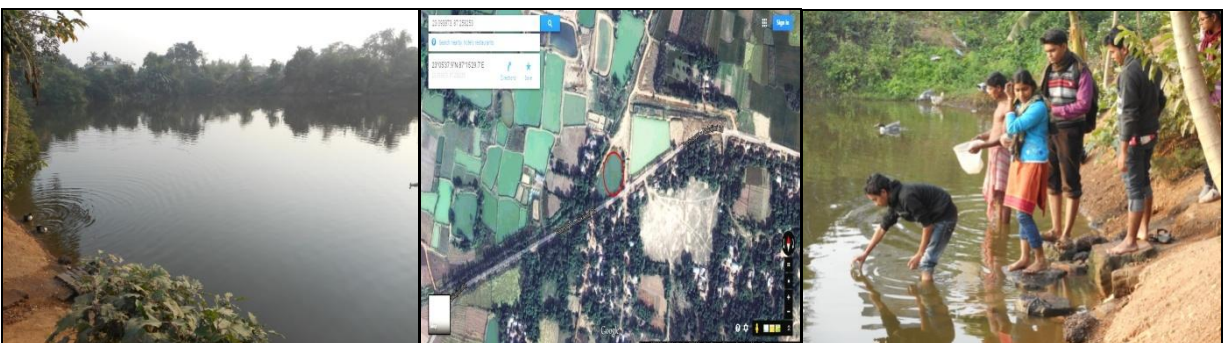


Fig. 6:- R-4 (Hatibari-3); Satellite view; Photograph during sample collection.

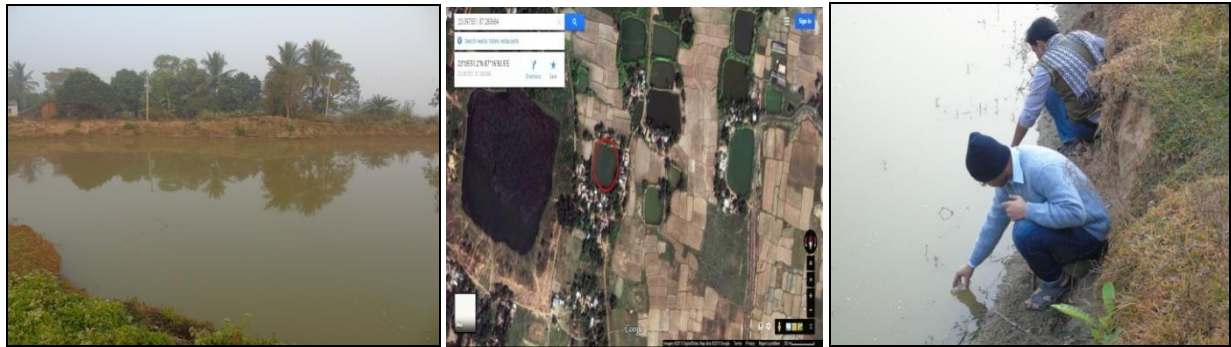


Fig. 7:- R-5 (Hadgora pukur); Satellite view; Photograph during sample collection

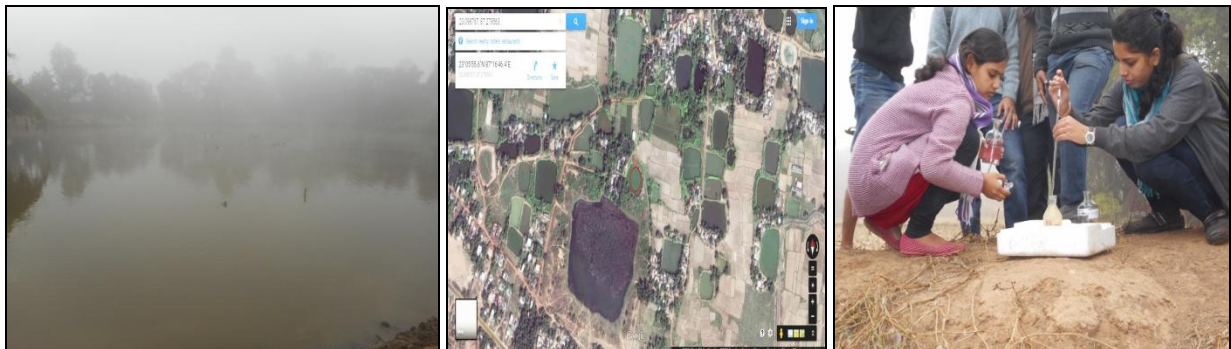


Fig. 8:- R-6 (Rakshit pukur); Satellite view; Photograph during sample collection



