CHAPTER 5: RESULTS

Results:

Present Status of Fish Farming and Livelihood of Fish Farmers in Purulia District

The western most districts like Purulia having red lateritic soil and primarily being rain fed have fallen behind the rate of growth in terms of productivity in this field. The production of fish in this district is not much encouraging though a large no. of tanks and reservoirsare there.

Fish Farming Status

Pond Size and Depth:

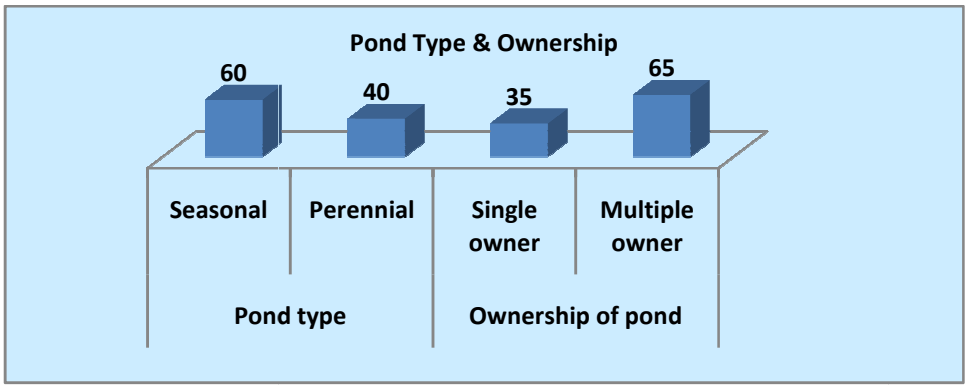
Pond size is an important factor because all management measures are planned considering the size of ponds. In the present study the average pond size was 0.13 to 0.65 hac.Khan (1986)stated that fish culture efficiency greatly varied with the size of the pond. The average depth of the pond in the study area was 2-5 meter.

Pond type and Ownership of the Pond:

In the present study area 60% of the ponds are seasonal and rests of the ponds (40%) are perennial (Table 3). The seasonal ponds are completely dry during summer season and become unsuitable for fish culture. They retained water in the month of June to month of December. The water levels of perennial ponds are also to be declined during summer month especially in the month of Feb and March. It was observed that highest no of pond i.e 35% are of single owner and rests of the 65% pond are joint or multiple owners. Multiple pond ownership was major constraint in pond aquaculture.

Table No 3:

Pond type	**% of Farmers**	**Ownership of pond**	**% of Farmers**
Seasonal	60%	**Single owner**	35 %
Perennial	40 %	**Multiple owner**	65 %



Cultured Fish Species and Stocking Density:

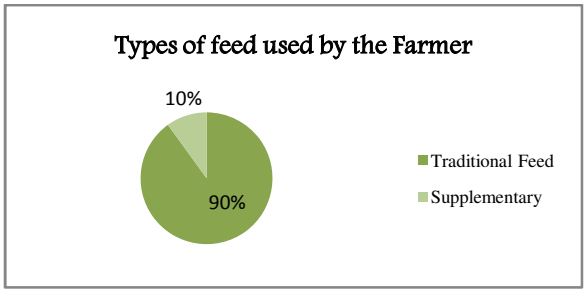
The fish farmers of the district traditionally cultured different varieties of fishes in polyculture system where species ratio and water quality management is not maintained scientifically throughout the culture period. It was revealed from the field study that the fish farming season in the study area was from June to January. Farmers mainly stocked fries when they become easily and cheaply available in the month ofJune to July and harvested at the end of the cultureperiod i.eDecember to January. In this system farmer cultured mainly Indian Major Carps, Catla (*Catla Catla*), Rohu (*Labeo rohita*), Mrigal (*Cirrhinus mrigala*) and Exotic fishes like Silver carp (*Hypophthalmichthys molitrix*), Grass carp (*Ctenoparyngodon idella*), and Common carp (*Cyrinus carpio*).No such stocking density was maintained by fish farmers of Purulia District.

Fertilization and Manuring System:

Maintenance of a healthy aquatic environment and production of sufficient fish food organisms (plankton) in ponds are two factors of primary importance for successful pond culture operation. During survey it has found that no specific fertilization and manuring schedule has been followed by the fish farmers of Purulia district during the culture period. They often used raw cow dung and poultry manure during pond preparation and culture period but that was nothing in respect of the need. They also have a wrong concept that more clear water (more transparent) means more production.

Feed and Feeding Practices:

Supply of supplementary feeds, which can complement nutritional deficiency, is important to increase fish production. Form the survey it was found that 90 % farmer depends on natural food found in the culture system and rest of the 10 % farmer applied supplementary feed such as rice bran, mustard oil cake and commercially manufactured feed. It is also mentioned that the farmers those applied supplementary feed in their culture system don't follow any standard rate of feeding or frequency.



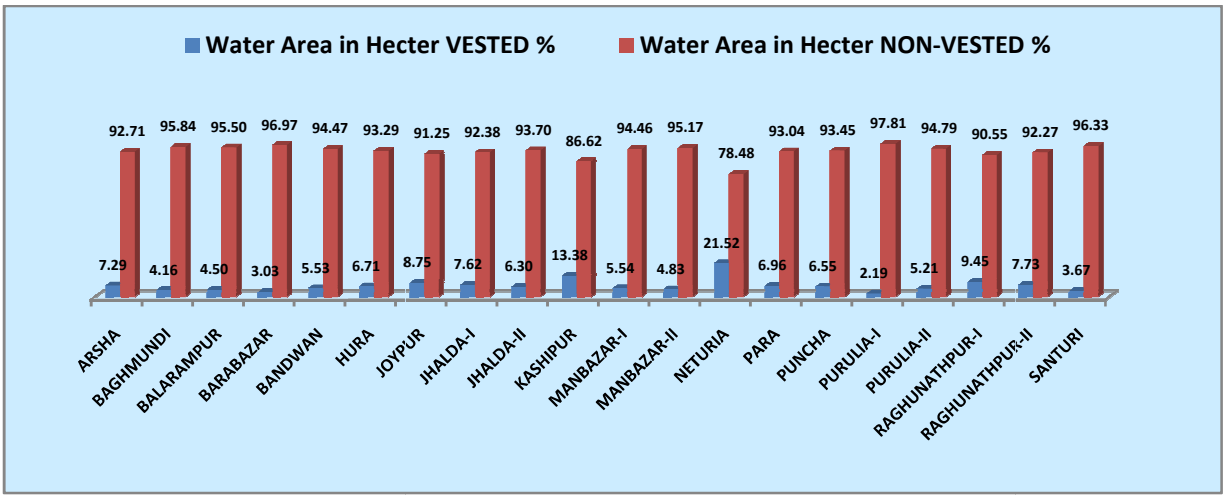
Fish Production, Harvesting and Marketing:

In the district of Purulia, the average yield of fish was found to be 2000 to 2500 kg/ha/yr. The annual production varies because of differences in farm size, feed, seed, other inputs and management measures. Farmer's harvested fish by using cast net locally known as *Fekajal or kheplajal*. Harvested fish were kept in hundi or bamboo baskets. According to survey it reveals that around 70% fish were sold by the farmers to local *paikers* and the rest 30% consumed by the households and given to the relatives.

Table 4: **Impounded water area of Purulia District**(As per the record of O/o the Assistant Director of Fisheries, Purulia, 2015)**:**

Sl. No.	Name of Block	No. of Mouza	Water Area in Hecter		
			VESTED	NON-VESTED	TOTAL
1	**ARSHA**	96	92.86	1180.96	1273.82
2	**BAGHMUNDI**	142	30.18	695	725.18
3	**BALARAMPUR**	94	50.55	1073.52	1124.07
4	**BARABAZAR**	216	49.85	1596.55	1646.4
5	**BANDWAN**	135	15.53	265.33	280.86
6	**HURA**	116	81.8	1137.06	1218.86
7	**JOYPUR**	113	76.96	802.12	879.08
8	**JHALDA-I**	143	47.61	577.13	624.74
9	**JHALDA-II**	131	57.7	857.85	915.55
10	**KASHIPUR**	211	157.32	1018.36	1175.68
11	**MANBAZAR-I**	244	43.17	735.54	778.71
12	**MANBAZAR-II**	136	22.71	447.42	470.13
13	**NETURIA**	126	131.04	477.86	608.9
14	**PARA**	136	88.56	1184.42	1272.98
15	**PUNCHA**	109	65.06	928.67	993.73
16	**PURULIA-I**	118	19.26	861.48	880.74
17	**PURULIA-II**	115	64.43	1171.3	1235.73
18	**RAGHUNATHPUR-**	107	90.29	865.3	955.59

	I				
19	**RAGHUNATHPUR-II**	107	69.24	826.52	895.76
20	**SANTURI**	104	22.74	596.44	619.18
	TOTAL	**2699**	**1276.86**	**17298.83**	**18575.69**



Fisher Folk Population:

According to Hand Book of Fishery Statistics, Govt of West Bengal (2014 -15) total 142 no of Fishing Village is there. Total 8008nos of Fisher Folk Family of the District are available. Among which male is 28580 and female is about 27462 **(Hand Book of Fishery Statistics, Govt. of West Bengal, 2014 -15)**.

Fish Based Industries in Purulia:

According to Hand Book of Fishery Statistics, Govt. of West Bengal (2014 -15) there are 9 no's of Ice plant in Purulia District with a production capacity of 11 ton, and Indian Major Carp (IMC) hatchery 3 no's present. There are 8 no's of Whole sale market where 42 no's of Whole seller available. There are 58 no's Retail Market and562 no's of retailer sell fish and fishery product. **(Hand Book of Fishery Statistics, Govt. of West Bengal, 2014 -15)**.

Fisherman's Co – operative Societies and Fish Production Groups, Women SHGs:

In the district there are one Central Fisherman Co – operative Society (CFCS) and 48 Primary Fisherman Co –operative Society (PFCS). Total five thousand seven hundred sixty nine (5769

no's) no's of people are engaged in fishery activity of Primary Fisherman Co –operative Society (PFCS). There are 27 Fish Production Group (FPG) present in the district. (**Assistant Director Fisheries, Purulia, 2014-15**).

List of Fishermen's Co-operative Society Ltd. for Purulia District:

The information taken from Assistant Director of Fisheries, Purulia, there is one Central Fisherman Co – operative Society and fourty eight (48) primary fisherman co – operative society in thedistrict. These 48 primary fishermen co – operative society spread over all twenty blocks of the district. The name of the primary fishermen co – operative society are Lagda FCS Ltd, Durku FCS Ltd, Sri Durga FCS Ltd, Manasatala FCS Ltd, Purulia MSS Ltd in Purulia I Block, Balarampur kaibartapara FCS Ltd, Charrah FCS Ltd, Golamara FCS Ltd in Purulia II Block, Baraurma FCS Ltd, Chhotogado FCS Ltd, in Balarampur Block, Bandwan FCS Ltd in Bandwan Block, Baghmundi Thana FCS Ltd in Baghmundi Block, Burda kalimati anchal FCS Ltd, Kangsabati MSS Ltd, Kurkutia Adibasi FCS Ltd, Manbazar-I Panchayat Samity FCS Ltd in Manbazar-I Block, Kumari Bargoria FCS Ltd in Manbazar-II Block, Anandabazar FCS Ltd, Puncha FCS Ltd in Puncha Block, Kalabani FCS Ltd, Keshargarh FCS Ltd in Hura Block, Babirdih Matsajibi samabai samity Ltd, Kashipur-Napara FCS Ltd, Beko- Rangiladih FCS Ltd in Kashipur Block, Shalka Ma Bishahari FCS Ltd, Bero FCS Ltd, Durmut Ma Manasa FCS Ltd, Arrah FCS Ltd, Raghunathpur Chandigoria FCS Ltd, Shanka FCS Ltd, Biltora ma manasa FCS Ltd, in Raghunathpur I Block, Chelyama Kargali FCS Ltd, Narendrapur FCS Ltd in Raghunathpur II Block, Muradih FCS Ltd, Brindabanpur FCS Ltd in Santuri Block, Garh panchakot FCS Ltd in Neturia Block, Para FCS Ltd, Surulia FCS Ltd in Purulia Block, Joypur kaibartapara FCS Ltd in Joypur Block, Pusti FCS Ltd, Rupai tribal FCS Ltd, Jhalda FCS Ltd in Jhalda I Block, Noahatu FCS Ltd, Begunkudar FCS Ltd in Jhalda II Block, Hentjari FCS Ltd, Palpal FCS Ltd, Rangamati FCS Ltd in Arsha Block.

Production of fish seed in Purulia District:

According to Hand Book of Fisheries Statistics, Govt. of West Bengal, (2014 – 15) the fish seed production in the year 2002 – 2003 was 10 million tons and gradually it was increasing. The highest fish seed production occurs in the year 2007 – 2008. It was in two hundred thirty million tons (230 million tons) in the year 2007 – 2008. Rest of the year the range varies in between 10 – 230 million tons.

Inland Fish Production of Purulia District:

The district has huge inland fishery resources in the form of pond, tank, and big water bodies mainly in the form of bandhs and reservoir. The district Purulia occupies maximum area under semi-derilict water bodies. Most of these water bodies are good source of Aquaculture. The Inland fish production of the district in the year 2010 – 2011 was fourty one thousand one hundred sixty tons (41160) (**Hand Book of Fisheries Statistics, Govt. of West Bengal, 2014 – 15**). The inland fish production of the district shows increasing trend. The fish production was found highest in the year 2014 – 2015. It was in fourty four thousand seven hundred twenty five tons (44725 tons). (**Hand Book of Fisheries Statistics, Govt. of West Bengal, 2014 – 15**)

Water Area covered under Fish Farmers Development Agency(FFDA) in Purulia District:

The highest water area covered in FFDA was occurring in the year 2008 – 2009, i.e 33.36 ha. In the year 2012 – 2013 it was in 19.80 ha. The lowest water area coverage occurs in the year 2009 -2010. Rest of the year the range varies in between 12.92 hac. to 33.36 hac. (Hanbook of fishery statistics, govt. of West Bengal 2014 - 15)**.**

The F. F. D. A. ponds are the good source of fish production. The fish production in F. F. D. A.pond was found high in the year 2010 – 2011 i.e 149.93 tons and lowest value occurs in the year 2012 – 13. In the year 2012 – 13 it was in 108.11 ton. Rest of the year the range varies in between 108.11 ton to 149.93 ton.

Dams and Reservoir Fishery Resources of the District:

The state West Bengal has 21 districts but the western most districts like Purulia have large no of water bodies mainly in the forms of reservoirs and pond. The district Purulia having total 36 no's reservoir covering 5557.74 ha water area and spreadover 19 blocks of the district (**Hand Book of Fisheries Statistics, Govt of West Bengal, 2014 - 15).**

The name of the reservoir which spread over the 19 blocks of the district are Bandu, Upper Bandu in Arsha Block, Sankha,Khairabera, Turga inBaghmundi Block, Kumari, Hanumata, Barabhum in Balarampur Block, Tatko, Popo, Nagintanr, Jamunajore in Bandwan Block, Futiari, in Hura Block, Patloi, Golamarajore, Pithajore, Jamunajore in Purulia II Block, Rupai, Karior, Narahara in Jhalda – I Block, Saharjore, Dimu, Parga in Jhalda – II Block, Dangra, Majra, Beko in Kashipur Block, Kumari – Kangsabati in both Manbazar I and Manbazar II Block, Panchet in Neturia Block, Taragonia, Lipaniajore, Hori in Para Block, Chaka in Puncha Block, Tara inPurulia I (Handbook of Fishery Statistics, Govt. of West Bengal, 2014 – 15).

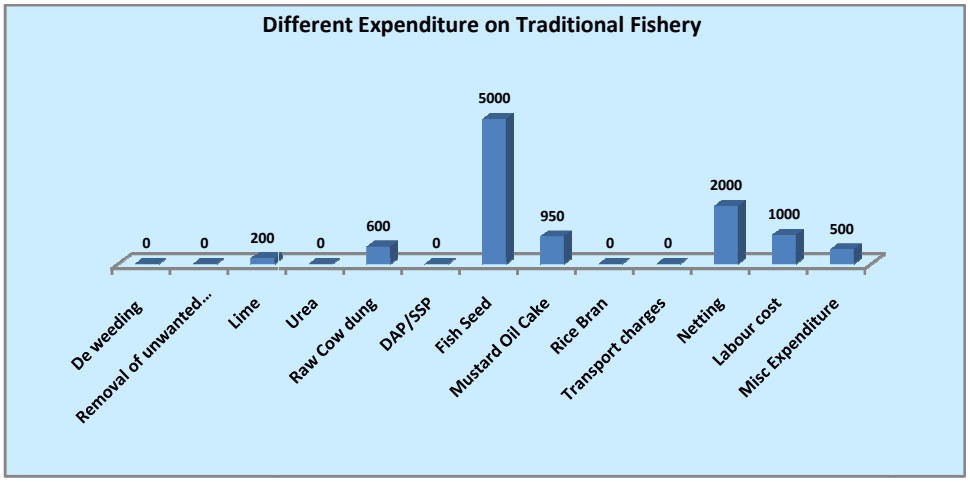
Problem faced by fish farmers of Purulia District:

The fish farmers of Purulia districts faced a wide variety of problem. Among the different problems faced by freshwater fish farmers of Purulia districts are diseases, financial problem, multi ownership pond, market price fluctuation and non-availability of good quality fish seed were the major ones. Non availability of Drugs and chemicals for prevention of fish disease is another major problem in case of Purulia District. Survey result reveals that in Purulia district 50 % to 55 % farmers are suffering in financial crisis. The fish farmers complained about the lack of financial assistance from the state Government and banks. Many of them were forced to avail loans from private sources with high interest rates. Most of the farmers complained about the lease period, and policy. Leasing period is a major problem in case of Purulia district. Here most of the farmers depend on lease rented water body because most of the tank is multi ownership type. Most of the cases lease period is 3 years or to some extent it is 5 yrs. But to avail credit facility from any financial institute under govt. subsidiary scheme like FFDA, at least lease period of 7 yrs is necessary.Likewise, lack of finance and poaching were reported as the major concerns.

Average Economics of the Traditional Fish Farming:

Culture system	**Traditional Culture (followed by fish farmers of Purulia)**		
Ingredient	**Amount (Kg)**	**Unit Price (Rs.)**	**Amount (Rs.)**
De weeding	0		0
Removal of unwanted Fish (MOC)	0		0
Lime	20	10	200
Urea	0		0
Raw Cow dung	LS	600	600
DAP/SSP	0		0
Fish Seed	LS	5000	5000
Mustard Oil Cake	50	19	950
Rice Bran	0	0	0
Transport charges	0	0	0
Netting	4	500	2000

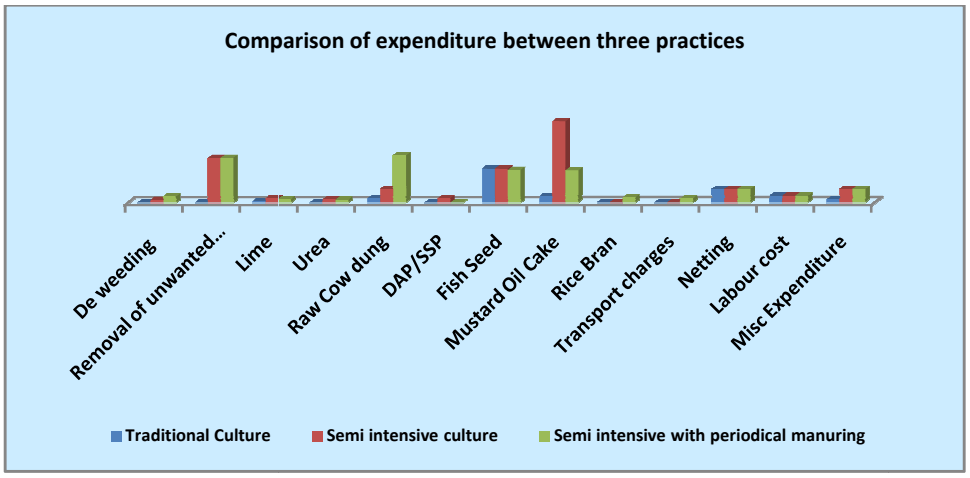
Labour cost	0	1000	1000
Misc Expenditure	LS	500	500
Total			10250
Production (Kg)			
Income from sale	180	80	14400
Net Income			14400
Net return on expenditure %			4150
B:C ratio			40.488

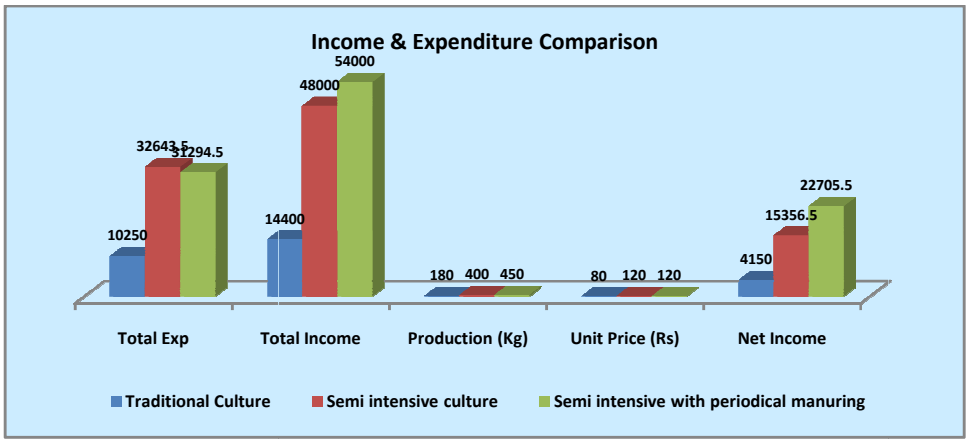


Econometry of Fish culture in trial pond under different management practices in 6 months culture period (Unit area: 0.13 hac.)

Culture System	Traditional Culture (followed by fish farmers of Purulia)			Semi intensive culture (following FFDA model scheme, Govt. of WB)			Semi intensive with periodical manuring (15 days interval)		
Ingredient	Amount (Kg)	Unit Price (Rs)	Amount (Rs)	Amount (Kg)	Unit Price (Rs)	Amount (Rs)	Amount (Kg)	Unit Price (Rs)	Amount (Rs)
De weeding	0		0	LS		350	LS	0	900

Removal of unwanted Fish (MOC)	0		0	330	20	6600	330	20	6600
Lime	20	10	200	65	10	650	50	10	500
Urea	0		0	45	10	450	40	10	400
Raw Cow dung	LS	600	600	1333	1.5	1999.5	4663	1.5	6994.5
DAP/SSP	0		0	66	9	594			0
Fish Seed	LS	5000	5000	1000	5	5000	1200	4	4800
Mustard Oil Cake	50	19	950	500	24	12000	250	19	4750
Rice Bran	0	0	0			0	250	3	750
Transport charges	0	0	0			0	LS	600	600
Netting	4	500	2000	4	500	2000	4	500	2000
Labour cost	0	0	1000			1000			1000
Misc Expenditure	LS	500	500			2000			2000
Total			10250			32643.5			31294.5
Production (Kg)	180	80	14400	400	120	48000	450	120	54000
Income from sale			14400			48000			54000
Net Income			4150			15356.5			22705.5
Net return on expenditure %			40.488			47.04305604			72.5542827
B:C ratio			0.4			0.47			0.72





Livelihood Status of Fish Farmers:

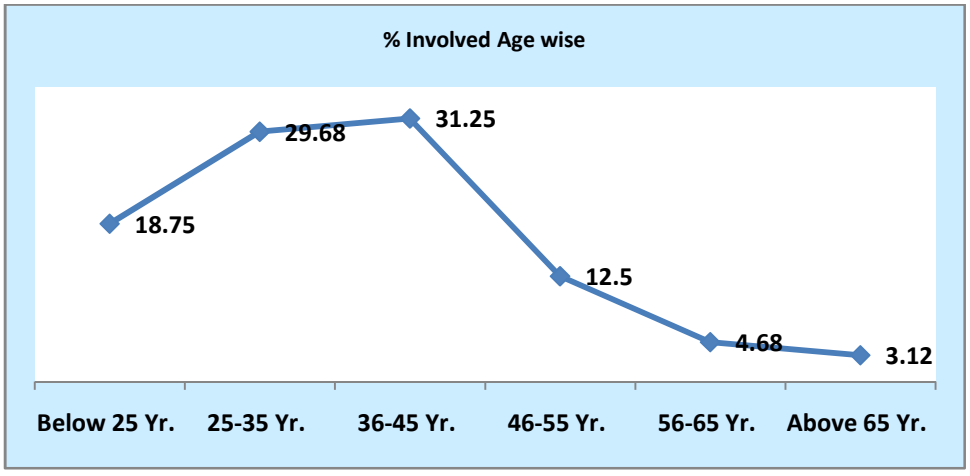
Age:

From (Table), it depicts that the maximum percentage of fish farmers were within medium age group (i.e. between the age group 36 to 45 years). The involvement of the age group of 36-45 years is mainly due to unemployment. Through this modified scientific fish farming; they wanted to establish themselves in the society within a short period of time, taking into consideration the lucrative return within a very short period. The young generation invested money from their parental sources viz. retirement benefits of their guardians, the amount received from the in law'sfamily, taking loans from bank or other sources and invested the money in this sector to generate the income and upgrading the social lively hood status. In the case of the age group of

46-65 years, most of them are basically involved with other business and they invested here to increase their level of income.

Table no 5: Age Distribution of the Selected Fish Farmers of selected Blocks under Purulia District

Stations / Age	Arsha Dev. Block	Balarampur Dev. Block	Purulia II Dev. Block	Hura Dev. Block	Kashipur Dev. Block	Para Dev. Block	Total	% Involved
Below 25 Yr.	2	2	2	1	3	2	**12**	**18.75**
25-35 Yr.	3	3	4	2	4	3	**19**	**29.68**
36-45 Yr.	3	4	3	3	4	3	**20**	**31.25**
46-55 Yr.	1	2	1	1	2	1	**8**	**12.5**
56-65 Yr.	0	0	1	0	1	1	**3**	**4.68**
Above 65 Yr.	0	1	0	0	1	0	**2**	**3.12**
Total	**9**	**12**	**11**	**7**	**15**	**10**	**64**	

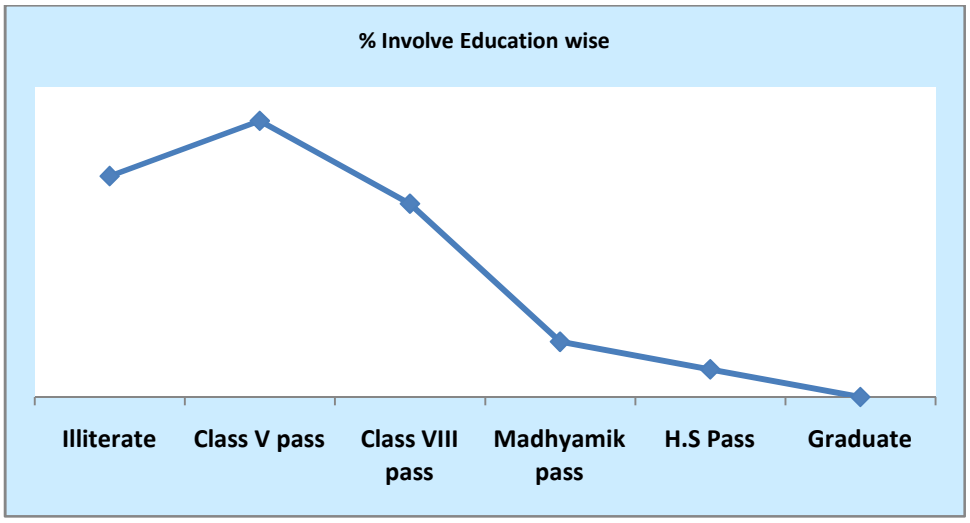


Education:

Historically, Purulia is one of the moderately literate districts in West Bengal. The average literacy rates in West Bengal are 43.29 in 1991; this value increased to 55.57 in 2001. Among all scheduled tribes, 43.4 % of the population has been returned as literate, which is lower than the national average 47.1 %. The male literacy rate of 57.4 % and female of 29.2%, show a gender disparity in literacy. (Census data, 2011, The Scheduled Tribes,Census of India 2011).

Table 6: Distribution of the Level of Education among the Selected Fish Farmers at selected Blocks of Purulia District

Stations / **Edu. Level**	**Arsha Dev. Block**	**Balarampur Dev. Block**	**Purulia II Dev. Block**	**Hura Dev. Block**	**Kashipur Dev. Block**	**Para Dev. Block**	**Total**	**% Involved**
Illiterate	3	3	2	2	3	3	**16**	**28.57**
Class V pass	3	3	4	3	4	3	**20**	**35.71**
Class VIII pass	2	2	2	2	3	3	**14**	**25**
Madhyamik pass	1	0	1	0	1	1	**4**	**7.14**
H.S Pass	0	0	1	0	1	0	**2**	**3.57**
Graduate	0	0	0	0	0	0	**0**	**0**
Total	**9**	**8**	**10**	**7**	**12**	**10**	**56**	



Caste Status:

Caste is one of the important factors affecting the choice of the occupation and possession of skill in different rural economic activities (Singh 2003). From the study area it depicts that most of the people engaged in fish farming activities are in the category of SC community (50%) and their sub caste is 'Dhibar' and 'Jelia kaibarta'.

Gender:

It depicts from the study that out of 60 respondent only 3 women (5%) heading their households and they are mainly the widows through fish farming.

Family Size and Type:

The family size has considerable influence on the income and expenditure of the family. Family size reflects the supply of family labour which played a vital role in fish farming. Investigated families were divided into three family size groups viz., small family (<4 Member),medium Family (4 - 6 Member) andLarge Family (> 6 Member). The highest 46.67 % of the respondents had 4 – 6 family members whereas the lowest only 23.33 % had less than four family members. In the present study, families were classified into two types as nuclear and joint family. About 65% of farmers lived in joint families and 35% in nuclear families. Joint family was predominant in the study area.

Table 7: Family size and type

Sl. No	Family Type	Total (%); N = 60
01	Joint Families	42 (70%)
02	Nuclear Families	18 (30%)

Sl. No	Family Size	Total (%); N = 60
01	Small Family (<4 Member)	14 (23.33 %)
02	Medium Family (4 - 6 Member)	28 (46.67%)
03	Large Family (> 6 Member)	18 (30%)

Financial Capital:

Sources of Credit:

It was found that most of the farmers used their own money for fish farming, and very few farmers received loan from bank for farming activities. Small marginal farmers were found in disadvantageous situation due to poor financial resources for fish farming and they did not have financial support from institutional credit.

Occupational Status:

In the study area the primary occupation of the respondent are categorized into four types these are farmers, businessman, govt. employee and wage earner.

Most of the fish farmer in Purulia district was involved in fish farming as their secondary occupation. From the present study it reveals that 25% to 30% of fish farmer were engaged in fish farming as their main occupation while 40% were in agricultural activity, 25% in business and rest of the 10% in service sector.

Experience in Fish Farming:

Experience plays a vital role in efficient utilization of resources and getting better output in any venture particularly in agricultural sector as it is the core factor in generation of traditional knowledge. In the present study the farmer has experience of 5 -10 years on an average in fish farming.

Annual Income:

Income determines standard of living, income is highly correlated to almost all indicators of well being. In the study area the investigated fish farmers were divided into four categories having annual income of up to 25,000; 25,001 to 50,000; 50,001 to 75,000 and above 75,000.

Table no. 8: Annual Income of Fish Farmers of Purulia District

Sl. No.	Income category	No of Fisherman under that category (N = 60)	Percentage (%) of that particular category
1	Rs. 25000.00	15	25%
2	Rs. 25001 – Rs. 50000.00	24	40%
3	Rs. 50001 – Rs.75000.00	15	25%
4	Above Rs. 75000.00	6	10%

Housing Condition:

The nature of the house indicates the social status of the people. From the present study it was found that most of the house of fish farmers was earthen house (70%), then brick wall (20%), and rest of the 10% brick wall with RCC roof.

Health Facilities:

Health facilities of the fish farmer were poor and they were not quite conscious about their health. From the study it was found that 70% of the fish farmers dependent on village doctors or the doctors of the Block Primary Health Centre. While 20% of the farmer got health services from Purulia Sadar Hospital. In some critical cases 10 % farmers referred to the outside of the District Ranchi.

Drinking Water Sources:

The provision of clean and safe drinking water is considered to be the most valued element in the society. The study showed that 100% of fish farmers used tube well water for drinking purposes.

Markets used for selling fish:

Most of the fish farmers sold their fish products first in the local markets. If the catch is more then they brought their product to Purulia Barohat Market. In some cases they sold their products nearby by districts like Jharkhand.

Reason for initializing a fish farm:

In the study area most of the farmers (60%) involved themselves with fish farming as their ancestral are also doing the same type of culture and they also wants to continue their family occupation. 20 % fish farmer engaged themselves in fish farming activities to supplement their family income. Only 8.33% of them want to maintain their economic status through fish farming. Rest of the 11.66 % farmers wants to improve their social status through fish farming activities.

Table no 9: Reason for initializing a fish farm

Sl. No	Reason	Total No of farmers involved (N= 60)	Percentage (%)
1	To continue family occupation	36	60%
2	To supplement family income	12	20%
3	To maintain economic status	5	8.33%
4	To improve social status	7	11.66

Seasonal Variation of Water quality parameter of Purulia District

Physico-chemical parameters

Temperature:

Seasonal variations in the values of physico-chemical parameters in the water body of Purulia District during studyperiod are shown below. During the study period, the mean water temperatures varied from minimum 17.19^{0}C in winter season and maximum 28.06^{0}C in Pre Monsoon months.Similar type of temperature variation found in Bankura dist by several workers. (Singh and Gupta, 2004; Sen *et. al.*, 2011; Srivastava and Srivastava, 2011; Siddiqi S. Z. and Chandrasekhar S.V. A. 2010).

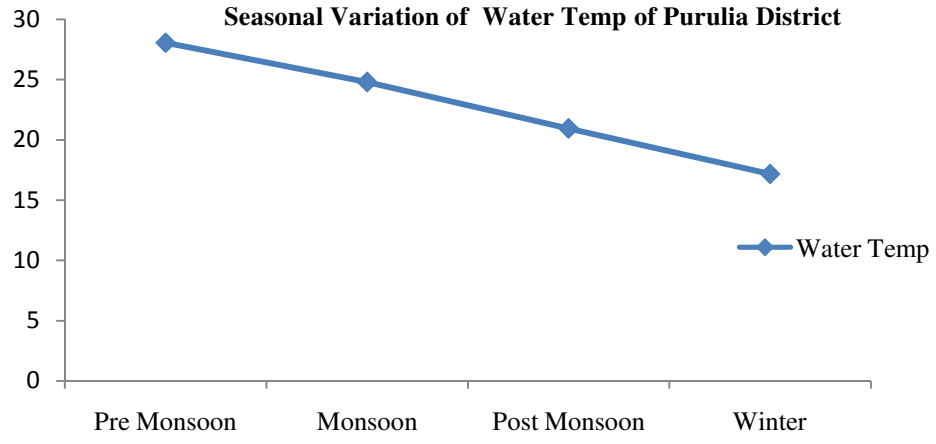


Fig 1: Seasonal Variation of Water Temperature of Purulia District

Temperature ANOVA:

Table no. 10: ANOVA of water temperature shows significant differences between seasons (P< 0.01) but do not show significant differences between sites (P> 0.01).

Two way ANOVA between sites and seasons for Water Temperature						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	1.9837833	5	0.396756667	0.146915656	0.977914829	4.555613984
Between Seasons	399.77873	3	133.2595778	49.34490069	5.25987E-08	5.416964863
Error	40.508617	15	2.700574444			
Total	442.27113	23				

pH:

The average pH value of the water bodies of the Purulia District during the study period varies from minimum 6.93 in winter season to maximum 7.45 in pre monsoon month. In the present investigation the average pH ranges between 6.93 - 7.45 shows near neutral to slightly alkaline condition of the pond water body.Higher value of pH in summer season may be due to low waterlevel in the pond and high photosynthesis of micro and macro organism resulting in high production of carbon dioxide which make the water little alkaline (Ganguly *et. al*., 2017). This result has been supported by the finding of Chaurasia and Pandey at Ajodhya, Faizabad (2007).

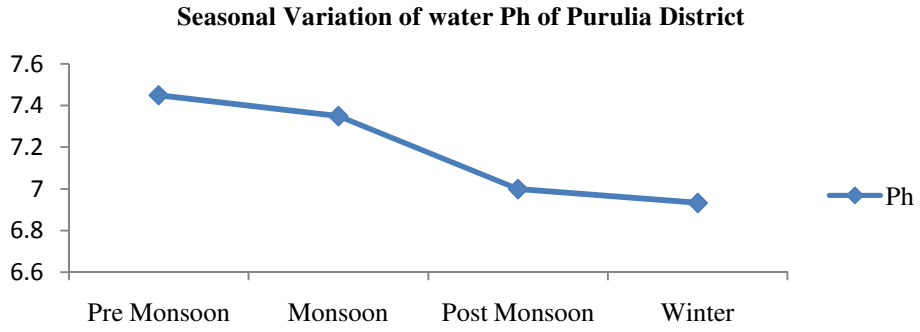


Fig 2: Seasonal Variation of Water pH of Purulia District

pH:

Table no. 11: ANOVA of water pH shows significant differences between seasons (P< 0.01) but do not show significant differences between sites (P> 0.01).

Two way ANOVA between sites and seasons for Water pH						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.3283333	5	0.0656667	0.989949749	0.456174167	4.555613984
Between Seasons	1.17	3	0.39	5.879396985	0.007332511	5.416964863
Error	0.995	15	0.0663333			
Total	2.4933333	23				

Dissolved oxygen (DO):

In the present study minimum dissolved oxygen concentration was recorded in Summer Season i.e Pre Monsoon month 3.8 mg/lt and maximum of 4.5 mg/lt in Monsoon month. Ganguly *et al.* 2017 also found similar variation at Bankura district. During the study period the mean value of DO ranges from 3.8 to 4.5 mg/lt.This may bedue to difference in water temperature. In high temperature thesolubility of oxygen is lowered and also the organic substancesare degraded. Concentration of D.O is inversely proportional totemperature at a given time. The amount of D.O. in water is directly or indirectly dependent on water temperature, partial pressureof air etc. Similar results were observed by Kamal *et. al.*, (2007).

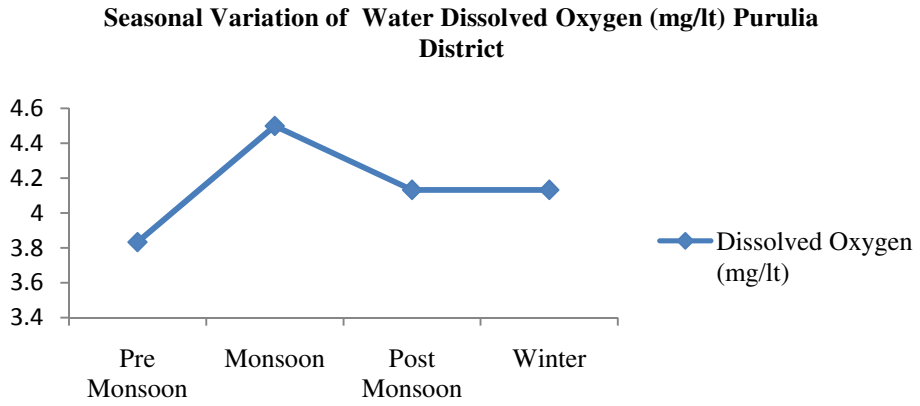


Fig 3: Seasonal Variation of Dissolved oxygen concentration of Purulia District

Dissolved Oxygen:

Table no. 12: ANOVA of dissolved oxygen of water shows significant differences between seasons and between sites also (P< 0.01).

Two way ANOVA between sites and seasons for Dissolved Oxygen of Water						
Source of	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***

Variation						
Between Sites	1.115	5	0.223	13.653061	3.92146E-05	4.555613984
Between Seasons	1.34	3	0.4466667	27.346939	2.49717E-06	5.416964863
Error	0.245	15	0.0163333			
Total	2.7	23				

Transparency:

During the study period the higher values of transparency was observed during post monsoon month's i.e. 34.51 cm and lower value was observed during Monsoon Season 22.95 cm.The result corroborates with the report ofSaksena *et al*, 2008 and Ganguly *et. al*., 2017.

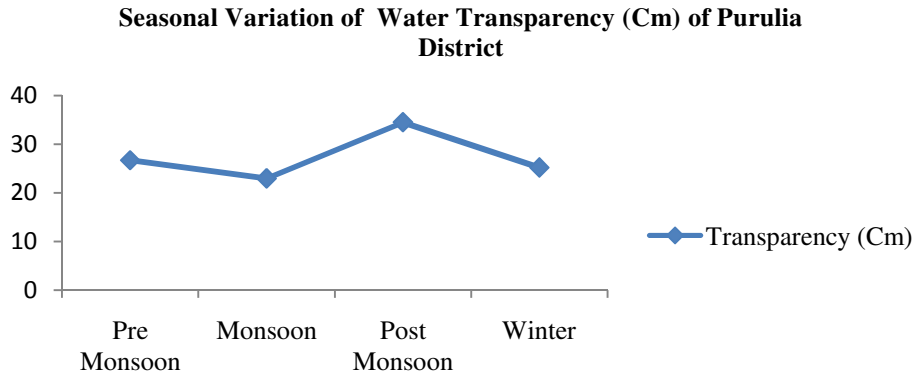


Fig 4: Seasonal Variation of water transparency (in cm) of Purulia District

Transparency:

Table no. 13: ANOVA of transparency of water shows significant differences between seasons but do not show significant differences between sites (P> 0.01).

Two way ANOVA between sites and seasons for Water Transparency						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	39.79548333	5	7.959096667	2.754608937	0.058539414	4.555613984
Between Seasons	453.8672833	3	151.2890944	52.36050133	3.51622E-08	5.416964863
Error	43.34061667	15	2.889374444			
Total	537.0033833	23				

Alkalinity:

In the present investigationalkalinity values varied from 59.54 – 65.36 mg/lt during the four seasons, of which maximum value was observed during pre monsoon month 65.36 mg/lt and minimum value was observed during monsoon month 59.54 mg/lt.Similar result has been recorded by Elayaraj and Selvaraju,2014, and Dutta, T. K.,2014.