Fig. 9:- S-1 (Police line area pond); Satellite view; Photograph during sample collection

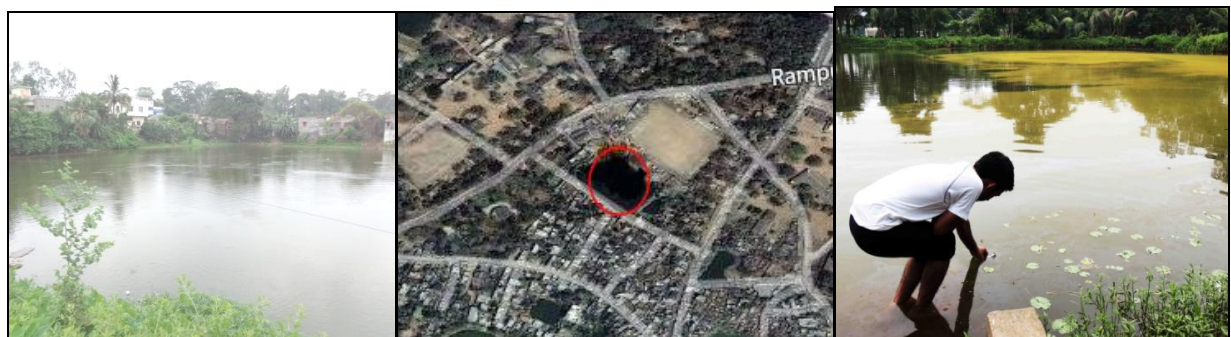


Fig. 10:- S-2 (Tamblibandh pond); Satellite view; Photograph during sample collection

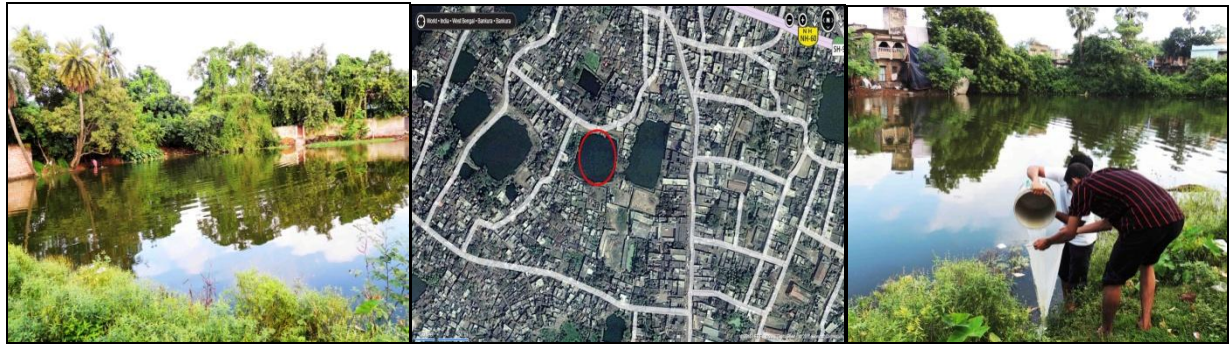


Fig. 11:- S-3 (Shit pukur lane area pond 1); Satellite view; Photograph during sample collection

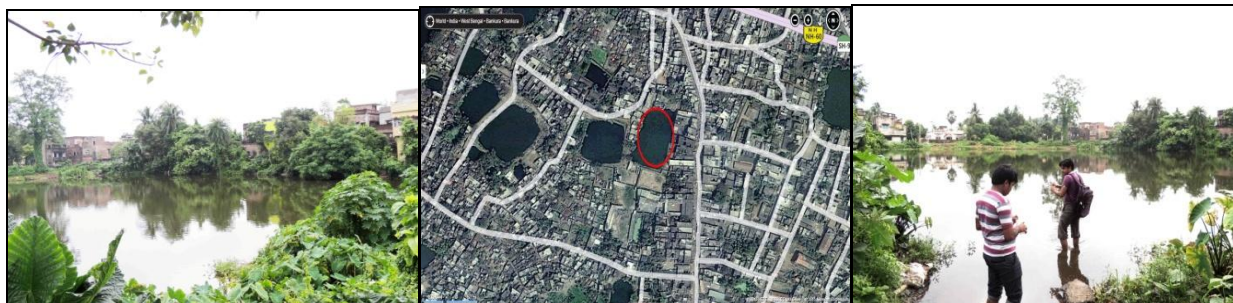


Fig. 12:- S-4 (Shit pukur lane area pond 2); Satellite view, Photograph during sample collection