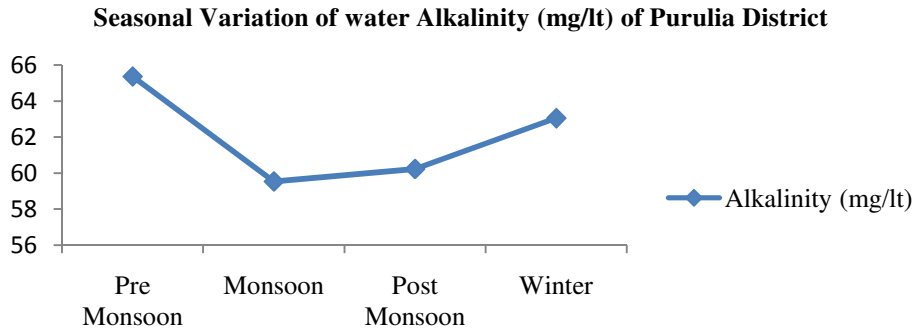


Fig 5: Seasonal Variation of Alkalinity of Water of Purulia District

Alkalinity:

Table no. 14: ANOVA of Alkalinity of water shows not significant difference between sites and season (P> 0.01).

Two way ANOVA between sites and seasons for Alkalinity of Water						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	832.6546333	5	166.5309267	1.2019432	0.354954599	4.555613984
Between Seasons	129.5875667	3	43.19585556	0.3117677	0.816592384	5.416964863
Error	2078.271133	15	138.5514089			
Total	3040.513333	23				

Hardness:

Total Hardness value ranged from 86.41 – 103.47 mg/L in different seasons of which higher value (103.47) in Pre Monsoon and lowest (86.41mg/L) in Post Monsoon season. Kaur and Sharma (2001) reported that generally maximum hardness values in thewater body found at summer. Similar observation found by Majumdar *et. al*. 2015 at Bankura.Increase in hardness value can be attributed to the decrease in water volume andsimultaneous increase in the rate of

evaporation at high temperature, as a result high loading organic substances, detergents and other pollutants (Rajgopal *et. al.*, 2010).

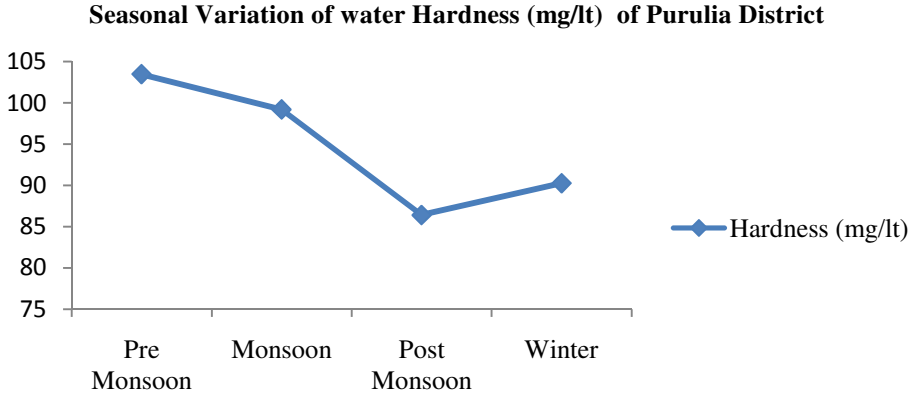


Fig 6: Seasonal Variation of Water Hardness of Purulia District

Hardness:

Table no. 15: ANOVA of Hardness of water shows significant differences between seasons and between sites also (P< 0.01).

Two way ANOVA between sites and seasons for Water Hardness						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	8795.2397	5	1759.0479	25.918172	7.01529E-07	4.555613984
Between Seasons	1112.9756	3	370.99185	5.4662698	0.009668876	5.416964863
Error	1018.0394	15	67.86929			
Total	10926.255	23				

Nutrient parameters:

Nitrate nitrogen (NO_3-N):

During the study period the Nitrate Nitrogen Concentration of pond water of Purulia District varied from 0.0108 to 0.0350 mg/lt. Similar result found by Majumdar *et. al.*, 2015.Maximum Nitrate nitrogen concentration was found in Monsoon Season (0.0350 mg/lt) and minimum value found in Winter Season (0.0108 mg/lt).The high nitrate concentration duringmonsoon might be due to influx of rain water into pond through agricultural field.In present investigation high values of nitrate found in monsoon season due to influx of nutrients from the watershed areas

along with runoff water in monsoon and low value in winter season, kinetics of nitrogen cycling was low due to less decomposition of organic matter and low water temperature.

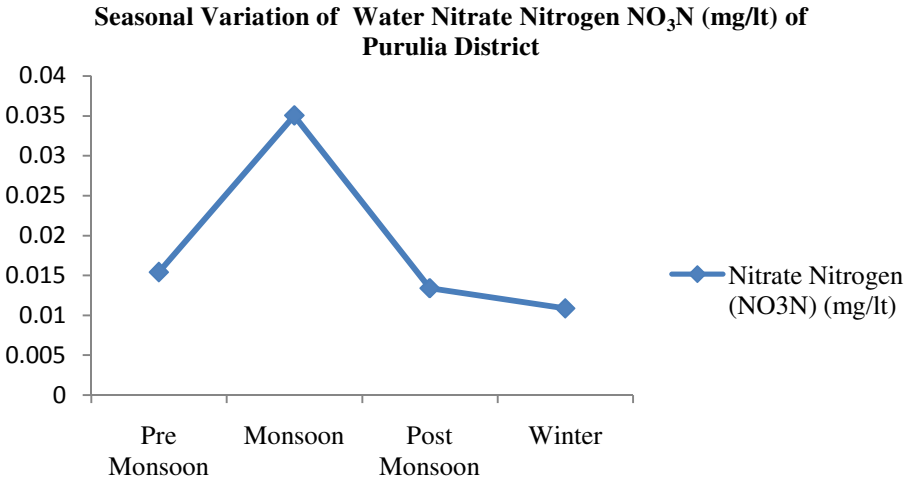


Fig 7: Seasonal Variation of Nitrate Nitrogen Concentration ofWater of Purulia District

Table no. 16: **Nitrate Nitrogen:**ANOVA of Nitrate Nitrogen of water shows not significant difference between sites and season (P> 0.01).

Two way ANOVA between sites and seasons for Nitrate Nitrogen of Water						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.006479008	5	0.001295802	1.946848282	0.14583251	4.555613984
Between Seasons	0.002200483	3	0.000733494	1.102022351	0.37900413	5.416964863
Error	0.009983842	15	0.000665589			
Total	0.018663333	23				

Available Phosphate (P_2O_5):

During the study period the available phosphate concentration of the water body of Purulia District varied from 0.0029 to 0.0044 mg/lt. Similar Observation made by Siddiqi S. Z. and Chandrasekhar S.V. A. 2010.The highest value of available phosphate was found during the Monsoon season and lowest value was found during winter season. Similar observations are made by Lendhe and Yeragi (2004) from Phirange Kharbau Lake, Maharashtra.

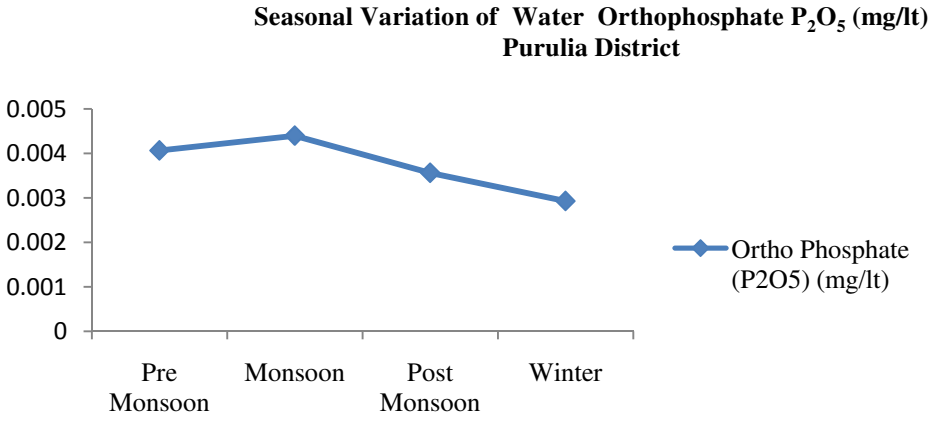


Fig 8: Seasonal Variation of Available Phosphate Concentration ofWater of Purulia District

Orthophosphate:

Table no. 17: ANOVA of Orthophosphate of water shows significant differences between sites (P< 0.01) but do not show significant differences between seasons (P> 0.01).

Two way ANOVA between sites and seasons for Orthophosphate of Water						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.000257243	5	5.14487E-05	22.2935965	1.87405E-06	4.555613984
Between Seasons	7.33833E-06	3	2.44611E-06	1.05994222	0.395348478	5.416964863
Error	3.46167E-05	15	2.30778E-06			
Total	0.000299198	23				

Nitrite Nitrogen (NO_2N):

During the study period the Nitrite Nitrogen concentration of water body of Purulia District varies from 0.010 to 0.017 mg/lt. The highest nitrite nitrogen concentration was found in Monsoon Season and lowest concentration was found in Pre monsoon Season.

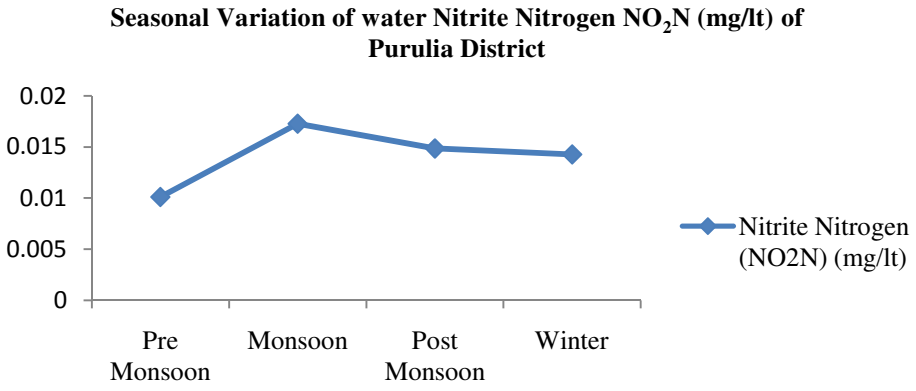


Fig 9: Seasonal Variation of Nitrite Nitrogen Concentration ofWater of Purulia District

Nitrite Nitrogen:

Table no. 18: ANOVA of Nitrite Nitrogen of water shows significant differences between sites (P< 0.01) but do not show significant differences between seasons (P> 0.01).

Two way ANOVA between sites and seasons for Nitrite Nitrogen of Water						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.004968674	5	0.0009937	22.65337	1.68983E-06	4.555613984
Between Seasons	0.000159698	3	5.323E-05	1.2135016	0.33896146	5.416964863
Error	0.000658005	15	4.387E-05			
Total	0.005786376	23				

Table 19: Seasonal Variation of Different Water Quality Parameters of Purulia District

Season	**Pre Monsoon**	**Monsoon**	**Post Monsoon**	**Winter**
Parameter	**Mean ± S.D**	**Mean ± S.D**	**Mean ± S.D**	**Mean ± S.D**
Water Temp	28.066± 0.974	24.813± 0.618	20.963± 2.41	17.19±1.146
Ph	7.45± 0.273	7.35± 0.273	7± 0.236	6.933± 0.242
Transparency (Cm)	26.693± 0.621	22.955 + 3.011	34.511± 1.704	25.203± 2.06
Dissolved Oxygen (mg/lt)	3.833± 0.30	4.5±0.2	4.133± 0.258	4.133± 0.265

Alkalinity (mg/lt)	65.366± 6.03	59.54±16.222	60.235± 8.44	63.051±14.53
Hardness (mg/lt)	103.478± 21.09	99.2± 28.05	86.415± 15.49	90.27±22.15
Nitrite Nitrogen (NO_2N) (mg/lt)	0.0101± 0.006	0.0172± 0.02	0.0148±0.018	0.0142± 0.018
Nitrate Nitrogen (NO_3N) (mg/lt)	0.0154± 0.003	0.0350± 0.05	0.0134± 0.008	0.0108± 0.005
Ortho Phosphate (P_2O_5) (mg/lt)	0.0040± 0.004	0.0044± 0.002	0.0035± 0.004	0.0029± 0.003

Analysis of soil Quality Parameter of different blocks under Purulia District

Bottom soils play an important role in controlling such nutrient transformations, especially the behaviours of the fertilizers in fish ponds (Chattopadhyay, 2004).The significance of bottom soils in influencing availability of different nutrient elements to primary fish food organisms has been discussed in detail by Boyd and Bowman (1997).

The present work illustrates the status of soil in the pond water of Purulia District.Physico-chemical parameters of soil from selected culture ponds wereanalyzed periodically. Physico-chemical properties of soil included soil pH, soil organic carbon, available P_2O_5, available nitrogen. In the present study all parameters were analyzed by standard method and theobtained results are described below.

Table 20: Soil Quality Parameter of different blocks under Purulia District

Soil Quality Parameter of different blocks under Purulia District				
Season	**Pre Monsoon**	**Monsoon**	**Post Monsoon**	**Winter**
Parameter	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Soil pH	6.17 ± 0.25	6.15 ± 0.204	6.15 ± 0.070	6.31 ± 0.149
Organic Carbon (%)	0.45 ± 0.076	0.59 ± 0.08	0.77 ± 0.103	0.659 ± 0.089
Available P2O5 (mg/100gm)	0.575 ± 0.025	0.512 ± 0.01	0.625 ± 0.02	0.683 ± 0.02
Available Nitrogen (mg/100gm)	39.91 ± 1.01	39.58 ± 0.88	41.83 ± 0.62	43.25 ± 0.80

Soil pH:

In the present investigation soil pH range varied from 6.15 to 6.31.A near neutral condition of pH (6.5-7.5) was most favourable for productive ponds.It was observed that both highly acid (pH <5.5) and highly alkaline (pH> 8.5) condition of the soil may be considered undesirable for a fish pond. The optimal soil reaction is a near-neutral condition (pH 6.5-7.5) while average production is expected from moderately acid (pH 5.5-6.5) and moderately alkaline (pH 7.5-8.5) soil. Between these two, moderately alkaline condition is relatively better. In the present investigation the bottom soil pH was high in Winter Season and low in Monsoon Season.

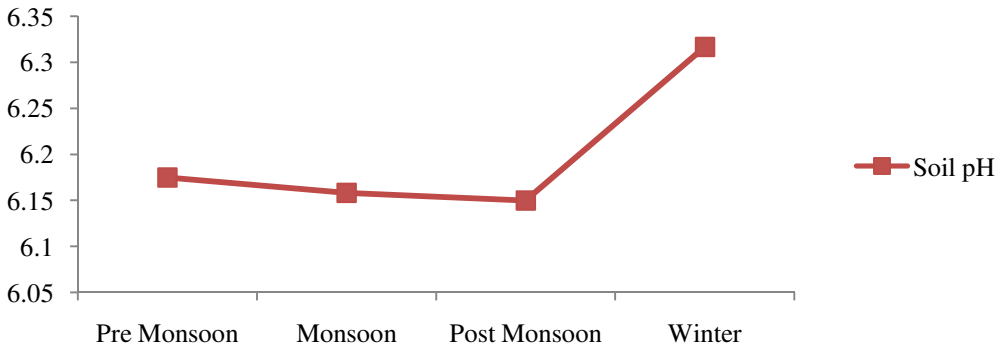


Fig 10: Seasonal Variation of Soil pH of Purulia District

Soil pH:

Table 21: ANOVA of pH of Soil shows significant differences between sites (P< 0.01) but do not show significant differences between seasons (P> 0.01).

Two way ANOVA between sites and seasons for Soil pH						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.4525	5	0.0905	3.9731707	0.0170395	4.55561398
Between Season	0.110833333	3	0.0369444	1.6219512	0.2262835	5.41696486
Error	0.341666667	15	0.0227778			
Total	0.905	23				

Soil Organic Carbon:

In the present investigation the organic carbon value varied from 0.85 mg/100gm of soil to 0.61 mg/100 gm of soil. The highest value of organic carbon was observed during pre monsoon season and lowest value was observed in post monsoon season. As the process of decomposition is temperature dependent it slows down during the winter months leading to the accumulation of organic carbon in pond soil.According to Jhingran (1989) the aquatic soil having organic carbon value 0.5 – 1.5 %, the soil is moderately productive.

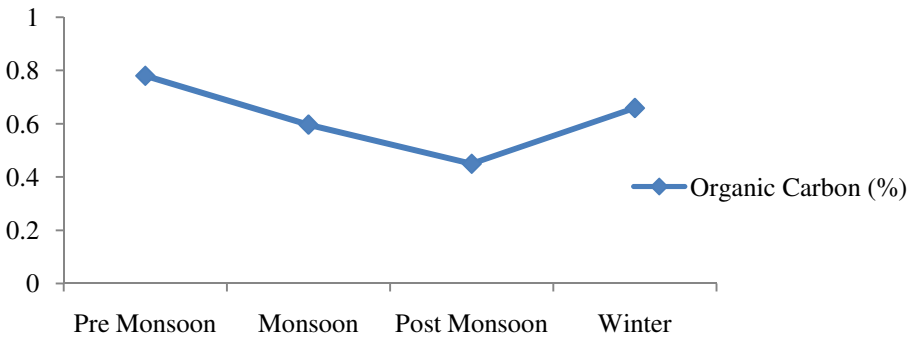


Fig 11: Seasonal variation of Organic Carbon (%) of Soil of Purulia District

Soil Organic Carbon:

Table 22: ANOVA of Organic Carbon of Soil shows significant differences between seasons and between sites also (P< 0.01).

Two way ANOVA between sites and seasons for Soil Organic Carbon						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.14343021	5	0.028686	9.7629222	0.0002639	4.55561398
Between Season	0.33001979	3	0.1100066	37.439318	3.319E-07	5.41696486
Error	0.04407396	15	0.0029383			
Total	0.51752396	23				

Available P_2O_5 of Soil:

In the present study the available phosphorus value varied from 0.512 mg/100gm of soil to 0.683 mg/100 gm of soil. The lowest value was observed during monsoon season and highest value was observed during winter season.

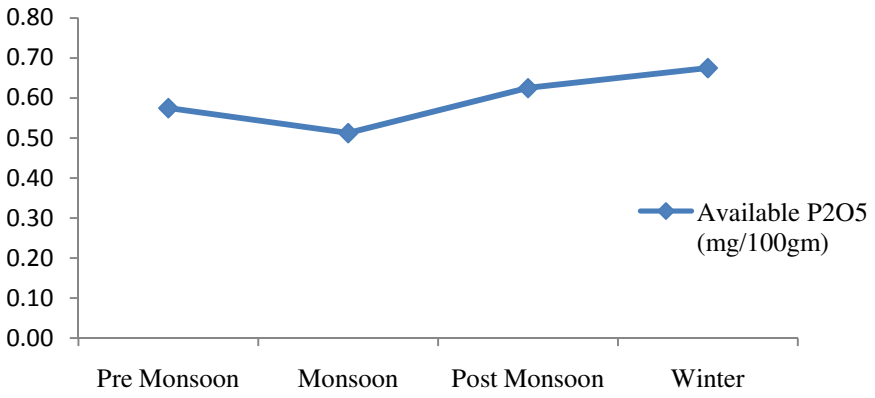


Fig 12: Seasonal Variation ofAvailable P_2O_5 (mg/100gm) of Soil of Purulia District

Available Phosphate:

Table 23: ANOVA of available phosphate of Soil shows significant differences between seasons (P< 0.01) but do not show significant differences between sites (P> 0.01).

Two way ANOVA between sites and seasons for available phosphorus of Soil						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.002395833	5	0.0004792	0.5798319	0.71504265	4.555614
Between Season	0.081041667	3	0.0270139	32.689076	8.024E-07	5.4169649
Error	0.012395833	15	0.0008264			
Total	0.095833333	23				

Soil Nitrogen:

In the present investigation the available nitrogen content varied from 43.25 mg/100 gm of soil to 39.58 mg/100 gm of soil. The available nitrogen content was high during Post monsoon and winter period and low during Pre Monsoon and Monsoon period. Banerjee (1967) has attempted to correlate fish production with the available nitrogen in soil of fresh water fish ponds and

recomended nitrogen in the range of 25 – 75 mg/100 gm soil as relatively more favourable for fish production.

Phytoplankton Analysis of Purulia District

During the study period the phytoplankton diversity was studied seasonally.All the dominant group ofphytoplankton was present throughout the year.Microscopic examination of phytoplankton revealed that there were 4 groups consisting of 23 genera of phytoplankton in order Cyanophyceae (6 genera), Chlorophyceae (8 genera), Bacillariophyceae (7 genera) and Euglenophyceae (2 genera).The phytoplankton identified were:*Anabaena sp*,*Lyngbya sp*,*Microcystis sp*, *Oscillatoria sp*,*Nostoc sp*,*Phormidium sp* (Cyanophyceae);*Ankistrodesmus sp*, *Chlorella sp*,*Closterium sp*,*Mougeotia sp*,*Scenedesmus sp*,*Spirogyra sp*,*Ulothix sp*,*Zygnemasp,* (Chlorophyceae),*Cyclotella sp*,*Diatoma sp*,*Fragillaria sp*,*Navicula sp*,*Nitzschia sp*,*Pinnularia sp*,*Synedra sp* (Bacillariophyceae),*Euglena sp*,*Phacus sp* (Euglenophyceae).In the present investigationChlorophyceae were the most dominant group followed byBacillariophyceae, Cyanophyceae and Euglenophyceae.Similar observations were made by (Adesalu, T. A., 2010 andTiwari, A., and Chauhan, S.V., 2006).

Table 24: Groupwise Phytoplankton Availability in the ponds of Purulia District

Groupwise Phytoplankton Availability in the ponds of Purulia District			
Taxa			
Cyanophyceae	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**
a. *Anabaena sp*.	a. *Ankistrodesmus sp*	a. *Cyclotella sp*	a. *Euglena sp*
b. *Lyngbya sp*.	b. *Chlorella sp*	b. *Diatoma sp.*	b. *Phacus sp*
c. *Microcystis sp*	c. *Closterium sp*.	c. *Fragillaria sp*	
d. *Oscillatoria sp*	d. *Mougeotia sp*	d. *Navicula sp*	
e. *Nostoc*	e. *Scenedesmus sp*	e. *Nitzschia sp*.	
f. *Phormidium sp*	f. *Spirogyra sp*	f. *Pinnularia sp*	
	g. *Ulothix sp*	g. *Synedra sp*	
	h. *Zygnema sp*		

Cyanophyceae:

This class was represented by genus of *Anabaena sp*,*Lyngbya sp*,*Microcystis sp*, *Oscillatoria sp*,*Nostoc sp*,*Phormidium sp*. was observed in all the season. The maximum occurrence of cyanophyceae was observed during Pre Monsoon month (38 no ind/lt) and minimum in Monsoon season (18 ind /lt). Similar findings observed by Senapati *et. al.,* 2011.

Cyanophyceae:

Table 25: ANOVA of phytoplankton group Cyanophyceae shows significant variation between sites (P< 0.01) and also show significant variation between seasons (P< 0.01) also.

Two way ANOVA between sites and seasons for Phytoplankton group Cyanophyceae						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	228.9270833	5	45.78541667	18.672048	5.798E-06	4.555614
Between Season	1384.78125	3	461.59375	188.24554	4.001E-12	5.4169649
Error	36.78125	15	2.452083333			
Total	1650.489583	23				

Bacillariophyceae:

The class Bacillariophyceae represented by the genus of *Cyclotella sp*, *Diatoma sp*, *Fragillaria sp,Navicula sp*, *Nitzschia sp*, *Pinnularia sp*, *Synedra sp*. As per the quantitative measurement the class Bacillariophyceae was the most dominant group followed by other group. The maximum occurrence of Class Bacillariophyceae was observed during Pre Monsoon season i.e 54 ind/lt. The minimumoccurrence of Class Bacillariophyceae was observed during Monsoon season i.e 24 ind/lt.Similar observation reported by Mondal *et. al., 2014* at Chhattisgarh, India.

Bacillariophyceae:

Table 26: ANOVA of phytoplankton group Bacillariophyceae shows significant differences between seasons (P< 0.01) but do not show significant differences between sites (P> 0.01).

Two way ANOVA between sites and seasons for Phytoplankton group Bacillariophyceae						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	143.80208	5	28.760417	3.36188	0.0309826	4.555614

Between Season	2988.3646	3	996.12153	116.43924	1.295E-10	5.4169649
Error	128.32292	15	8.5548611			
Total	3260.4896	23				

Chlorophyceae :

Chlorophyceae was observed to be the mostdominant class of phytoplankton. Thusqualitatively Chlorophyceae formed the largestgroup and was followed by other group. The class Chlorophyceae was represented by the genus of *Ankistrodesmus sp*, *Chlorella sp*, *Closterium sp*, *Mougeotia sp*, *Scenedesmus* sp, *Spirogyra sp*, *Ulothix sp*, *Zygnema sp*. During the study period Chlorophyceae was most dominant in Pre Monsoon i.e Summer Months and minimum in Monsoon Season. The maximum and minimum occurrence of Chlorophyceae varied from 47 org/lt - 21 org/ lt.Devika *et al*., (2006) also recordedhigh population during summer and suggestedthat this might be due to physical rather thanchemical condition in which the watertemperature and transparency had a directrelation with phytoplankton population. Similar observation reported by Mondal *et. al., 2014* at Chhattisgarh, India.

Chlorophyceae:

Table 27: ANOVA of phytoplankton group Chlorophyceae shows significant differences between seasons (P< 0.01) but do not show significant differences between sites (P> 0.01).

Two way ANOVA between sites and seasons for Phytoplankton group Chlorophyceae						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	79.583333	5	15.9166667	2.4445392	0.082383136	4.555614
Between Season	2247.5833	3	749.194444	115.06399	1.41E-10	5.4169649
Error	97.666667	15	6.51111111			
Total	2424.8333	23				

Euglenophyceae:

The phytoplankton group Euglenophyceae was represented by the two genera *Euglena sp* and *Phacus sp*. During the study period Euglenophyceae were most dominated in Pre Monsoon Season and minimum in Monsoon Season.Devika et al., (2006) also recordedhigh population during summer and suggestedthat this might be due to physical rather thanchemical condition in

which the watertemperature and transparency had a directrelation with phytoplankton population. The maximum and minimum occurrence of Euglenophyceae varied from 5 ind/lt to 3 ind/lt.Similar observation reported by Mondal *et. al., 2014* at Chhattisgarh, India.

Euglenophyceae:

Table 28: ANOVA of phytoplankton group Euglenophyceae shows significant variation between sites (P< 0.01) and also show significant variation between seasons (P< 0.01) also.

Two way ANOVA between sites and seasons for Phytoplankton group Euglenophyceae						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	3.9270833	5	0.785416667	4.366795367	0.01184185	4.555613984
Between Season	33.864583	3	11.28819444	62.76061776	1.0142E-08	5.416964863
Error	2.6979167	15	0.179861111			
Total	40.489583	23				

Total Phytoplankton:

Table 29: ANOVA of total phytoplankton shows significant differences between seasons (P< 0.01) but do not show significant differences between sites (P> 0.01).

Two way ANOVA between sites and seasons for total Phytoplankton						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	477.34375	5	95.46875	2.824809419	0.05426723	4.555613984
Between Seasons	21043.615	3	7014.538194	207.5520373	1.96116E-12	5.416964863
Error	506.94792	15	33.79652778			
Total	22027.906	23				

Phytoplankton Diversity Analysis

Table 30: Seasonal Diversity of Phytoplankton Group in the Ponds of Purulia District:

Seasonal Diversity of Available Phytoplankton Group in the Ponds of Purulia District					
Group	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre	38±5	47±5	54±5	5±1	1.2

Monsoon					
Monsoon	18±2	21±1	24±2	2±0	1.19
Post Monsoon	22±3	26±3	30±3	3±0	1.2
Winter	26±4	31±1	36±3	3±0	1.19

Table 31: Composition (%) of Different Group of Phytoplankton Availability in Purulia District:

Seasonal Abundance (%) of different group of Phytoplankton in Purulia District				
Season	**Group**			
	Cyanophyceae	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**
Pre Monsoon	38.0	47.0	54.0	5.0
Monsoon	18.0	21.0	24.0	2.0
Post Monsoon	22.0	26.0	30.0	3.0
Winter	26.0	31.0	36.0	3.0
Total	104.0	125.0	144.0	13.0
Percentage (%)	26.9	32.4	37.3	3.4

The total no of species recorded were 386 org/lt, out of which Cyanophyceae are 104 org/lt (26.9 %), Cholorophyceae are 125 org/lt (32.4 %), Bacillariophyceae are 144 org/lt (37.3 %) and Euglenophyceae are 13 org/lt (3.4 %).

Graphical representation of Seasonal Diversity of Phytoplankton Group in the Ponds of Purulia District:

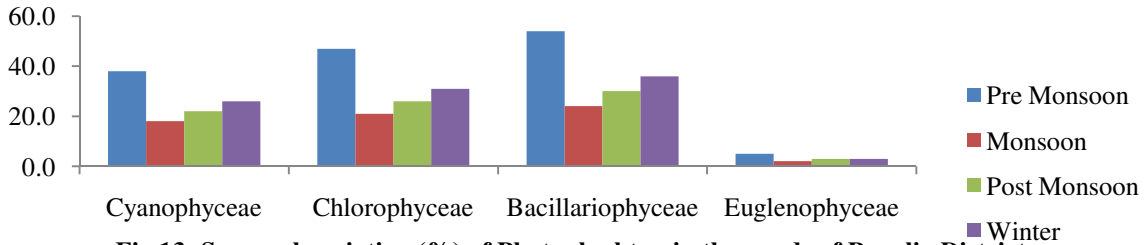


Fig 13: Seasonal variation (%) of Phytoplankton in the ponds of Purulia District

Phytoplankton Availability percentage (%) of Purulia District:

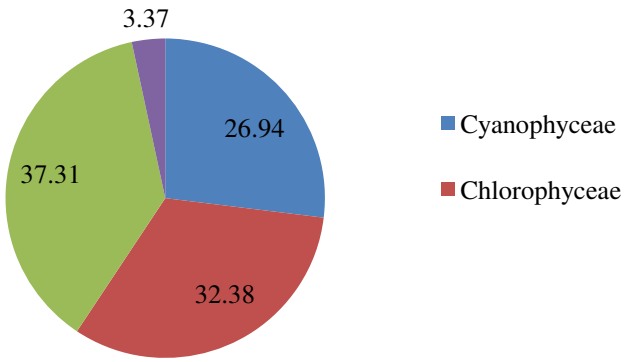


Fig 14: Phytoplankton composition in ponds of Purulia District

Table 32: Seasonal Abundance (%) of different group of Phytoplankton in Purulia District:

Seasonal Abundance (%) of different group of Phytoplankton in Purulia District				
Group	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**
Season	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**
Pre Monsoon	26.4	32.6	37.5	3.5
Monsoon	27.7	32.3	36.9	3.1
Post Monsoon	27.2	32.1	37	3.7
Winter	27.1	32.3	37.5	3.1

In the present study the occurrence of season wise Phytoplankton groups was dominant in the following increasing order.

Pre Monsoon: Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophyceae

Monsoon: Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophyceae

Post Monsoon:Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophyceae

Winter:Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophyceae

Seasonal Variation of Different Group of Phytoplankton in Different Blocks of Purulia District:

Table 33: Seasonal Variation of Different Group of Phytoplankton of Purulia II Dev Block:

Seasonal Variation of Phytoplankton availability of Purulia II Block					
Group	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**	**Diversity**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Index**
Pre Monsoon	33.5 ± 1.5	41.5 ± 1.5	49 ± 2	6 ± 1	1.22
Monsoon	16 ± 1	19.5 ± 1.5	24 ± 1	2.5± 0.5	1.21
Post Monsoon	22 ± 2	30 ± 2	33.5 ± 2.5	3 ± 0	1.19
Winter	23.5 ± 0.5	32 ± 3	34.5 ± 2.5	3.5 ± 0.5	1.2

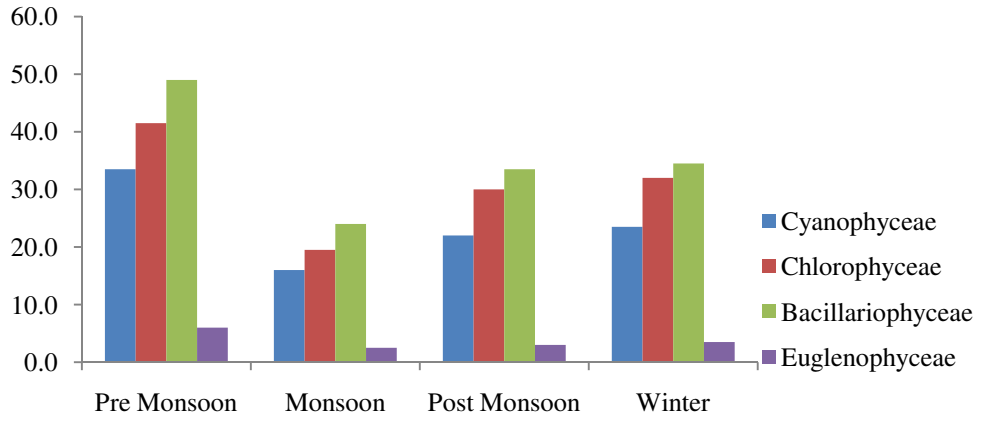


Fig 15: Seasonal variation of Phytoplankton in the ponds of Purulia II Block

Composition (%) of Different group of Phytoplankton in the ponds of Purulia II Dev Block

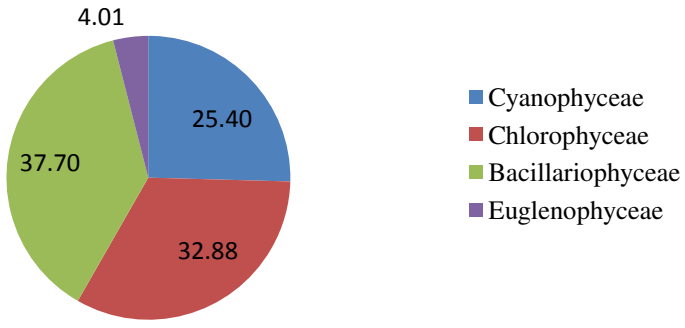


Fig 16: Composition (%) of Phytoplankton in the ponds of Purulia II Block

Table 34: Seasonal variation of Different Group of Phytoplankton of Hura Dev Block:

Seasonal Variation of Phytoplankton availability of Hura Block					
Group	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**	**Diversity**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Index**
Pre Monsoon	40.5 ± 1.5	49 ± 1	57.5 ± 1.5	6 ± 1	1.21
Monsoon	19 ± 2	21.5 ± 1.5	27 ± 1	2± 0	1.18
Post Monsoon	22.5 ± 0.5	26.5 ± 1.5	31.5 ± 1.5	3 ± 1	1.2
Winter	25.5 ± 0.5	31.5 ± 2.5	34 ± 2	4 ± 1	1.22

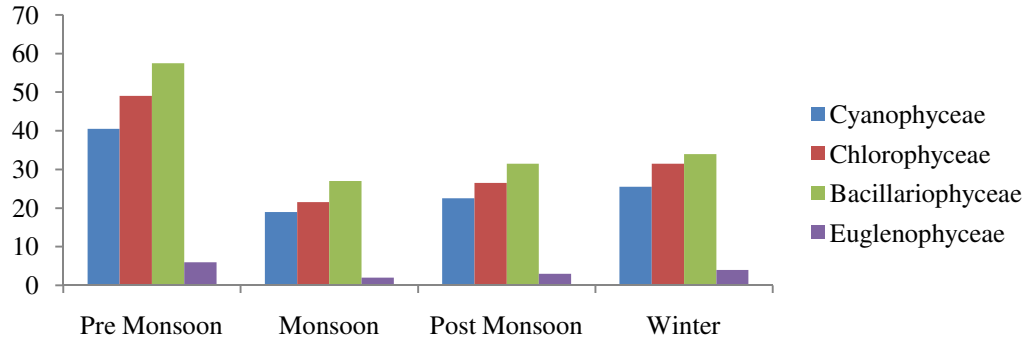


Fig 17: Seasonal variation (%) of Phytoplankton in the ponds of Hura Block

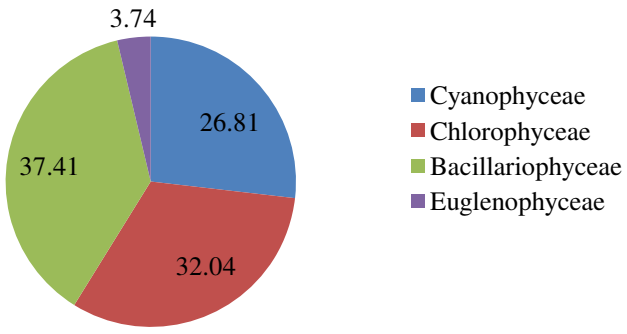


Fig 18: Composition (%) of Phytoplankton in the ponds of Hura Block

Table 35: Seasonal variation of Different Group of Phytoplankton of Arsha Dev Block:

Seasonal Variation of Phytoplankton availability of Arsha Block					
Group	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	36 ± 1	44 ± 1	50 ± 1	3.5 ± 0.5	1.18
Monsoon	16 ± 1	21 ± 1	22.5 ± 1.5	1.5± 0.5	1.17
Post Monsoon	18.5 ± 1.5	24 ± 1	28 ± 1	2.5 ± 0.5	1.19
Winter	22 ± 2	29.5 ± 1.5	33.5 ± 1.5	3 ± 1	1.19

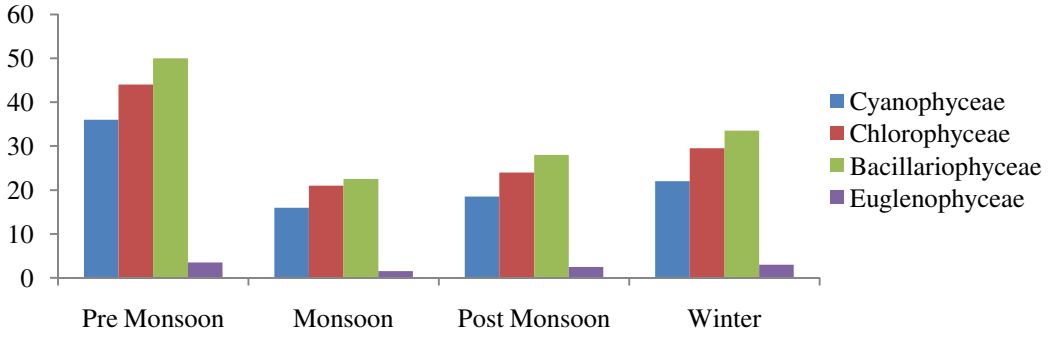


Fig - 19: Seasonal variation (%) of Phytoplankton in the ponds of Arsha Block

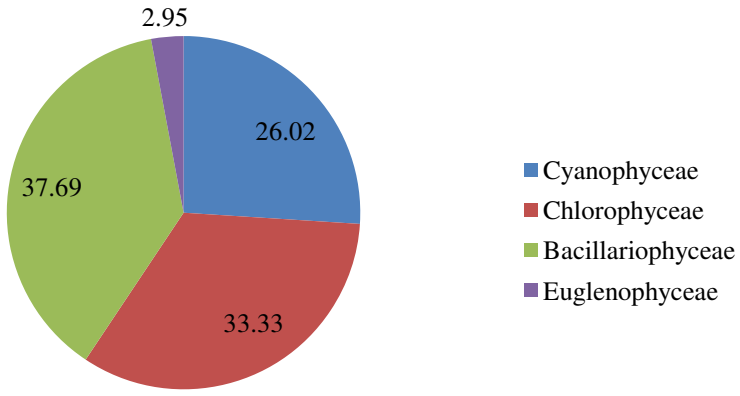


Fig - 20: Composition (%) of Phytoplankton in the ponds of Arsha Block

Table 36: Seasonal variation of Different Group of Phytoplankton of Balarampur Dev Block:

Seasonal Variation of Phytoplankton availability of Balarampur Block					
Group	Cyanophyceae	Chlorophyceae	Bacillariophyceae	Euglenophyceae	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	41 ± 1	52.5 ± 1.5	57.5 ± 1.5	5 ± 0	1.19
Monsoon	19 ± 1	22.5 ± 1.5	25 ± 2	2 ± 0	1.19
Post Monsoon	23.5 ± 1.5	28 ± 1	30.5 ± 0.5	3 ± 1	1.2
Winter	29.5 ± 1.5	32 ± 2	34.5 ± 2.5	3.5 ± 0.5	1.21

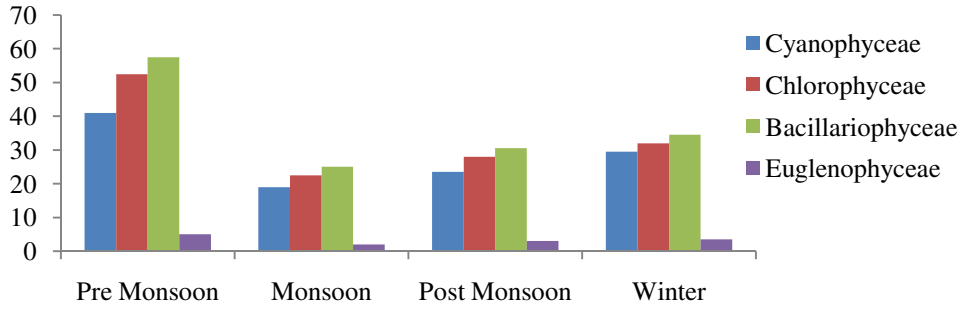


Fig 21: Seasonal variation (%) of Phytoplankton in the ponds of Balarampur Block

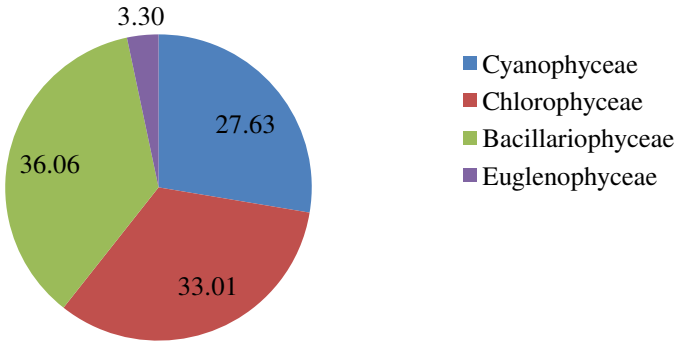


Fig 22: Composition (%) of Phytoplankton in the ponds of Balarampur Block

Table 37: Seasonal variation of Different Group of Phytoplankton of Para Dev. Block:

Seasonal Variation of Phytoplankton availability of Para Block					
Group	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**	**Diversity**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Index**
Pre Monsoon	33 ± 1	52.5 ± 1.5	60 ± 1	5.5 ± 0.5	1.18
Monsoon	16 ± 1	21.5 ± 1.5	23.5 ± 1.5	1.5 ± 0.5	1.17
Post Monsoon	19 ± 1	27 ± 1	31.5 ± 2.5	2.5 ± 0.5	1.18
Winter	21.5 ± 0.5	32.5 ± 2.5	42 ± 2	3 ± 1	1.16

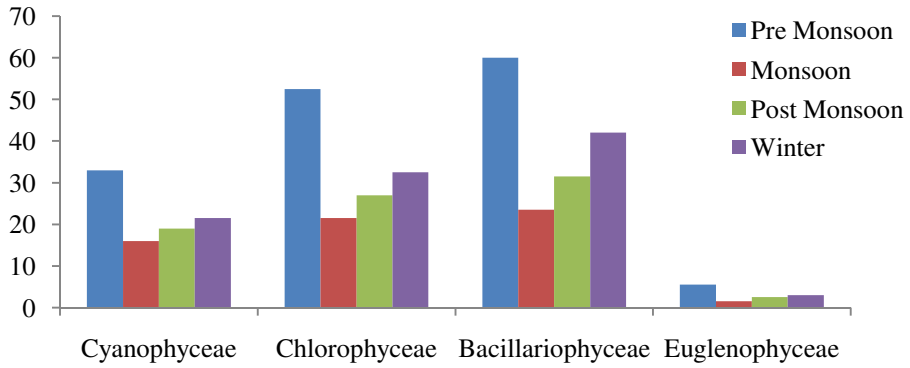


Fig 23: Seasonal variation (%) of Phytoplankton in the ponds of Para Block

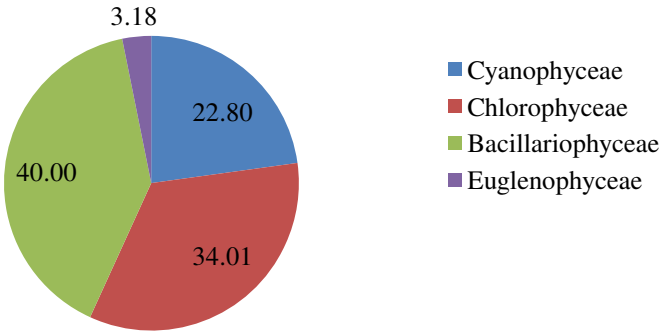


Fig 24: Composition (%) of Phytoplankton in the ponds of Para Block

Table 38: Seasonal variation of Different Group of Phytoplankton of Kashipur Dev. Block:

Seasonal Variation of Phytoplankton availability of Kashipur Block					
Group	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**	**Diversity**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Index**
Pre Monsoon	45 ± 1	42 ± 1	47.5 ± 2.5	4.5 ± 0.5	1.2
Monsoon	21.5 ± 1.5	20 ± 1	20 ± 2	1.5 ± 0.5	1.18
Post Monsoon	25.5 ± 1.5	22.5 ± 2.5	24.5 ± 1.5	2.5 ± 0.5	1.2
Winter	32 ± 2	31 ± 2	36 ± 1	3.5 ± 0.5	1.2

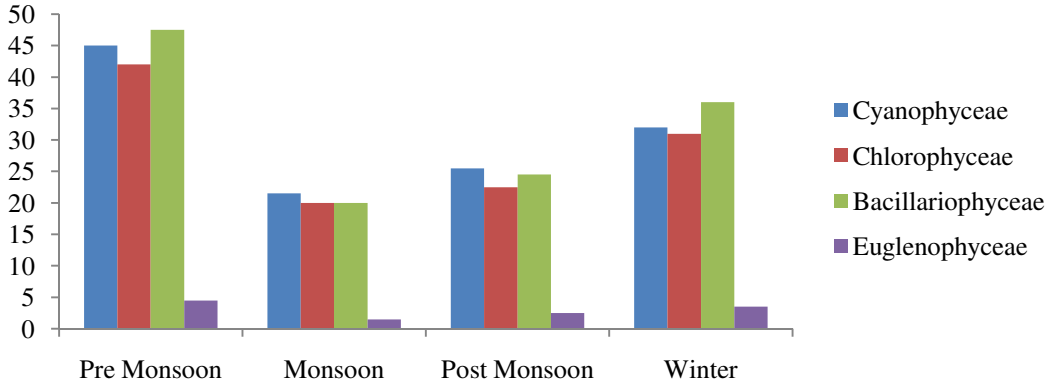


Fig 25: Seasonal variation (%) of Phytoplankton in the ponds of Kashipur Block

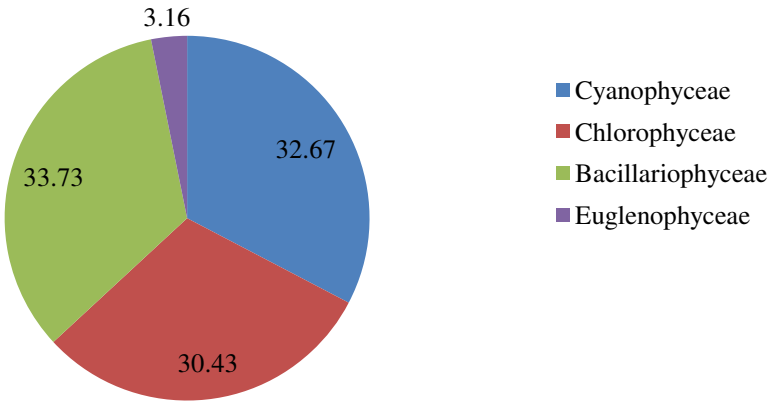


Fig 26: Composition (%) of Phytoplankton in the ponds of Kashipur Block

Table 39: Correlation matrix between Physico-chemical parameters of water bodies and different Phytoplankton group found in ponds of Purulia District

	Water Temp	Ph	Transparency (Cm)	Dissolved Oxygen (mg/lt)	Alkalinity (mg/lt)	Hardness (mg/lt)	Nitrite Nitrogen (NO2N) (mg/lt)	Nitrate Nitrogen (NO3N) (mg/lt)	Ortho Phosphate (P2O5) (mg/lt)	Cyanophyceae	Chlorophyceae	Bacillariophyceae	Euglenophyceae
Water Temp	1.00												
Ph	0.97	1.00											
Transparency (Cm)	-0.19	-0.44	1.00										
Dissolved Oxygen (mg/lt)	-0.22	-0.09	-0.34	1.00									
Alkalinity (mg/lt)	0.27	0.27	-0.16	-0.87	1.00								
Hardness (mg/lt)	0.86	0.95	-0.64	-0.15	0.45	1.00							
Nitrite Nitrogen (NO2N) (mg/lt)	-0.40	-0.32	-0.14	0.97	-0.93	-0.40	1.00						
Nitrate Nitrogen (NO3N) (mg/lt)	0.44	0.56	-0.55	0.77	-0.56	0.47	0.60	1.00					

Ortho Phosphate (P2O5) (mg/lt)	0.87	0.88	-0.27	0.28	-0.21	0.72	0.09	0.80	1.00				
Cyanophyceae	0.45	0.39	-0.01	-0.92	0.97	0.50	-0.99	-0.52	-0.04	1.00			
Chlorophyceae	0.46	0.41	-0.01	-0.92	0.96	0.51	-0.99	-0.51	-0.02	1.00	1.00		
Bacillariophyceae	0.45	0.39	-0.01	-0.92	0.97	0.50	-0.99	-0.52	-0.04	1.00	1.00	1.00	
Euglenophyceae	0.48	0.38	0.16	-0.95	0.90	0.44	-0.99	-0.55	0.00	0.98	0.98	0.98	1.00

Cyanophyceae:

Cyanophyceae population was positively correlated with temp. (r = 0.45), pH (r= 0.39), alkalinity (r = 0.96), hardness (r = 0.51) etc. This population was negatively correlated with transparency (r = 0.01), dissolved oxygen (r = 0.92), nitrite nitrogen (r = 0.99), nitrate nitrogen (r = 0.52), and ortho phosphate (r = 0.04).

Chlorophyceae:

Chlorophyceae made positive correlation with water temperature (r = 0.46), pH (r= 0.41), alkalinity (r = 0.96), Hardness (r = 0.51). While made negative correlation with transparency (0.01), D.O. (r = 0.92), nitrite nitrogen (r= 0.99),nitrate nitrogen (r = 0.51), and ortho phosphate (r = 0.02) etc.

Bacillariophyceae:

The phytoplanktonic group Bacillariophyceae showed markedly positive correlation with temperature (r = 0.45), pH (r = 0.39), alkalinity (r = 0.97), hardness (r = 0.50) etc. and negative correlation with transparency (r = 0.01), dissolved oxygen (r = 0.92), nitrite nitrogen (r = 0.99) and nitrate nitrogen (r = 0.52), and ortho phosphate (r = 0.04)etc.

Euglenophyceae:

The phytoplanktonic group euglenophyceae showed markedly positive correlation with temperature (r = 0.48), pH (r = 0.38), transparency (r = 0.16), alkalinity (r = 0.90), hardness (r = 0.44) etc. and negative correlation with dissolved oxygen (r = 0.95), nitrite nitrogen (r = 0.99) and nitrate nitrogen (r = 0. 55) etc.

Pearson correlation matrix showed that phytoplankton group positively correlated with water temperature, pH, alkalinity, Hardness and negatively correlated with transparency, dissolved oxygen, nitrite nitrogen, nitrate nitrogen, and ortho phosphate. This result supported by the findings of Barve M. Band Sonawane D. L. (2017).

Phytoplankton density and pond productivity

Phytoplankton is the pioneer of any aquatic food chain. The productivity of an aquatic ecosystem is directly depending on the density of phytoplankton. The physico-chemical parameters are directly related with their productions.

Phytoplankton is the basic of primary production of all types of water bodies and is used as food by fish directly or indirectly. The aquatic organisms are directly or indirectly depend on phytoplankton population. A requisite amount of plankton density is required by the fresh water bodies for sustainable development of fisheries.

In the present investigation it shows that the plankton production of the selected water bodies is not optimum quantity. So the fish yeiled of the water body is average.

Zooplankton Analysis of Purulia District

In ecological point of view,zooplankton influences all the functional aspects of an aquaticecosystem such as food chains, food webs, energy flow andcycling of matter (Sinha and Islam, 2007).

This present study was conducted to evaluate the species composition and temporal distribution of zooplankton in ten no of ponds in each selected blocks of each sub division (Purulia Sadar East, Purulia West, Raghunathpur). Some physico – chemical parameters of the studied ponds were also analyzed to find out their effects on pond ecosystem.

The zooplankton study in the selected ponds of Purulia District consists of five major groups like Rotifera, Copepoda, Protozoea, Ostracoda and Cladocera represented the zooplankton population of the studied water bodies. A total 6 genus of Rotifera group (*Brachionus sp, Asplanchna sp, Keratella sp, Synchaeta sp, Euchlanis sp, Filinia sp*) 10 genus of Copepoda (*Nauplii, Diaptomus sp, Pseudodiaptomus sp, Cyclops, Mesocyclops sp, Paracyclops sp, Microcyclops sp, Eucyclops, Acanthocyclops sp, Heliodiaptomus*), 3 genus of Protozoea (*Amoeba, Paramecium, Arcella*) 6 genus of Cladocerans (*Daphnia sp, Ceriodaphnia, Simocephalus, Bosmina, Moina, Diaphanosoma sp*) and one genus of Ostracoda (*Cypris sp*) were identified from the ponds. Nauplius larvae were found in some ponds.

Rotifera:

In the present study 6 genera of Rotifera group were identified from the water bodies of Purulia district. The recorded population density of rotifer was varied from 44 ind /l to 19 ind/l. In the present investigation the maximum no of Rotifera was found during summer season and minimum no was observed during monsoon season due to its preference for warm waters. Similar findings were observed by Basawarajeshwari .Indur *et al*., (2015) and Segers (2003).

Rotifera:

Table 40: ANOVA of zooplankton group Rotifera shows significant differences between seasons (P< 0.01) but do not show significant differences between sites (P> 0.01).

Two way ANOVA between sites and seasons for Zooplankton group Rotifera						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	144.927083	5	28.98541667	3.709803	0.021934956	4.555613984
Between Seasons	2361.11458	3	787.0381944	100.7319	3.64967E-10	5.416964863
Error	117.197917	15	7.813194444			
Total	2623.23958	23				

Cladocerans:

The zooplanktonic group Cladocerans represented by six genera (*Daphnia sp*, *Ceriodaphnia*, *Simocephalus*, *Bosmina*, *Moina*, *Diaphanosoma sp*.). The seasonal density of Cladocerans varied from 80 ind/lt to 42 ind/lt. The highest concentration of Cladocerans was observed during Pre Monsoon months (80 ind/l) and minimum concentration was found during Monsoon (42 ind/l) months.During summer the cladoceran population was moderate due to dense growth of rotifers and thus avoiding competition.Dushyantkumar Sharma (2012) reported that cladocerans population was higher in summer season and lower in winter season.

Cladocera:

Table 41: ANOVA of zooplankton group Cladocera shows significant variation between sites ($P< 0.01$) and also show significant variation between seasons ($P< 0.01$) also.

Two way ANOVA between sites and seasons for Zooplankton group Cladocera						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	6549.4688	5	1309.8938	85.773589	1.71987E-10	4.555613984
Between Season	5035.3646	3	1678.4549	109.90746	1.95858E-10	5.416964863
Error	229.07292	15	15.271528			
Total	11813.906	23				

Copepoda:

In the present investigation Copepods are represented by ten genera (*Nauplii*, *Diaptomus sp*, *Pseudodiaptomus sp*., *Cyclops*, *Mesocyclops sp*., *Paracyclops sp.*, *Microcyclops sp*., *Eucyclops*, *Acanthocyclops sp*, *Heliodiaptomus*). During the study period the seasonal density of copepod varied from 89 ind/l to 34 ind/l. Copepods showed higher population density in summer season (89 ind/l) and lower population density in monsoon period. This result supported by the findings of (Dar and Dar 2009) who told that Copepod develop better in warm periods.

Copepoda:

Table 42: ANOVA of zooplankton group Copepoda shows significant variation between sites (P< 0.01) and also show significant variation between seasons (P< 0.01) also.

Two way ANOVA between sites and seasons for Zooplankton group Copepoda						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Bwtween Sites	949.9583333	5	189.99167	18.470699	6.206E-06	4.555614
Bwtween Seasons	10308.58333	3	3436.1944	334.06157	5.931E-14	5.4169649
Error	154.2916667	15	10.286111			
Total	11412.83333	23				

Ostracoda:

In the present investigation only one species of Ostracoda found. These are represented by *Cypris sp*. In the present investigation highest concentration of Ostracoda found in 2 ind/lt and lowest in 1 no /lt.The population density of Ostracoda was higher in Pre Monsoon and Post Monsoon season and lower during Monsoon season.This result has also been observed by Sukand and Patil (2004) in Fort Lake of Belgaum and Kedar *et al.* (2008) in Rishi freshwater lake of Washim district. Occurance of of some species of ostracods in Dharwad district has been reported (Patil C.S.*et al*., 1989).

Ostracoda:

Table 43: ANOVA of zooplankton group Ostracoda shows significant differences between seasons (P< 0.01) but do not show significant differences between sites (P> 0.01).

Two way ANOVA between sites and seasons for Zooplankton group Ostracoda						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.833333333	5	0.1666667	2.7272727	0.060302126	4.555613984
Between Seasons	6.083333333	3	2.0277778	33.181818	7.28546E-07	5.416964863
Error	0.916666667	15	0.0611111			
Total	7.833333333	23				

Protozoa:

In the present investigation only three species of Protozoea are found (*Amoeba sp, Paramecium sp, Arcella sp*). The population density of Protozoa was higher in post monsoon month and lower in monsoon month.Shivashankar P. *et al*., (2013), also reported that the population density of Protozoa was also lower in Monsoon season.

Protozoa:

Table 44: ANOVA of zooplankton group Protozoado not show significant variation between sites and beteen seasons also (P> 0.01).

Two way ANOVA between sites and seasons for Zooplankton group Protozoa						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.677083333	5	0.1354167	0.4482759	0.808028	4.555613984
Between Seasons	2.53125	3	0.84375	2.7931034	0.0763344	5.416964863
Error	4.53125	15	0.3020833			
Total	7.739583333	23				

Table 45: Zooplankton availability in the ponds of Purulia District

Groupwise Zooplankton Availability in the ponds of Purulia District				
Taxa				
Rotifera	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**
a. *Brachionus sp*.	a. *Nauplii*	a. *Amoeba*	a. *Cypris sp.*	a. *Daphnia sp*.
b. *Asplanchna sp*	b. *Diaptomus sp*	b. *Paramecium*		b. *Ceriodaphnia*
c. *Keratella sp*.	c. *Pseudodiaptomus sp*.	c. *Arcella*		c. *Simocephalus*
d. *Synchaeta sp*.	d. *Cyclops*			d. *Bosmina*
e. *Euchlanis sp*.	e. *Mesocyclops sp*.			e. *Moina*
f. *Filinia sp*.	f. *Paracyclops sp*.			f. *Diaphanosoma sp*.
	g. *Microcyclops sp*.			
	h. *Eucyclops*			
	i. *Acanthocyclops sp*			
	j. *Heliodiaptomus*			

Table 46: Seasonal Diversity of Zooplankton Group in the Ponds of Purulia District:

Seasonal Diversity of Available Zooplankton Group in the Ponds of Purulia District						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Index**
Pre Monsoon	44±5	89±9	1±1	2±0	80±21	1.12
Monsoon	19±2	64±7	1±0	1±0	42±14	1.07
Post Monsoon	23±2	47±6	2±1	2±0	52±16	1.17
Winter	32±3	34±5	1±0	1±0	47±15	1.16

Table 47: Composition (%) of Different Group of Zooplankton Availability in Purulia District:

Composition (%) of Different group of Zooplankton Available in Purulia District	
Group	**Composition (%)**
Rotifera	20.21
Copepoda	40.07
Protozoa	0.86
Ostracoda	1.03
Cladocera	37.84

The total no of species recorded were 584 org/lt, out of which Rotifers are 118 org/lt (20.21 %), Cladocerans 221 org/lt (37.84 %), Copepods 234 org/lt (40.07%), Ostracods 6 org/lt (1.03 %), and Protozoa 5 org/lt (0.86 %).

Graphical representation of Seasonal Diversity of Zooplankton Group in the Ponds of Purulia District:

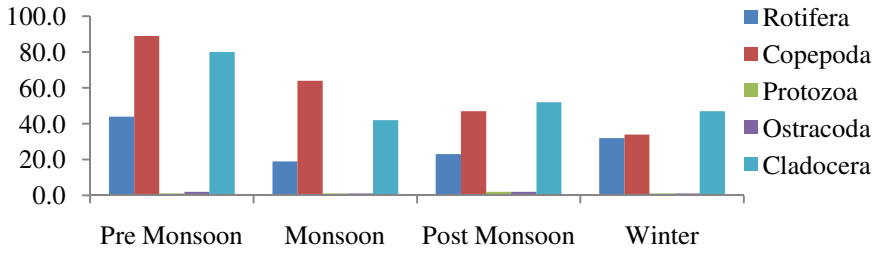


Fig 27: Seasonal variation of Zooplankton in the ponds of Purulia District

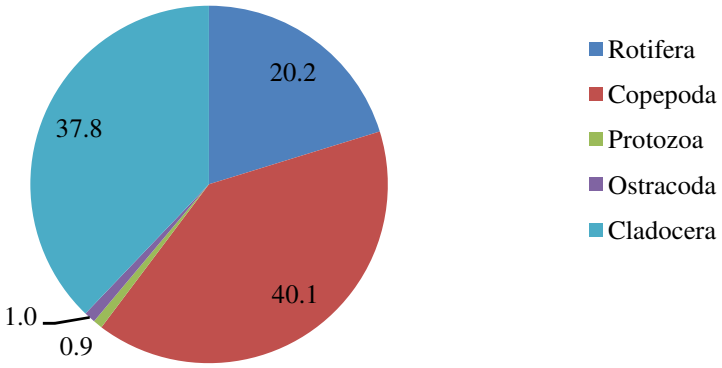


Fig 28: Composition (%) of Zooplankton in the ponds of Purulia District

Table 48: Seasonal Abundance (%) of different group of Zooplankton in Purulia District:

Seasonal Abundance (%) of different group of Zooplankton in Purulia District					
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**
Season	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**
Pre Monsoon	20.37	41.20	0.46	0.93	37.04
Monsoon	14.96	50.39	0.79	0.79	33.07
Post Monsoon	18.25	37.30	1.59	1.59	41.27
Winter	27.83	29.57	0.87	0.87	40.87

In the present study the occurrence of season wise zooplankton groups was dominant in the following increasing order.

Pre Monsoon: Copepoda > Cladocera > Rotifera > Ostracoda > Protozoa

Monsoon: Copepoda > Cladocera > Rotifera > Ostracoda > Protozoa

Post Monsoon: Copepoda> Cladocera > Rotifera > Ostracoda > Protozoa

Winter:

Cladocera> Copepoda > Rotifera > Protozoa > Ostracoda

Total Zooplankton:

Table 49: ANOVA of total zooplankton shows significant variation between sites (P< 0.01) and also show significant variation between seasons (P< 0.01) also.

Two way ANOVA between sites and seasons for total Zooplankton						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	9278.6771	5	1855.7354	56.746703	3.27696E-09	4.555613984
Between Seasons	40539.531	3	13513.177	413.22068	1.23087E-14	5.416964863
Error	490.53125	15	32.702083			
Total	50308.74	23				

Table 50: Total Plankton: ANOVA of total plankton shows significant variation between sites (P< 0.01) and also show significant variation between seasons (P< 0.01) also.

Two way ANOVA between sites and seasons for total Plankton						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	6568.458333	5	1313.691667	26.76300153	5.67689E-07	4.555613984
Between Seasons	112916.7083	3	37638.90278	766.7933337	1.2461E-16	5.416964863
Error	736.2916667	15	49.08611111			
Total	120221.4583	23				

Table 51: Seasonal Variation of Different Group of Zooplankton of Purulia II Dev. Block:

Seasonal Variation of Zooplankton availability of Purulia II Block						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	52 ± 2	96.5 ± 3.5	0.5 ± 0.5	2 ± 0	72.5 ± 2.5	1.1
Monsoon	20 ± 1	70 ± 3	0.5 ± 0.5	1 ± 1	39 ± 2	1.04
Post Monsoon	23 ± 2	56 ± 1	2 ± 0	1.5 ± 0.5	49 ± 3	1.15
Winter	34 ± 1	42.5 ± 2.5	0.5 ± 0.5	1 ± 1	47 ± 1	1.14

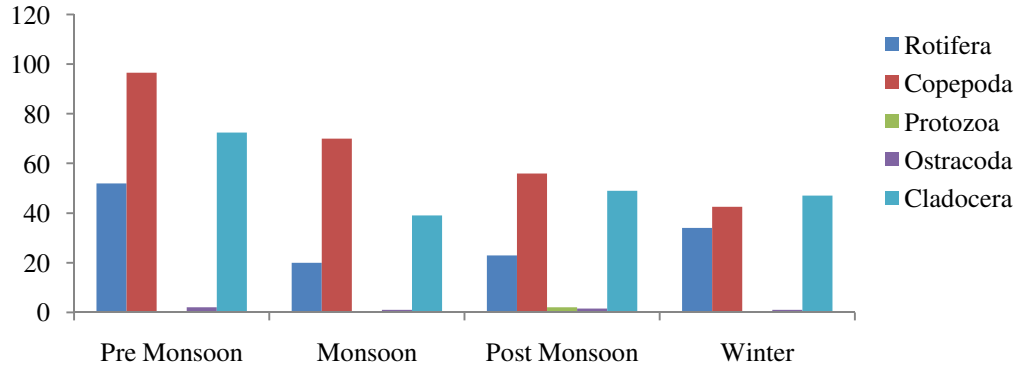


Fig 29: Seasonal variation of Zooplankton in the ponds of Purulia II Block

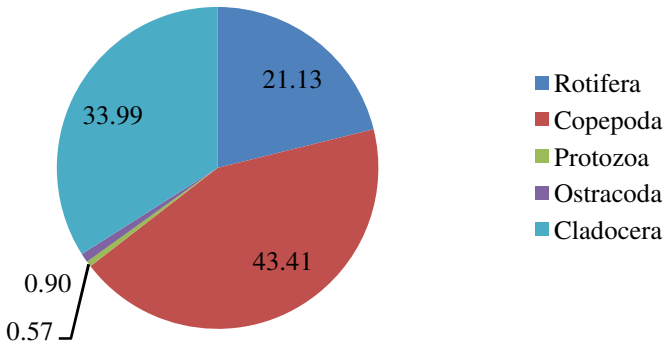


Fig 30: Composition (%) of Zooplankton in the ponds of Purulia II Block

Table 52: Seasonal Variation of Different Group of Zooplankton of Hura Dev. Block

Seasonal Variation of Zooplankton availability of Hura Block						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	49.5 ± 1.5	84.5 ± 3.5	0.5 ± 0.5	1.5 ± 0.5	63 ± 3	1.1
Monsoon	18.5 ± 1.5	60 ± 3	1 ± 0	0.5 ± 0.5	32 ± 2	1.03
Post Monsoon	22 ± 2	48.5 ± 2.5	2.5 ± 0.5	1.5 ± 0.5	37 ± 3	1.19
Winter	31.5 ± 2.5	34.5 ± 2.5	0.5 ± 0.5	1 ± 0	32 ± 1	1.16

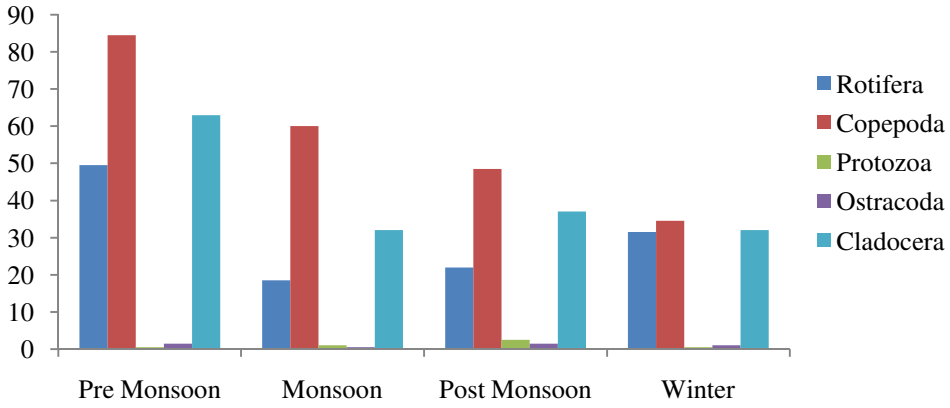


Fig 31: Seasonal variation of Zooplankton in the ponds of Hura Block

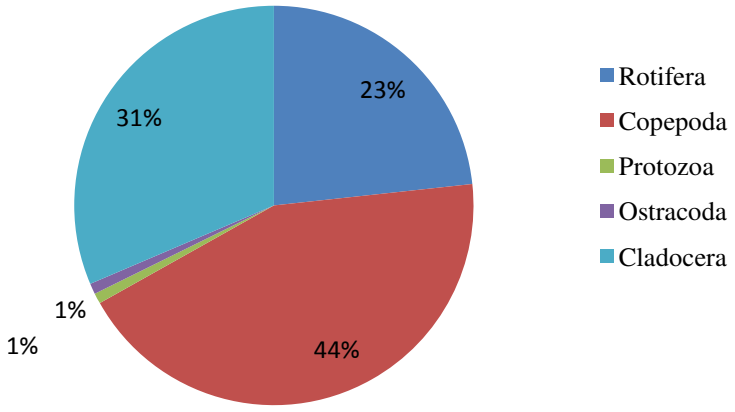


Fig 32: Composition (%) of Zooplankton in the ponds of Hura Block

Table 53: Seasonal Variation of Different Group of Zooplankton of Arsha Dev. Block

Seasonal Variation of Zooplankton availability of Arsha Block						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	38.5 ± 1.2	105 ± 2.4	1 ± 0.8	2.5 ± 0.4	125 ± 4.1	1.1
Monsoon	14.5 ± 1.5	77 ± 3	0.5 ± 0.5	1 ± 0	71.5 ± 2.5	1
Post Monsoon	18.5 ± 1.5	52.5 ± 2.5	1.5 ± 0.5	2 ± 0	86 ± 3	1
Winter	26 ± 1	38.5 ± 1.5	1 ± 1	1.5 ± 0.5	79 ± 2	1.1

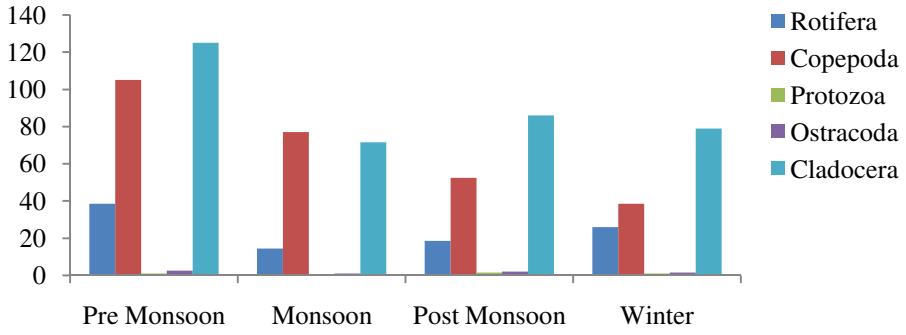


Fig - 33: Seasonal variation of Zooplankton in the ponds of Arsha Block

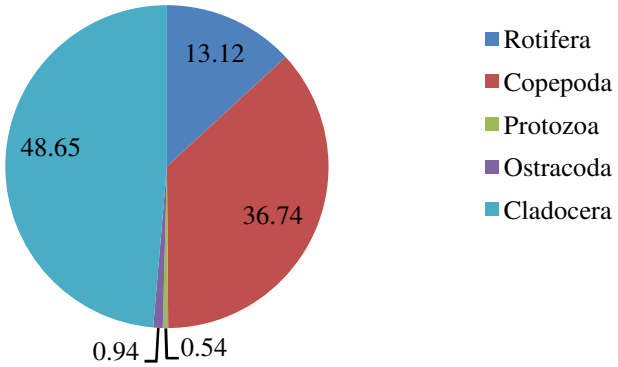


Fig 34: Composition (%) of Zooplankton in the ponds of Arsha Block

Table 54: Seasonal Variation of Different Group of Zooplankton of Balarampur Dev. Block

Seasonal Variation of Zooplankton availability of Balarampur Block						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	41 ± 1	84 ± 1	0.5 ± 05	2.5 ± 0.5	79.5 ± 1.5	1.1
Monsoon	21 ± 2	60 ± 2	1 ± 0	1 ± 1	43.5 ± 2.5	1.09
Post Monsoon	24 ± 1	40.5 ± 1.5	1 ± 0	1.5 ± 0.5	56 ± 2	1.13
Winter	37 ± 2	28.5 ± 1.5	0.5 ± 0.5	1 ± 1	47.5 ± 2.5	1.14

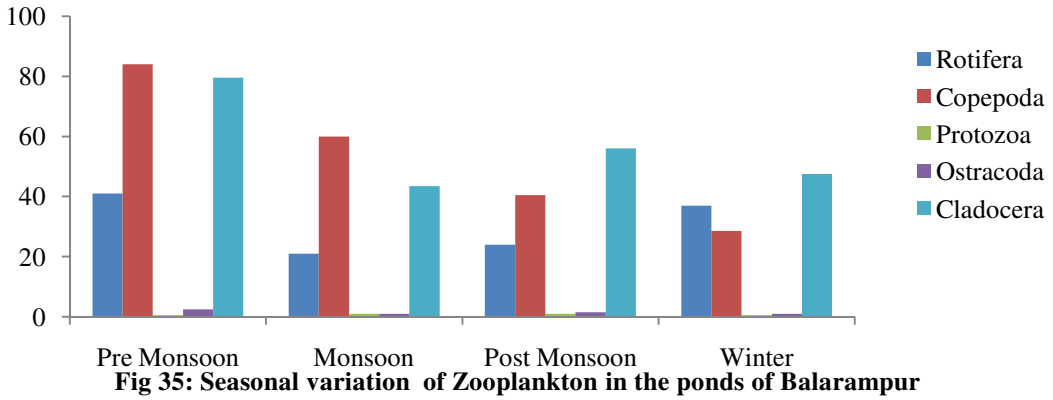


Fig 35: Seasonal variation of Zooplankton in the ponds of Balarampur Block

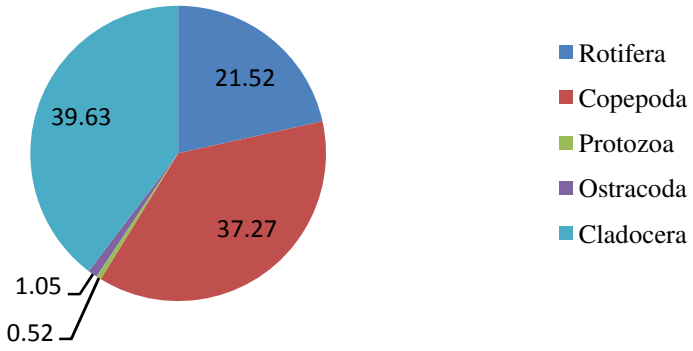


Fig 36: Composition (%) of Zooplankton in the ponds of Balarampur Block

Table 55: Seasonal Variation of Different Group of Zooplankton of Para Dev. Block

Seasonal Variation of Zooplankton availability of Para Block						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	43 ± 1	80.5 ± 2.5	1.5 ± 0.5	2 ± 1	71.5 ± 2.5	1.13
Monsoon	17.5 ± 1.5	57.5 ± 2.5	0.5 ± 0.5	1 ± 1	35 ± 3	1.04
Post Monsoon	26.5 ± 1.5	45 ± 3	1 ± 0	1.5 ± 0.5	42.5 ± 1.5	1.15
Winter	32 ± 1	28 ± 1	0.5 ± 0.5	1 ± 0	37.5 ± 2.5	1.14

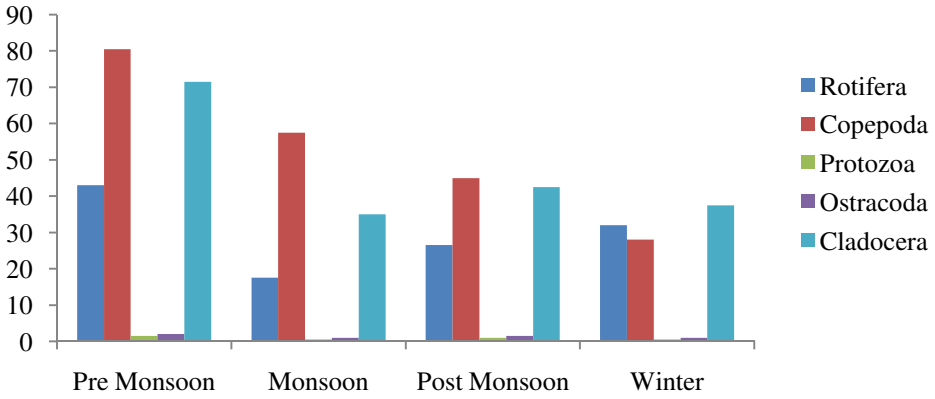


Fig 37: Seasonal variation of Zooplankton in the ponds of Para Block

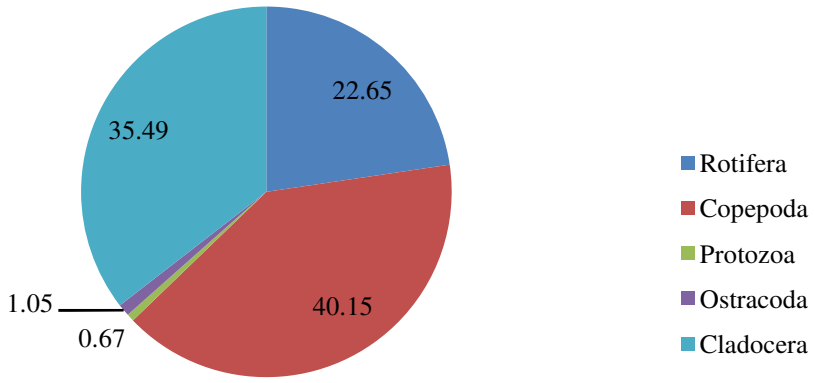


Fig 38: Composition (%) of Zooplankton in the ponds of Para Block

Table 56: Seasonal Variation of Different Group of Zooplankton of Kashipur Dev. Block

Seasonal Variation of Zooplankton availability of Kashipur Block						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	42.5 ± 1.5	85 ± 2	2 ± 0	2.5 ± 0.5	65.5 ± 2.5	1.16
Monsoon	19.5 ± 1.5	60 ±2	0.5 ± 0.5	1 ± 1	32.5 ± 2.5	1.06
Post Monsoon	23.5 ± 1.5	41.5 ± 2.5	1 ± 1	1.5 ± 0.5	43.5 ± 2.5	1.16
Winter	32 ± 2	30 ± 2	1.5 ± 0.5	0.5 ± 0.5	37 ± 2	1.18

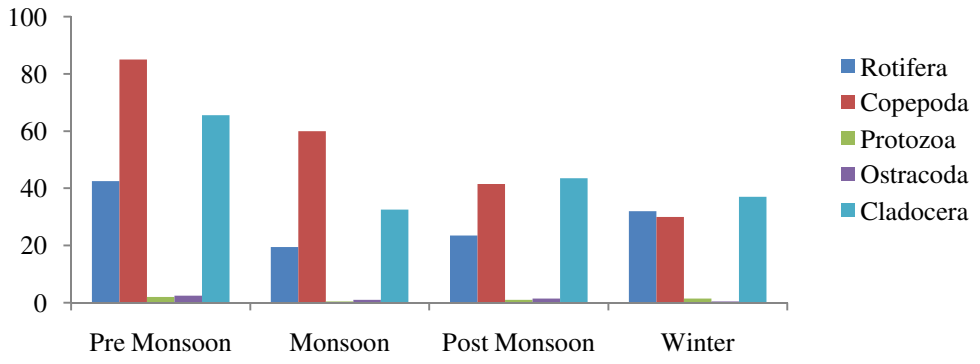


Fig 39: Seasonal variation of Zooplankton in the ponds of Kashipur Block

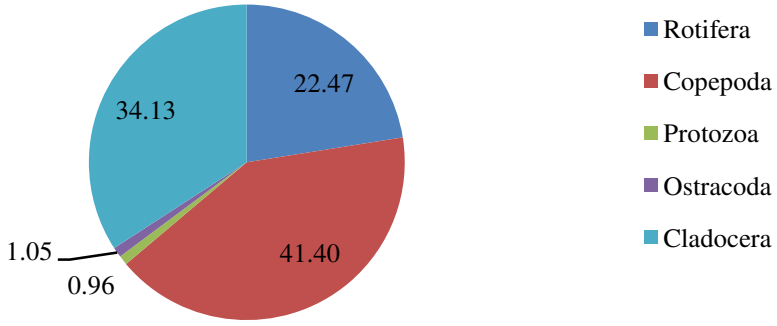


Fig 40: Composition (%) of Zooplankton in the ponds of Kashipur Block

Table 57: Correlation matrix between Physico-chemical parameters of water bodies and different Zooplanktonic group found in ponds of Purulia District

	Water Temp	Ph	Transparency (Cm)	Dissolved Oxygen (mg/lt)	Alkalinity (mg/lt)	Hardness (mg/lt)	Nitrite Nitrogen (NO2N) (mg/lt)	Nitrate Nitrogen (NO3N) (mg/lt)	Ortho Phosphate (P2O5) (mg/lt)	Rotifera	Copepoda	Protozoa	Ostracoda	Cladocera
Water Temp	1.00													
Ph	0.97	1.00												
Transparency (Cm)	-0.19	-0.44	1.00											
Dissolved Oxygen (mg/lt)	-0.22	-0.09	-0.34	1.00										
Alkalinity (mg/lt)	0.27	0.27	-0.16	-0.87	1.00									
Hardness	0.86	0.95	-0.64	-0.15	0.45	1.00								

(mg/lt)														
Nitrite Nitrogen (NO2N) (mg/lt)	-0.40	-0.32	-0.14	0.97	-0.93	-0.40	1.00							
Nitrate Nitrogen (NO3N) (mg/lt)	0.44	0.56	-0.55	0.77	-0.56	0.47	0.60	1.00						
Ortho Phosphate (P2O5) (mg/lt)	0.87	0.88	-0.27	0.28	-0.21	0.72	0.09	0.80	1.00					
Rotifera	0.34	0.32	-0.09	-0.90	0.99	0.47	-0.97	-0.56	-0.15	1.00				
Copepoda	0.98	0.95	-0.21	-0.37	0.44	0.89	-0.55	0.31	0.78	0.50	1.00			
Protozoa	-0.25	-0.48	0.95	-0.04	-0.45	-0.71	0.16	-0.32	-0.18	-0.39	-0.32	1.00		
Ostracoda	0.43	0.19	0.75	-0.71	0.32	0.02	-0.64	-0.45	0.14	0.42	0.46	0.58	1.00	
Cladoc	0.65	0.5	0.14	-	0.8	0.5	-	-0.38	0.20	0.8	0.7	-	0.7	1.00

era		4		0.88	3	5	0.95			8	6	0.13	3	

Rotifera:

Rotifer population was positively correlated with temp. (r = 0.34), pH (r= 0.32), alkalinity (r = 0.99), hardness (r = 0.47) etc. This population was negatively correlated with transparency (r = 0.09), dissolved oxygen (r = 0.90), nitrite nitrogen (r = 0.97), nitrate nitrogen (r = 0.56), and ortho phosphate (r = 0.15).

Copepoda:

Copepods made positive correlation with water temperature (r = 0.98), pH (r= 0.95), alkalinity (r = 0.44), Hardness (r = 0.89), nitrate nitrogen (r = 0.31), and ortho phosphate (r = 0.78). While made negative correlation with transparency (0.21), D.O. (r = 0.37), nitrite nitrogen (r= 0.32) etc.