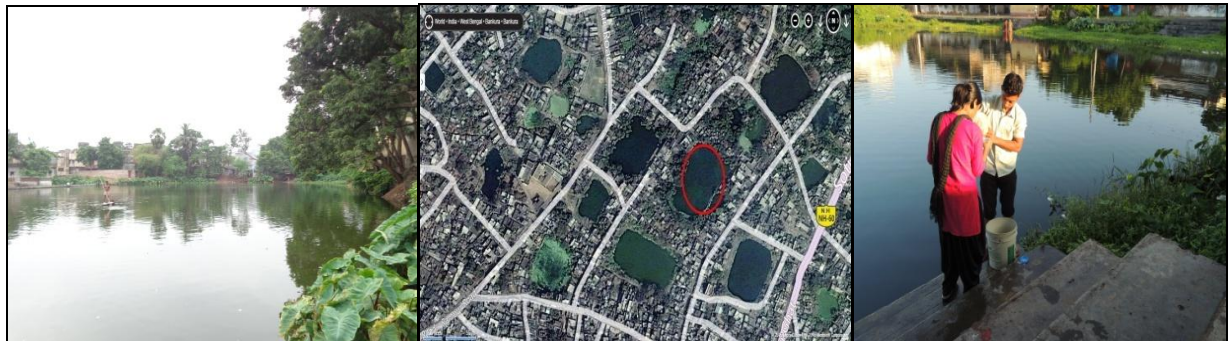


Fig. 13:- S-5 (Rathtala area pond); Satellite view; Photograph during sample collection

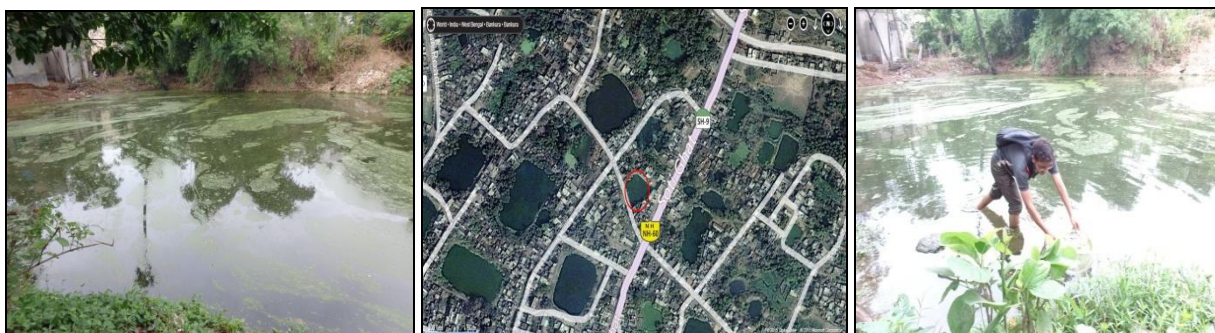


Fig. 14:- S-6 (Dol mandir area pond); Satellite view; Photograph during sample collection

Results and Discussion:-

The physico-chemical parameters of twelve different ponds of two different zones of Bankura district from September, 2015 to February, 2016 are being summarized in Table-1. The values of different hydro-biological parameters are Mean \pm S.E. where N=12. Some observable variations in hydro biological parameters were observed for all these twelve ponds located at Bankura.

Place	Ramsagar zone						Bankura town zone					
	R-1	R-2	R-3	R-4	R-5	R-6	S-1	S-2	S-3	S-4	S-5	S-6
Place	Hati bari-1	Hati bari-2	Sima bandh	Hati bari-3	Had gora pukur	Rak shit pukur	Police line area pond	Tambli band pond	Shit pukur lane area pond 1	Shit pukur lane area pond 2	Rath tala area pond	Dol mandir area pond
Latitude	23°05'34.7"N	23°05'36.8"N	23°05'42.8"N	23°05'37.9"N	23°05'51.2"N	23°05'55.6"N	23°14'03.6"N	23°14'14.1"N	23°13'51.9"N	23°13'51.8"N	23°14'18.1"N	23°14'14.1"N
Longitude	87°15'53.4"E	87°15'52.3"E	87°15'31.0"E	87°15'29.7"E	87°16'50.5"E	87°16'46.4"E	87°03'26.5"E	87°03'35.2"E	87°04'12.2"E	87°04'15.1"E	87°04'20.8"E	87°04'22.3"E
Air Temperature (°C)	20	30	32	20	17	17	34	33.8	34.3	35.1	34.5	29.6
Water Temperature (°C)	15.5	24	27	16	18	18	20.2	21.3	20.4	27.1	23	20.2
pH	7.64	8.6	8.50	7.54	7.2	7.4	7.45	7.89	8.02	7.89	7.80	7.73
Total alkalinity (mg/L)	158	118	113	210.6	74.68	176	238	58.6	10.9	10.2	238.01	234.2
DO (mg/L)	0.75	0.45	0.30	0.50	0.30	0.03	0.80	0.90	0.60	0.46	0.42	0.60
CO ₂ (mg/L)	24	10	22	21	18	30	12.66	14.6	34.6	33.2	47.0	57
Bi-carbonate (mg/L)	158	118	74.68	78	70.68	176	7.3	8.2	10.9	10.2	238	234
% of Carbon in the soil	0.351	0.360	0.2398	1.039	0.198	0.335	0.975	1.755	0.449	0.195	0.039	0.019
Organic Matter (in %)	0.603	0.620	0.412	0.604	0.522	0.5762	1.667	3.01	0.771	0.335	0.067	0.032
GP (O ₂ /L/day)	0.20	0.2	0.6	0.16	0.3	0.25	0.4	0.4	1.2	1.18	0.46	0.30
GPP (C/M ³ /hr)	75	75	225	60	105	93.75	150	150	450	442.5	86.25	243.75
NPP (C/M ³ /hr)	37.5	56.25	150	75	75	56.25	112.5	37.5	326.25	375.0	48.75	187.5
CR (C/M ³ /hr)	37.5	18.75	26.5	15	22.75	37.5	37.5	112.5	247.5	67.5	37.5	56.25
Phosphate –P [at 690 nm]	0.598	0.501	0.669	1.261	0.032	0.032	15	20	775	500	147.39	170.92
Ammonium – N [at 640 nm]	0.055	0.045	0.625	0.460	0.324	0.514	0.000012	0.00002	0.000010	0.0000096	0.0000011	0.0000014
Nitrite – N [at 640 nm]	0.0515	0.0245	0.0565	0.0345	0.0455	0.0825	0.000018	0.000007	0.000009	0.0000065	0.0000021	0.0000090
Hardness (mg/L)	116	118	89.32	102	93.22	146	114	150.6	128.6	120.0	186.25	174.3
Chloride ion (mg/L)	10	12	240	232	196	560	23.34	18.0	48.0	30.0	40.0	44.2
Electrical Conductivity μ S/cm (k=0.1)	0.30	0.30	0.52	0.57	0.23	0.46	0.75	0.69	1.20	1.00	0.80	0.90

Air & Water Temperature:-

Water temperature varies seasonally from 15.5°C to 27.1°C. The air temperature ranges minimum from 17°C to maximum to 35.1°C (Table-1) as the data collect in two seasons. Similar types of variation in water temperature were observed by Sen *et. al.*, 2011; Srivastava and Srivastava, 2011; Majumder and Dutta, 2014. It is reported by Lewis (1987) who mentioned that lower and higher water temperatures might produce a large difference in the primary productivity between temperate and tropical aquatic ecosystems and supported by Chattopadhyay and

Banerjee, 2008. We found that in R-1 pond water the temperature was 15.5°C and its NPP is 37.5 C/M³/hr and in S-4 pond water temperature is 27.1°C and NPP is 375.0 C/M³/hr. Solubility of oxygen in the water increased when water temperature decreases.

pH:-

pH is a critical factor, especially in aquatic condition which determines many biological factors and various chemical factors. The pH values were recorded ranging from 7.2 to 8.6, slightly basic. In Ramsagar zone we get higher values of pH, it's due to high utilization of bicarbonate and carbonate buffer system, as the ponds are well manicured. In Bankura town zone we found slightly low pH value may be due to organic matter decomposition (Gracia *et. al.*, 2007). In the rainy season the pond waters were flooded over and the aquatic organisms are affected due to change in pH values because, most of their metabolic activities are pH dependent as reported by Wang *et. al.*, 2002.