Cladocera:

The zooplanktonic group Cladocerans showed markedly positive correlation with temperature (r = 0.65), pH (r = 0.54), transparency (r = 0.14), alkalinity (r = 0.83), hardness (r = 0.55) etc. and negative correlation with dissolved oxygen (r = 0.88), nitrite nitrogen (r = 0.95) and nitrate nitrogen (r = 0. 38) etc.

Protozoa:

The zooplanktonic group Protozoan showed markedly positive correlation with transparency (r = 0.14) and nitrite nitrogen (r = 0.16) etc. and negative correlation withtemperature (r = 0.25), pH (r = 0.48), dissolved oxygen (r = 0.04), alkalinity (r = 0.45), hardness (r = 0.71), nitrate nitrogen (r = 0.32) and orthophosphate (r = 0. 18) etc.

Ostracoda:

The zooplanktonic group Ostracoda showed markedly positive correlation with temperature (r = 0.43), pH (r = 0.19), transparency (r = 0.75), alkalinity (r = 0.32), hardness (r = 0.02) and ortho phosphate (r = 0.14) etc. and negative correlation with dissolved oxygen (r = 0.71), nitrite nitrogen (r = 0.64) and nitrate nitrogen (r = 0. 45) etc.

Reservoir Fishery Resources of Purulia District:

Water quality parameter of reservoirs of Purulia District

The physico-chemical parameters of six reservoirs of Purulia District namely Patloi, Futiary, Bandu, Kumari, Dangra, Taragonia in four different seasons (Pre Monsoon, Monsoon, Post Monsoon and winter) from February 2014 to January 2016 are being summarized in Table–.58-63

Table 58 : Seasonal Variation of Water Quality parameter in Patloi Reservoir of Purulia II Block

Seasonal Variation of Water Quality parameter in Patloi Reservoir of Purulia II Block				
Season	**Pre Monsoon**	**Monsoon**	**Post Monsoon**	**Winter**
Parameter	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Water Temp	28.045 ± 0.70	22.875 ± 0.38	19.885 ± 0.24	16.975 ± 0.52
Ph	8.2 ± 0.10	7.45 ± 0.15	7.75 ± 0.15	7.7 ± 0.10
Transparency (Cm)	27.035 ± 0.46	35.75 ± 2.05	25.83 ± 0.38	21.05 ± 0.70
Dissolved Oxygen (mg/lt)	7.7 ± 0.10	7.75 ± 0.25	8.35 ± 0.15	8.8 ± 0.30
Alkalinity (mg/lt)	90.75 ± 4.25	76.9 ± 6.70	69.51 ± 1.01	77.05 ± 1.60
Hardness (mg/lt)	152.675 ± 2.32	171.61 ± 1.04	129.6 ± 1.15	121.625 ± 1.13
Nitrite Nitrogen (NO_2N) (mg/lt)	0.014 ± 0.01	0.01175 ± 0.01	0.00375 ± 0.00	0.0055 ± 0.00
Nitrate Nitrogen (NO_3N) (mg/lt)	0.0315 ± 0.01	0.013 ± 0.01	0.006 ± 0.00	0.0025 ± 0.00
Ortho Phosphate (P_2O_5) (mg/lt)	0.0066 ± 0.00	0.026 ± 0.00	0.0075 ± 0.00	0.0045 ± 0.00

Table 59: Seasonal Variation of Water Quality parameter in Futiary Reservoir in Hura Block

Seasonal Variation of Water Quality parameter in Futiary Reservoir in Hura Block				
Season	**Pre Monsoon**	**Monsoon**	**Post Monsoon**	**Winter**
Parameter	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Water Temp	28.785 ± 0.215	26.175 ± 0.175	23.175 ± 0.325	19.075 ± 0.425
Ph	8.4 ± 0.2	8 ± 0.2	8.05 ± 0.15	7.95 ± 0.15
Transparency (Cm)	31.25 ± 0.75	35.05 ± 0.55	33.15 ± 0.35	27.5 ± 1
Dissolved Oxygen (mg/lt)	7.5 ± 0.2	8.15 ± 0.15	8.3 ± 0.2	8.4 ± 0.4
Alkalinity (mg/lt)	92.5 ± 2.5	84.125 ± 3.625	78.2 ± 2.55	65.535 ± 4.965
Hardness (mg/lt)	143.225 ± 2.355	159.215 ± 1.325	135.595 ± 4.945	120.555 ± 4.985
Nitrite Nitrogen (NO_2N) (mg/lt)	0.06 ± 0.01	0.02 ± 0.01	0.023 ± 0.017	0.02 ± .016
Nitrate Nitrogen (NO_3N) (mg/lt)	0.0775 ± 0.225	0.0255 ± 0.0195	0.0365 ± 0.011	0.0225 ±0.019
Ortho Phosphate (P_2O_5) (mg/lt)	0.01475 ± 0.01	0.02525 ± 0.019	0.0265 ± 0.0235	0.03125 ± 0.028

Table 60: Seasonal Variation of Water Quality parameter in Bandu Reservoir of Arsha Block

Seasonal Variation of Water Quality parameter in Bandu Reservoir of Arsha Block				
Season	**Pre Monsoon**	**Monsoon**	**Post Monsoon**	**Winter**
Parameter	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Water Temp	29.2 ± 0.55	25.175 ± 0.32	23.05 ± 0.60	18.115 ± 0.54

Ph	8.35 ± 0.05	7.65 ± 0.15	7.8 ± 0.10	8 ± 0.10
Transparency (Cm)	31.075 ± 0.58	36.6 ± 1.95	29.1 ± .40	24.64 ± 1.11
Dissolved Oxygen (mg/lt)	7.35 ± 0.15	7.85 ± 0.15	7.55 ± 0.05	8.65 ± 0.15
Alkalinity (mg/lt)	86.5 ± 1.50	67.5 ± 2.50	74.71 ± 1.14	78.66 ± 2.16
Hardness (mg/lt)	156.55 ± 1.05	183.175 ± 2.52	142.175 ± 1.47	138.215 ± 2.35
Nitrite Nitrogen (NO_2N) (mg/lt)	0.0775 ± 0.01	0.0225 ± 0.00	0.0055 ± 0.00	0.0195 ± 0.02
Nitrate Nitrogen (NO_3N) (mg/lt)	0.055 ± 0.01	0.09 ± 0.06	0.036 ± 0.03	0.0625 ± 0.01
Ortho Phosphate (P_2O_5) (mg/lt)	0.019 ± 0.01	0.0195 ± 0.01	0.00475 ± 0.00	0.03175 ± 0.03

Table 61: Seasonal Variation of Water Quality parameter in Kumari Reservoir in Balarampur Block

Seasonal Variation of Water Quality parameter in Kumari Reservoir in Balarampur Block				
Season	**Pre Monsoon**	**Monsoon**	**Post Monsoon**	**Winter**
Parameter	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Water Temp	29 ± 0.5	24.8 ± 0.8	22.4 ± 0.1	17.625 ± 1.125
Ph	8.5 ± 0.1	7.75 ± 0.15	7.65 ± 0.15	7.85 ± 0.25
Transparency (Cm)	32.05 ± 0.4	38.65 ± 1.85	32.14 ± 1.61	27.6 ± 0.95
Dissolved Oxygen (mg/lt)	7.65 ± 0.15	7.85 ± 0.05	8.1 ± 0.1	8.55 ± 0.05
Alkalinity (mg/lt)	87.75 ± 0.25	76.4 ± 3.6	78.77 ± 1.23	80.85 ± 0.65
Hardness (mg/lt)	149.05 ± 8.55	163.15 ± 2.35	157.9 ± 2.6	130.685 ± 4.885
Nitrite Nitrogen (NO_2N) (mg/lt)	0.04875 ± 0.041	0.0071 ± 0.0004	0.00725 ± 0.00075	0.00685 ± 0.00135
Nitrate Nitrogen (NO_3N)	0.061 ±	0.03 ± 0.005	0.0255 ±	0.025 ± 0.02

(mg/lt)	0.004		0.0195	
Ortho Phosphate (P_2O_5) (mg/lt)	0.0166 ± 0.0134	0.0309 ± 0.0291	0.02885 ± 0.02615	0.0183 ± 0.0167

Table 62: Seasonal Variation of Water Quality parameter in Dangra Reservoir in Kashipur Block

Seasonal Variation of Water Quality parameter in Dangra Reservoir in Kashipur Block				
Season	**Pre Monsoon**	**Monsoon**	**Post Monsoon**	**Winter**
Parameter	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Water Temp	28.1 ± 0.6	24.75 ± 0.75	22.3 ± 0.7	18.15 ± 0.35
Ph	8.2 ± 0.3	7.7 ± 0.1	7.8 ± 0.1	8 ± 0.1
Transparency (Cm)	32.02 ± 0.48	38.675 ± 0.825	31.5 ± 1	29.1 ± 2.4
Dissolved Oxygen (mg/lt)	7.6 ± 0.1	7.95 ± 0.15	8.1 ± 0.1	8.5 ± 0.3
Alkalinity (mg/lt)	87.75 ± 2.25	75.325 ± 4.675	70.25 ± 4.75	64.57 ± 4.18
Hardness (mg/lt)	142.93 ± 2.57	155.65 ± 5.1	140.18 ± 4.82	130.54 ± 4.96
Nitrite Nitrogen (NO_2N) (mg/lt)	0.28 ± 0.22	0.105 ± 0.025	0.065 ± 0.015	0.052 ± 0.048
Nitrate Nitrogen (NO_3N) (mg/lt)	0.15 ± 0.1	0.1 ± 0.05	0.035 ± 0.015	0.0525 ± 0.0175
Ortho Phosphate (P_2O_5) (mg/lt)	0.0175 ± 0.0125	0.0256 ± 0.0244	0.0475 ± 0.0025	0.0355 ± 0.029

Table 63: Seasonal Variation of Water Quality parameter in Dangra Reservoir in Kashipur Block

Seasonal Variation of Water Quality parameter in Taragonia Reservoir in Para Block				
Season	**Pre Monsoon**	**Monsoon**	**Post Monsoon**	**Winter**

Parameter	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Water Temp	28.3 ± 0.5	24.75 ± 1	22.185 ± 0.315	17.965 ± 0.035
Ph	8.15 ± 0.25	7.55 ± 0.25	7.75 ± 0.15	7.55 ± 0.15
Transparency (Cm)	32.085 ± 1.415	33.75 ±1.25	30.945 ± 2.055	27.05 ± 1.6
Dissolved Oxygen (mg/lt)	6.9 ± 0.2	7.25 ± 0.15	7.45 ± 0.25	8.1 ± 0.1
Alkalinity (mg/lt)	86.535 ± 3.965	78.5 ± 3	74.385 ± 4.115	66.535 ± 3.965
Hardness (mg/lt)	131.4 ± 3.6	142.3 ± 3.45	123.85 ± 3.7	113.06 ± 2.49
Nitrite Nitrogen (NO_2N) (mg/lt)	0.03295 ± 0.02705	0.03 ± 0.023	0.0767 ± 0.0733	0.03875 ± 0.03625
Nitrate Nitrogen (NO_3N) (mg/lt)	0.024 ± 0.006	0.03 ± 0.015	0.03355 ± 0.03145	0.04 ± 0.015
Ortho Phosphate (P_2O_5) (mg/lt)	0.02155 ± 0.01845	0.1759 ± 0.174	0.0182 ± 0.0168	0.0258 ± 0.0242

Water Temperature:

The water temperature varied from the range between 29.2 ± 0.55 to 16.975 ± 0.52. The occurrence of highest temperature was observed in Pre Monsoon Season in Bandu Reservoir of Arsha Block and lowest temperature was observed in Winter Season in Patloi Reservoir of Purulia II Block.

pH:

The average pH values of the reservoir water in the study area were varied from 8.5 ± 0.1 to 7.55 ± 0.15.Higher value of pH in summer season found in the Kumari reservoir of Balarampur Block may be due to low water level in the river. This result has been supported by the finding of Chaurasia and Pandey (2007). The lower value of pH found in winter season in the Taragonia reservoir of Para Block.

Dissolved Oxygen:

The minimum dissolved oxygen concentration was recorded during Pre Monsoon Season (i.e 6.9 ± 0.2) in Dangra reservoir of Kashipur Block and maximum D.O concentration was observed in

Winter Season (8.8 ± 0.30) in Patloi reservoir of Puruli II Block. Sometimes minimum D.O concentration was also observed in Monsoon season also. The DO of water of reservoirs of Purulia District was high in winter months and comparatively lower during monsoon and lowest concentration of DO recorded in the summer months in both the year of investigation.The maximum dissolve oxygen in winter may be due to low atmospheric temperature and minimum dissolve oxygen in summer may be due to high metabolic rate of organisms. This was supported by the findings of (Tara *et.al* 2011).

Alkalinity:

During the study it was observed that the lowest value of alkalinity was observed during winter season i.e 64.57 ± 4.18 mg /lt and highest value of alkalinity was observed during Pre Monsoon season i.e 92.5 ± 2.5 mg /lt. Similar result has been observed by (Bera et. al 2014) According to the guidelines for water quality management for fish culture in Tripura, the ideal value of alkalinity for fish culture is 50–300mg/L. According to the report of SRAC, the desirable limit for fish culture is 50 to 150mg/L, and the acceptable range is from 20 to 400mg/L. So, the alkalinity range of Reservoirs of Purulia district permits the fisheries activity.

Hardness:

During the study period the hardness value of reservoirs of Purulia District varied from 113.06 ± 2.49 mg/lt to 183.175 ± 2.52 mg/lt. Higher value of hardness observed during Monsoon season and lowest value observed during winter season.

Nitrite Nitrogen (NO_2N):

The nitrite nitrogen value of reservoirs of Purulia districtvaried from 0.004 mg/lt to 0.5 mg/lt. The higher value of nitrite nitrogen observed during Pre Monsoon months and lower value of nitrite nitrogen observed during winter month.

Nitrate Nitrogen (NO_3N):

The nitrate nitrogen value of reservoirs of Purulia district varied from 0.003 mg/lt to 0.1 mg/lt. The higher value of nitrite nitrogen observed during Pre Monsoon months and lower value of nitrite nitrogen observed during winter month.

Ortho Phosphate (P_2O_5):

The ortho phosphate value of reservoirs of Purulia district varied from 0.0025 mg/lt to 0.0055 mg/lt. The higher value of ortho phosphate observed during Pre Monsoon months and lower value of nitrite nitrogen observed during winter month.

Phytoplankton Diversity in the Reservoir of Purulia District

The population of phytoplankton in reservoirs of Purulia district composed of four major groups namely Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae.All the dominant group ofphytoplankton was present throughout the study period. Diversity analysis showed that Cyanophyceae group represent 6 genera, Chlorophyceae group 8 genera, Bacillariophyceae group 7 genera and Euglenophyceae 2 genera. Group wise phytoplankton availability in the reservoirs of Purulia District is shown below.

Table 64: Groupwise Phytoplankton Availability in the Reservoirs of Purulia District

Groupwise Phytoplankton Availability in the Reservoirs of Purulia District			
Taxa			
Cyanophyceae	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**
a. *Anabaena sp*.	a. *Ankistrodesmus sp*	a. *Cyclotella sp*	a. *Euglena sp*
b. *Lyngbya sp*.	b. *Chlorella sp*	b. *Diatoma sp.*	b. *Phacus sp*
c. *Microcystis sp*	c. *Closterium sp*.	c. *Fragillaria sp*	
d. *Oscillatoria sp*	d. *Mougeotia* sp	d. *Navicula s*p	
e. *Nostoc sp*	e. *Scenedesmus sp*	e. *Nitzschia sp*.	
f. *Phormidium sp*	f. *Spirogyra sp*	f. *Pinnularia sp*	
	g. *Ulothix sp*	g. *Synedra sp*	
	h. *Zygnema sp*		

Cyanophyceae:

The phytoplankton group Cyanophyceae represents by the following genera namely *Anabaena sp, Lyngbya sp, Microcystis sp, Oscillatoria sp, Nostoc, Phormidium sp*.The seasonal occurrences of cyanophyceace ranged from a maximum and minimum of 84.17 ind/lt to 42.33 ind/lt. In the present investigation, the density of cyanophyceace in the reservoirs of Purulia District was found to be maximum during summer seasons and minimum during Monsoon season. It may be due to higher water temperature. This result was supported by the findings Nirmal Kumar – Cini Oommen (2011), Zafar, (1967); Hegde and Bharati, (1985) and Swarnalatha and Narasinga Rao, 1993 who told that high temperature favours the luxuriant growth of blue-greens.

Chlorophyceae:

The Chlorophyceae group represents by the genus *Ankistrodesmus sp*, *Chlorella sp*, *Closterium sp*, *Mougeotia sp*, *Scenedesmus sp*, *Spirogyra sp*, *Ulothix sp*, *Zygnema sp*. The seasonal occurrences of chlorophyceace ranged from a maximum and minimum of 107.33 ind/lt to 56.83 ind/lt. In the present investigation, the density of Chlorophyceace in the reservoirs of Purulia District was found to be maximum during summer seasons and minimum during Monsoon season. This result was supported by the findings of Huisman *et al*., (2005); James G.N. and Paul R.N., (1992).

Bacillario phyceae:

Bacillariophyceae are the dominant group of phytoplankton. It consists of the following genera like*Cyclotella sp*, *Diatoma sp*, *Fragillaria sp*, *Navicula sp*, *Nitzschia sp*, *Pinnularia sp*, *Synedra*. The maximum no of Bacillariophyceae was observed during Pre Monsoon month (118.17 ind/lt) and minimum no was observed during Monsoon month (63.83 ind/lt). This result was supported by the findings of Devika et al., (2006) also recorded high population during summer and suggested that this might be due to physical rather than chemical condition in which the water temperature and transparency had a direct relation with phytoplankton population.

Euglenophyceae:

These are the least dominated group among the other group of phytoplankton. This group is dominated by only two genera i.e. *Euglena sp* and *Phacus sp*. The maximum no of Euglenophyceae was observed during summer season (19 ind/lt) and minimum no observed during Monsoon month (6 ind/lt).Verma *et al.,* (2001) and Milind S. Hujare, (2008) were also reported phytoplankton density in different seasons in order of summer > winter > monsoon.

Table 65: Seasonal Variation of Phytoplankton Availability of Reservoir of Purulia District:

Seasonal Variation of Phytoplankton availability of Reservoir of Purulia District				
Group	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Pre Monsoon	84.17 + 7.40	107.33 + 6.39	118.17 + 9.21	19 + 4.20
Monsoon	42.33 + 4.92	56.83 + 3.02	63.83 + 3.13	6 + 2
Post	56.33 + 6.15	73 + 2.82	78.66 + 3.29	8.66 + 2.56

Monsoon				
Winter	66.5 + 4.5	84.83 + 3.28	94.33 + 6.42	11.16 + 3.02

Table 66: Percentage composition of different group of Phytoplankton in the Reservoir of Purulia District:

Seasonal Variation (%) of Phytoplankton in the Reservoir of Purulia district				
Season	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**
Percentage (%)	25.67	33.16	36.55	4.62

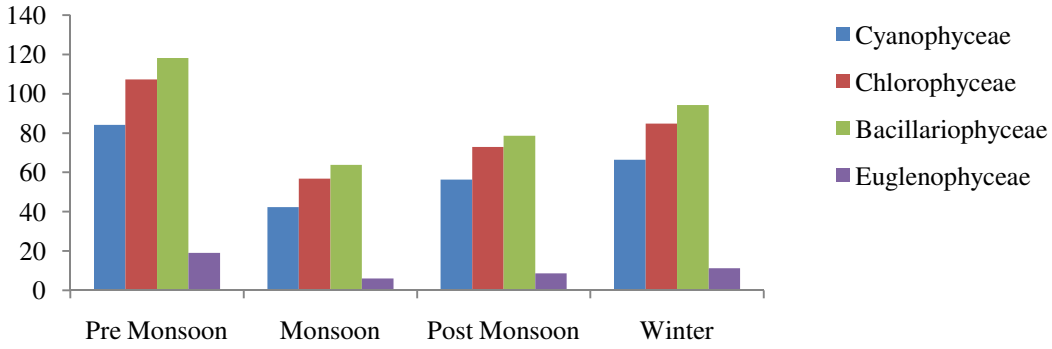


Fig 41: Seasonal Variation of Phytoplankton availability in the Reservoir of Purulia District

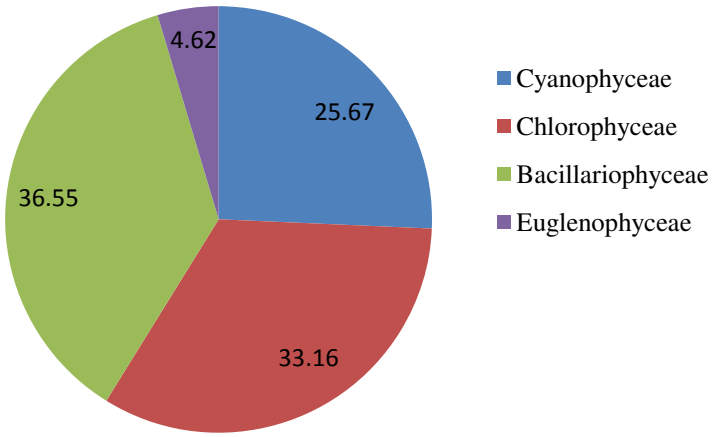


Fig 42: Composition (%) of Phytoplankton in the reservoirs of Purulia District

Table 67: Seasonal Abundance (%) of different group of Phytoplankton in the Reservoir of Purulia District

Seasonal Abundance (%) of different group of Phytoplankton in the Reservoir of Purulia District				
Group	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**
Season	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**
Pre Monsoon	25.6	32.65	35.95	5.7
Monsoon	25.04	33.62	37.77	3.5
Post Monsoon	26	33.69	36.3	3.9
Winter	25.89	33.03	36.73	4.34

Zooplankton Diversity in the Reservoir of Purulia District

The study revealed that the total number of zooplankton was low in rainy season (July – October) and high in summer (March – June) followed by winter (November – February). A total number of 26 genera of zooplankton belonging to six groups namely Rotifera (6 genera), Copepoda (10 genera), Cladocera (6 genera), Protozoa (3 genera), Ostracoda (1 genera).

Table 68: Zooplankton availability in the Reservoirs of Purulia District:

GroupWise Zooplankton Availability in the Reservoirs of Purulia District				
Taxa				
Rotifera	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**
a. *Brachionus sp.*	a. *Nauplii*	a. *Amoeba*	a. *Cypris sp.*	a. *Daphnia sp.*
b. *Asplanchna sp*	b. *Diaptomus sp*	b. *Paramecium*		b. *Ceriodaphnia*
c. *Keratella sp.*	c. *Pseudodiaptomus sp.*	c. *Arcella*		c. *Simocephalus*
d. *Synchaeta sp.*	d. *Cyclops*			d. *Bosmina*
e. *Euchlanis sp.*	e. *Mesocyclops sp.*			e. *Moina*
f. *Filinia sp.*	f. *Paracyclops sp.*			f. *Diaphanosoma*

				sp.
	g. *Microcyclops sp.*			
	h. *Eucyclops*			
	i. *Acanthocyclops sp*			
	j. *Heliodiaptomus*			

Rotifera:

The higher populations of rotifera were recorded during Pre Monsoon season, while low density was observed in monsoon season of study period. The total number of individuals of rotifer group was consist of 94.5 ind/l (Pre Monsoon season), 58.33 ind/l (monsoon season). The rotifera group was represented by 6 genera. The most commonly occurring genera are *Brachionus sp, Asplanchna sp, Keratella sp, Synchaeta sp, Euchlanis sp, Filinia sp.* The same finding has been also reported by Abdus and Altaff, (1995) and Kumar, (2001). Less zooplankton population during monsoon season is on account of high turbidity which restricts growth of the planktonic population.

Cladocera:

Cladocerans are important food source for fry; fingerlins and adult of many economically important fish species. Cladocerans are also reported to be the indicators of eutrophic nature of water bodies (Sharma, 2001).Among Zooplankton, cladocera was the dominant group.This group is represented by 6 genera. Most commonly occurring genera are *Daphnia sp, Ceriodaphnia, Simocephalus, Bosmina, Moina, Diaphanosoma sp*. Their density ranged from 137.17 ind/lt (Pre Monsoon) to 85.83 ind / lt (Monsoon). Cladocerans exhibited higher density during summer months and lower during winter month.

Copepoda:

Copepoda is the most dominant group among other group of zooplankton. This group is represented by the genus of *Cyclops, Eucyclops, Mesocyclops sp, Paracyclops sp, Acanthocyclops sp, Microcyclops sp, Pseudodiaptomus sp, Diaptomus sp, Heliodiaptomus, Nauplii.* Their density range varies from maximum 131.50 no/lt to minimum 66 no/lt.The population of cyclopoida was observed through out the year at all sampling sites. The lowest

number was observed in monsoon months, while higher population was found in summer. A peak was observed in May (Lewis JR WM, 1978) opines that cyclopoida production shows strong evidence of association withabundance of diatoms and blue green algae.

Ostracoda:

This group is represented by only one genus i.e Cypris sp. Ostracoda population was higher during pre monsoon month and lower during monsoon month. Their density range varied from 9.33 no/lt to 3.50 no/lt. Ostracoda population was higher populations was observed during summer months. N. Manickam et al. 2012 found ostracoda maximum population in the month of May and minimum during the monsoon month at HaledharmapuriLake, Dharmapuri Town.Sunkad and Patil (2004) recorded maximum Ostracoda population in summer at Fort Lake in Belgaum (Karnataka). Similar results were also reported by Mahor R.K, 2011.

Protozoa:

Protozoans are the least dominant group among the zooplankton. The zooplanktonic group Protozoa represented by the genus of *Amoeba, Paramecium, Arcella.*Protozoan density was maximum during Pre Monsoon month (15.33 no/lt) and minimum during Monsoon month (4.50 no/lt).

Table 69: Seasonal Variation of Zooplankton Availability of Reservoir of Purulia District:

Seasonal Variation of Zooplankton availability of Reservoir of Purulia District						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	94.50 ± 6.55	131.50 ± 9.03	15.33 ± 2.81	9.33 ± 1.80	137.17 ± 11.75	1.29
Monsoon	58.33 ± 8.16	66 ± 9.59	4.50 ± 1.50	3.50 ± 0.96	85.83 ± 10.16	1.22
Post Monsoon	71.16 ± 7.66	86.33 ± 7.84	6.66 ± 1.97	5 ± 1.29	106.33 ± 13.22	1.24
Winter	93 ± 8.67	116.16 ± 10.51	9 ± 2	6.66 ± 1.49	125.83 ± 10.46	1.25

Table 70: Percentage composition of different group of Zooplankton in the Reservoir of Purulia District:

Seasonal variation (%) of Zooplankton in the Reservoir of Purulia District					
Season	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**
Percentage (%)	25.73	32.45	2.88	1.99	36.95

The total no of species recorded were 1232 org/lt, out of which Rotifera are 317 org/lt (25.73 %), Cladocera 455 org/lt (36.95 %), Copepoda 400 org/lt (32.45%), Ostracoda 24 org/lt (1.99 %), and Protozoa 35 org/lt (2.88 %)

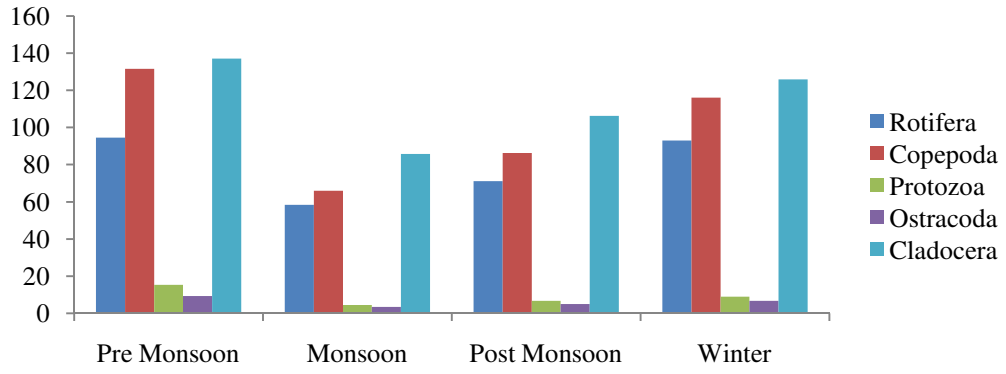


Fig 43: Seasonal Variation of Zooplankton availability in the Reservoir of Purulia District

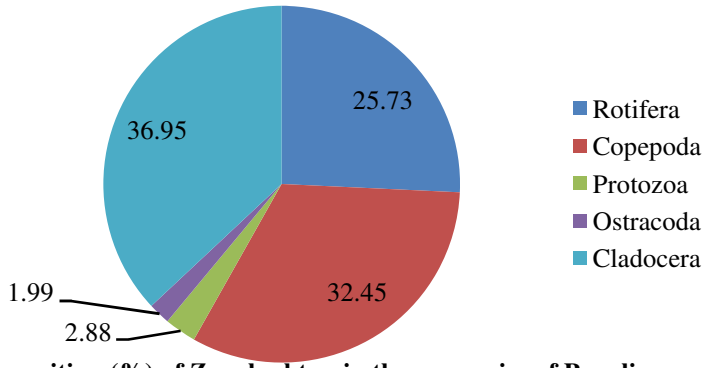


Fig 44: Composition (%) of Zooplankton in the reservoirs of Purulia District

Table 71: Seasonal Abundance (%) of Different group of Zooplankton in the Reservoir of Purulia District:

Seasonal Abundance (%) of different group of Zooplankton in the Reservoir Purulia District					
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**
Season	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**
Pre Monsoon	24.36	33.9	3.95	2.4	35.36
Monsoon	26.73	30.25	2.06	1.6	39.34
Post Monsoon	25.83	31.33	2.41	1.81	38.59
Winter	26.53	33.09	2.56	1.9	35.9

Icthyofaunal diversity of different Reservoirs of Purulia district

In the present study total 37 species belonging to 7 orders, 15 families and 26 genera are reported in the reservoirs of Purulia Districts. On the basis of species composition, Cypriniformes were dominant (16 species) followed by Perciformes (7species), Siluriformes (6species) and Channiformes (3 species), Osteoglossiformes and Synbranchiformes (each of 2 species), and Anguilliformes (1 species). Species belong to family Cyprinidae were found more abundant (43.26%) followed by Channidae (8.10%), Ambassidae (5.41%), Cichlidae (5.41%), Bagridae (5.41%), Mastascembellidae (5.41%), Osphronemidae (2.7%), Anabantidae (2.7%), Gobidae (2.7%), Siluridae (2.7%), Claridae (2.7%), Schilbeidae (2.7%), Heteropneustidae (2.7%), Anguilidae (2.7%). The fish recorded from the reservoirs of the Purulia District were *Labeo rohita, Labeo bata, Labeo calbasu,Puntius ticto, Puntius sophore, Puntius gelius, Catla catla , Amblypharyngodon mola , Rasbora daniconius, Cirrhinus mrigala, , Cirrhinus reba, Cyprinus carpio, Esomus danricus, Hypophthalmichthys molitrix, Ctenopharyngodon idella , Chanda ranga,Chanda nama,, Oreochromis niloticus , Oreochromis mossambicus, Trichogaster lalius, Anabas testudineus, Glossogobius giuris, Ompok pabda, Wallago attu , Clarias batrachus, Heteropneustes fossilis, Mystus vittatus, Mystus tengra, Macrognathus pancalus, Macrognathus*

aculeatus , *Channa punctata, Channa striata, Channa orientalis, Notopterus notopterus* , *Notopterus chitala, Anguilla bengalensis* .The average of fish abundance obtained in the reservoir showed that the species *Labeo rohita* recorded the highest catch by the number. Fish diversity and its abundance are being eroded every day mainly because of unending anthropogenic pressure. Habitat loss and environmental degradation has seriously affected the fish fauna (Saha and Patra, 2013). Recent data regarding fish abundance of the study area, aiming to contribute a better knowledge of the fish diversity and a tool for conservation planning of aquatic environments in this region. To maintain fish biodiversity has an immense importance as it is not always possible toidentify individual species critically to sustain aquatic ecosystem (Vijaykumar *et al*., 2008).The fish abundance of the reservoirs of the Purulia district constitute a valuable natural resources in Economic, aesthetic and scientific and educational terms and its conservation and management are critical to the interests of human kind itself.

Table 72: The geographical coordinates of the selected reservoirs of Purulia district:

Sl. No	**Name of the Reservoir**	**Situated in Block**	**Latitude**	**Longitude**
01	Bandu	Arsha	23.280079	86.138258
02	Kumari	Balarampur	23.163572	86.284794
03	Futiary	Hura	23.384333	86.558475
04	Patloi	Purulia II	23.368918	86.478018
05	Dangra	Kashipur		
06	Taragonia	Para	23.475051	86.38908

Table 73 : Fish species availability in the dams and reservoirs of Purulia District:

Sl. No.	Order	Family	Scientific name	Common name	Local name	IUCN status	Seasonal abundance	Economic value
1	Cypriniformes	Cyprinidae	*Labeo rohita* (Ham.)	Rohu	Rui	LC	TY	Food fish

2			*Labeo calbasu* (Ham.)	Black rohu/karnataka labeo	Kalbose	LC	TY	Food fish
3			*Labeo bata* (Ham.)	Bata labeo/minor carp	Bata	LC	SM	Food fish
4			*Puntius ticto* (Ham.)	Ticto barb	Tit punti	LC	SM	Ornamental, food fish
5			*Puntiussophore*(Ham.)	Pool barb	Jatpunti	LC	SM	Ornamental
6			*Puntius gelius*Ham.)	Golden dwarf barb	Dor punti	LC	SM	Ornamental
7			*Catla catla* (Ham.)	Catla	Catla	LC	TY	Food fish
8			*Amblypharyngodon mola* (Ham.)	Mola carplet	Mouralа	LC	SM	Ornamental
9			*Amblypharyngodon microlepis* (Bleeker)	Indian carplet	Mouralа	LC	SM	Ornamental
10			*Rasbora daniconius*(Ham.)	Slender rasbora	Siram punti	LC	TY	Ornamental
11			*Cirrhinus mrigala*(Ham.)	Mrigal	Mrigal/ Mrig	LC	RS	Food fish
12			*Cirrhinus*	Reba	Bhango	LC	SM	Food fish

			reba(Ham.)	carp	nbata			
13			*Cyprinus carpio*(Linn.)	Wild common carp	Cyprinus	VU	TY	Ornamental/food fish
14			*Esomus danricus*(Ham.)	Flying barb	Darkya	LC	TY	Ornamental
15			*Hypophthalmichthys* molitrix (Val.)	Silver carp	Silver carp	NT	TY	Food fish
16			*Ctenopharyngodon idella* (Val.)	Grass carp	Grass carp	NE	TY	Food fish
17	Perciformes	Ambassidae	*Chanda ranga*(Ham.)	Indian glassy fish	Ranjan chanda	LC	WN	Ornamental
18			*Chanda nama*(Ham.)	Elongate glass-perchlet	Kanta chanda	LC	TY	Ornamental
19		Cichlidae	*Oreochromis niloticus* (Linn.)	Nile tilapia	Nilotica	NE	TY	Food fish
20			*Oreochromis mossambicus*(Peters)	Mozambique tilapia	Tilapia	NT	TY	Food fish
21		Osphronemidae	*Trichogaster lalius*(Ham.)	Dwarf gourami	Khoira	LC	SM	Ornamental
22		Anabantidae	*Anabas testudineus*(B	Climbing perch	Koi	DD	TY/RS	Ornamental

			loch)					
23		Gobiidae	*Glossogobius giuris*(Ham.)	Bareye goby	Bele	LC	WN	Ornamental/food fish
24	Siluriformes	Siluridae	*Ompok pabda*(Ham.)	Pabdah catfish	Pabda	NT	SM	Food fish
25			*Wallago attu* (Bl. & Schn.)	Fresh water shark	Boal	NT	WN	Food fish/ornamental
26		Claridae	*Clarias batrachus*(Linn.)	Air breathing catfish	Magur	LC	WN	Ornamental/food fish
27		Heteropneustidae	*Heteropneustes fossilis* (Bloch)	Stinging catfish	Singhi	LC	SM	Ornamental/food fish
28		Bagridae	*Mystus vittatus*(Bloch)	Striped dwart catfish	Tangra	LC	WN	Ornamental/food fish
29			*Mystus tengara*(Ham.)	Tengara catfish	Tangra	LC	WN	Food fish/ornamental
30	Synbranchiformes	Mastacembelidae	*Macrognathus pancalus* (Ham.)	Barred spiny eel	Pacal	LC	WN	Food fish
31			*Macrognathus aculeatus* (Bloch)	Lesser spiny eel	Pacal	NE	WN	Ornamental/food fish

32	Channiformes	Channidae	*Channa punctata*(Bloch)	Spotted snakehead	Lata	LC	SM	Food fish/ornamental
33			*Channa striata*(Bloch)	Stripped or Snakehead murrel	Shol	LC	SM	Food fish/ornamental
34			*Channa orientalis*(Bl. & Schn.)	Walking snakehead	Cheng	NE	SM	Food fish
35	Osteoglossiformes	Notopteridae	*Notopterus notopterus* (Pallas)	Bronze featherback	Folui	LC	WN	Ornamental/food fish
36			*Notopterus chitala/Chitala chitala* (Ham.)	Humped featherback	Chital	NT	WN	Ornamental/food fish
37	Anguilliformes	Anguillidae	*Anguilla bengalensis* (Gray)	Indian mottled eel	Ban fish	NT	RS	Ornamental

LC = least concern, VU = vulnerable, NT = near threatened, NE = not evaluated, DD = data deficient;

WN = winter, SM = summer, TY = throughout the year, and RS = rainy season.

Table 74: Composition of the fish community by order:

Sl. No.	Taxa	Number of species	Percentage (%)
1	Order: Cypriniformes	16	43.26
2	Order: Perciformes	7	18.93

3	Order: Siluriformes	6	16.21
4	Order: Channiformes	3	8.10
5	Order: Osteoglossiformes	2	5.40
6	Order: Synbranchiformes	2	5.40
7	Order: Anguilliformes	1	2.70
Total		37	100.00

Table 75: Composition of the fish community by family:

Sl. No.	**Taxa/families**	**Number of Species**	**Percentage (%)**
1	Family: Cyprinidae	16	43.26
2	Family: Ambassidae	2	5.41
3	Family: Cichlidae	2	5.41
4	Family: Osphronemidae	1	2.7
5	Family: Anabantidae	1	2.70
6	Family: Gobiidae	1	2.70
7	Family: Siluridae	1	2.70
8	Family: Claridae	1	2.70
9	Family: Heteropneustidae	1	2.70
10	Family: Bagridae	2	5.41
11	Family: Schilbeidae	1	2.70
12	Family: Channidae	3	8.10
13	Family: Notopteridae	2	5.40
14	Family: Mastacembelidae	2	5.41
15	Family: Anguillidae	1	2.70
Total		37	100.00

Table 76: IUCN Status of commonly available fish species in the Reservoirs of Purulia District

Least Concern (LC)	**Vulnerable (VU)**	**Near threatened (NT)**	**Not evaluated (NE)**	**Data deficient (DD)**
Labeo rohita	*Cyprinus carpio*	*Hypophthalmichthys molitrix*	*Ctenopharyngodon idella*	*Anabas testudineus*
Labeo calbasu		*Oreochromis mossambicus*	*Oreochromis niloticus*	
Labeo bata		*Ompok pabda*	*Macrognathus aculeatus*	
Puntius ticto		*Wallago attu*	*Channa orientalis*	
Puntius sophore		*Notopterus chitala/Chitala chitala*		
Puntius gelius		*Anguilla bengalensis*		
Catla catla				
Amblypharyngodon mola				
Amblypharyngodon microlepis				
Rasbora daniconius				
Cirrhinus mrigala				
Cirrhinus reba				
Esomus danricus				
Chanda nama				
Chanda ranga				
Trichogaster lalius				

Glossogobius giuris				
Clarias batrachus				
Heteropneustes fossilis				
Mystus vittatus				
Mystus tengra				
Macrognathus pancalus				
Channa punctata				
Channa striata				
Notopterus notopterus				

Table 77: Distribution Status of commonly available fish species in the Reservoirs of Purulia District

Throughout the year (TY)	**Summer (SM)**	**Rainy season (RS)**	**Winter (WN)**
Labeo rohita	*Labeo bata*	*Cirrhinus mrigala*	*Chanda ranga*
Labeo calbasu	*Puntius ticto*	*Anabas testudineus*	*Glossogobius giuris*
Catla catla	*Puntius sophore*	*Anguilla bengalensis*	*Wallago attu*
Rasbora daniconius	*Puntius gelius*		*Clarias batrachus*
Cyprinus carpio	*Amblypharyngodon mola*		*Mystus vittatus*
Esomus danricus	*Amblypharyngodon microlepis*		*Mystus tengra*
Hypophthalmichthys molitrix	*Cirrhinus reba*		*Macrognathus pancalus*
Ctenopharyngodon idella	*Trichogaster lalius*		*Macrognathus aculeatus*

Chanda nama	*Ompok pabda*		*Notopterus notopterus*
Oreochromis mossambicus	*Heteropneustes fossilis*		*Notopterus chitala/Chitala chitala*
Oreochromis niloticus	*Channa punctata*		
Anabas testudineus	*Channa striata*		
	Channa orientalis		

Pie Distribution of commonly available fish species (By Order) present in reservoirs of Purulia Disrict:

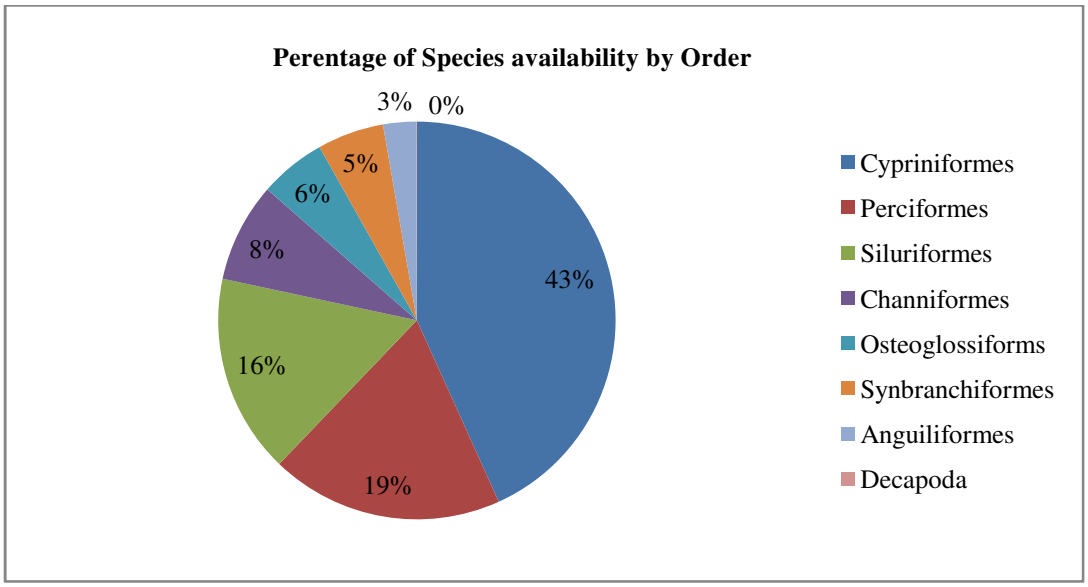


Fig 45: Pie Distribution of commonly available fish species (By Order) present in reservoirs of Purulia Disrict:

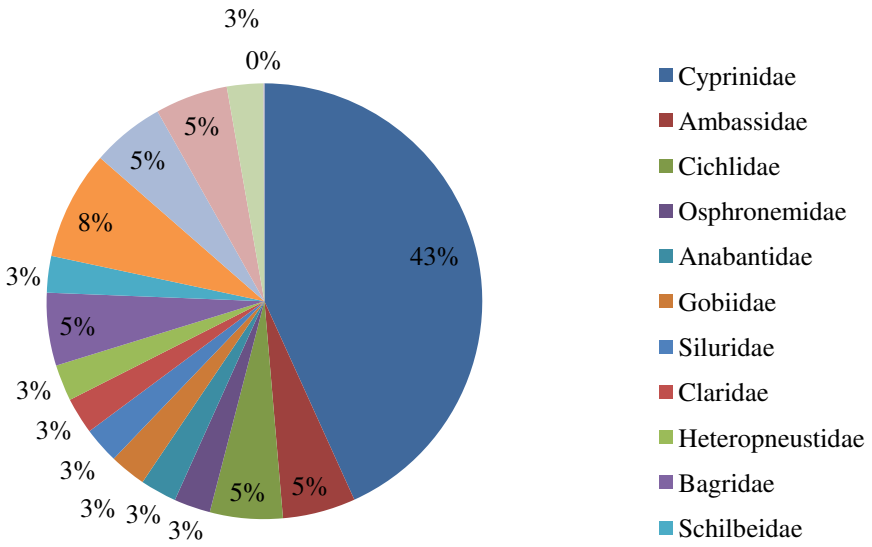


Fig 46: Percentage of availability of Species by Family

Aquatic Macrophyte diversity in the Reservoirs of Purulia District

Aquatic macrophytes comprise a diverse assemblage of macroscopic plants that spend whole or at least a part of their life cycle in aquatic environment. Macrophyte are the Aquatic plants those who are photo synthetically active parts remain permanently or at least for several months in each year submerged in water or floating onto the water surface (Singh, A.K. 2006).

In the study area the aquatic macrophyte diversity assessment was done seasonally for the period of one year. Sample collection was done at frequent interval and preserved it in a herbarium sheet for further study. All collected aquatic macrophyte species correctly indentified using pertinent literature and flora Cook (1996), Gupta (2001) and Yadav and Sardesai (2002).

Total 15 genera of macrophytes are found in the study area. The aquatic macrophytes of the study area have been classified into following groups.

Table 78: List of macro phytes found in the reservoirs of Purulia district durig the study period

Sl no	Name	Family	Common name	Nature

1	*Vallisnaria sp.*	Hydrocharitaceae	Eel grass	Submerged
2	*Hydrilla*	Hydrocharitaceae	Water thyme	Submerged
3	*Ceratophyllum*	Ceratophylaceae	Coontail	Submerged
4	*Chara sp*	Characeae	Stoneworts/macroscopic algae	Submerged
5	*Ipomoea*	Convolvulaceae	Morning glory bsh	Emergent
6	*Potamogeton*	Potamogetonaceae	Leafy pond weed	Submerged
7	*Najas*	Hydrocharitaceae	Water nymph	Submerged
8	*Bacopa monnieri*	Scrophulariaceae	Brahmi	Emergent
9	*Enhydra sp*	Asteraceae	Helencha	Hygrophylus rooted, floating
10	*Elodea canadensis*	Hydrocharitaceae	Common water weed	Submerged
11	*Cyprus sp*	Cyperaceae	Dwarf papyrus	Emergent
12	*Eichornia sp.*	Pontederiaceae	water hyacinth	free floating
13	*Nymphaea*	Nymphaeaceae	water lily	Emergent
14	*Ludwigia*	onagraceae	water primrose	Submerged
15	*Typha*	Typhaceae	Cattail	Submerged

Submerged Macrophyte:

They are certain rooted plants which anchor with the ground for anchorage and nutrient purposes.These plants grow in submerged soil up to a water depth of about 10 m. The commonly occurring submerged plants under the study area are*Vallisnaria sp.*,*Hydrilla*,*Ceratophyllum*,*Chara sp*,*Potamogeton,Najas*,*Elodea Canadensis*,*Ludwigia*,*Typha.*

Emergent Macrophytes:

They grow in shallow water and existing near the wet environment.Such type of plant had been seen in shallow water and most of them having the growth above water.*Ipomoea sp*, *Bacopa monnieri*,*Nymphaea*and *Cyprus sp* were the representative of emergent plants.

Free Floating Macrophytes:

The plants which are included in this group are seen floating on the water surface. They can move freely from one place to another on the water surface as their roots do not from direct contact with the soil. The representatives of this group are *Eichornia sp.* and *Salvinia sp*.

Rooted Floating Macrophytes:

They may be either rooted with leaves and flowers above the water surface or free floating. *Enhydra sp* is the representative of this group.

Present Status of Fish Farming and Livelihood of Fish Farmers in Bankura District

Fish Farming Status

Pond Size and Depth:

Pond size is an important factor because all management measures are planned considering the size of ponds. In the present survey it has been found that the pond size varies from 10 kathas to 12 bighas. The smaller ponds like 10 – 20 kathas preferably used as nursery pond in the Hatcheries, and the bigger sized pond used for table fish production as well as brooder fish rearing in the hatcheries. The depth of ponds also varies in respect of their uses. The nursery ponds were of maximum 3 ft. depth but the rearing ponds were of 10 – 12 ft depth.

Pond type and Ownership of the Pond:

In the present study area 20% of the ponds are seasonal and rests of the ponds (80%) are perennial. The seasonal ponds are completely dry during summer season and become unsuitable for fish culture. They retained water in the month of June to month of December. The water level of perennial pond was also declined during summer month in the month of Feb and March. It was observed that highest no of pond i.e 70% are single owner and rest of the 30% pond are joint or multiple owner.

Table No 79:

Pond type	% of Farmers	Ownership of pond	% of Farmers
Seasonal	20%	Single owner	70 %
Perennial	80 %	Multiple owner	30 %

Cultured Fish Species and Stocking Density:

Bankura was pioneer in respect of production of fish seed of Indian major carp by simulating natural conditions in captivity. Pisciculture is an important factor of economical development of Bankura. The fish farmer of the district cultured wide variety of fish species in polyculture system. Aquaculture practices in the study sites were found to be semi-intensive type. Few farms were commercially operated for culture. About 50 % of the farmer in the study site commercially adopted multiple stocking and multiple harvesting technologies. In case of commercially operated farms the new season of pond fish production started in May by stocking ponds with new season fingerlings, while in case of perennial pond stock in February with the previous year fingerlings. In Semi intensive culture practice farmers mainly practiced polyculture and stocked a range of Indian and Chinese major carp species. Stocking density varied 10000 to 15000 no/ha/yr. Stocking density varied among individual farmers with respect to size, species and capability to invest in aquaculture. In some cases few farmers are doing their practices in traditional way. Apart from this in Onda and Ramsagar site most of the fish farmers are engaged in hatchery operation for breeding of Indian Major carps and exotic carp and sometimes they are doing magur breeding also. It was revealed form the field study that the fish farming season in the study area was from June to January in case of seasonal pond and throughout the year in case of perennial pond . Hatchery operation was done during the period February (For *Cyprinus Carpio*) and March to first week of September (Indian Major Carp and other exotic carp). In this system farmer cultured mainly Indian Major Carp's catla (*Catla Catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) and Exotic fishes like Silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenoparyngodon idella*), common carp (*Cyrinus carpio*) and other fish species like Sar punti (*Puntius sarana*), Pangus (*Pangasius sutchi*), Chital (*Chitala chitala*), Magur (*Clarias batrachus*), Monosex Tilapia etc.

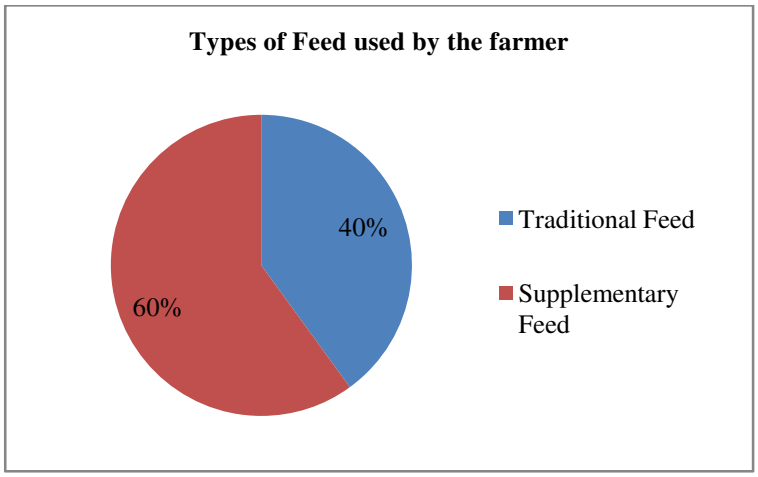
Fertilization and Manuring System:

Maintenance of a healthy aquatic environment and production of sufficient fish food organisms (plankton) in ponds are two factors of primary importance for successful pond culture operation. During survey it has found that most of the farmer has maintained fertilization and manuring schedule during pond preparation and the culture period also. They often used raw cow dung and poultry manure as organic manure and use urea and single super phosphate as inorganic fertilizer

during pond preparation and culture period. Some progressive farmer prepare juice organically with the help of ingredients like yeast, ground nut oil cake, rice bran and molasses and apply in the pond at 15 days interval for better growth of plankton and obtained more fish production.

Feed and Feeding Practices:

Apply of supplementary feeds, in the culture is necessary which can improve nutritional deficiency and increase fish production. Form the survey it was found that 40 % farmer depends on natural food found in the culture system and rest of the 60 % farmer applied supplementary feed such as rice bran, mustard oil cake and commercially manufactured feed. It is also mentioned that the farmers those applied supplementary feed in their culture system don't follow any standard rate of feeding or frequency.



Fish Production, Harvesting and Marketing:

In the study area, the average yield of fish was found to be 3000 to 4000 kg/ha/yr. The annual production varies because of differences in farm size, feed, seed, other inputs and management measures. Although fish were harvested throughout the year, but the peak harvesting period was found from November to January. Progressive those who follow the multiple stocking and multiple harvesting method (MSMH technique) they can achieve more production 6 to 8 ton/ha/yr. In case of Table fish, harvested fish were sold by the farmers to local *paikers* and the rest of the fish consumed by the households and given to the relatives. The market chain from farmers to consumers passes through local agent/*paiker* to local market where retailer sells the

fish to consumers. But fish seed were sold to all over West Bengal and other state like Gujrat, Maharastra and Jharkhand.

Fisher Folk Population:

According to Hand Book of Fishery Statistics, Govt of West Bengal total no of Fishing Village in the district is 982. Total no of Fisher Folk Family of the District is 23, 638. Among which male fishermen population is 56395 and female fishermen population is51828 **(Hand Book of Fishery Statistics, Govt of West Bengal, 2014 - 2015).**

Fish Based Industries in Bankura:

According to the report of Assistant Director of Fisheries, Bankura, Govt. of West Bengal there are 2 no's of Ice plant in Bankua District, and Indian Major Carp (IMC) hatchery one govt. , 350 no's of private IMC hatchery. There are 3no's of Whole sale market and 29 no's of Whole seller. There are 156 no's Retail Market and1086 no's of retailer. There is one feed mill plant in Barjora Block **(Assistant Director of Fisheries, Bankura).**

Fisherman's Co – operative Societies and Fish Production Groups, Women SHGs:

In the district there are two no's of Central Fisherman Co – operative Society (CFCS) and 76 no's Primary Fisherman Co –operative Society (PFCS). Total two thousand nine hundred fifteen (2915no's) no's of people are engaged in fishery activity of Primary Fisherman Co –operative Society (PFCS). There are 27 Fish Production Group (FPG) (**Assistant Director Fisheries, Bankura**).

List of Fishermen's Co-operative Society Ltd. for Bankura District:

According to Hand book of Fishery Statistics, 2014 – 15, Govt, of West Bengal there are 2 no's of Central Fisherman Co-operative Society and 76 no's of Primary Fisherman Co-operative Society. Among 76 no's of Primary Fisherman Co-operative Society 24 no's are A' type, 6 no's 'B' type and 46 no's are 'C' type of Co-operative Society. Total water under culture is 11989 Ha. Total Co-operative member are 2915 no's. The name of the fishermen co operative society spread over 22 blocks of the Bankura district are Patpur Thakurbari PFCS ltd, Masiara Anchal Dhibar P. F. C. .S.Ltd, Bairipal Mahadeb Sinan F.C.S ltd, Ambikanagar PFCS ltd, Shyamnagar Anchal PFCS ltd, Ramsagar Anchal Mach Dimpona Utpadak Primary Co-Op society Ltd, Gorabari Uttar Anchal MSS ltd, Gorbari Dakshin Anchal MSS ltd , Purusattampur PFCS ltd, Gangajalghati –O- KapistaP.F.C.S ltd, Chhto metyala M.D.S.S ltd, Chakbaid Hetyagora P.F.C.S

ltd, Kalyani Anchal P.F.C.S ltd, Puddi Anchal P.F.C.S ltd, Bishnupur P.F.C.S ltd, Dadhimukha P.F.C.S ltd, Bhagaldighi P.F.C.S ltd, Chandipur Banshi F.C.S ltd, Kanuri Sudarsan M.R.MS.S ltd, Fulandeb i M.R.M.M.S.S ltd, Krishnapur Maa Kali Rangin Maach Samity ltd, Krishnapur Maa Kali Rangin Maach Samity ltd, PatdohaM.D.MR.M..S ltd, Khatra Supur M.S.S ltd, Rautora Anchalik PFCS ltd, Tiluri Anchal Dhibar Samabai Samity Ltd, Bagdobar Ma Manasa RMSS Ltd, Haludkanali FCS ltd, Paboya FCS ltd, Mejia Anchal M.S.S Ltd, Barshal Nityanandapur F.C.S ltd, Ratanpur Anchal F.C.S ltd, Damodarbati F.C.S Ltd, Matsyakanya Rangin Machh Chas,Bagrabari Rangin Machh Chas, Harinabada FCS ltd, Paharpur Fcs Ltd, Saharjora FCS ltd, Saharjora FCS ltd, Ardhagram FCS ltd, Beliatoe FCS ltd, Nirisha FCS Ltd, Hatashuria FCS ltd, Barjora FCS ltd, Maliara FCS ltd, Pakhanna FCS ltd, Arrah FCS ltd, Ratkola D.S.S ltd, Kenjakura FCS Ltd, Bankura Keotpara FCS ltd, Banki Azad hind Dhibar FCS ltd, Lego Matsya jibi S.S ltd, Arjunpur F.CS ltd, Tejpal Fcs Ltd, Jamkuri Union FCS Ltd, Rajeswari FCS ltd, Rasmoni FCS ltd, Samudrabundh FCS Ltd, Palashi FCS ltd, Karisunda Union FCS ltd, Chakaiasundi FCS Ltd, Sonamukhi FCs Ltd, Bibarda FCS ltd, Sabrakon FC.S ltd, Lalbundh FCS ltd, Dundaria FcS Ltd, Bhagra F.C.S ltd, MatgodaFcS ltd, Khatra Dhibar SS ltd,Deulbira Aibasi FCS ltd, Shilaboti MSS ltd, Chiltore F.CS ltd, Bikrampur FCS ltd, Jamda Kalpathar fCS ltd, Bhutsahari FCS ltd, Jamda Kalpathar fCS ltd, Bhutsahari FCS ltd, Doldoria FCS ltd, Simlapal FCS ltd, Dubrajpur FCS ltd, Rautora Anchalik F.C.S ltd, Kalpathar PFCS ltd.

Inland Fish Production of Bankura District:

According to the report of Assistant Director of Fisheries, Bankura, Govt. of West Bengal, the highest fish production occur in the year 2011 – 2012 i.e seventy one thousand eight hundred fourteen tons (71814 tons) and lowest production was found in the year 2010 – 2011 i. e fourty nine thousand four hundred fifty five tons (49455 tons) (Assistant Director of Fisheries, Bankura).

Production of fish seed in Bankura District:

According to the report of Assistant Director of Fisheries, Bankura, Govt. of West Bengal, the fish seed production in Bankura District shows an increasing trend. This activity was highest in the year 2012 – 2013 i.e four thousand thirty one tons (4031 tons).In this district the fish seeds are produced by two ways. One is the seed production through bundh breeding technique. This activity was done in Taldangra and Simlapal Block of Bankura District. Another one is establishment of private Chinese hatchery mainly Onda – Ramsagar Block of Bankura District.

Nearly three hundred and thirty five hatcheries are producing seed in this area (Assistant Director of Fisheries, Bankura).

Water Area covered and Fish Production under FFDA in Bankura District:

According to the report of Chief Executive Officer Fish Farmers Development Agency, Bankura, the highest water area covered in F. F. D. A was 77.86 hac in the year 2011 – 2012 and fish production was also high i.e 276.95 tons. In the year2011 – 2012 the no of people benefited from F. F. D. A scheme was one hundred and thirty. The lowest water area covered in F. F. D. A was41.05 hac in the year 2010 – 2011 and fish production was also low i. e 213.79 tons **(C. E. O, F. F. D. A., Bankura).**

Reservoir Fishery Resources of the District:

There are fourteen reservoirs in Bankura district. Among them Kangsabati is the largest reservoir in the state of West Bengal situated in Bankura district at Khatra Ranibandh Block. It covers a water area of about 40 Sq.Km. situated at 22.51^0 Latitude and 56.44^0 Longitude having a catchments area of 3626 Sq. Km. with full storage level (FSL) 13668ha and at dead storage level (DSL) 3400 ha and mean sea level (MSL) about 6400ha with maximum depths of 42 meters. The Kangsabati reservoir falls mainly under two districts, Bankura and Purulia district. The average water area of Kangsabati reservoir in Bankura District is three thousand (3000 hac) hac. In Fisheries prospective these reservoirs opens up a new dimension for capture & culture fisheries. The smallest reservoir of the district is Birkar Bundh covering twenty hac areas in ranibundh block. The other reservoirs are Kanjore in Barjora Block covering hundred hac water areas, Sali in Gangajal Ghati Block covering one hundred thirty five hac, Maliara Jor Bandh in Gangajal Ghati Block covering ninety two hac (92.00hac). There are four reservoir in Ranibundh Block namely Teleberia dam (30.00 hac), Kumari bandh (20 hac), Palash boni Bundh (23.2 hac), Birkar Bundh (20 hac). There are also Kalindi Bundh (36 hac) in Simlapal Block and Tarapur Bill (36.70 hac) in Mejia Block and Deulvira Dam (20 hac) in Hirbundh Block. There are three reservoirs are situated in Bishnupur Block namely Lal Bundh (25 hac), Krishna Bundh (44.89 hac) and Jamuna Bundh (25 hac).

Problem faced by fish farmers of Bankura District:

The fish farmers of the Bankura districts faced a wide variety of problems. Among the different problems faced by freshwater fish farmers of the districts are, disease, inundation due to floods, financial problem, poaching and market price fluctuation were the major ones. In Bankura district 40 % farmers are suffering in financial crisis. The fish farmers complained about the lack of financial assistance from the state Government and banks. Many of them were forced to avail loans from private sources with high interest rates. Most of the farmers complained about the lease period, and policy. Most of the cases lease period is 3 years or to some extent it is 5 yrs. But to avail credit facility from any financial institute under govt. subsidiary scheme like FFDA, at least lease period of 7 yrs is necessary. Inundation due to flood is one of the major problem faced by fish farmer of Bankura district. Due to heavy shower during July and September, a large part of the West Bengal freshwater fish farms get inundated, ultimately loosing majority of the stock. Siltation was another problem, usually during rainy season. Occurrence of disease (argulas infection and EUS disease) outbreak mainly brood stock fish is another problem. Poaching and market price fluctuation is another problem.

Problem faced by hatchery owner of Bankura district:

1. The rail and road infrastructure is inadequate at Ramsagar site, resulting in poor connectivity and difficulty of market access.
2. Over time Ramsagar lost its near monopoly status as fish seed farming came to be adopted on a large scale in West Bengal. The new procedures embraced advanced and sophisticated technology improved breeding techniques ala the Andhra aqua culturists and thus offered stiff competition to the Ramsagar farmers, who still followed the initial practices first proposed by the ICAR scientists.
3. Compounding the already poor connectivity is the absence of an easy to administer and well defined permit system to facilitate the transport of live animals. Consequently fish seed farmers are subjected to considerable harassment by the police who stop them to investigate the contents of the oxypacks and therefore delay consignments and even cause death of the seed.
4. The failure to avail live stock insurance by the fish seed producers at Ramsagar as a result of their lack of knowledge and awareness about the potential benefits stemming from such insurance meant that they could not protect themselves from seed loss in transit.

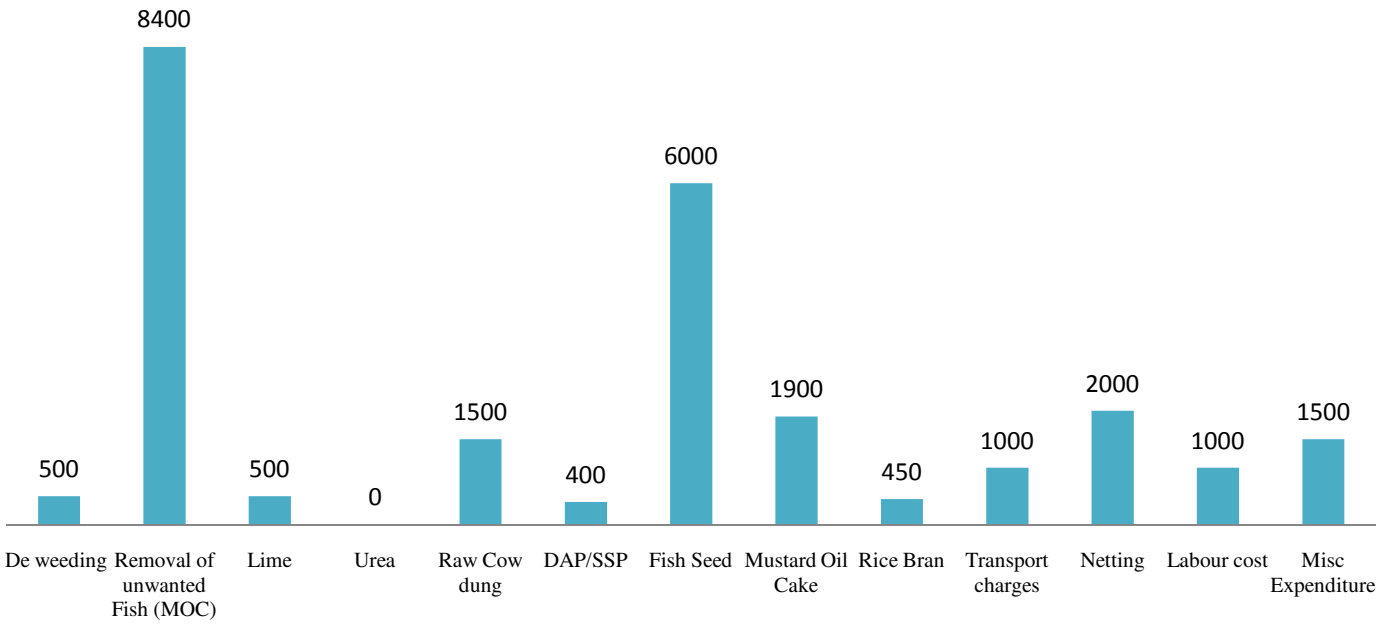
5. Given their loss of competitiveness the fish seed producers at Ramsagar are feeling the pinch of being at a relative disadvantage vis a vis agriculturists is owing to discriminatory treatment with respect to taxation and subsidization. Fish farmers have to pay income tax to the tune of Rs. 3600 per acre where as agriculturist with holding up to 6 acres are exempted from income tax. More over the fish farmers can not avail any subsidy on electric and irrigation and are charged at the commercial rate. In contrast agriculturist get substantial subsidies on inputs like electricity and irrigation facilities, thus bringing down the total cost of production dramatically.
6. Lack of capital is also important. They are expecting some financial support from fisheries department.
7. Lack of technical know how
8. Unhealthy competition between the hatchery owners.
9. Middle Man
10. Only 6 month's work. Rest of the year no work no pay.
11. Disease outbreak in brood stock.

Average Economics of the Traditional Fish Farming:

Culture system	**Traditional Culture (followed by fish farmers of Bankura)**		
Ingredient	**Amount (Kg)**	**Unit Price (Rs.)**	**Amount (Rs.)**
De weeding	0	LS	500
Removal of unwanted Fish (MOC)	300	28	8400
Lime	50	10	500
Urea	0		0
Raw Cow dung	LS	LS	1500
DAP/SSP		LS	400
Fish Seed	2000 no's	3	6000
Mustard Oil Cake	100	19	1900
Rice Bran	150	3	450
Transport charges	LS	LS	1000

Netting	4	250	2000
Labour cost	0	LS	1000
Misc Expenditure	LS	LS	1500
Total			24150
Production (Kg)	400	100	40000
Income from sale			40000
Net Income			15850
Net return on expenditure %			65.631
B:C ratio			0.656

Different expenditure on traditional farming of Bankura District



Econometry of Fish culture in trial pond under different management practices in 6 months culture period (Unit area: 0.13 hac.)

Culture System	Traditional Culture (followed by fish farmers of Bankura)			Semi intensive culture (following FFDA model scheme, Govt. of WB)			Semi intensive with periodical manuring (15 days interval)		
Ingredient	Amount (Kg)	Unit Price (Rs)	Amount (Rs)	Amount (Kg)	Unit Price (Rs)	Amount (Rs)	Amount (Kg)	Unit Price (Rs)	Amount (Rs)
De weeding	0	LS	500	LS		350	LS	0	900
Removal of unwanted Fish (MOC)	300	28	8400	330	20	6600	330	20	6600
Lime	50	10	500	65	10	650	50	10	500
Urea	0		0	45	10	450	40	10	400
Raw Cow dung	LS	LS	1500	1333	1.5	1999.5	4663	1.5	6994.5
DAP/SSP		LS	400	66	9	594			0
Fish Seed	2000 no's	3	6000	1000	5	5000	1200	4	4800
Mustard Oil Cake	100	19	1900	500	24	12000	250	19	4750
Rice Bran	150	3	450			0	250	3	750
Transport charges	LS	LS	1000			0	LS	600	600
Netting	4	250	2000	4	500	2000	4	500	2000
Labour cost	0	LS	1000			1000			1000
Misc Expenditure	LS	LS	1500			2000			2000
Total			24150			32643.5			31294.5
Production (Kg)	400	100	40000	400	120	48000	450	120	54000

Income from sale			40000			48000			54000
Net Income			15850			15356.5			22705.5
Net return on expenditure %			65.631			47.04305604			72.5542827
B:C ratio			0.656			0.47			0.72

Social Parameters

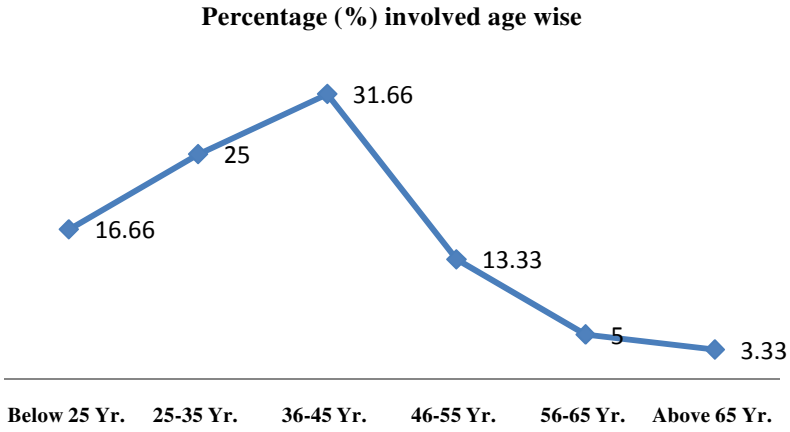
Age:

From (Table), it depicts that the maximum percentage of fish farmers were within medium age group (i.e. between the age group 36 to 45 years). The involvement of the age group of 25-45 years is mainly due to unemployment. Through this modified scientific fish farming; they wanted to establish themselves in the society within a short period of time, taking into consideration the lucrative return within a very short period. The young generation invested money from their parental sources viz. retirement benefits of their gurdians, the amount received from the in law's family, taking loans from bank or other sources and invested the money in this sector to generate the income and upgrading the social lively hood status. In the case of the age group of 46-65 years, most of them are basically involved with other business and they invested here to increase their level of income.

Table 80: Age Distribution of the Selected Fish Farmers of selected Blocks under Bankura District

Stations / **Age**	**Bankura I Block**	**Onda Dev. Block**	**Bishnupur Dev. Block**	**Joypur Dev. Block**	**Taldangra Dev. Block**	**Khatra Dev. Block**	**Total**	**% Involved**
Below 25 Yr.	1	2	2	1	2	2	**10**	**16.66**
25-35 Yr.	3	3	2	2	3	2	**15**	**25**

36-45 Yr.	3	4	3	3	3	3	**19**	**31.66**
46-55 Yr.	2	1	1	1	2	1	**8**	**13.33**
56-65 Yr.	1	0	1	0	0	1	**3**	**5**
Above 65 Yr.	0	0	1	0	0	1	**2**	**3.33**
Total	**10**	**10**	**10**	**10**	**10**	**10**	**60**	



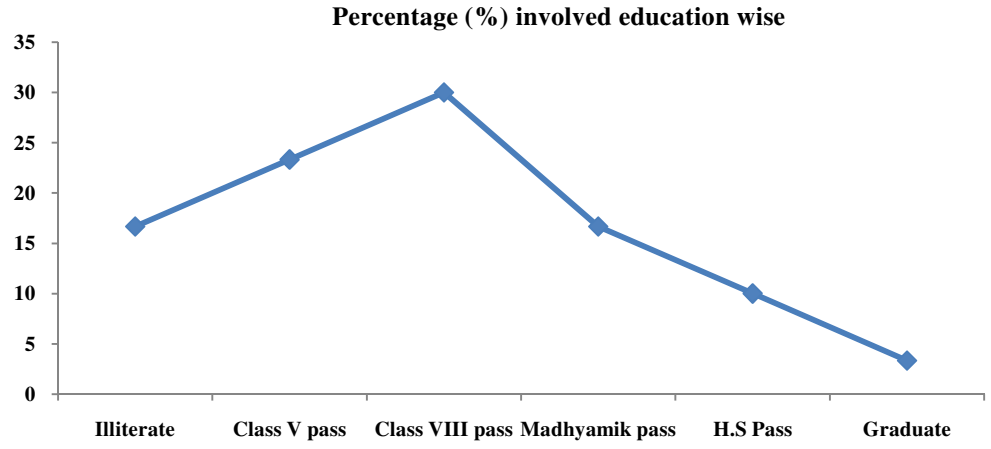
Education:

Education is the foundation stone of human development and it shapes the individual to fit to be a member of the ever-changing modern society and is one of the main tools for socio-economic development.Fish farmers were categorized into six major categories (**Illiterate, Class V pass,Class VIII pass, Madhyamik pass, H.S Pass, Graduate**) on the basis ofthe level of education. Out of 60 fish farmers, 16.66 % had no education, 23.33 % had primary level, 30 % are of class VIII standard, 16.66% had secondary level, 10% hadhigher secondary level and 3.33% had bachelor level of education.

Table 81: Distribution of the Level of Education among the Selected Fish Farmers at selected Blocks of Bankura District

Stations	**Bankura I**	**Onda Dev. Block**	**Bishnupur**	**Joypur**	**Taldangra Dev.**	**Khatra**	**Total**	**% Involve**

Edu. Level	Block		Dev. Block	Dev. Block	Block	Dev. Block		d
Illiterate	2	1	1	2	2	2	**10**	**16.66**
Class V pass	2	2	2	2	3	3	**14**	**23.33**
Class VIII pass	3	3	3	3	3	3	**18**	**30**
Madhyamik pass	2	2	2	2	1	1	**10**	**16.66**
H.S Pass	1	1	1	1	1	1	**6**	**10**
Graduate	0	1	1	0	0	0	**2**	**3.33**
Total	**10**	**10**	**10**	**10**	**10**	**10**	**60**	



Caste Status:

Caste is one of the important factors affecting the choice of the occupation and possession of skill in different rural economic activities (Singh 2003). From the study area it depicts that most of the people engaged in fish farming activities are general category (70%) and 30% people are of SC community and their sub caste is 'Dhibar' and 'Jelia kaibarta'.

Gender:

It depicts from the study that out of 60 respondent only 6 women (10%) heading their households and they are mainly the widows through fish farming.

Family Size and Type:

The family size has considerable influence on the income and expenditure of the family. Family size reflects the supply of family labour which played a vital role in fish farming. Investigated families were divided into three family size groups viz., small family (<4 Member), medium Family (4 - 6 Member) and Large Family (> 6 Member). The highest 50% of the respondents had 4 – 6 family members whereas the lowest only 23.33 % had less than four family members. In the present study, families were classified into two types as nuclear and joint family. About 58.33% of farmers lived in joint families and 41.66% in nuclear families. Joint family was predominant in the study area.

Table 82:

Sl. No	Family Type	Total (%); N = 60
01	Joint Families	35 (58.33%)
02	Nuclear Families	25 (41.66%)

Sl. No	Family Size	Total (%); N = 60
01	Small Family (<4 Member)	14 (23.33 %)
02	Medium Family (4 - 6 Member)	30 (50%)
03	Large Family (> 6 Member)	16 (26.66%)

Financial Capital:

Sources of Credit:

It was found that most of the farmers (60%) used their own money for fish farming, and few farmers (40%) received loan from bank for farming activities. Small marginal farmers were

found in disadvantageous situation due to poor financial resources for fish farming and they did not have financial support from institutional credit.

Occupational Status:

The standard of living and earning of fish farmers depend on their occupation (Goswami, *et al.*2002). In the study area the primary occupation of the respondent are categorized into four types these are farmers, businessman, govt. employee and wage earner.

From the present study it reveals that 40% of fish farmer were engaged in fish farming as their main occupation while 30% were in agricultural activity, 20% in business and rest of the 10% in service sector.

Experience in Fish Farming:

Experience plays a vital role in efficient utilization of resources and getting better output in any venture particularly in agricultural sector as it is the core factor in generation of traditional knowledge. In the present study the farmer has experience of 10 -15 years on an average in fish farming.

Annual Income:

Income determines standard of living, income is highly correlated to almost all indicators of well being.

In the study area the investigated fish farmers were divided into four categories having annual income of up to 25,000; 25,001 to 50,000; 50,001 to 75,000 and above 75,000.

Table 83:

Sl. No.	Income category	No of Fisherman under that category (N = 60)	Percentage (%) of that particular category
1	Rs. 25000.00	5	8.33%
2	Rs. 25001 – Rs. 50000.00	15	25%
3	Rs. 50001 – Rs.75000.00	26	43.33%
4	Above Rs. 75000.00	14	23.33%

Physical Capital:

Housing Condition:

The nature of the house indicates the social status of the people. From the present study it was found that most of the house of fish farmers was earthen house (50%), then brick wall (35%), and rest of the 15% brick wall with RCC roof.

Health Facilities:

Health facilities of the fish farmer were poor and they were not quite conscious about their health. From the study it was found that 70% of the fish farmers dependent on village doctors or the doctors of the Block Primary health centre. While 20% of the farmer got health services from Bankura Zila Hospital. In some critical cases 10 % farmers referred to the outside of the District, Durgapur.

Drinking Water Sources:

The provision of clean and safe drinking water is considered to be the most valued element in the society. The study showed that 100% of fish farmers used tube well water for drinking purposes.

Markets used for selling fish:

Most of the fish farmers sold their fish products first in the local markets. If the catch is more then they brought their product to Bankura town Market. In some cases they sold their products nearby by districts like Purulia, west Midnapur and Jharkhand.

Average Consumption of fish per family:

Reason for initializing a fish farm:

In the study area most of the farmers (50%) involved themselves with fish farming as their ancestral are also doing the same type of culture and they also wants to continue their family occupation. 25 % fish farmer engaged themselves in fish farming activities to supplement their family income. Only 16.66% of them want to maintain their economic status through fish farming. Rest of the 8.33% farmers wants to improve their social status through fish farming activities.

Table 84:

Sl. No	Reason	Total No of farmers involved (N= 60)	Percentage (%)
1	To continue family occupation	30	50%

2	To supplement family income	15	25%
3	To maintain economic status	10	16.66%
4	To improve social status	5	8.33%

Seasonal Variation of Water quality parameter of Bankura District

In the present study the water quality parameter of fish culture pond was analyzed in different season of the selected blocks of the Bankura district to aware the fish farmers about the importance of water quality parameter. The fish production of aquaculture pond largely depends on the optimum water quality parameters. The physico-chemical parameters of water body infour different seasons (Pre monsoon, monsoon, Post monsoon and winter) from February 2014 to January 2016 are being summarized in **Table–**. The water seasonal variation of water quality parameter discussed below.

Physico-chemical parameters

Temperature:

Variations in temperature in a water body have a great influence upon itsproductivity. Temperature influence all metabolic and physiological activities and lifeprocesses such as feeding, reproduction, movement and distribution of aquatic organisms. Temperature also affects the speed of chemical changes in soil and water.Seasonal variations in the values of physico-chemical parameters in the water body of Bankura District during studyperiod are shown in Table .During the study period, the mean water temperatures varied from minimum 20.21^0C in winter season and maximum 25.85^0C in Pre Monsoon months.This result has also been supported by the findings of Sonawane, 2011 in Sukhana River, Maharastra, India.

Temperature ANOVA:

Table 85: ANOVA of water temperature shows significant differences between seasons (P< 0.01) but do not show significant differences between sites (P> 0.01).

Two way ANOVA between sites and seasons for Water Temperature of Bankura District						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	5.0626333	5	1.012526667	1.4559605	0.261638974	4.555613984
Between Season	169.78977	3	56.59658889	81.382938	1.65372E-09	5.416964863
Error	10.431533	15	0.695435556			
Total	185.28393	23				

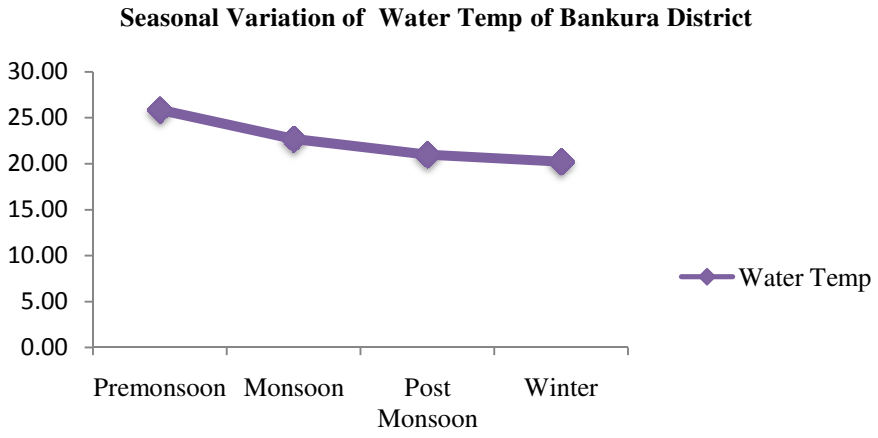


Fig 46: Seasonal Variation of Water Temperature of Bankura District

pH:

During the study period the minimum average pH value of pond water of Bankura District was 7.08 and maximum value was 7.78. The minimum pH value was observed during Monsoon season and maximum value was observed during Pre Monsoon Period. In the present study the pH value varied from 7.08 to 7.78 which indicate favorable condition of water body.Higher value of pH in summer season may be due to low waterlevel in the pond and high photosynthesis

of micro and macro organism resulting in high production of carbon dioxide which make the water little alkaline (Trivedi, 1989; Shiddamallayya and Pratima, 2008).

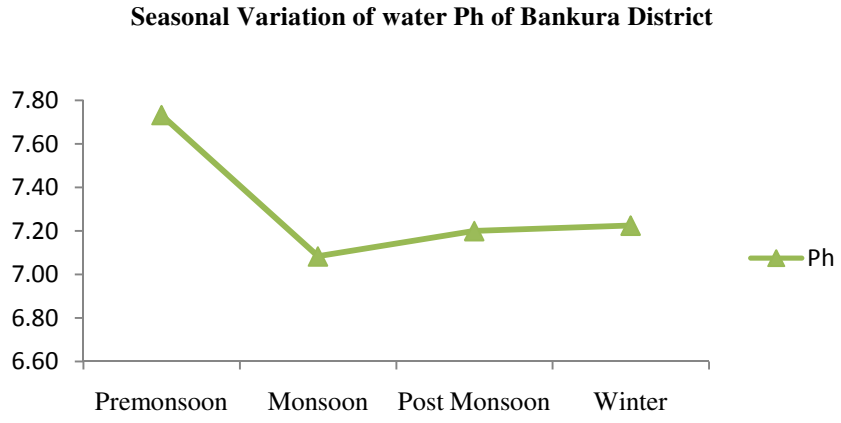


Fig 47: Seasonal Variation of Water pH of Bankura District

Table 86: ANOVA of pH of water shows significant differences between seasons and between sites also (P< 0.01).