Total alkalinity:-

The parameter alkalinity of water is important due to its capacity to neutralize a strong acid and it is normally due to the presence of carbonates, bicarbonates and hydroxides compounds of Ca²⁺, Mg²⁺ and Na⁺. Total alkalinity values for all the investigated sample were found in the range of 10.2 to 238.01 mg/L. The high alkalinity is a function of ion exchange that is calcium ions are replaced by Sodium ions and later contributed to alkalinity (Wurts & Durborow, 1992). Alkalinity may also cause due to evolution of CO₂ during decomposition of organic matter. In the Ramsagar zone the alkalinity value ranges from 74.68 (R-5) to 210.6 (R-4) and in Bankura town zone it fluctuate with very large scale from 10.2 (S-4) to 238.01 (S-5).

Dissolved oxygen (DO):-

Dissolved oxygen plays a critical role in sustaining fauna. The DO concentration present in water reflects atmospheric dissolution, as well as autotrophic and heterotrophic processes that respectively, produce and consume oxygen (Brraich and Saini, 2015). Among all the ponds, S-2 shows the highest level of dissolved oxygen and here also all ponds of Bankura town zone shows higher DO level in comparative to Ramsagar zone. 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. In Ramsagar zone there is a scarcity of aquatic plants in the water bodies (maintained by the farmers) as they can block the fish movement; thus this fact gives direct impact on the dissolved oxygen. On the other hand, the Bankura town zonal ponds have no such maintenance in this purpose and as a result aquatic plants give slightly more DO in comparison to the Ramsagar zonal ponds.

Free carbon dioxide (CO₂):-

Carbon dioxide dissolved in water plays an important role in maintaining the aquatic life. Main sources of carbon dioxide are due to respiration of aquatic organisms and also due to mixing of air CO₂ with the water bodies. Due to its high solubility it mixes easily with water and after that it can form carbonic acids and carbonate which alters the pH of the water. In our study S-6 showed the highest value (57 mg/L) and its surrounds as well as in Bankura town zones the CO₂ level is moderate high in compare to Ramsagar zone where R-2 showed the lowest value (10 mg/L). Reason behind this could be the ponds of Bankura town zone are used by local daily users. But, from the ecological point of view, the free CO₂ levels rarely limit the growth of the phytoplankton (Cole and Cloern, 1987).

Organic carbon (OC):-

Organic carbon of soil is the amount of organic carbon hold by soil particles. Due to the decomposition of plant and animal residues, root exudates, living and dead microorganisms, and soil biota, organic carbon (OC) enters the soil; 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 retention to changes in organic matter content was highest in sandy soils. Increase in organic matter content led to increase of water retention in sandy soils, and to a decrease in fine-textured soils. At high organic carbon values, all soils showed an increase in water retention (Rawls *et. al.*, 2003). Organic carbon content varies between 0.5% to 2.5% in India (Hiederer and Kochy, 2011). In our study the organic carbon content of soil in Ramsagar zone average more or less same where R-4 pond show maximum 1.039%. In other hands the Bankura town zonal ponds shows abrupt variation and the S-2 have highest data 1.755% and S-6 show lowest value 0.019%. Very high level OC may give the results of high eutrophication.

Organic matter:-

Organic matter constitutes 55% carbon content and it determines the water holding capacity. In Bankura district the maximum ponds are the under perennial water body; thus it is important to check the water capacity of those pond. Again in this study it is found that there, in Ramsagar zone the organic matter is more or less averagely same which range between 0.412% (R-3) to 0.620% (R-2); where as in Bankura town zone the recorded value abruptly in high range, 0.032% (S-6) to 3.01% (S-2).

Primary productivity:-

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 in a particular level. 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 Gaareder and Gran (1927). The primary productivity parameters like gross productivity (GP), gross primary productivity (GPP), net primary productivity (NPP) and community respiration (CR) were measured using the dissolved oxygen values of light, initial and dark bottle.