Two way ANOVA between sites and seasons for Water pHof Bankura District						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	1.1630208	5	0.232604167	4.0693719	0.015566639	4.555613984
Between Season	1.6469792	3	0.548993056	9.6045438	0.000873294	5.416964863
Error	0.8573958	15	0.057159722			
Total	3.6673958	23				

Transparency:

During the study period the transparency of water varied seasonally. The minimum transparency value was observed during Winter Season i.e 23.57 (cm) and maximum value was observed

during Monsoon month's i.e 30.75 (cm).Water transparency in the range of 20-50cm was found to be conducive for fish ponds.

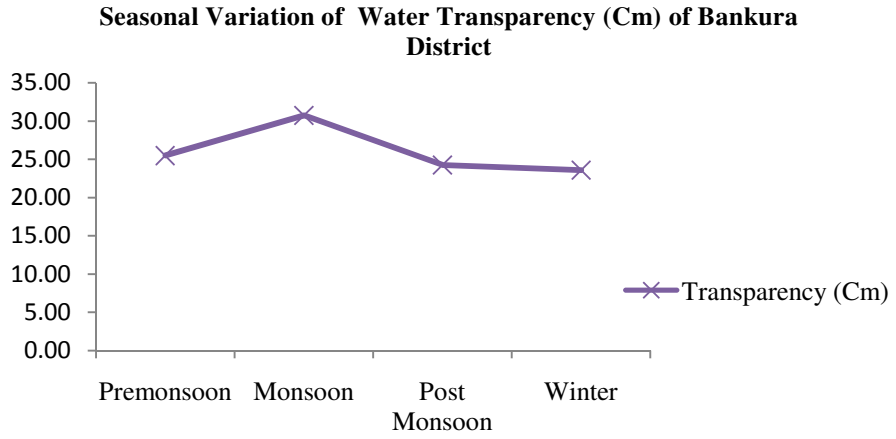


Fig 48: Seasonal Variation of Water Transparency of Bankura District

Transparency:

Table 87: ANOVA of transparency of water shows significant differences between seasons and between sites also (P< 0.01).

Two way ANOVA between sites and seasons for Water Transparency of Bankura District						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	69.54935521	5	13.909871	9.9238243	0.000241412	4.555613984
Between Season	226.5046031	3	75.501534	53.86563	2.89849E-08	5.416964863
Error	21.02496562	15	1.4016644			
Total	317.078924	23				

Dissolved Oxygen:

During the study period the dissolved oxygen concentration of water bodies of Bankura District varied from 4.01 mg/lt to 4.51 mg/lt. The minimum value was observed during summer month's i.e Pre Monsoon season and maximum value was observed during Monsoon months.

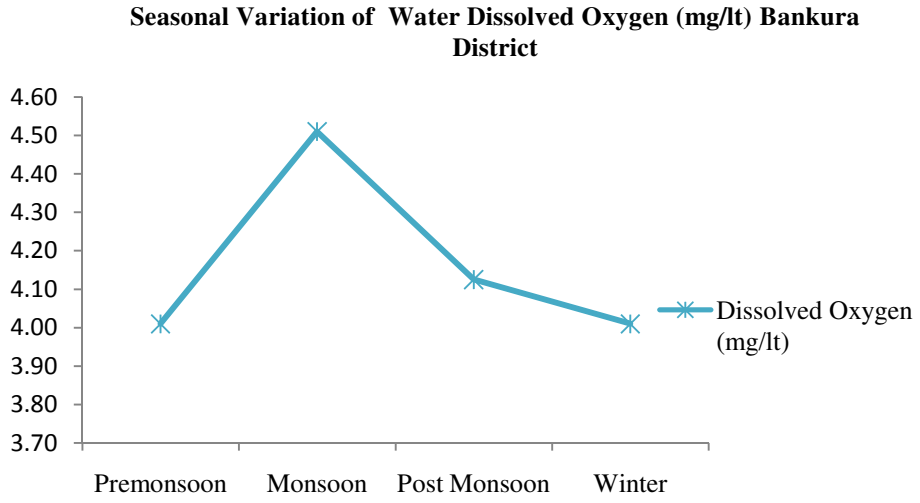


Fig 49: Seasonal variation of Dissolved Oxygen concentration of water body of Bankura District

Dissolved Oxygen:

Table 88: ANOVA of dissolved oxygen of water shows significant differences between seasons and between sites also (P< 0.01).

Two way ANOVA between sites and seasons for Dissolved Oxygen of Water of Bankura District						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.999583333	5	0.19991667	8.04134078	0.0007351	4.55561398
Between Season	1.205833333	3	0.40194444	16.1675978	5.7506E-05	5.41696486
Error	0.372916667	15	0.02486111			
Total	2.578333333	23				

Alkalinity:

During the study period the alkalinity values varied from 77.42 mg/lt to 102.92 mg/lt. The highest alkalinity value was observed during Pre Monsoon month and lowest value was observed during winter months.Similar result has been recorded by Elayaraj and Selvaraju, 2014.

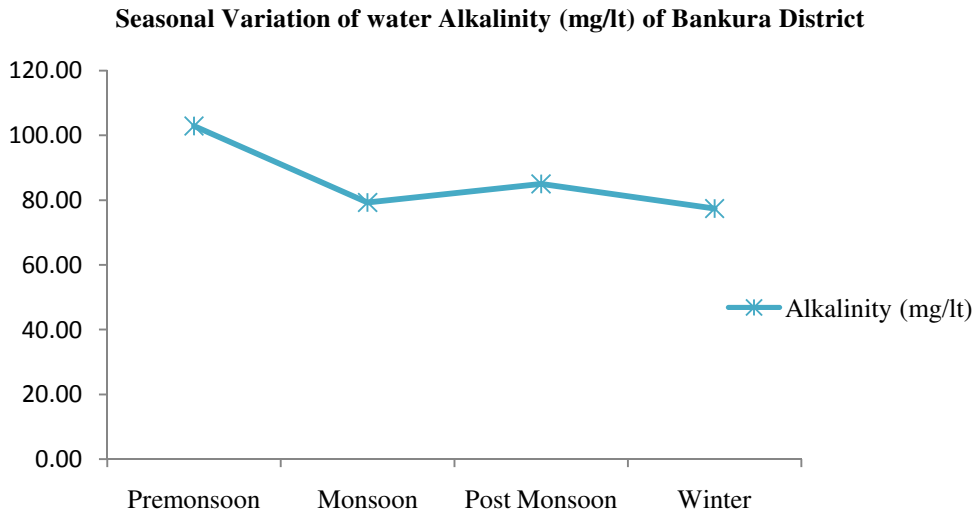


Fig 50: Seasonal variation of Alkalinity of water body of Bankura District

Hardness:

In the present investigation the total hardness value ranged from 103.75 mg/lt to 138.33 mg/lt. During the study period the hardness value was observed during Pre Monsoon month's i.e 138.33 mg/lt and lowest value (103.75mg/lt) was observed during Monsoon months. Similar findings have been reported by Kaur and Sharma (2001). They reported that generally maximum hardness values in thewater body found at summer. Increase in hardness worth may be attributed to the decrease in water volume and cooccurring increase in the rate of evaporation at warm temperature, as a result high loading organic substances, detergents and different pollutants (Rajgopal et. al., 2010).

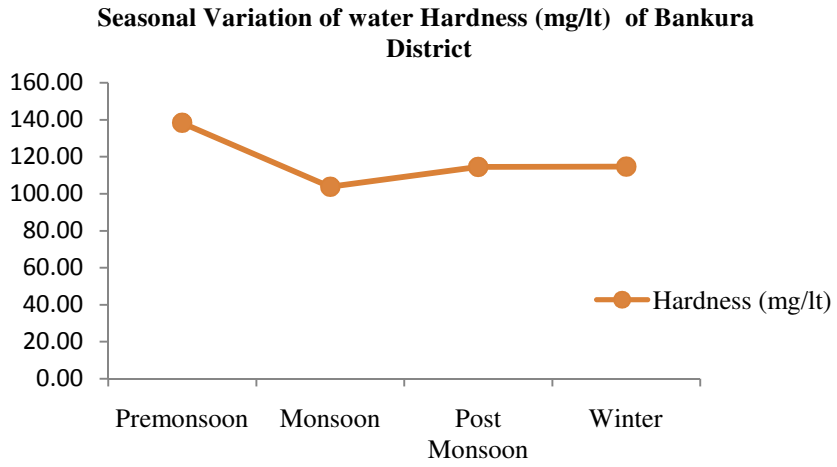


Fig 51: Seasonal Variation of Water Hardness ofBankura District

Table 89: ANOVA of hardness of water shows significant differences between seasons and between sites also (P< 0.01).

Two way ANOVA between sites and seasons for Water Hardness of Bankura District						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	3583.552083	5	716.7104167	13.04707786	5.12301E-05	4.555613984
Between Season	3832.197917	3	1277.399306	23.2539221	6.80885E-06	5.416964863
Error	823.9895833	15	54.93263889			
Total	8239.739583	23				

Nutrient parameters:

Nitrate nitrogen (NO_3-N):

Nitrates are contributed to freshwaterthrough discharge of sewage and industrial wastesand run off from agricultural fields.During the study period the Nitrate Nitrogen Concentration of pond water of Bankura District varied from 0.02 to 0.01 mg/lt.Maximum Nitrate nitrogen

concentration was found in Monsoon Season and minimum value was found in winter season.The high nitrate concentration duringmonsoon might be due to influx of rain water into pond through agricultural field.In present investigation high values of nitrate found in monsoon season due to influx of nutrients from the watershed areas along with runoff water in monsoon and low value in winter season, kinetics of nitrogen cycling was low due to less decomposition of organic matter and low water temperature. Similar findings was reported by Suresh Kumar *et., al* .,2014.

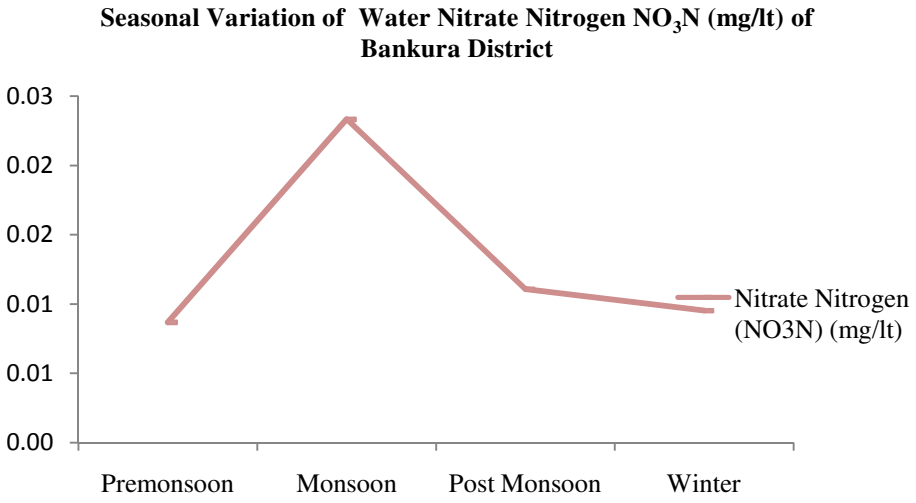


Fig 52: Seasonal Variation of Nitrate Nitrogen Concentration ofWater ofBankura District

Table 90: ANOVA of Nitrate Nitrogen of water not shows significant differences between sites and between seasons also (P> 0.01).

Two way ANOVA between sites and seasons for Nitrate Nitrogen of Water of Bankura District						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.000451274	5	9.02547E-05	0.5863629	0.710435818	4.555613984
Between Season	0.000839287	3	0.000279762	1.817547 2	0.187216091	5.416964863
Error	0.002308845	15	0.000153923			

Total	0.003599406	23				

Nitrite Nitrogen (NO_2N):

During the study period the Nitrite Nitrogen concentration of water body of Bankura District varies from 0.0045 to 0.002 mg/lt. The highest nitrite nitrogen concentration was found in Pre Monsoon Season and lowest concentration was found in Post monsoon Season.

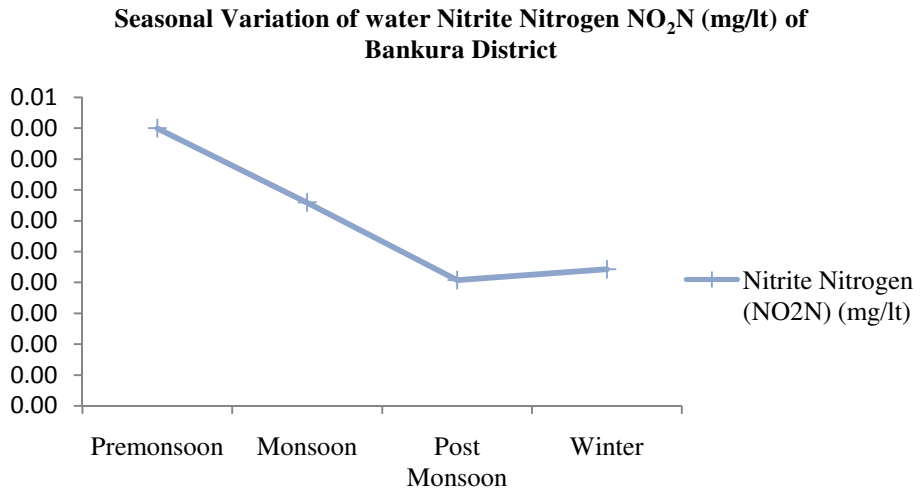


Fig 53: Seasonal Variation of Nitrite Nitrogen Concentration ofWater of Bankura District

Table 91: ANOVA of Nitrite Nitrogen of water shows significant differences between seasons (P< 0.01) but do not show significant differences between sites (P> 0.01).

Two way ANOVA between sites and seasons for Nitrite Nitrogen of Water of Bankura District						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	1.81153E-05	5	3.62305E-06	2.37608117	0.088972605	4.555613984
Between Season	2.54549E-05	3	8.48496E-06	5.56463377	0.009044556	5.416964863
Error	2.2872E-	1	1.5248E-			

	05	5	06			
Total	6.64421E-05	23				

Available Phosphate (P_2O_5):

During the study period the available phosphate concentration of the water body of Bankura District varied from 0.0022 to 0.0015 mg/lt. The highest value of available phosphate was found during the Monsoon season and lowest value was found during winter season. Similar observations are made by Lendhe and Yeragi (2004) from Phirange Kharbau Lake, Maharashtra.

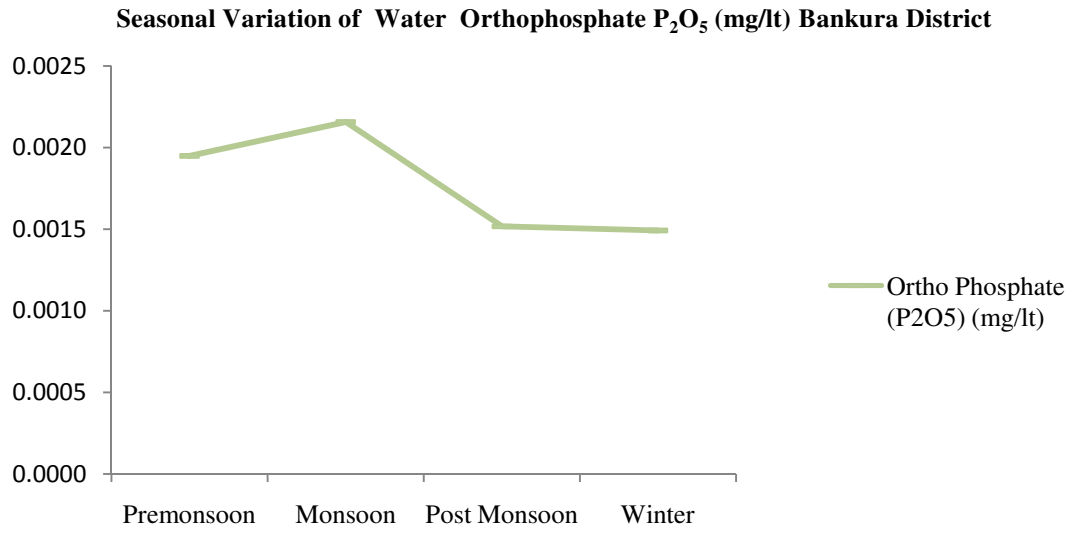


Fig 54: Seasonal Variation of Available Phosphate Concentration ofWater of Bankura District

Table 92: ANOVA of orthophosphate of water not shows significant differences between sites and between seasons also (P> 0.01).

Two way ANOVA between sites and seasons for Orthophosphate of Water of Bankura District						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	1.07709E-05	5	2.15419E-06	2.803233357	0.055542532	4.555613984
Between Season	2.71615E-	3	9.05382E-	1.17816897	0.35115842	5.41696486

	06		07		2	3
Error	1.1527E-05	15	7.68465E-07			
Total	2.50141E-05	23				

Table 93: Seasonal Variation of different water quality parameters of Bankura District

Season	**Premonsoon**	**Monsoon**	**Post Monsoon**	**Winter**
	Mean + SD	**Mean + SD**	**Mean + SD**	**Mean + SD**
Water Temp	25.85+1.37	22.685 + 0.32	20.97 + 0.66	20.21 + 1.34
Ph	7.73 + 0.22	7.08 + 0.10	7.2 + 0.35	7.23 + 0.36
Transparency (Cm)	25.48 + 1.08	30.745 + 2.85	24.25 + 1.80	23.57 + 1.14
Dissolved Oxygen (mg/lt)	4.01 + 0.22	4.51 + 0.35	4.125 + 0.167	4.01 + 0.13
Alkalinity (mg/lt)	79.25 + 10.93	102.92 + 15.83	85 + 9.57	77.42 + 6.87
Hardness (mg/lt)	138.33 + 16.24	103.75 + 12.39	114.5 + 12.69	114.66 + 12.84
Nitrite Nitrogen (NO_2N) (mg/lt)	0.0045 + 0.0013	0.0033 + 0.0018	0.002 + 0.0011	0.002 + 0.0011
Nitrate Nitrogen (NO_3N) (mg/lt)	0.023 + 0.0142	0.011 + 0.0056	0.01 + 0.0011	0.008 + 0.010
Ortho Phosphate (P_2O_5) (mg/lt)	0.0021 + 0.0011	0.00195 + 0.0012	0.0014 + 0.00074	0.0015 + 0.00074

Analysis of soil Quality Parameter of Bankura District

The present work illustrates the status of soil in the pond water of Bankura District.Physico-chemical parameters of soil from selected culture ponds wereanalyzed periodically. Physico-chemical properties of soil included soil pH, soil organic carbon, available P_2O_5, available

nitrogen. In the present study all parameters were analyzed by standard method and theobtained results are described below.

Table 94:

Soil Quality Parameter of Bankura District				
Season	**Pre Monsoon**	**Monsoon**	**Post Monsoon**	**Winter**
Parameter	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Soil pH	6.12 ± 0.18	6.29 ± 0.13	6.51 ± 0.16	6.83 ± 0.20
Organic Carbon (%)	0.85 ± 0.12	0.81 ± 0.19	0.61 ± 0.27	0.615 ± 0.09
Available P2O5 (mg/100gm)	0.56 ± 0.11	0.45 ± 0.08	0.43 ± 0.06	0.53 ± 0.10
Available Nitrogen (mg/100gm)	42.32 ± 1.49	41.14 ± 1.29	40.50 ± 0.61	38.33 ± 0.95

Soil pH:

In the present investigation the soil pH range varied from 6.12 to 6.83. The soil pH range was high in winter season and lowest in Pre monsoon season.Pond bottom soil pH can range from less than 4 to more than9, but the best pH for pond soils is considered to be about neutral (Boyd, 1995).Maximum availability of soil phosphorus usually occurs at about pH 7.

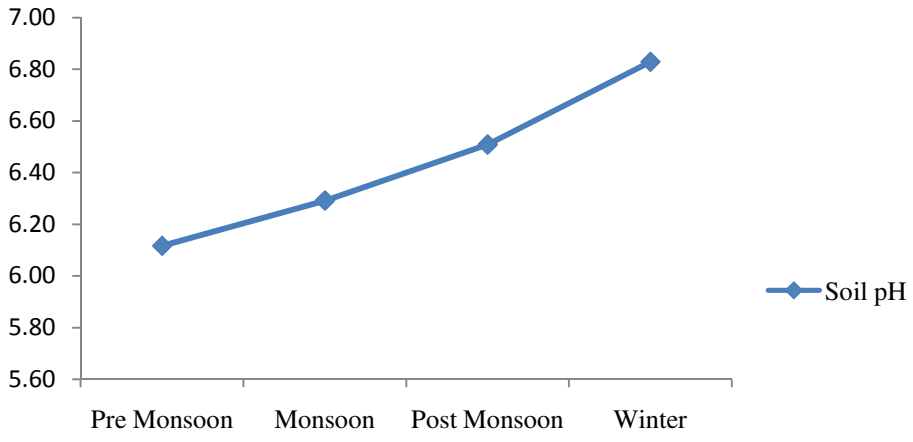


Fig 55: Seasonal Variation of Soil pH of Bankura Disttrict

Table 95:ANOVA of pH of Soil shows significant differences between seasons and between sites also (P< 0.01).

Two way ANOVA between sites and seasons for Soil pH of Bankura District						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.5909375	5	0.1181875	18.731015	5.68419E-06	4.555613984
Between Seasons	1.691779167	3	0.563926389	89.374202	8.53609E-10	5.416964863
Error	0.094645833	15	0.006309722			
Total	2.3773625	23				

Soil Organic Carbon:

In the present investigation the organic carbon value varied from 0.85 mg/100gm of soil to 0.61 mg/100 gm of soil. The highest value of organic carbon was observed during pre monsoon season and lowest value was observed in post monsoon season. As the process of decomposition is temperature dependent it slows down during the winter months leading to the accumulation of organic carbon in pond soil. Saha (1985) reported lowest value of organic carbon during the winter months and higher values during the pre monsoon season. According to Jhingran (1989) the aquatic soil having organic carbon value 0.5 – 1.5 %, the soil is moderately productive.

Table 96:ANOVA of Organic Carbon of Soil shows significant differences between seasons and between sites also (P< 0.01).

Two way ANOVA between sites and seasons for Soil Organic Carbon of Bankura District						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.491305208	5	0.098261042	5.216496 4	0.005680531	4.555613984

Between Season	0.284719792	3	0.094906597	5.0384152	0.013014171	5.416964863
Error	0.282548958	15	0.018836597			
Total	1.058573958	23				

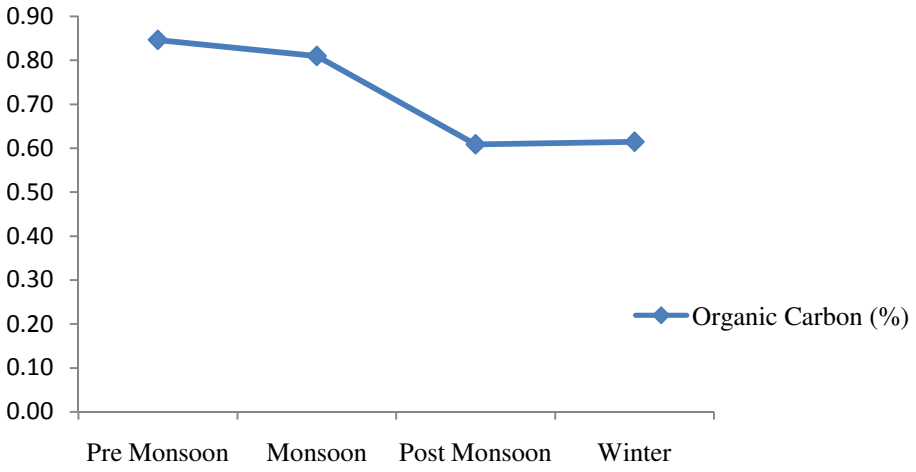


Fig 56: Seasonal variation of Organic Carbon (%) of Bankura District

Available P_2O_5 of Soil:

In the present investigation the available P_2O_5 content was high during pre monsoon season (0.56 mg/100gm of soil) and low during post monsoon period (0.43 mg/100 gm of soil).

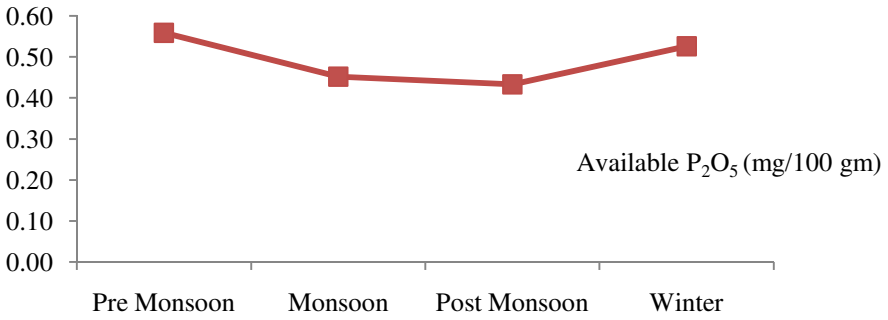


Fig 57: Seasonal Variation of Available P_2O_5 (mg/100gm) of Soil of Bankura District

Table 97:ANOVA of available phosphate of Soil shows significant differences between seasonsand between sites also (P< 0.01).

Two way ANOVA between sites and seasons for available phosphorus of Soil of Bankura District						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	0.173755208	5	0.034751042	27.630446	4.5955E-07	4.555613984
Between Season	0.063678125	3	0.021226042	16.87676	4.51055E-05	5.416964863
Error	0.018865625	15	0.001257708			
Total	0.256298958	23				

Soil Nitrogen:

In the present investigation the available nitrogen content varied from 42.32 mg/100 gm of soil to 38.33 mg/100 gm of soil. The available nitrogen content was high during pre monsoon period and low during winter period. Banerjee (1967) has attempted to correlate fish production with the available nitrogen in soil of fresh water fish ponds and recommended nitrogen in the range of 25 – 75 mg/100 gm soil as relatively more favourable for fish production. Nath *et. al* (1994) recorded available nitrogen in the range of 17 – 58.2 mg/100 gm soil in the soil of some semi intensive carp culture pond of West Bengal.

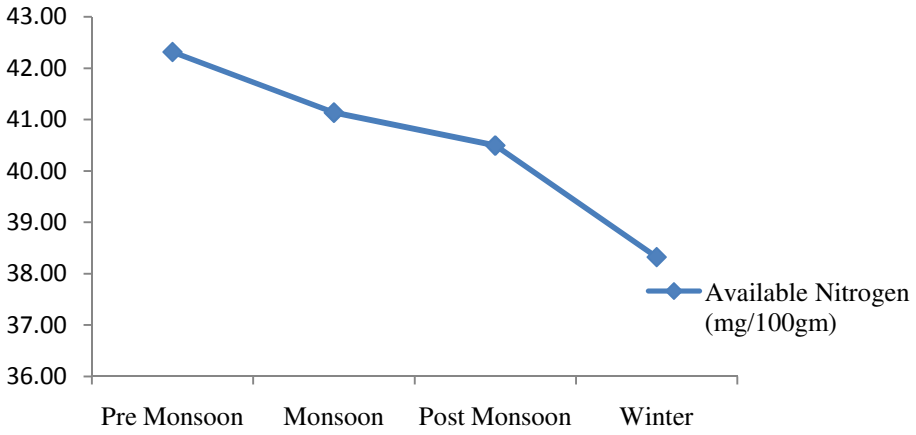


Fig 58: Seasonal Variation ofAvailable Nitrogen (mg/100gm) of Soil of Bankura District

Table 98:ANOVA of Soil Nitrogen shows significant differences between seasons (P< 0.01) but do not show significant differences between sites (P> 0.01).

Two way ANOVA between sites and seasons for Soil Nitrogen of Bankura District						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	16.36490833	5	3.272981667	3.377591299	0.030494216	4.555613984
Between Season	50.4243125	3	16.80810417	17.34531756	3.85791E-05	5.416964863
Error	14.535425	15	0.969028333			
Total	81.32464583	23				

Phytoplankton Analysis of Bankura District

During the study the phytoplankton diversity was studied in four seasons of a year namely Pre Monsoon, Monsoon, Post Monsoon and winter. The phytoplanktonmembers comprised of 23 genera of which 6 genera belongs to Cyanophyceae group, 8 genera belongs to Chlorophyceae group, 7 genera belongs to Bacillariophyceae group, and 2 genera belongs to Euglenophyceae group.

Table 99: Phytoplankton availability in the ponds of Bankura District:

Groupwise Phytoplankton Availability in the ponds of Bankura District			
Taxa			
Cyanophyceae	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**
a. *Anabaena sp.*	a. *Ankistrodesmus sp*	a. *Cyclotella sp*	a. *Euglena sp*
b. *Lyngbya sp.*	b. *Chlorella sp*	b. *Diatoma sp.*	b. *Phacus sp*
c. *Microcystis sp*	c. *Closterium sp.*	c. *Fragillaria sp*	
d. *Oscillatoria sp*	d. *Mougeotia sp*	d. *Navicula sp*	
e. *Nostoc*	e. *Scenedesmus sp*	e. *Nitzschia sp.*	
f. Phormidium sp	f. *Spirogyra sp*	f. *Pinnularia sp*	
	g. *Ulothix sp*	g. *Synedra sp*	
	h. *Zygnema sp*		

Cyanophyceace :

The seasonal occurrences of cyanophyceace ranged from a maximum (50 org/lt) and minimum of (22 org/lt). The maximum occurrence of Cyanophyceae was observed during Pre Monsoon Season and minimum in Monsoon Season. The density of Cyanophyceae was higher in Pre Monsoon season is due to higher water temperature.Nirmal Kumar – Cini Oommen (2011), Zafar, (1967); Hegde and Bharati,(1985) and Swarnalatha and Narasinga Rao, 1993 were of the opinion that high temperature favours the luxuriant growth of blue-green algae.

Table 100:ANOVA of phytoplankton group Cyanophyceae shows significant variation between sites (P< 0.01) and also show significant variation between seasons (P< 0.01) also.

Two way ANOVA between sites and seasons for Phytoplankton group Cyanophyceae						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	1364.59375	5	272.91875	28.705208	3.56523E-07	4.555613984
Between Seasons	2618.447917	3	872.8159722	91.801548	7.06006E-10	5.416964863
Error	142.6145833	15	9.507638889			

Total	4125.65625	23				

Chlorophyceae :

The maximum seasonal density of chlorophyceae was in Pre Monsoon Season i.e (60 no's org/lt) and minimum in Monsoon Season i.e (26 no's org/lt).The phytoplankton density showed maximum count in summer and monsoonal months which may be attributed to the prevailing high temperature of summer season along with high amount of dissolved nutrients in the pond water (Table). With the on setting of monsoon rains from the month of June onwards, phytoplankton density was reported to be decreased with the dilution of pond water.The results were also in conformity with Sreenivasan *et al. (*1974) and Hujare (2008), who worked on some tropical freshwater bodies in India.

Table 101:ANOVA of phytoplankton group Chlorophyceae shows significant variation between sites (P< 0.01) and also show significant variation between seasons (P< 0.01) also.

Two way ANOVA between sites and seasons for Phytoplankton group Chlorophyceae						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	1383.8	5	276.76875	23.58405823	1.30132E-06	4.555613984
Between Season	3989.3	3	1329.760417	113.3117344	1.57433E-10	5.416964863
Error	176.03	15	11.73541667			
Total	5549.2	23				

Bacillariophyceae:

The Class Bacillariophyceae mainly consists of the following genus *Cyclotella sp*, *Diatoma sp*, *Fragillaria sp*, *Navicula sp*, *Nitzschia sp*, *Pinnularia s*p, and *Synedra sp*. Among all the genera diatoms area major group of algae and one of the most common types of phytoplankton, belong to member of Bacillariophyceae. During the study period the maximum density of

Bacillariophyceae was found during Pre Monsoon Season (73 org/lt) and minimum density was found during Monsoon months (33 org/lt).Devika et al., (2006) also recordedhigh population during summer and suggestedthat this might be due to physical rather thanchemical condition in which the watertemperature and transparency had a directrelation with phytoplankton population.Verma and Mohanty, (1995);Swarnalatha and Rao, (1998) and Harikrishnan *et al.*, (1999) stated that alkaline pH favours the abundance of diatomic population.

Table 102:ANOVA of phytoplankton group Bacillariophyceae shows significant variation between sites (P< 0.01) and also show significant variation between seasons (P< 0.01) also.

Two way ANOVA between sites and seasons for Phytoplankton group Bacillariophyceae						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	2488.09375	5	497.61875	27.25537256	5.03153E-07	4.555613984
Between Season	5290.197917	3	1763.399306	96.58419231	4.92286E-10	5.416964863
Error	273.8645833	15	18.25763889			
Total	8052.15625	23				

Euglenophyceae:

The phytoplankton group Euglenophyceae comprised of only two genus Euglena sp and Phacus sp. In the present study the maximum concentration of Euglenophyceae was found in Pre Monsoon month (7org/lt) and minimum density was found in Monsoon month (3 org/lt).Verma *et al.,* (2001) and Milind S. Hujare, (2008) were also reported phytoplankton density in different seasons in order of summer > winter > monsoon.

Table 103:ANOVA of phytoplankton group Euglenophyceae shows significant variation between sites (P< 0.01) and also show significant variation between seasons (P< 0.01) also.

Two way ANOVA between sites and seasons for Phytoplankton group Euglenophyceae						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	42.96875	5	8.59375	5.56680162	0.004274444	4.555613984

Between Season	58.03125	3	19.34375	12.5303644	0.000229926	5.416964863
Error	23.15625	15	1.54375			
Total	124.15625	23				

Phytoplankton Diversity Analysis

Table 104:Seasonal Diversity of Phytoplankton Group in the Ponds of Bankura District:

Seasonal Diversity of Available Phytoplankton Group in the Ponds of Bankura District					
Group	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	50±9	60±8	73±15	7±3	1.2
Monsoon	22±7	26±7	33±10	3±1	1.1
Post Monsoon	30±8	34±10	41±9	4±1	1.2
Winter	34±11	45±9	49±12	5±2	1.2

Table 105:Composition (%) of Different Group of Phytoplankton Availability in Bankura District:

Seasonal Abundance (%) of different group of Phytoplankton in Bankura District				
Season	**Group**			
	Cyanophyceae	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**
Pre Monsoon	50.0	60.0	73.0	7.0
Monsoon	22.0	26.0	33.0	3.0
Post Monsoon	30.0	34.0	41.0	4.0
Winter	34.0	45.0	49.0	5.0
Total	136.0	165.0	196.0	19.0
Percentage (%)	26.35	31.97	37.98	3.68

The total no of species recorded were 516 org/lt, out of which Cyanophyceae are 136 org/lt (26.35%), Cholorophyceae are 165 org/lt (31.97 %), Bacillariophyceae are 196 org/lt (37.98 %) and Euglenophyceae are 19 org/lt (3.68 %).

Table 106:ANOVA of total phytoplankton shows significant variation between sites (P< 0.01) and also show significant variation between seasons (P< 0.01) also.

Two way ANOVA between sites and seasons for total Phytoplankton of Bankura District						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Rows	14463.75	5	2892.75	47.16440217	1.1997E-08	4.555613984
Columns	37695.25	3	12565.083	204.8654891	2.1572E-12	5.416964863
Error	920	15	61.333333			
Total	53079	23				

Graphical representation of Seasonal Diversity of Phytoplankton Group in the Ponds of Bankura District:

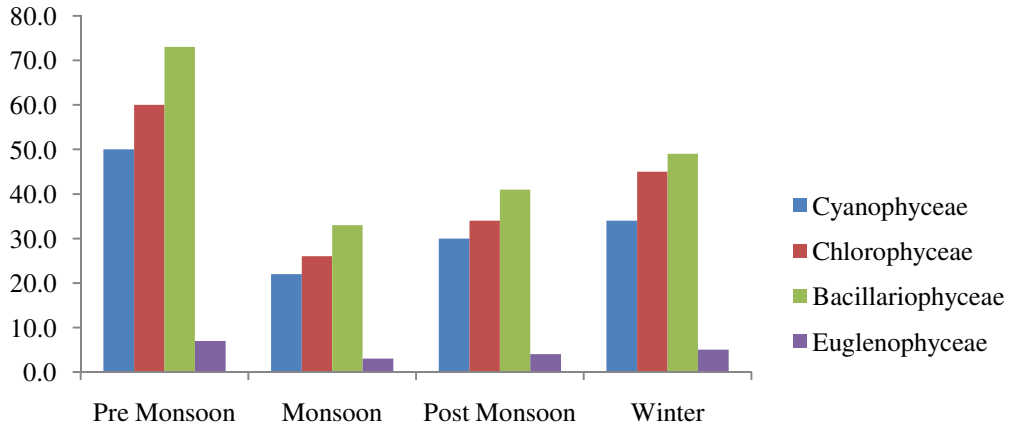
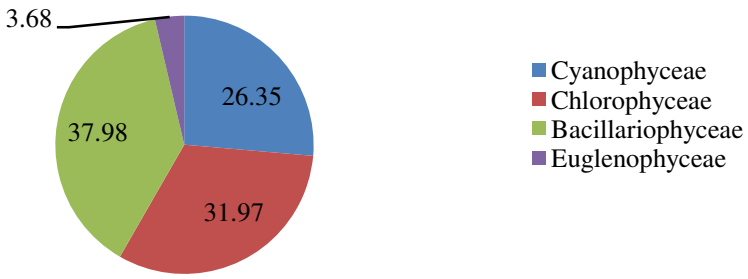


Fig 59: Seasonal Diversity of Phytoplanton in ponds of Bankura District



Phytoplankton composition (%) in ponds of Bankura District

Fig 60: Phytoplankton Availability percentage (%) of Bankura District

Table 107:Seasonal Abundance (%) of different group of Phytoplankton in Bankura District:

Seasonal Abundance (%) of different group of Phytoplankton in Bankura District				
Group	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**
Season	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**
Pre Monsoon	26.31	31.57	38.42	3.68
Monsoon	26.19	30.95	39.28	3.57
Post Monsoon	27.52	31.19	37.61	3.66
Winter	25.56	33.83	36.84	3.79

In the present study the occurrence of season wise Phytoplankton groups was dominant in the following increasing order.