In Ramsagar zone the GP, GPP, NPP and CR values are moderately within the same range where R-3 shows highest values. High level of GPP in R-3 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 case of Bankura town zone the GP, GPP, NPP and CR values are abruptly distributed throughout the studied ponds where as S-3 & S-4 shows the maximum number of table values and it is very much higher than the Ramsagar zone. Thus the ponds of Bankura town zone are going towards the eutrophication.

Phosphate-P:-

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, street runoff etc. (Goswami & Mankodi, 2012). 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 PO_4 -P can stimulate plant growth above its natural rate (Water Quality with Vernier, Phosphates). In our present study we found that studied ponds of Bankura zone has considerably higher range of phosphate but the maximum was found in S-3 (775 mg/L); which really a high level in compare with Ramsagar zone where maximum value is 1.261 mg/L (R-4). This kind of value may be caused by human activities and not by natural processes, it is called - Cultural Eutrophication (Welch & Lindell, 1980).

Ammonium-N:-

Ammonium-N is the most reactive form of nitrogen 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 dissimilator 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 0.32 mg/L to 0.71 mg/L. In our present study we found that the ammonium-N level is very high in Ramsagar zone where maximum is the 0.625 mg/L (R-3). It may be caused of fish culture process as well as aggregation of fish fecal matter. In other studied area Bankura town zone the ammonium-N level is very poor where the S-2 has the highest value (0.00002 mg/L).

Nitrite-N:-

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 present study we found that in Ramsagar zone, all ponds have moderately higher level of Nitrite–N and maximum value is 0.082mg/L (R-6). This kind of result may found due to fish culture as using various kind of fertilizers.

Total hardness:-

Total 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 89.32 mg/L (R-3) to 186.25 mg/L (S-5). In compare the two zonal data, it is found that the Ramsagar zone ponds are with almost same range which is within the moderately hard category. In other hand the Bankura town zone ponds are almost within the hard category. 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 and in perennial water body, it is common. 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 (Rajagopal *et. al.*, 2010).

Chloride ion (Cl⁻):-

Alkalis, chlorides, sulphides and carbonate compounds that dissolve into ions are also known as electrolytes. Chloride as anion occurs in all natural waters in widely varying concentrations. The origin of chloride in surface water is from weathering and leaching of sedimentary rocks, domestic and industrial waste discharge, municipal influence etc. Chloride ion (Cl⁻) values in the present study were found ranging between 10 to 560 mg/L of which maximum value (560 mg/L) was noticed in R-6 pond in and the minimum value (10 mg/L) in R-1. The higher concentration of chloride is considered to be an indicator of higher pollution due to higher organic waste of animal origin. Sahu *et.al.*, (2007) observed that the higher concentration of chloride in the summer period may be due to increased temperature, low level of water and sewage mixing. Higher concentration also is associated with frequently runoff loaded with contaminated water from surrounding. In the ponds of Ramsagar in R-1 & R-2 we see low level of chloride ion concentration and in R-3, R-4, R-5 & R-6 there is high level of chloride ion concentration which indicate higher organic waste of animal origin deposited in the ponds. In the ponds of Bankura town zone there is very low level of chloride concentration, ranging 18.0 mg/L (S-2) to 48.0 mg/L (S-3), which indicate that these ponds consume low level of organic waste of animal origin as not used in fishing purpose.

Electrical conductivity (EC):-

Electrical conductivity (EC) of the water depends on the nature and concentration of salts. In the present study high values of conductivity, could be due to high ionic concentration, pollution status, trophic levels, some domestic effluents and other organic matter in water (Ahluwalia, 1999; Fokmare and Musaddique, 2001). The range of electrical conductivity of present study was between 0.23 μ S/cm (R-5) to 1.20 μ S/cm (S-3). The values of electrical conductivity showed marked seasonal variation, being maximum during rainy and minimum during winter season. Similar results were observed by various workers (Hulyal and Kaliwal, 2011; Ramulu and Benarjee, 2013). The water during the summer decreases as a result of death and decay of plants and animals.

Table 2:- Abundance of zooplankton of study sites

Sl. No.	Genera	Counting in study site (as per Nos./L)											
		R-1	R-2	R-3	R-4	R-5	R-6	S-1	S-2	S-3	S-4	S-5	S-6
	Cladocera												
1.	<i>Daphnia sp.</i>	125	50	75	40	75	150	0	0	100	40	75	275
2.	<i>Bosmina sp.</i>	25	10	25	25	25	50	0	-	-	-	-	50
3.	<i>Moina sp.</i>	50	40	25	25	25	40	0	0	25	-	25	100
4.	<i>Ceriodaphnia sp.</i>	-	-	10	-	10	15	0	-	-	10	-	25
	Total	200	100	135	90	135	255	0	0	125±6	50±3	100±5	450±27
	Copepoda												
5.	<i>Cyclops sp.</i>	250	300	40	125	40	25	250	112	42	50	40	625
6.	<i>Mesocyclops sp.</i>	90	100	20	50	20	5	75	38	8	20	10	200
7.	<i>Diaptomus sp.</i>	20	50	-	20	-	-	25	-	-	5	-	25
	Total	360	450	60	195	60	30	350±18	150±8	50±3	75±4	50±3	850±43
	Rotifera												
8.	<i>Brachionus bidentata</i>	500	300	25	75	50	500	52	42	25	75	25	25
9.	<i>Brachionus diversicornis</i>	200	25	25	20	-	150	22	28	25	50	-	-
10.	<i>Brachionus quadridentata</i>	50	50	-	-	-	100	18	25	-	-	-	25
11.	<i>Keratella tropica</i>	25	25	25	30	25	50	8	-	-	-	25	-
12.	<i>Asplanchna sp.</i>	25	25	-	25	-	-	-	5	-	-	-	-
	Total	800	425	75	150	75	825	100±5	100±5	50±3	125±6	50±3	50±3
	Ostracoda												
13.	<i>Cypris sp.</i>	75	175	75	125	60	75	-	25	25	50	-	175
14.	<i>Stenocypris sp.</i>	25	100	30	70	55	60	-	25	25	25	-	75
	Total	100	275	105	195	105	135	0	50±3	50±3	75±4	0	250±15
	Larva And Protozoa												
15.	Nauplius larva	2500	1500	750	1500	750	500	325	350	150	100	75	125
16.	Zoea	250	250	100	250	125	-	75	50	-	-	25	25
17.	<i>Paramecium sp.</i>	750	500	150	750	300	100	175	50	75	50	50	50
18.	<i>Euglena sp.</i>	500	250	350	500	175	150	125	250	-	25	-	50
	Total	4000	2500	1350	3000	1350	750	700±35	700±35	225±12	175±9	150±8	250±15
19.	Worm	80	50	75	75	75	90	-	-	0	0	0	100±5
	Grand Total	5540	3800	1800	3705	1800	2085	1150	1000	500	500	350	1950

Zooplankton referred to as true ecological link for transforming plant material into animal tissue. Hence they major link in energy transfer to the higher trophic level. They form an integral component of an aquatic ecosystem and consist of microscopic animal life that passively float or swim freely (Purushothama *et al.*, 2011). According to Rao (2005) and supported by Sachinkumar *et al.*, 2015, zooplankton incorporates primary and partly secondary micro faunal consumer operative system. This serves the functional biomass on the detritus spectrum in water. Zooplankton plays an important role in the food chain. These constitute important supply for many fishes as well as other organisms like crustacean. Thus zooplankton plays a major role within the water bodies as a source of food for fishes, since they occupy the second trophic level as primary consumer as feed upon phytoplankton (Balarabe, 1989). But the distribution of zooplankton is influenced by interaction of both biotic and abiotic factors as well as physicochemical parameters (Jeje and Fernando, 1986). In lentic system zooplanktons are represented by taxonomic group of Rotifera, Cladocera, Copepoda and Ostracoda. Rotifera is the second most abundant group of zooplankton.