Pre Monsoon: Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophyceae

Monsoon: Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophyceae

Post Monsoon:Bacillariophyceae> Chlorophyceae > Cyanophyceae > Euglenophyceae

Winter:Bacillariophyceae> Chlorophyceae > Cyanophyceae > Euglenophyceae

Table 108:Seasonal Variation of Different Group of Phytoplankton of Bankura I Dev. Block:

Seasonal Variation of Phytoplankton availability of Bankura I Block					
Group	Cyanophyceae	Chlorophyceae	Bacillariophyceae	Euglenophyceae	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	54 ± 2	60 ± 4	73.5 ± 3.5	10 ± 1	1.4
Monsoon	24.5 ± 1.5	20.5 ± 0.50	37.5 ± 1.5	4 ± 1	1.2
Post Monsoon	31.5 ± 1.5	29.5 ± 2.5	44.5 ± 2.5	6 ± 1	1.4
Winter	40.5 ± 2.5	40 ± 1	54 ± 1	6.5 ±0.50	1.3

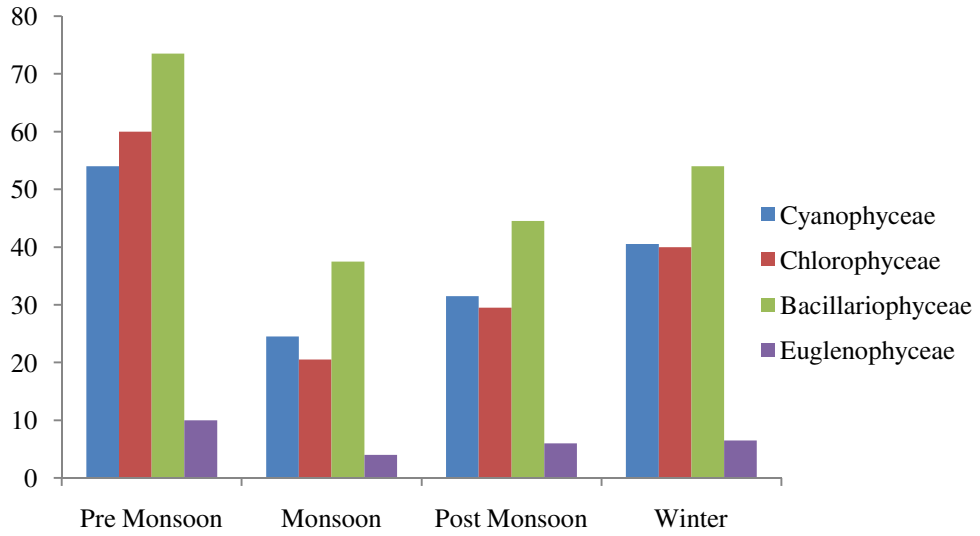


Fig 61: Seasonal variation of Phytoplankton in the ponds of Bankura I Block

Composition (%) of Different group of Phytoplankton in the ponds of Bankura I Dev Block

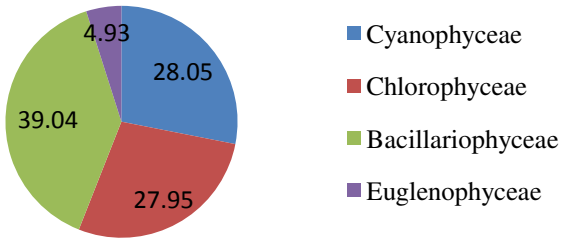


Fig 62: Composition (%) of Phytoplankton in the ponds of Bankura I Block

Table 109:Seasonal variation of Different Group of Phytoplankton of Onda Dev Block

Seasonal Variation of Phytoplankton availability of Onda Block					
Group	Cyanophyceae	Chlorophyceae	Bacillariophyceae	Euglenophyceae	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	63.5 ± 2.5	66.5 ± 2.5	88 ± 2	9.5 ± 1.5	1.3
Monsoon	31.5 ± 1.5	37.5 ± 0.50	43.5 ± 1.5	3 ± 1	1.3
Post Monsoon	42 ± 3	49 ± 1	55 ± 2	5 ± 1	1.3
Winter	50 ± 2	57.5 ± 2.5	68.5 ± 2.5	7.5 ± 1.5	1.3

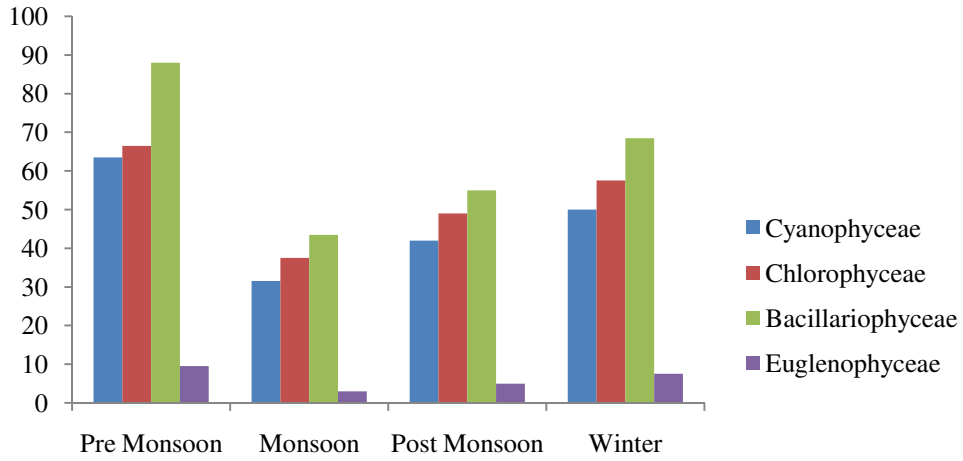


Fig 63: Seasonal variation of Phytoplankton in the ponds of Onda Block

Composition (%) of Different group of Phytoplankton in the ponds of Onda Dev Block:

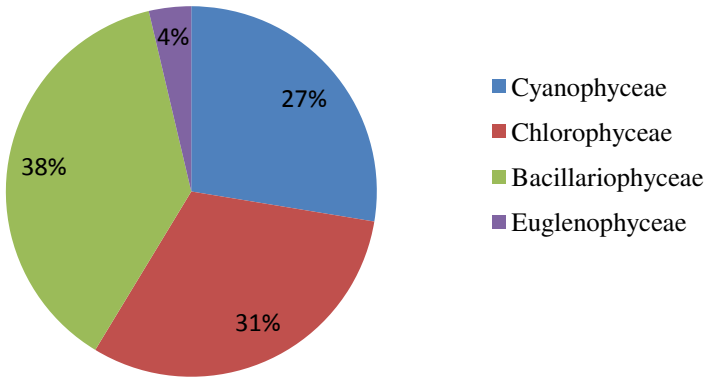


Fig 64: Composition (%) of Phytoplankton in the ponds of Onda Block

Table 110:Seasonal variation of Different Group of Phytoplankton of Khatra Dev Block:

Seasonal Variation of Phytoplankton availability of Khatra Block					
Group	Cyanophyceae	Chlorophyceae	Bacillariophyceae	Euglenophyceae	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	45.5 ± 1.5	49 ± 3	53.5 ± 3.5	4.5 ± 0.50	1.2
Monsoon	14± 1	17.5 ± 4.5	22.5 ± 4.5	1.5 ± 0.50	1.2
Post Monsoon	22±4.24	19 ± 1.41	32±7.07	3.5 ± 0.70	1.2
Winter	22.5 ± 2.5	30.5 ± 4.5	36.5 ± 4.5	4 ± 1	1.2

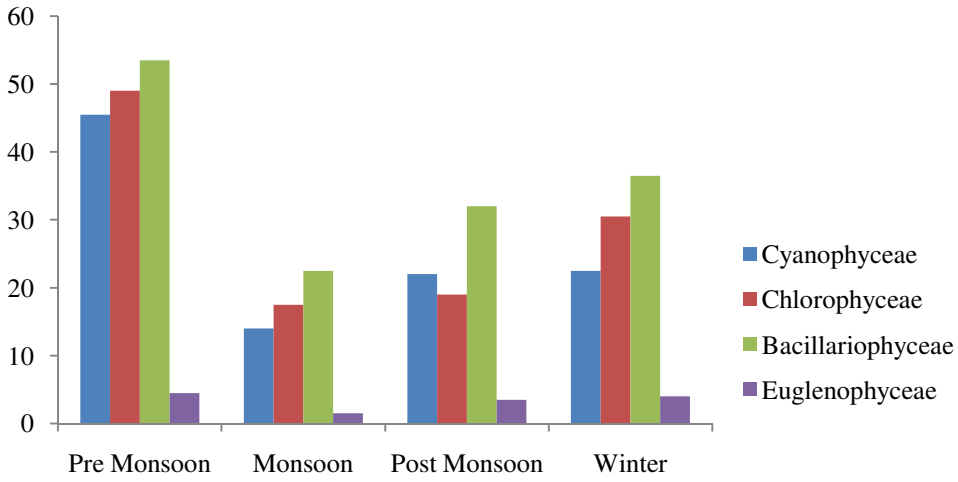


Fig 65: Seasonal variation of Phytoplankton in the ponds of Khatra Block

Composition (%) of Different group of Phytoplankton in the ponds of Khatra Dev Block:

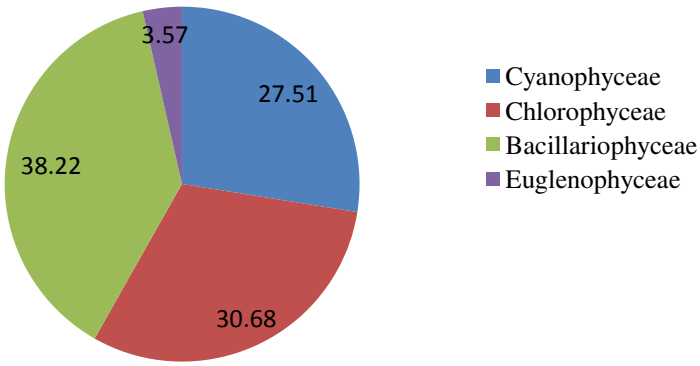


Fig 66: Composition (%) of Phytoplankton in the ponds of Khatra Block

Table 111:Seasonal variation of Different Group of Phytoplankton of Taldangra Dev Block

Seasonal Variation of Phytoplankton availability of Taldangra Block					
Group	Cyanophyceae	Chlorophyceae	Bacillariophyceae	Euglenophyceae	**Diversity**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Index**
Pre Monsoon	56 ± 4	67.5 ± 2.5	86 ± 3	7.5 ± 1.5	1.2
Monsoon	24.5 ± 1.5	27.5 ± 2.5	37±5	1.5± 0.50	1.1
Post Monsoon	34.5 ± 2.5	31.5 ± 1.5	40 ± 2	2.5 ± 0.50	1.2
Winter	39.5 ± 1.5	46.5 ± 3.5	47 ± 3	3 ± 1	1.2

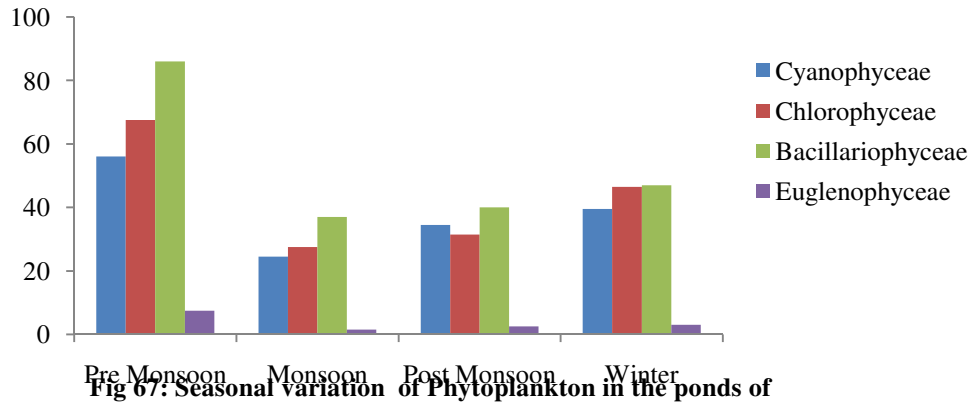


Fig 67: Seasonal variation of Phytoplankton in the ponds of Taldangra Block

Composition (%) of Different group of Phytoplankton in the ponds of Taldangra Dev Block:

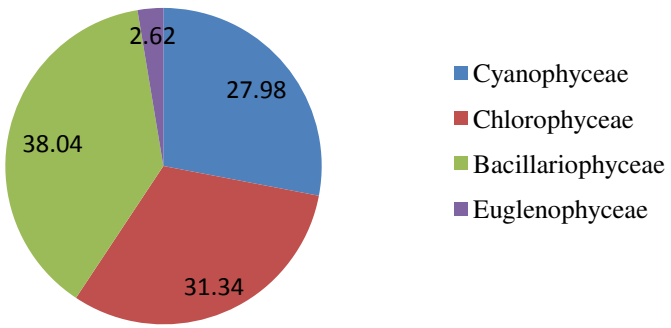


Fig 68: Composition (%) of Phytoplankton in the ponds of Taldangra Block

Table 112:Seasonal variation of Different Group of Phytoplankton of Bishnupur Dev Block:

Seasonal Variation of Phytoplankton availability of Bishnupur Block					
Group	Cyanophyceae	Chlorophyceae	Bacillariophyceae	Euglenophyceae	**Diversity**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Index**
Pre Monsoon	39 ± 1	66.5 ± 6.5	78.5 ± 6.5	8.5 ± 1.5	1.2
Monsoon	22.5 ± 4.5	29.5 ± 1.5	37.5 ± 2.5	4± 1	1.2
Post Monsoon	24 ± 3	41 ± 4	44.5 ± 4.5	5 ± 1	1.2
Winter	27 ± 3	50.5 ± 5.5	54.5 ± 2.5	6 ± 1	1.2

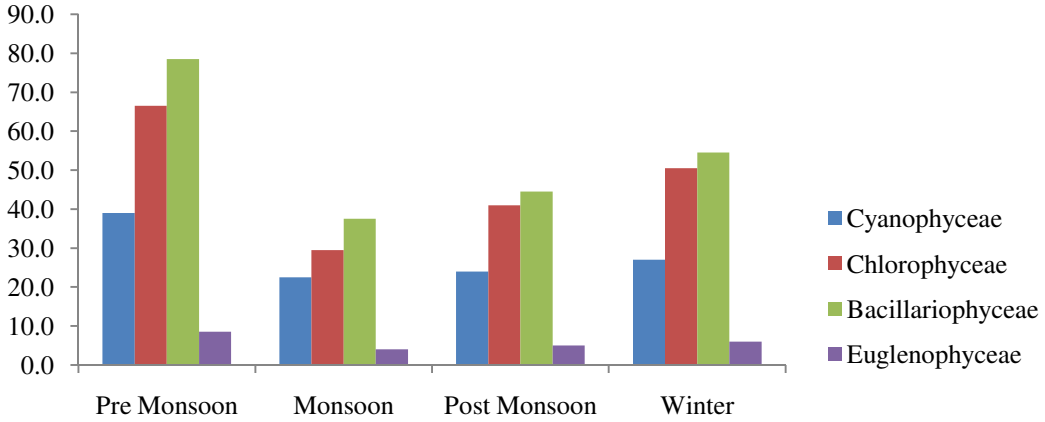


Fig 69: Seasonal variation of Phytoplankton in the ponds of Bishnupur Block

Composition (%) of Different group of Phytoplankton in the ponds of Bishnupur Dev Block:

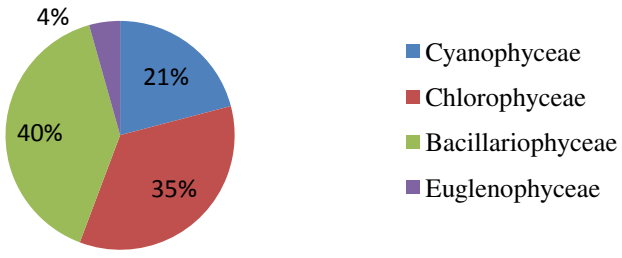


Fig 70: Composition (%) of Phytoplankton in the ponds of Bishnupur Block

Table 113:Seasonal variation of Different Group of Phytoplankton of Joypur Dev Block:

Seasonal Variation of Phytoplankton availability of Joypur Block					
Group	Cyanophyceae	Chlorophyceae	Bacillariophyceae	Euglenophyceae	**Diversity**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Index**
Pre Monsoon	44± 4	51.5± 4.5	56± 2	3.5± 1.5	1.2
Monsoon	13 ± 1	21.5 ± 1.5	19.5 ± 1.5	4 ± 2	1.3
Post Monsoon	25 ± 2	33.5 ± 3.5	29 ± 3	3.5 ± 0.50	1.2
Winter	27 ± 2	42 ± 5	36 ± 1	4.5 ± 0.50	1.2

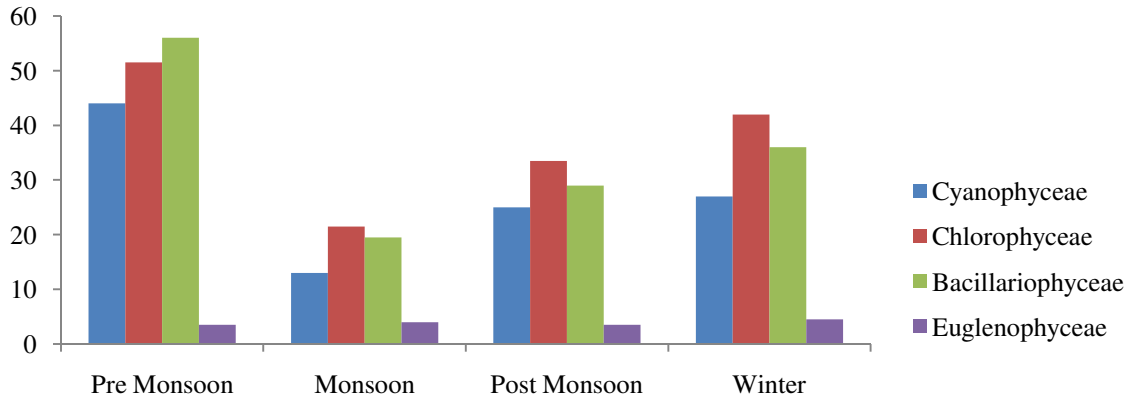


Fig 71: Seasonal variation of Phytoplankton in the ponds of Joypur Block

Composition (%) of Different group of Phytoplankton in the ponds of Joypur Dev Block

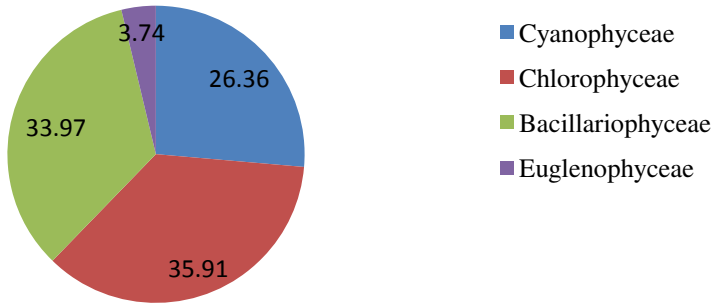


Fig 72: Composition (%) of Phytoplankton in the ponds of Joypur Block

Zooplankton Analysis of Bankura District

Five major groups like Rotifera, Copepoda, Protozoea, Ostracoda, Cladocera represented the zooplankton population of the studied water bodies. A total 6 genus of Rotifera group (*Brachionus sp*, *Asplanchna sp*, *Keratella sp*, *Synchaeta sp*, *Euchlanis sp*, *Filinia sp*) 10 genus of Copepoda (*Nauplii*, *Diaptomus sp*, *Pseudodiaptomus sp*, *Cyclops*, *Mesocyclops sp*,*Paracyclops sp*, *Microcyclops sp*, *Eucyclops*, *Acanthocyclops sp*, *Heliodiaptomus*), 3 genus of Protozoea (*Amoeba*, *Paramecium*, *Arcella*) 6 genus of Cladocerans (*Daphnia sp*, *Ceriodaphnia*, *Simocephalus*, *Bosmina*, *Moina*, *Diaphanosoma sp*) and one genus of Ostracoda (*Cypris sp*) were identified from the ponds (**Table No**). Nauplius larvae were found in some ponds.

Rotifera:

In the present study they dominated with 06genera of zooplankton group. The population density of rotifers was rich in summer season (81.92 org/lit) and less in Monsoon season (47.67 org/lit). According to the observation the Brachionus species are very common in the water bodies of Bankura district which indicates the alkaline nature of water body. Similar observation was found in both tropical and temperate water bodies according toHutchinson, G. E. 1967.

Table 114:ANOVA of zooplankton group Rotifera shows significant differences between seasons and between sites also (P< 0.01).

Two way ANOVA between sites and seasons for Zooplankton group Rotifera						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	1993.458333	5	398.6916667	6.816860603	0.001671698	4.555614
Between Season	3654.583333	3	1218.194444	20.82878176	1.32304E-05	5.416965
Error	877.2916667	15	58.48611111			
Total	6525.333333	23				

Cladocerans:

Cladocerans are the most useful and nutritive group of crustaceans for higher members of fishes in the food chain. During the study period, a total of 6 genuses were recorded.The population densities of cladocerans were higher in summer season (27.17 org/lit) and lower in winter (10.5 org/lit.). It was higher during summer followed by monsoon and lowest during winter. Abundance has also been earlier reported in summer season and lower in winter by Dushyantkumar Sharma (2012) in Thigra Reservoir Gwalior (M.P.).

Table 115:ANOVA of zooplankton group Cladocera shows significant differences between seasons and between sites also (P< 0.01).

Two way ANOVA between sites and seasons for Zooplankton group Cladocera						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	158.21875	5	31.64375	3.90161829	0.018236262	4.555613984
Between Seasons	884.78125	3	294.927083	36.363986	4.01686E-07	5.416964863
Error	121.65625	15	8.11041667			
Total	1164.65625	23				

Copepoda:

In the present study, 10 genuses were recorded. In the present study Copepoda are the most dominant group among all zooplankton groups.Copepods showed higher population density in summer season (88.17 org/lit) and lower in winter (62.0 org/lit).This pattern of seasonal fluctuation of copepods has also been observed by Mahor (2011) in Trigha reservoir of Gwalior.

Table 116 : ANOVA of zooplankton group Copepoda shows significant differences between seasons and between sites also (P< 0.01).

Two way ANOVA between sites and seasons for Zooplankton group Copepoda						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***

Between Sites	4147.1771	5	829.4354167	52.82327186	5.42733E-09	4.555613984
Between Season	2064.2813	3	688.09375	43.82181239	1.16917E-07	5.416964863
Error	235.53125	15	15.70208333			
Total	6446.9896	23				

Ostracoda:

In the presentstudy, one species of ostracoda were recorded.The population density was higher in summer season (4.0 org/lit) and less in winter (1.17 org/lit). This result has also been observed by Sukand and Patil (2004) in Fort Lake of Belgaum and Kedar et al. (2008) in Rishi freshwater lake of Washim district.

Table 117:ANOVA of zooplankton group Ostracoda shows significant differences between seasons (P< 0.01) but do not show significant differences between sites (P> 0.01).

Two way ANOVA between sites and seasons for Zooplankton group Ostracoda						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	11.625	5	2.325	3.65502183	0.023139924	4.555613984
Between Season	24.333333	3	8.1111111	12.7510917	0.000209769	5.416964863
Error	9.5416667	15	0.6361111			
Total	45.5	23				

Protozoa:

In the present study I have recorded Paramoecium sp., Amoeba sp. and Arcella sp. In the present study, 3 species of protozoa were recorded. The population densitywas higher in summer season (11.58 org/lit) and less in winter (4.83 org/lit). Similar observation was made by Shivashankar P. et al (2013) at Bhadra Reservoir, Karnatka.

Table 118:ANOVA of zooplankton group Protozoa shows significant differences between seasons and between sites also (P< 0.01).

Two way ANOVA between sites and seasons for Zooplankton group Protozoa						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Sites	241.125	5	48.225	16.97067449	1.05152E-05	4.555613984
Between Season	137.25	3	45.75	16.09970674	5.88836E-05	5.416964863
Error	42.625	15	2.841666667			
Total	421	23				

Table 119:Zooplankton availability in the ponds of Bankura District:

GroupWise Zooplankton Availability in the ponds of Bankura District				
Taxa				
Rotifera	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**
a. *Brachionus sp.*	a. *Nauplii*	a. *Amoeba*	a. *Cypris sp.*	a. *Daphnia sp.*
b. *Asplanchna sp*	b. *Diaptomus sp*	b. *Paramecium*		b. *Ceriodaphnia*
c. *Keratella sp.*	c. *Pseudodiaptomus sp.*	c. *Arcella*		c. *Simocephalus*
d. *Synchaeta sp.*	d. *Cyclops*			d. *Bosmina*
e. *Euchlanis sp.*	e. *Mesocyclops sp.*			e. *Moina*
f. *Filinia sp.*	f. *Paracyclops sp.*			f. *Diaphanosoma sp.*
	g. *Microcyclops sp.*			

	h. *Eucyclops*			
	i. *Acanthocyclops sp*			
	j. *Heliodiaptomus*			

Table 120:Seasonal Diversity of Zooplankton Group in the Ponds of Bankura District:

Seasonal Diversity of Available Zooplankton Group in the Ponds of Bankura District						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	81.92 ± 10.79	88.17 ± 15.84	11.58 ± 4.84	4 ± 1.61	27.17 ± 5.01	1.2
Monsoon	65.50 ± 11.21	74.75 ± 13.41	8.5 ± 3.80	2.5 ± 0.71	16.67 ± 2.56	1.2
Post Monsoon	59.58 ± 9.87	73.5 ±11.31	8.08 ± 2.26	2.33 ± 0.47	15.42 ± 3.31	1.2
Winter	47.67 ± 11.79	62 ± 13.11	4.83 ± 2.07	1.17 ± 0.47	10.5 ± 2.02	1.1

Table 121:Composition (%) of Different Group of Zooplankton Availability in Bankura District:

Sl. No	Season	Group				
		Rotifera	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**
1	**Pre Monsoon**	81.92	88.17	11.58	4.00	27.17
2	**Monsoon**	65.50	74.75	8.50	2.50	16.67
3	**Post Monsoon**	59.58	73.50	8.08	2.33	15.42
4	**Winter**	47.67	62.00	4.83	1.17	10.50
Total		254.66	298.42	32.99	10.00	69.76
Percentage		38	45	5	2	10

The total no of species recorded were 665.83 org/lt, out of which Rotifers are 254.66 org/lt (38 %), Cladocerans 69.76 org/lt (10 %), Copepods 298.42 org/lt (45%), Ostracods 10 org/lt (2 %), and Protozoa 32.99 org/lt (5 %).

Table 122:ANOVA of total zooplankton shows significant variation between sites (P< 0.01) and also show significant variation between seasons (P< 0.01) also.

Two way ANOVA between sites and seasons for total Zooplankton						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Rows	15657.583	5	3131.5167	22.81338	1.61456E-06	4.555613984
Columns	22998.375	3	7666.125	55.848409	2.2638E-08	5.416964863
Error	2059	15	137.26667			
Total	40714.958	23				

Table 123:ANOVA of total zooplankton shows significant variation between sites (P< 0.01) and also show significant variation between seasons (P< 0.01) also.

Two way ANOVA between sites and seasons for total Plankton						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between sites	50752.2083	5	10150.44	48.0273247	1.06E-08	4.555614
Between seasons	93634.0417	3	31211.35	147.6780574	2.34E-11	5.416965
Error	3170.20833	15	211.3472			
Total	147556.458	23				

Graphical representation of Seasonal Diversity of Zooplankton Group in the Ponds of Bankura District:

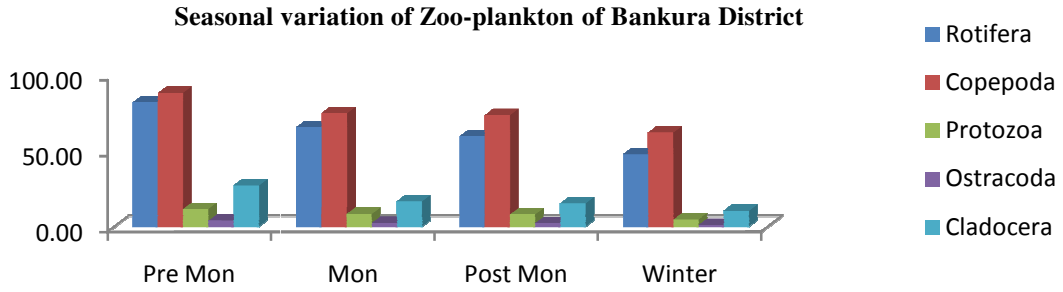


Fig 73: Seasonal variation of Zooplankton Availability of Bankura District

Zooplankton Availability percentage (%) of Bankura District:

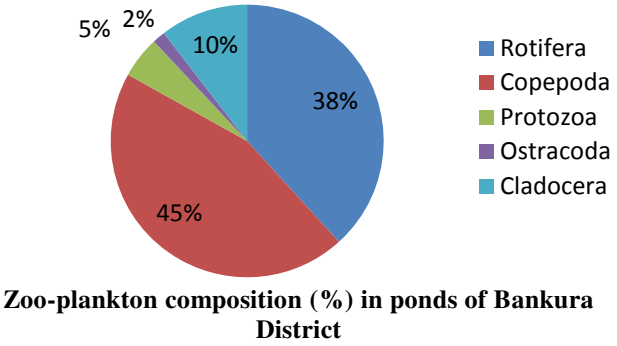


Fig 74: Zooplankton availability percentage (%) of Bankura District

Table 124:Seasonal Abundance (%) of different group of Zooplankton in Bankura District:

Seasonal Abundance (%) of different group of Zooplankton in Bankura District					
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**
Season	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**
Pre Monsoon	38.5	41.4	5.4	1.9	12.8
Monsoon	39	44.5	5.1	1.5	9.9
Post Monsoon	37.5	46.3	5	1.5	9.7

Winter	37.6	48.9	3.8	1.4	8.3

In the present study the occurrence of season wise zooplankton groups was dominant in the following increasing order.

Pre Monsoon: Copepoda > Rotifera > Cladocera > Protozoa > Ostracoda

Monsoon: Copepoda > Rotifera > Cladocera > Protozoa > Ostracoda

Post Monsoon:Copepoda> Rotifera > Cladocera > Protozoa > Ostracoda

Winter:Copepoda> Rotifera > Cladocera > Protozoa > Ostracoda

Table 125:Seasonal Variation of Different Group of Zooplankton of Bankura I Dev. Block:

Seasonal Variation of Zooplankton availability of Bankura I Block						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	86.5 ± 1.5	70 ±2	12 ± 3	2.5 ± 0.5	25 ± 3	1.2
Monsoon	57.5 ± 1.5	58.5 ± 1.5	7.5 ± 1.5	2 ± 0	16.5 ± 1.5	1.2
Post Monsoon	54 ± 4	62.5 ± 2.5	8 ± 1	1.5 ± 0.5	9 ± 1	1.1
Winter	34 ± 3	43± 2	6.5± 0.5	1± 0	7.5± 0.5	1.1

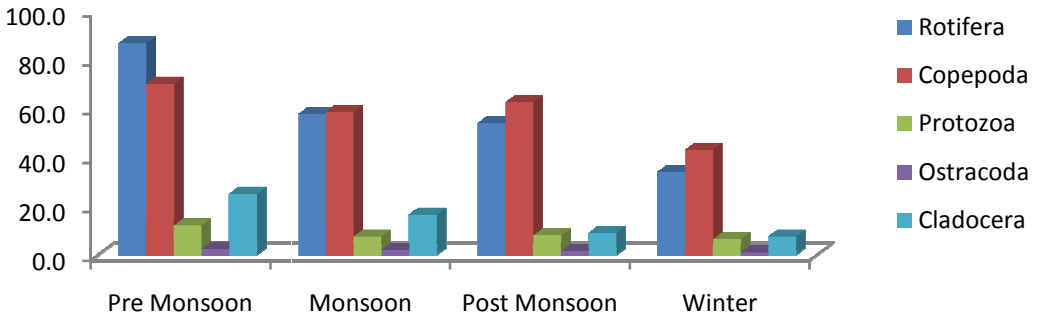


Fig 75: Seasonal variation of Zoo-plankton in the ponds of Bankura-I Block

Composition (%) of Different group of Zooplankton in the ponds of Bankura I Dev Block

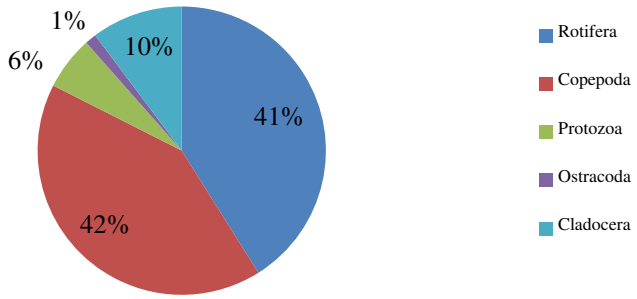


Fig 76: Composition of Zoo-plankton in the ponds of Bankura-I Block

Table 126:Seasonal variation of Different Group of Zooplankton of Onda Dev Block

Seasonal Variation of Zooplankton availability of Onda Block						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	97± 4	102.5 ± 0.5	21.5 ± 1.5	6 ± 1	35.5 ± 1.5	1.3
Monsoon	80.5 ±3.5	77 ± 7	16 ± 1	3 ± 0	21.5 ± 1.5	1.2
Post Monsoon	59 ± 5	80.5 ± 2.5	12.5 ± 1.5	2.5 ± 0.5	19.5 ± 1.5	1.2
Winter	42.5 ± 2.5	72.5 ± 0.50	8.5± 1.5	0.5 ± 0.5	13.5 ± 1.5	1.1

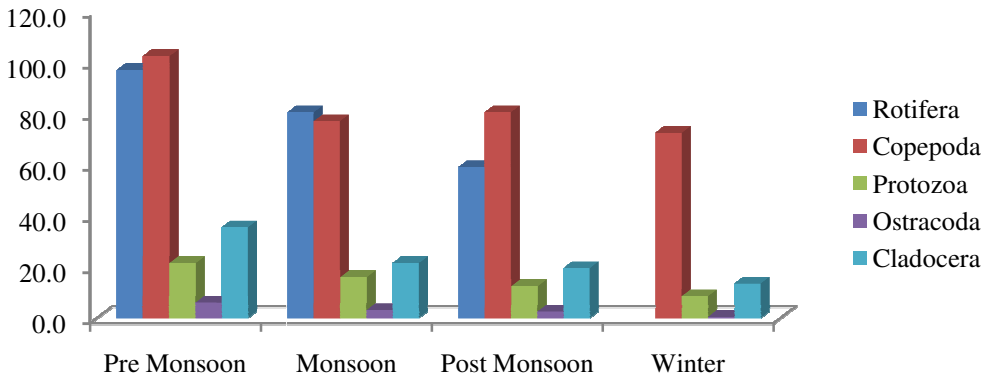


Fig 77: Seasonal variation of zooplankton in ponds of Onda Block

Composition (%) of Different group of Zooplankton in the ponds of Onda Dev Block:

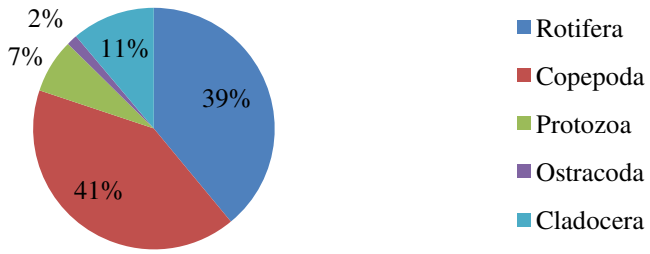


Fig 78: Composition of zooplankton in ponds of Onda Block

Table 127:Seasonal variation of Different Group of Zooplankton of Khatra Dev Block

Seasonal Variation of Zooplankton availability of Khatra Block						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	61.5 ± 3.5	63.5 ±5.5	8.5 ± 2.5	3 ±0	19.5 ± 2.5	1.2
Monsoon	46.5 ± 1.5	56 ± 1	5 ± 2	2 ± 0	13.5 ± 1.5	1.2
Post Monsoon	42± 2	54.5 ± 6.5	6 ±3	2.5 ± 0.50	17.5 ± 2.5	1.2
Winter	32.5 ± 2.5	45 ± 7	2.5 ± 0.50	1 ± 0	10.5 ± 1.5	1.1

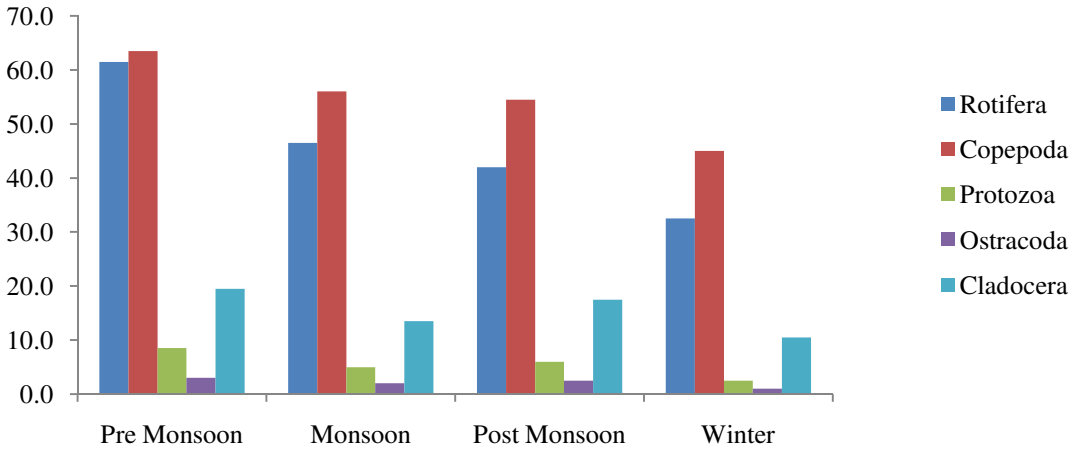


Fig 79: Seasonal variation of zooplankton in ponds of Khatra Block

Composition (%) of Different group of Zooplankton in the ponds of Khatra Dev Block:

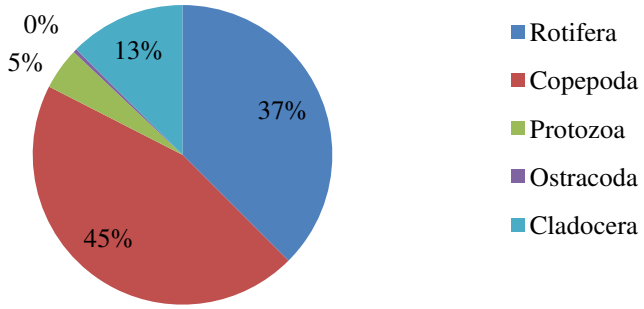


Fig 80: Composition of zooplankton in ponds of Khatra Block

Table 128:Seasonal variation of Different Group of Zooplankton of Taldangra Dev Block:

Seasonal Variation of Zooplankton availability of Taldangra Block						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	85 ± 1	100.5 ± 8.5	12 ± 2	6.5 ± 0.50	31 ± 3	1.2
Monsoon	75.5 ± 1.5	90 ± 12	9.5 ± 1.5	3.5 ± 0.50	15 ± 1	1.1
Post Monsoon	61.5 ± 6.5	77.5 ± 5.5	8.5 ± 1.5	3 ± 0	16.5 ± 1.5	1.2
Winter	57.5± 7.5	74 ± 2	4 ± 1	2 ± 0	8.5 ± 1.5	1

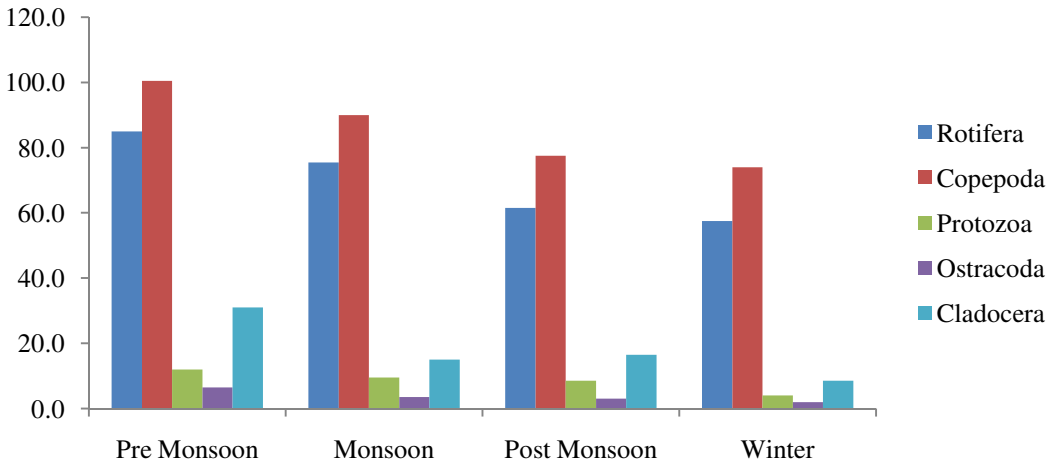


Fig 81: Seasonal variation of zooplankton in ponds of Taldangra Block

Composition (%) of Different group of Zooplankton in the ponds of Taldangra Dev Block:

Fig 82: Composition of zooplankton in ponds of Taldangra Block

Table 129:Seasonal variation of Different Group of Zooplankton of Bishnupur Dev Block:

Seasonal Variation of Zooplankton availability of Bishnupur Block						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Index**
Pre Monsoon	84 ± 0	102.5 ± 7.5	9 ± 4	3 ± 0	26 ± 2	1.2
Monsoon	65.5 ± 8.5	89.5 ± 11.5	8.5 ± 1.5	3 ± 1	15.5 ± 1.5	1.1
Post Monsoon	69.5 ± 1.5	87.5± 2.5	8 ± 1	2.5 ± 0.50	14 ± 1	1.1
Winter	59 ± 1	73 ± 0	4.5 ± 1.5	1.5 ± 0.50	12 ± 2	1

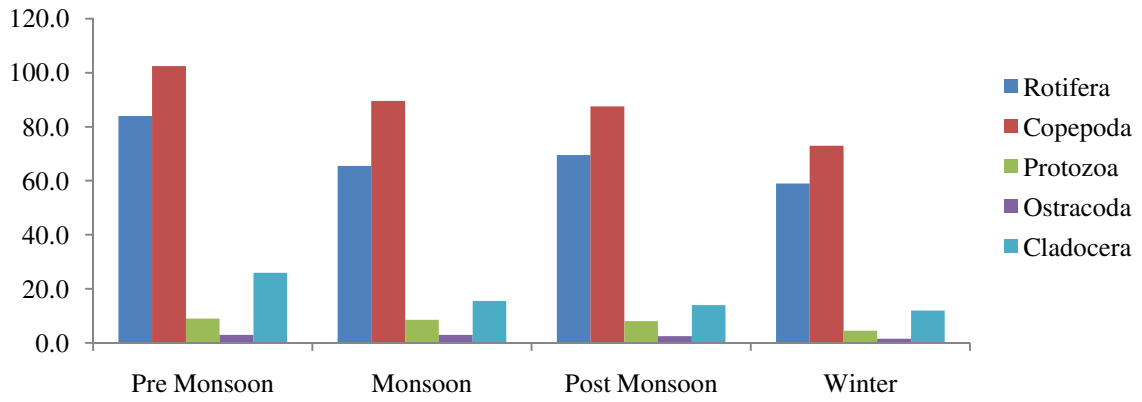


Fig 83: Seasonal variation of zooplankton in ponds of Bishnupur Block

Composition (%) of Different group of Zooplankton in the ponds of Bishnupur Dev Block:

Fig 84: Composition of zooplankton in ponds of Bishnupur Block

Table 130:Seasonal variation of Different Group of Zooplankton of Joypur Dev Block:

Seasonal Variation of Zooplankton availability of Joypur Block						
Group	**Rotifera**	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Diversity Index**
Season	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	
Pre Monsoon	77.5 ± 5.5	90.0 ± 1	6.5 ± 0.50	3 ± 0	26 ± 3	1.2
Monsoon	67.5 ± 4.5	77.5 ± 2.5	4.5 ± 0.50	1.5 ± 0.50	18 ± 1	1.1
Post Monsoon	71.5 ± 2.5	78.5± 4.5	5.5 ± 0.50	2.0± 0	16± 1	1.1
Winter	60.5 ± 2.5	64.5 ± 3.5	3 ± 1	1 ± 0	11 ± 1	1

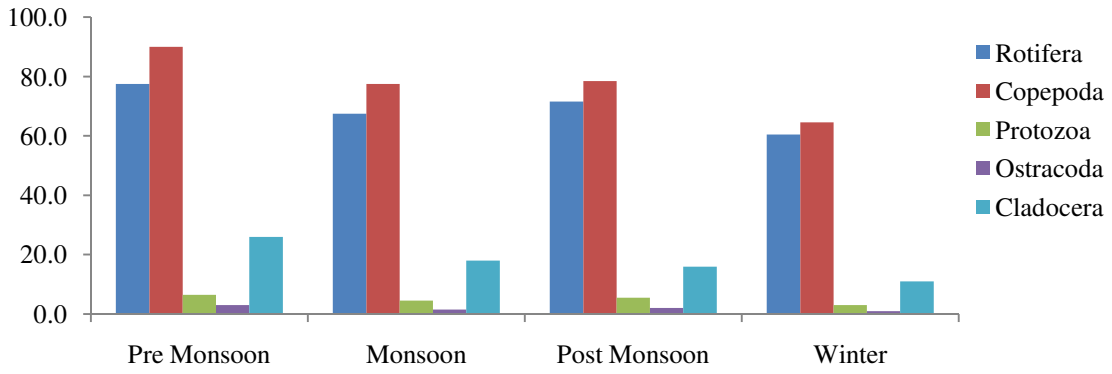


Fig 85: Seasonal variation of zooplankton in ponds of Joypur Block

Composition (%) of Different group of Zooplankton in the ponds of Joypur Dev Block:

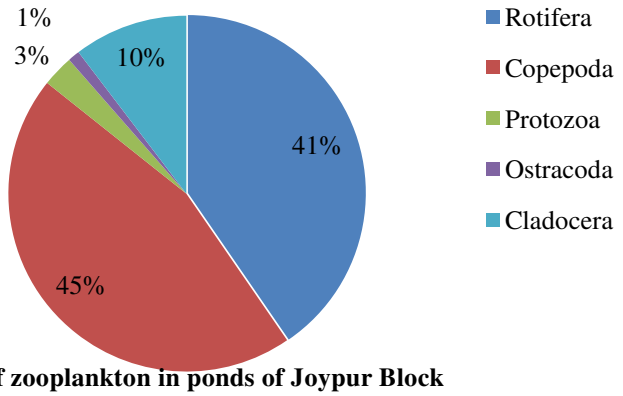


Fig 86: Composition of zooplankton in ponds of Joypur Block

Reservoir fishery management

Table 131: Seasonal Variation of Water Quality parameter in Kangsabati Reservoir in Bankura:

Seasonal Variation of Water Quality parameter in Kangsabati Reservoir in Bankura				
Season / **Parameter**	Pre Monsoon	Monsoon	Post Monsoon	Winter
Water Temp	28	25	21	18
Ph	8.8	7.9	8.1	8.3
Transparency (Cm)	32	35	28	26
Dissolved Oxygen (mg/lt)	7.3	8.8	8.5	8
Alkalinity (mg/lt)	95	82	77	65

Hardness (mg/lt)	140	155	132	115
Nitrite Nitrogen (NO_2N) (mg/lt)	0.05	0.01	0.006	0.004
Nitrate Nitrogen (NO_3N) (mg/lt)	0.1	0.006	0.025	0.003
Ortho Phosphate (P_2O_5) (mg/lt)	0.0045	0.0055	0.003	0.0025

Water Temperature:

The water temperature of Kangsabati Reservoir varies seasonally. It also depends on water depth and climatic condition. Water temperature varies between maximum 28^0C (Pre Monsoon) to minimum 18^0C (winter). Similar type of result have also been observed by Sonawane, 2011 in Sukhana river, Maharastra.

pH:

The ph range fluctuates in between 7.9 to 8.8. The water with pH values ranging from about 6.5-9.0 at daybreak is most suitable for fish production (ICAR, 2011).