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

Study site	Diversity Index	Species Richness	Species Evenness
R-1	1.638	3.743	0.437
R-2	1.610	3.579	0.450
R-3	1.612	3.728	0.432
R-4	1.129	3.568	0.316
R-5	1.661	3.255	0.509
R-6	1.969	3.319	0.594
S-1	1.262	3.060	0.412
S-2	1.322	3.000	0.445
S-3	2.870	2.698	1.064
S-4	2.468	2.698	0.914
S-5	6.235	2.544	2.451
S-6	1.764	3.290	0.536

Rotifers are the most important soft-bodied metazoans (invertebrates), are prominent group among the zooplankton of a water body irrespective of its trophic status. This may be due to the less specialized feeding, parthenogenetic reproduction and high fecundity (Kalff, 2002). The rotifera group is generally represented by 6 genera. The most dominant being *Brachionus sp.*, represented by 3 species viz., *Brachionus diversicornis*, *B. bidentata*, and *B. quadridentata*. 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 as well as eutrophic 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, 1995). Studies carried out by Liang *et al.*, (1981) and 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. Dhanapathi (2000) found that they increase in large quantity rapidly under favourable environmental conditions.

Purushothama *et al.*, (2011) has observed that rotifers show negative correlation with nutrients like phosphorus and phosphate. Similar observation supported by Sachinkumar *et al.*, 2015 that high density of rotifers was recorded from lower phosphorus and phosphate containing water bodies during present study. In our present study R-1, R-3 & R-6 has recorded as rotifer dominancy as well as low phosphate contained.

Cladocerans are a crucial component of zooplankton community. The group appears to proliferation more in ponds, lakes and reservoir. This group occupies a prime place in pisciculture activity because of two seasons viz., 1) They attain a maximum population within a short time that the parthenogenic reproduction. 2) This crustaceans forms an important food source for various kinds of fishes. Among zooplankton, Cladocera was the dominant group. This group is represented by *Daphnia sp.*, *Moina sp.*, *Ceriodaphnia sp.* and *Bosmina sp.* They have psychomorphic characters which leads several taxonomists to draw attention for the study. 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. S-6 pond showed very high population of the Cladocera, where in S-1 & S-2 Cladocera were absent where bicarbonate is abruptly low and organic matter as well as soil carbon is high in compare to other pond.

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). It

is reported that Calanoid Copepods best adapt to oligotrophic lakes, and Cyclopoid Copepods best adapt to eutrophic lakes (Gannon and Stremberger, 1978). In addition to rotifers, a low density and diversity of Copepods in the water body provides additional evidence of the presence of high amount of organic components. In present study in S-6 Copepods shows the dominancy and R-1, R-2 & S-1 pond showed a moderately high population of Copepodian compare to other pond Copepoda domination may also be due to their feeding on diatoms, Rotifera and Cladocera, (Hutchinson, 1967) and high reproduction capacity.

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 the present investigation, R-2 and S-6 showing the maximum population where as in S-1 and S-5; Ostracodan population is absent.

Larva, mainly Nauplius and Zoea and Protozoa as *Paramoecium*, *Euglena* etc., showed very dense population in Ramsagar Zone ponds which are moderately manicured, where in Bankura Zone the population is low. These larvae are maintaining the Crustacean population in those aquatic bodies.

Again in the Ramsagar zone worms generally nematods are found modarately in counting, while only S-6 in Bankura zone gives the population. These worms may not suitable or hygienic for human activites but they are ecofriendly in fish culture as well as aquatic eco system.

Highest species diversity Index as well as species evenness is observed in S-5 where species richness is low (**Table-3**). Instead of high diversity index, there found the absence of one zooplankton group as evenness is high. In the present study it is found that in the Bankura zone there abruptly microfaunal population distributed throughout the season as there are no maintenance and manicuring treatment is done. In other study area the Ramsagar zone ponds shows all the parameter as Diversiy Index, Species Richness & Species Evenness are averagely maintain and no such abnormal Species Dominancy founded. Therefore, the knowledge of their abundance, species diversity and special distribution is important in understanding trophodynamic and tropic progression of water bodies. Thus the Ramsagar Zone is considered to be a suitable one for natural fin-fish and shell-fish (pisciculture) culture practices. 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:-

It is necessary to maintain proper zooplankton community to draw out the pond condition in relation with particular nature of work on the pond. Zooplanktons are the connector of autotrophs and heterotrophs. Density of zooplanktons is directly correlated with fishery potentiality. The results obtained during the present study clearly demonstrate the richness of the rotifer component of the zooplankton probably due to high microhabitat diversity. In present study, it is clearly noticed that if ponds are manicured by the proper way through using fertilizer and other material that regulate physico-chemical factor which ultimately lead to change the biological factors.

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