Transparency:

The higher value of transparency was observed during Monsoon season (35cm) and lower value of transparency was observed during winter season (26 cm). The transparency value of Kangsabati reservoir is good for fish culture.

Dissolved Oxygen:

The dissolved oxygen value of the Kangsabati reservoir ranged from 7.3 mg/lt to 8.8 mg/lt. The maximum value of dissolved oxygen was found in Monsoon season and minimum value was observed during Pre Monsoon season.

Alkalinity:

During the study it was observed that the lowest value of alkalinity was observed during winter season i.e 65 mg /lt and highest value of alkalinity was observed during Pre Monsoon season i.e 95 mg /lt.Similar result has been observed by Bera *et. al* 2014.

Hardness:

During the study period the hardness value of Kangsabati reservoir varied from 115 mg/lt to 140 mg/lt. Highervalue of hardness observed during Pre Monsoon season and lowest value observed during winter season.

Nitrite Nitrogen (NO_2N):

The nitrite nitrogen value of Kangsabati reservoir varied from 0.004 mg/lt to 0.5 mg/lt. The higher value f nitrite nitrogen observed during Pre Monsoon months and lower value of nitrite nitrogen observed during winter month.

Nitrate Nitrogen (NO_3N):

The nitrate nitrogen value of Kangsabati reservoir varied from 0.003 mg/lt to 0.1 mg/lt. The higher value f nitrite nitrogen observed during Pre Monsoon months and lower value of nitrite nitrogen observed during winter month.

Ortho Phosphate (P_2O_5):

The ortho phosphate value of Kangsabati reservoir varied from 0.0025 mg/lt to 0.0055 mg/lt. The higher value of ortho phosphate observed during Pre Monsoon months and lower value of nitrite nitrogen observed during winter month.

The population of phytoplankton in the Kangsabati Reservoir of Bankura District composed of four major groups namely Cyanophyceae, Chlorophyceae, Bacillariophyceae, and Euglenophyceae. All the group of phytoplankton was present throughout the year. During the study period the diversity analysis of phytoplankton showed that total 29 genera of phytoplankton belonging to four major groups. Among them Cyanophyceae consists of seven genera, Chlorophyceae consists of 12 genera, Bacilariophyceae consists of 8 genera and Euglenophyceae 2 genera.

Regarding the density the dominance of phytoplankton group are the following order Chlorophyceae > Bacillariophyceae > Cyanophyceae > Euglenophyceae

Table 132: GroupWise Phytoplankton Availability in the Kangsabati Reservoirs of Bankura District

GroupWise Phytoplankton Availability in the Kangsabati Reservoirs of Bankura District			
Taxa			
Cyanophyceae	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**
a. *Anabaena sp*.	a. *Ankistrodesmus sp*	a. *Cyclotella sp*	a. Euglena sp.
b. *Lyngbya sp*.	b. *Chlorella sp*	b. *Diatoma sp*.	b. Phacus sp.

c. *Microcystis sp*	c. *Closterium sp*.	c. *Fragillaria sp*	
d. *Oscillatoria sp*	d. *Mougeotia sp*	d. *Navicula sp*	
e. *Nostoc sp*.	e. *Scenedesmus sp*	e. *Nitzschia sp*.	
f. *Phormidium sp*	f. *Spirogyra sp*	f. *Pinnularia sp*	
g. *Merismopedia sp*.	g. *Ulothix sp*	g. *Synedra*	
	h. *Zygnema sp*	h. *Asterionella sp*.	
	i. *Pedistrum sp*.		
	j. *Schizochlamys sp*.		
	k. *Udorina s*p.		
	l. *Asterococcus sp*.		

Cyanophyceae:

The phytoplankton group Cyanophyceae represents by the following genera namely *Anabaena sp, Lyngbya sp, Microcystis sp, Oscillatoria sp, Nostoc sp, Phormidium sp* and *Merismopedia sp*. The seasonal occurrences of cyanophyceace ranged from a maximum 90 no's /l to minimum 51 no's /l.In the present investigation, the density of Cyanophyceace in the Kangsabati reservoirs of Bankura District was found to be maximum during summer seasons and minimum during Monsoon season.It may be due to higher water temperature. This result was supported by the findingsNirmal Kumar – Cini Oommen (2011), Zafar, (1967); Hegde and Bharati,(1985) and Swarnalatha and Narasinga Rao, 1993.

Chlorophyceae:

Among all the group of phytoplankton found in the Kangsabati reservoir of Bankura District Chlorophyceae was the dominant group. This group was dominant by following genera namely *Ankistrodesmus sp,Chlorella sp,Closterium sp,Mougeotia sp,Scenedesmus sp,Spirogyra sp,Ulothix sp,Zygnema sp,Pedistrum sp,Schizochlamys sp,Udorina s*p,*Asterococcus sp*. The seasonal occurrences of chlorophyceae ranged from maximum 115 no's / l to minimum 65 no's/l. Maximum density of chlorophyceae found during Pre Monsoon Season and minimum

density was found during Monsoon Season.This result was supported by the findings ofHuisman *et al*., (2005) ; James G.N. and Paul R.N., (1992).

Bacillariophyceae:

Bacillariophyceae are the another dominant group of phytoplankton found in the Kangsabati Reservoir of Bankura District.It consists of the following genera like*Cyclotella sp*, *Diatoma sp*, *Fragillaria sp*, *Navicula sp*, *Nitzschia sp*, *Pinnularia sp*, *Synedra sp,*and *Asterionella sp.* Thephytoplankton group Bacillariophyceae was dominant in Pre Monsoon Season (130 no's / l) and found least number (75 no's /l) in Monsoon Season. This result was supported by the findings of Devika et al., (2006).

Euglenophyceae:

These are the least dominated group among the other group of phytoplankton found in the Kangsabati reservoir of Bankura District. This group is dominated by only two genera i.e. *Euglena sp* and *Phacus sp*. The maximum no of Euglenophyceae was observed during summer season (25 no's / l) and minimum no observed during Monsoon month (8 no's / l).Verma *et al.,* (2001) and Milind S. Hujare, (2008) were also reported phytoplankton density in different seasons in order of summer > winter > monsoon.

Table 133: Seasonal Variation of Phytoplankton Availability of Kangsabati Reservoir of Bankura District:

Seasonal Variation of Phytoplankton availability of Kangsabati Reservoir of Bankura District

Group / season	Cyanophyceae	Chlorophyceae	Bacillariophyceae	Euglenophyceae
Pre Monsoon	90	115	130	25
Monsoon	51	65	75	8
Post Monsoon	63	78	83	11
Winter	72	82	102	15
Total	276	340	390	59

Table 134:Percentage composition of different group of Phytoplankton in the Kangsabati Reservoir of Bankura District:

Seasonal variation (%) of Phytoplankton in the Kangsabati Reservoir of Bankura District				
Group	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**
Percentage (%)	25.92	31.92	36.62	5.54

Seasonal Variation of Phytoplankton availability in the Kangsabati Reservoir of Bankura District

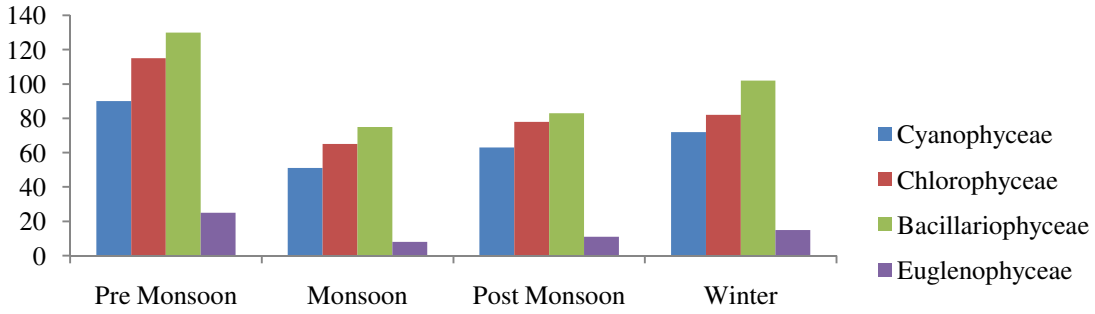


Fig 87: Seasonal Variation of Phytoplankton availability in the Kangsabati Reservoir of Bankura District

Seasonal variation (%) of Phytoplankton in the Kangsabati Reservoir of Bankura District

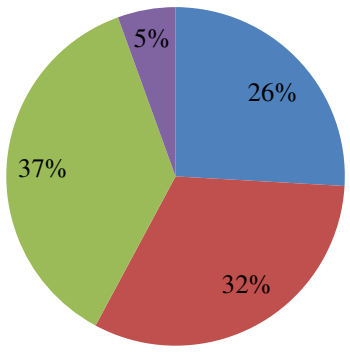


Fig 88: Seasonal variation (%) of Phytoplankton in the Kangsabati Reservoir of Bankura District

Table 135:Seasonal Abundance (%) of different group of Phytoplankton in the Reservoir of Bankura District

Seasonal Abundance (%) of different group of Phytoplankton in the Kangsabati Reservoir of Bankura District					
Group	**Cyanophyceae**	**Chlorophyceae**	**Bacillariophyceae**	**Euglenophyceae**	**Diversity index**
Season	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	
Pre Monsoon	25.00	31.94	36.11	6.94	1.26
Monsoon	25.63	32.66	37.69	4.02	1.21
Post Monsoon	26.81	33.19	35.32	4.68	1.23
Winter	26.57	30.26	37.64	5.54	1.24

The data obtained from the study indicates that a total 36 genera of zooplankton were identified which is belonging to six groups namely Rotifera (10 genera), Copepoda (10 genera), Cladocera (9 genera), Protozoa (4 genera), Ostracoda (2 genera) and Amphipoda (1 genera).

Table 136:Zooplankton availability in the Kangsabati Reservoirs of Bankura District:

Groupwise Zooplankton Availability in the Kangsabati Reservoirs of Banura District					
Taxa					
Rotifera	**Copepoda**	**Protozoa**	**Ostracoda**	**Cladocera**	**Amphipoda**
a. *Brachionus sp.*	a. *Nauplii*	a. *Amoeba*	a. *Cypris sp.*	a. *Daphnia sp.*	a. *Hyperia sp*
b. *Asplanchna sp*	b. *Diaptomus sp*	*b. Paramecium*	*b. Cyprinotus*	b. *Ceriodaphnia*	
c. *Keratella sp.*	c. *Pseudodiaptomus sp.*	c. *Arcella*		c. *Simocephalus*	
d. *Synchaeta sp.*	d. *Cyclops*	d. *Difflugia*		d. *Bosmina*	
e. *Euchlanis sp.*	e. *Mesocyclops sp.*			e. *Moina*	
f. *Filinia sp.*	f. *Paracyclops sp.*			f.	

				Diaphanosoma sp.	
g. *Trichocera sp*	g. *Microcyclops sp.*			g. *Eubosmina sp*	
h. *Anuraeopsis sp*	h. *Eucyclops*			h. *Holopedium sp*	
i. *Monostyla sp*	i. *Acanthocyclops sp*			i. *Leptodora sp*	
j. *Polyarthra sp*	j. *Heliodiaptomus*				

Rotifera:

This group represented by 10 genera.. The most commonly occurring genera are *Brachionus sp, Asplanchna sp, Keratella sp, Synchaeta sp, Euchlanis sp, Filinia sp.Trichocera sp., Anuraeopsis sp, Monostyla sp, Polyarthra sp.* The occurrence of Rotifer population was higher in winter and post monsoon season and lower in monsoon months. Out of total Rotifera population i.e 421 no's /l highest population was observed in winter months i.e 160 no's /l and lowest population was observed in monsoon months i.e 71 no's /l. The same finding has been also reported by Abdus and Altaff, (1995) and Kumar, (2001).Less zooplankton population during monsoon season is on account of high turbidity whichrestricts growth of the planktonic population. Besides this, regular flash out of pond waterduring the rain is also a major cause of less plankton diversity as well as density.

Cladocera:

Among Zooplankton, cladocera was the dominant group.This group is represented by 9 genera. The most commonly occurring genera are *Daphnia sp.*,*Ceriodaphnia sp*, *Simocephalus sp*,*Bosmina sp*,*Moina sp*,*Diaphanosoma sp*,*Eubosmina sp.*,*Holopedium sp.*,*Leptodora sp*.Their density ranged from 145 no's/lt (Winter) to 45 ind / lt (Post Monsoon).

Copepoda:

This group is represented by the genus of *Cyclops, Eucyclops, Mesocyclops sp, Paracyclops sp, Acanthocyclops sp, Microcyclops sp, Pseudodiaptomus sp, Diaptomus sp, Heliodiaptomus, Nauplii*. Their density range varies from maximum 155 no's /lt to minimum 88 no's /lt. The population density of Copepoda was maximum in Pre Monsoon Season and minimum in winter months.

Ostracoda:

This group is represented by two genera namely *Cypris sp*. and *Mesocypris sp*.Ostracoda population was higher during Post monsoon month and lower during Pre monsoon month. Their density range varied from 20 no's /lt to 9 no's /lt.

Protozoa:

Protozoans are the least dominant group among the zooplankton. The zooplanktonic group Protozoa represented by the genus of *Amoeba sp, Paramecium sp, Arcella sp* and*Difflugia sp*.Protozoan density was maximum during Monsoon month (70 no's /lt) and minimum during winter month (20 no's /lt).

Amphipoda:

Only one species namely *Hyperia sp* found in this group during the study period. The population density of Amphipoda was maximum during Pre Monsoon season i.e 5 no's/lt. The occurrence of this group was only Pre Monsoon and Monsoon season.

Table 137:Seasonal Variation of Zooplankton Availability ofKangsabati Reservoir of Bankura District:

Seasonal Abundance of Zooplankton in the Kangsabati Resevoir of Bankura District						
Group / Season	**Rotifera**	**Copepoda**	**Cladocera**	**Protozoa**	**Ostracoda**	**Amphipoda**
Pre Monsoon	80	155	73	26	9	5
Monsoon	71	115	57	70	10	3
Post Monsoon	110	145	48	55	24	0
Winter	160	88	145	20	20	0
Total	**421**	**503**	**323**	**171**	**63**	**8**

Table 138:Percentage composition of different group of Zooplankton in the Kangsabati Reservoir of Bankura District:

Seasonal Variation (%) in the Kangsabati Reservoir of Bankura District						
Season	**Rotifera**	**Copepoda**	**Cladocera**	**Protozoa**	**Ostracoda**	**Amphipoda**
Percentage (%)	**28.27**	**33.78**	**21.69**	**11.48**	**4.23**	**0.53**

The total no of species recorded were 1489 no's /lt, out of which Rotifera are 421 no's /lt (28.27 %), Cladocera 323 no's /lt (21.69 %), Copepoda 503 no's /lt (33.78%), Ostracoda 63 no's /lt (4.23 %), and Protozoa 171 no's /lt (11.48 %) and Amphipoda 8 no's /lt (.53%).

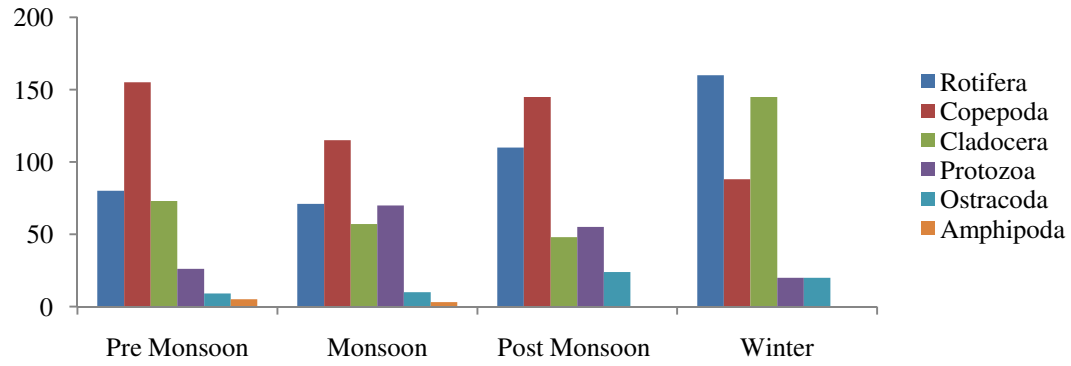


Fig 89: Seasonal Variation of Zooplankton availability in the Kangsabati Reservoir of Bankura District

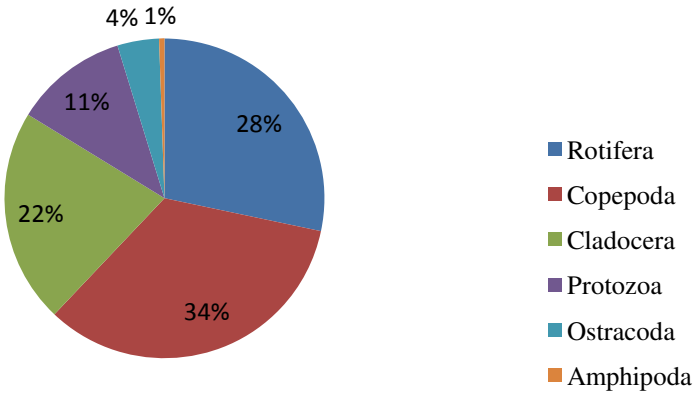


Fig 90: Composition (%) of Zooplankton in the Kangsabati reservoir of Bankura District

Table 139:Seasonal Abundance (%) of different group of Zooplankton in the Kangsabati Reservoir Bankura District

Seasonal Abundance (%) of different group of Zooplankton in the Kangsabati Reservoir Bankura District						
Group	**Rotifera**	**Copepoda**	**Cladocera**	**Protozoa**	**Ostracoda**	**Amphipoda**
Season	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**	**Percentage (%)**
Pre	22.98	44.54	20.97	7.47	2.58	1.43

Monsoon						
Monsoon	21.77	35.27	17.48	21.473.	3.06	0.92
Post Monsoon	28.79	37.95	12.56	14.39	6.28	0
Winter	36.95	20.32	33.48	4.61	4.61	0

Ichthyofaunal Diversity in the Kangsabati Reservoir

The Kangsabati is the largest reservoir in the state of West Bengal, covers a water area of about 40 Sq.Km. situated at 22.51^0 Latitude and 56.44^0 Longitude having a catchments area of 3626 Sq. Km. with full storage level (FSL) 13668ha and at dead storage level (DSL) 3400 ha and mean sea level (MSL) about 6400ha with maximum depths of 42 meters.The Kangsabati reservoir falls mainly under two districts, Bankura and Purulia and the name Kangsabati derived from the river Kangsabati, which originates from Jabrabad Hill of Chotonagpur platue of Jharkhand State. From Jabrabad to Mukutmanipur it crosses 60 KM.

In Fisheries prospective it opens up a new dimension for capture & culture of reservoir fisheries and way back to 1987 Fisheries Department kept in constant touch through its different plans & programme to alive and perpetual development of distressed local people who have lost their land & traditional livelihood of agriculture farming. In considering its vast potentiality of fish production resources as it has become a natural habitat and breeding ground of various fish species.

The study was conducted seasonally during the year February 2014 to January 2016. Fish samples were collected from various sampling station and other valuable information were collected from the local fisherman and resident adjacent to the selected sites of different reservoirs of the district. Fishing was carried out with help of local skilled fishers using cast net and drag net. The samples were photographed, immediately prior to preservation as formalin (8%) decolorizes the fish colour on long preservation (Bagra, 2010).

The geographical co ordinates of the Kangsabati reservoirs of Bankura district are given below.

The fish samples were captured with the help of local skilled fishermen in one preselected sampling sites of the district. Fish samples were randomly collected. Castanet and Dragnet were used for capturing fish. All fish species were preserved in 4 - 10% formaldehyde solution as per the size for identification to genus and species level using taxonomic keys and standard literatures. Fishes were identified based on standard taxonomic literature (Talwar and Jhingran, 1991; Jayaram, 1999; www.fishbase.org var. 02/2015), grouped into four categories based on their abundance viz., Abundant, Moderate, Low and Very low and categorized according to Red Book of IUCN.

The Kangsabati reservoir of Bankura district showed rich ichthyofauna diversity. The data on the fish community of the Kangsabai Reservoirs of Bankura district are presented in Tables 1, 2 and 3. The periodical survey of the ichthyofauna revealed the occurrence of 38 species belonging to 7 orders 15 families, 26 genera, and. On the basis of species composition, Cypriniformes were dominant (16 species) followed by Perciformes (7species) andSiluriformes (7species) and Channiformes (3 species), Osteoglossiformes and Synbranchiformes (each of 2 species), and Anguilliformes (1 species). The fast growing Indian major carps, occupy a prominent place in Indian reservoirs (Sugunan, 1995) supported the finding of the study.

Discussion:

In the present study total 38 species belonging to 7 orders, 15 families and 26 genera are reported in the Kangsabati reservoir of Bankura District. On the basis of species composition, Cypriniformes were dominant (16 species) followed by Perciformes (7species) andSiluriformes (7 species) and Channiformes (3 species), Osteoglossiformes and Synbranchiformes (each of 2 species), and Anguilliformes (1 species). Species belong to family Cyprinidae were found more abundant (42.11%) followed by Channidae (7.89%), Ambassidae (5.26%), Cichlidae (5.26%), Bagridae (5.26%), Mastascembellidae (5.26%), Siluridae (5.26%), Notopteridae (5.26%), Osphronemidae (2.63%), Anabantidae (2.63%), Gobidae (2.63%), Claridae (2.63%), Schilbeidae (2.63%), Heteropneustidae (2.63%), Anguilidae (2.63%). The fish recorded from the reservoirs of the Purulia District were *Labeo rohita, Labeo bata, Labeo calbasu,Puntius ticto, Puntius sophore, Puntius gelius, Catla catla , Amblypharyngodon mola , Rasbora daniconius, Cirrhinus mrigala, , Cirrhinus reba, Cyprinus carpio, Esomus danricus, Hypophthalmichthys molitrix, Ctenopharyngodon idella , Chanda ranga,Chanda nama,, Oreochromis niloticus , Oreochromis*

mossambicus, Trichogaster lalius, Anabas testudineus, Glossogobius giuris, Ompok pabda, Wallago attu , Clarias batrachus, Heteropneustes fossilis, Mystus vittatus, Mystus tengra, Eutropichthys vacha, Macrognathus pancalus, Macrognathus aculeatus , Channa punctata, Channa striata, Channa orientalis, Notopterus notopterus , Notopterus chitala, Anguilla bengalensis .The average of fish abundance obtained in the reservoir showed that the species Labeo rohita recorded the highest catch by the number. Fish diversity and its abundance are being eroded every day mainly because of unending anthropogenic pressure. Habitat loss and environmental degradation has seriously affected the fish fauna (Saha and Patra, 2013). Recent data regarding fish abundance of the study area, aiming to contribute a better knowledge of the fish diversity and a tool for conservation planning of aquatic environments in this region. To maintain fish biodiversity has an immense importance as it is not always possible toidentify individual species critically to sustain aquatic ecosystem (Vijaykumr *et al*., 2008).The fish abundance of the reservoirs of the Purulia district constitute a valuable natural resources in Economic, aesthetic and scientific and educational terms and its conservation and management are critical to the interests of humankind itself.

Seasonal abundance of ichthyofauna in the Kangsabati reservoir had been shown in Table no 5. The no of fish species availability observed in various season during the study period. From the study we found that more no of species were available during Summer and late Winter season and less no of species were available during Rainy season. The detailed of fish species found in the Kangsabati reservoir indicating order, family, scientific name, common name, local name, IUCN status (2014.1 versions) and seasonal abundance and economical value of available fish species showed in Table no 1. Composition of fish community by order and family with their percentage distribution had been documented in Table no 2 and 3.

Table 140:Ichthyofaunal diversity of Kangsabati Reservoir of Bankura District

Sl. No.	Order	Family	Scientific name	Common name	Local name	IUCN status	Seasonal abundance	Economic value
1	Cypriniformes	Cyprinidae	*Labeo rohita* (Ham.)	Rohu	Rui	LC	TY	Food fish

2			*Labeo calbasu* (Ham.)	Black rohu/karnataka labeo	Kalbose	LC	TY	Food fish
3			*Labeo bata* (Ham.)	Bata labeo/minor carp	Bata	LC	SM	Food fish
4			*Puntius ticto* (Ham.)	Ticto barb	Tit punti	LC	SM	Ornamental, food fish
5			*Puntius sophore* (Ham.)	Pool barb	Jatpunti	LC	SM	Ornamental
6			*Puntius gelius* (Ham.)	Golden dwarf barb	Dor punti	LC	SM	Ornamental
7			*Catla catla* (Ham.)	Catla	Catla	LC	TY	Food fish
8			*Amblypharyngodon mola* (Ham.)	Mola carplet	Mourala	LC	SM	Ornamental
9			*Amblypharyngodon microlepis* (Bleeker)	Indian carplet	Mourala	LC	SM	Ornamental
10			*Rasbora daniconius* (Ham.)	Slender rasbora	Siram punti	LC	TY	Ornamental
11			*Cirrhinus mrigala* (Ham.)	Mrigal	Mrigal/Mrig	LC	RS	Food fish
12			*Cirrhinus reba* (Ham.)	Reba carp	Bhangon bata	LC	SM	Food fish

13			*Cyprinus carpio* (Linn.)	Wild common carp	Cyprinus	VU	TY	Ornamental/ food fish
14			*Esomus danricu*s (Ham.)	Flying barb	Darkya	LC	TY	Ornamental
15			*Hypophthalmichthys molitrix* (Val.)	Silver carp	Silver carp	NT	TY	Food fish
16			*Ctenopharyngodon idella* (Val.)	Grass carp	Grass carp	NE	TY	Food fish
17	Perciformes	Ambassidae	*Chanda ranga*(Ham.)	Indian glassy fish	Ranjan chanda	LC	WN	Ornamental
18			*Chanda nama*(Ham.)	Elongate glass-perchlet	Kanta chanda	LC	TY	Ornamental
19		Cichlidae	*Oreochromis niloticus* (Linn.)	Nile tilapia	Nilontica	NE	TY	Food fish
20			*Oreochromis mossambicus*(Peters)	Mozambique tilapia	Tilapia	NT	TY	Food fish
21		Osphronemidae	*Trichogaster lalius*(Ham.)	Dwarf gourami	Khoira	LC	SM	Ornamental
22		Anabantidae	*Anabas testudineus*(Bloch)	Climbing perch	Koi	DD	TY/RS	Ornamental
23		Gobiidae	*Glossogobius giuris*(Ham.)	Bareye goby	Bele	LC	WN	Ornamental/ food fish

24	Siluriformes	Siluridae	*Ompok pabda*(Ham.)	Pabdah catfish	Pabda	NT	SM	Food fish
25			Wallago attu (Bl. & Schn.)	Fresh water shark	Boal	NT	WN	Food fish/ornamental
26		Claridae	*Clarias batrachus*(Linn.)	Air breathing catfish	Magur	LC	WN	Ornamental/ food fish
27		Heteropneustidae	*Heteropneustes fossilis* (Bloch)	Stinging catfish	Singhi	LC	SM	Ornamental/ food fish
28		Bagridae	*Mystus vittatus*(Bloch)	Striped dwart catfish	Tangra	LC	WN	Ornamental/ food fish
29			*Mystus tengara*(Ham.)	Tengara catfish	Tangra	LC	WN	Food fish/ornamental
30		Schilbeidae	*Eutropichthys vacha* (Ham.)	Bacha	Bacha	LC	WN	Food Fish
31	Synbranchiformes	Mastacembelidae	*Macrognathus pancalus* (Ham.)	Barred spiny eel	Pacal	LC	WN	Food fish
32			*Macrognathus aculeatus* (Bloch)	Lesser spiny eel	Pacal	NE	WN	Ornamental/ food fish
33	Channiformes	Channidae	*Channa punctata*(Bloch)	Spotted snakehead	Lata	LC	SM	Food fish/ornamental

34			*Channa striata*(Bloch)	Stripped or Snakehead murrel	Shol	LC	SM	Food fish/ornamental
35			*Channa orientalis*(Bl. & Schn.)	Walking snakehead	Cheng	NE	SM	Food fish
36	Osteoglossiformes	Notopteridae	*Notopterus notopterus* (Pallas)	Bronze featherback	Folui	LC	WN	Ornamental/ food fish
37			*Notopterus chitala/Chitala chitala* (Ham.)	Humped featherback	Chital	NT	WN	Ornamental/ food fish
38	Anguilliformes	Anguillidae	*Anguilla bengalensis* (Gray)	Indian mottled eel	Ban fish	NT	RS	Ornamental

LC = least concern, VU = vulnerable, NT = near threatened, NE = not evaluated, DD = data deficient;

WN = winter, SM = summer, TY = throughout the year, and RS = rainy season.

Table 141:Composition of the fish community by order:

Sl. No.	Taxa	Number of species	Percentage (%)
1	Order: Cypriniformes	16	42.11
2	Order: Perciformes	7	18.42
3	Order: Siluriformes	7	18.42
4	Order: Channiformes	3	7.89

5	Order: Osteoglossiformes	2	5.26
6	Order: Synbranchiformes	2	5.26
7	Order: Anguilliformes	1	2.63
Total		38	100.00

Table 142: Composition of the fish community by family:

Sl. No.	Taxa/families	Number of Species	Percentage (%)
1	Family: Cyprinidae	16	42.11
2	Family: Ambassidae	2	5.26
3	Family: Cichlidae	2	5.26
4	Family: Osphronemidae	1	2.63
5	Family: Anabantidae	1	2.63
6	Family: Gobiidae	1	2.63
7	Family: Siluridae	2	5.26
8	Family: Claridae	1	2.63
9	Family: Heteropneustidae	1	2.63
10	Family: Bagridae	2	5.26
11	Family: Schilbeidae	1	2.63
12	Family: Channidae	3	7.89

13	Family: Notopteridae	2	5.26
14	Family: Mastacembelidae	2	5.26
15	Family: Anguillidae	1	2.63
Total		38	100.00

Table 143:IUCN Status of commonly available fish species in the Kangsabati Reservoirs of Bankura District

Least Concern (LC)	**Vulnerable (VU)**	**Near threatened (NT)**	**Not evaluated (NE)**	**Data deficient (DD)**
Labeo rohita	*Cyprinus carpio*	*Hypophthalmichthys molitrix*	*Ctenopharyngodon idella*	*Anabas testudineus*
Labeo calbasu		*Oreochromis mossambicus*	*Oreochromis niloticus*	
Labeo bata		*Ompok pabda*	*Macrognathus aculeatus*	
Puntius ticto		*Wallago attu*	*Channa orientalis*	
Puntius sophore		*Notopterus chitala/Chitala chitala*		
Puntius gelius		*Anguilla bengalensis*		
Catla catla				
Amblypharyngodon mola				
Amblypharyngodon microlepis				
Rasbora daniconius				

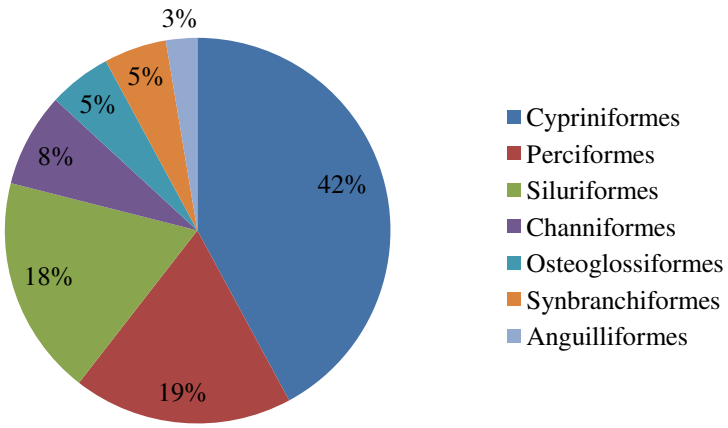
Cirrhinus mrigala				
Cirrhinus reba				
Esomus danricus				
Chanda nama				
Chanda ranga				
Trichogaster lalius				
Glossogobius giuris				
Clarias batrachus				
Heteropneustes fossilis				
Mystus vittatus				
Mystus tengra				
Macrognathus pancalus				
Channa punctata				
Channa striata				
Notopterus notopterus				
Eutropichthys vacha				

Table 144:Distribution Status of commonly available fish species in the Kangsabati Reservoirs of Bankura District

Throughout the year (TY)	**Summer (SM)**	**Rainy season (RS)**	**Winter (WN)**
Labeo rohita	*Labeo bata*	*Cirrhinus mrigala*	*Chanda ranga*
Labeo calbasu	*Puntius ticto*	*Anabas testudineus*	*Glossogobius giuris*
Catla catla	*Puntius sophore*	*Anguilla bengalensis*	*Wallago attu*
Rasbora daniconius	*Puntius gelius*		*Clarias batrachus*

Cyprinus carpio	*Amblypharyngodon mola*		*Mystus vittatus*
Esomus danricus	*Amblypharyngodon microlepis*		*Mystus tengra*
Hypophthalmichthys molitrix	*Cirrhinus reba*		*Macrognathus pancalus*
Ctenopharyngodon idella	*Trichogaster lalius*		*Macrognathus aculeatus*
Chanda nama	*Ompok pabda*		*Notopterus notopterus*
Oreochromis mossambicus	*Heteropneustes fossilis*		*Notopterus chitala/Chitala chitala*
Oreochromis niloticus	*Channa punctata*		*Eutropichthys vacha*
Anabas testudineus	*Channa striata*		
	Channa orientalis		

Distribution of commonly available fish species (By Order) present in Kangsabati reservoirs of Bankura District:



Percentage of Species availability by Order

Limiting Factors of Production:

1. **Absence of Fish Seed Farm in the reservoir site:**

   In absence of Nursery and Rearing tanks at nearby site of the reservoir as well as there is no other water bodies except Kangsabati Reservoir under the possession of the Primary Fishermen Co operative Society. The fish seed were brought from distant places.

2. **Inadequate infrastructure Facility:**

Inadequate infrastructure facilities like community Hall, office building of Kangsabati CFCS limiting the scope of proper monitoring and supervision of the ongoing routine works.

3. **Lack of Awareness among local fishermen:**

   Local fishermen caught all types of fishes during breeding season July to September that hinder the natural breeding and spawning ground of fishes.

4. **Siltation:**
5. **Abundance of Macrophyte:**
6. **Loss of natural source of fish seed by Local Fishermen:**

   The natural stock of fish seed was destroyed by the fishers due to use of 'Chatjaal" as well as lack of awareness among them.

7. **Improper Harvesting:**

   Difficulty in successful harvesting of fishes due to uneven bed and bottom of the reservoir which is covered with tree stumps, boulders, rocks ditches, river lets other structures etc. and lack of skilled experienced fishers. Sometimes it needs to hire the experienced and skilled fishers from other district.

Specific Recommended Measures:

1. **Fish Seed Farm:**

In the year 1986 the Fisheries Department, GOWB has decided to construct Fish Seed Farms surroundings to the reservoir. Some areas adjacent to the reservoir were selected at Ranibandh, Khatra-I, Khatra-II Development Blocks under Bankura district and Manbazar-I Dev. Block under Purulia district and constructed 41 ha Nursery & Rearing tanks in 13 sites under RLEG Programme during 1986-1988.

2. **Initiative taken from National Cooperative development Corporation:**

In the years 1996-1999, the NCDC-BENFISH launched a project for development of Kangsabati reservoir fisheries in the head of distribution of crafts & gears and stocking of fish seed programme for the Cooperatives.

3. **Initiative of Kangsabati Central Fishermen Co operative Society:**

In the mean time the KCFCS Ltd. along with its PFCS decided some policies to ensure fish production through stocking of fish seeds from their own fund and they decided that the fund will be created by the collection of Registration fees and Fishing license fees from the participants' fishers. The required fish seed should be collected from the societies and the deficit if any, will be procured from nearby Societies, FPGs, SHGs, Local farmers etc.

4. **Stocking of Fish Seed:**

The stocking of fishseed in the Kangsabati Reservoir are in 2 ways: (1) Auto-stocking / Natural stocking and (2) Artificial stocking

(A) Auto-stocking / Natural stocking: (a) Auto stocking occurs from the river Kangsabati and Kumari during rainy season and

(b) **Natural breeding**: Natural breeding of different fish species usually occurs at different time. Recent past it was observed that the Indian major carps along with other fishes were

breeds naturally at the shallow parts of upstream (head water recharge areas) during Monsoon period; adjacent to the area of Manbazar-I and Manbazar-II Development Block under Purulia District.

(2) Artificial Stocking:

a) Stocking of fish seed by rearing in Nursery and Rearing tanks. Attempt was taken to produce seeds in pen and cages also**.** The Kangsabati CFCS Ltd. along with members of the societies, extension personnel of Fisheries Department, Local Administration and Panchayat Raj Institution commonly decided that the fishers should refrain themselves from catching all type of fishes during July to September to stop disturbance of natural spawning and spawning ground at higher strata.

5. Organizing Awareness Programme:

Awareness camps were also organized in village to village along with mike broadcasting, leaflets distribution, role playing, participating in the local Melas etc.

6. **Complete Harvesting of Fishes:**

Now mostly they fished by gill net and in some parts of the reservoir they use drag nets, cast net along with other fishing devices like traps, lining and hooking.

Now Fisheries Department Govt. of West Bengal has taken initiation for execution of scheme distribution of Minikit in Big water bodies (Kangsabati Reservoir) under social Fishery scheme. The motto of the scheme was to improve the fish farming of Kangsabati by way of increasing the fish stock and to improve the Socio economic condition of the fisher folk whose livelihood depends only on fish catching at Kangsabati,

Existing production of the reservoir per Ha/Year is about 45kg/Ha/yr, which is expected to be 125/Ha/yr after stocking. The per capita income of the fishers is Rs.5000/-Rs.6000/ per month before stocking which is likely to be increased Rs.12000/-Rs.15000/ per month after stocking.

7. Development of Eco Tourism:

Apart from fisheries point of view there is tremendous scope of eco-tourism development in the Kangsabati reservoir surrounding Mukutmonipur which may cater and provide good opportunity to the other members of the fishers family to add earnings and side by side their livelihood also in river riding of the tourists through their traditional boats . Mukutmanipur perhaps the best picnic spot in the state of West Bengal as well as the biggest earthen dam in Asia. The scenic natural beauty of Mukutmanipur attracts people across the state over the years. The village

environs are striking combination of rolling land, natural vegetation, lake and tribal hamlets. It is marked by the prominent hillock about 200 meters high, locally named "Baroghutu" (Baro-twelve, ghutu-/stones/hill). The tribal hamlets of Baroghutu, Jambeda, Kumorbahal, Dhagora and Mukutmanipur encircle this hillock. With a landscape that seems naturally designed for adventure, Mukutmanipur offers opportunities in rock climbing, trekking and a variety of water sports. The local festivals, 'Tusu', 'Bhadu', 'Sahrai' and 'Badna' are symbolized by much music and dance, and strengthen the Mukutmanipur experience, laden with the relaxed air of nature in the heartland.

Aquatic Macrophyte diversity in the Kangsabati reservoir of Bankura District

Total 11 genera of macrophytes are found in the study area. Collected macrophytes are classified according to their various habitats.

Submerged:

These are generally rooted plants which remain anchor with the ground for anchorage and nutrient purpose.These plants grow in submerged soil up to a water depth of about 10 m. These species grow, germinate, and reproduce beneath the water surface. The commonly occurring submerged plant under the study area are following *Vallisnaria sp., Hydrilla, Ceratophyllum, Chara sp, Potamogeton,* and *Elodea Canadensis* etc.

Emergent macrophytes:

They grow in shallow water and existing near the wet environment. These grow along the margin and are either erect or prostrate-floating in habit. Such type of plant had been seen in shallow water and most of them having the growth above water. *Ipomoea sp*, *Bacopa monnieri*, and *Cyprus sp* were the representative of emergent plants. They provide habitat for wild life, reduce shoreline erosion, shed leaves and other plant debris.

Rooted Floating macrophytes:

They may be either rooted with leaves and flowers above the water surface or free floating. *Enhydra sp* is the representative of this group.

Table 144:List of Macrophytes found in the Kangsabati reservoir during the study period

Sl no	Name	Family	Common name	Nature
1	*Vallisnaria sp.*	Hydrocharitaceae	Eel grass	Submerged

2	*Hydrilla*	Hydrocharitaceae	Water thyme	Submerged
3	*Ceratophyllum*	Ceratophylaceae	Coontail	Submerged
4	*Chara sp*	Characeae	Stoneworts/macroscopic algae	Submerged
5	*Ipomoea*	Convolvulaceae	Morning glory bsh	Emergent
6	*Potamogeton*	Potamogetonaceae	Leafy pond weed	Submerged
7	*Najas*	Hydrocharitaceae	Water nymph	Submerged
8	*Bacopa monnieri*	Scrophulariaceae	Brahmi	Emergent
9	*Enhydra sp*	Asteraceae	Helencha	Hygrophylus rooted, floating
10	*Elodea canadensis*	Hydrocharitaceae	Common water weed	Submerged
11	*Cyprus sp*	Cyperaceae	Dwarf papyrus	Emergent