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RESEARCH ARTICLE

TEMPERATURE: A VITAL FACTOR FOR THE ZOOPLANKTON GROWTH AND SEASONAL FLUCTUATIONS.

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Abstract

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Seasonal succession and population dynamics of zooplankton communities is a well-documented phenomenon in an aquatic ecosystem. In this pretext, investigations on zooplankton diversity and abundance along with density of zooplankton was carried out for a period of one year in unexplored water bodies of Udhampur . A total of 34 genera were recorded from both the stations belonging to 5 groups , Protozoa (8 Genera), Rotifera (12 Genera), Copepoda (6 Genera), Cladocera (6 Genera) and Ostracoda (2 Genera). Quantitatively, Rotifers dominated station-1 while cladocerans dominated station-2 among the five groups indicating the deteriorating status of the water-bodies. Well-marked seasonal dynamics among these groups were noticed due to the fluctuating trend of the temperature and other physico-chemical parameters witnessed in the present investigation.

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Introduction:-

Zooplankton, the free swimming organisms inhabits different zones of aquatic ecosystem and provides the valuable information about the ecological status of any water body and act as indispensible link between producers and consumers. They have their peaks and falls on seasonal basis which depends on their adaptability to the available habit and habitat. Predation among themselves is one of the major factor controlling their number. Various physico-chemical parameters are the controlling factor of any flourishing community of zooplankton in an aquatic habitat.Thus a combined effect of these factors and especially the temperature is well studied in these two study stations.

Present study deals with the zooplankton analysis in the two study areas which are pioneer to be recognised. The study was done from January 2015 – December 2015. During this 12 month study, monthly sampling was done at both study stations. Both stations are located in different environment which have different degree of anthropogenic impacts which is directly revealed by the difference in the community of organisms as well as difference in their quantity.

Material & Methods:-

Station 1(Talpad pond) : This pond is located at about 25 km away from the main Udhampur city in the vicinity of a village with some shops and a school nearby and the agricultural fields along the road. It is a small domestic pond used for cattle bathing and drinking purpose. It has the input of agricultural waste including organic or inorganic

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waste as well as waste from the surrounding which help in profuse growth of organisms, both phytoplankton and zooplankton. The bottom is very muddy and the water on little agitation becomes turbid. The geographical position of this station on map is 32^{0} 51′38″ N (latitude), 75^{0} 11′40″ E (Longitude) and at an elevation of 675 m from sea level.

Station 2 (Jonu pond): It is a pond, fully embanked with cement and has a small temple nearby and the pond is surrounded by agricultural fields and some houses. It is about 28 km away from the main city. The bottom is not so muddy because of more gravel content at the base, so water remained clear in most of the seasons. The geographical position of this station on map is 32^{0} 51′06″ N (latitude), 75^{0} 12′19″ E (Longitude) and at an elevation of 757 m from sea level.

Methodology:-

Collection of Zooplankton sample: Monthly samples for zooplankton study were collected for a period of one year (July, 2013-June, 2014). Collection was done by filtering 50 litres of water through plankton net (Nytex 70µm mesh size). The filtrate was transferred to glass vials and was preserved in 5% formalin. For the qualitative anlaysis, Edmondson & Winberg (1971)[5], Pennak (1978) [14] and Adoni (1985) [1] were referred. For quantitative analysis, the drop count method was applied and the number of zooplankton per litre of the concentrate was calculated by using the formula:

Organism/litre = A x 1/L x n/V

Where V = Volume of 1 drop (ml)

A = Number of organism per drop (ml)

n = Total volume of concentrated sample (ml)

L = Volume of original sample (l)

Along with that sampling was done on monthly basis from (Jan, 2015- Dec, 2015) for the analysis of physico-chemical parameters . There were 14 parameters studied viz a viz: air temperature, water temperature, depth, dissolved oxygen, pH, free carbon-dioxide , carbonates, bicarbonates, chlorides, calcium, magnesium, nitrate, sulphate and phosphates, out of which 7 parameters were done at the site itself and the remaining were done in the laboratory. For the further analysis in the laboratory, water samples were collected in 500 ml bottles.

Results and Discussions:-

In the attempt of investigating invertebrates of these water bodies for a period of one year showed the presence of five zooplankton groups viz. Protozoa, Rotifera, Copepoda, Cladocera and Ostracoda. (Table I). The number of organisms in each group were directly influenced by the impact of seasonal dynamism of physico-chemical parameters. These parameters showed seasonal dynamism and thus effects life cycles of these zooplankton colonies

During the study period extending from January, 2015 to December, 2015, the various physico-chemical analysis showed a well marked seasonal variation at both the study stations. At both these stations the air temperature varied between 19.5 º C- 34 º C at station-1 while it was between 19 º C-33 º C at station-2 . Water temperature varied between 17 º C-26 º C for station-1and 16.5 º C-29 º C at station-2. Dissolved Oxygen varied between 1.6-8 mg/l, 7.2-11 mg/l at station-1 and 2 respectively. Free Carbon-dioxide concentration varied between 6-20 mg/l, 0-24 mg/l at station-1and 2 respectively. Carbonates were totally absent at station-1 while they were present at station-2 in the month of Jan only. Likewise all the parameters showed seasonal variation throughout the study period. These parameters are greatly influenced by the topography, source of water, vegetation, type of catchment area and the extent of anthropogenic interference. (Shinde *et al*., 2011) The amount of minerals present in a water body depends on the catchment area and the solubility of minerals which ultimately depends on the water temperature.

Among the zooplankton recorded a total of 34 genera were recorded from both the stations belonging to 5 groups , Protozoa (8 Genera), Rotifera (12 Genera), Copepoda (6 Genera), Cladocera (6 Genera) and Ostracoda (2 Genera). Among Protozoa Family Peritrichidae dominated at station 1 with 3 Genera while two genera were present at station-2. Among Rotifers Family Brachionidae dominated with 4 genera at station 1 followed by station 2. Among Cladceraans Family Chydoridae and Daphinidae both showed equal contribution at station-1 but decreased at station-2. Among Copepods Family Cyclopida was the most dominant one at both the study stations represented by 6 genera among total zooplankton recorded. Ostracoda showed dominance with two Generas at stations 1 and were found absent at station-2.

At Station I (Talpad pond), zooplankton recorded belong to Protozoa (7 Genera), Cladocera (6 Genera), Rotifera (12 Genera), Copepoda (5 Genera) and Ostracoda (2 Genera).The herierachy recorded is
Rotifera > Protozoa > Cladocera > Copepoda > Ostracoda

Quantitatively, rotifers showed an undulating graph throughout the year, number of coexisting species varied throughout the year with maximum 8 species coexisting in February, July, October and minimum of 3 species in April (Table-8; fig-22). Quantitatively also a well marked fluctuation was seen in Rotifers presence maximum being contributed by *Platiyas patulus* and least by *Keretella cochlearis*. Similar trend of undulating presence was observed by Malhotra *et al., 1995 and* Langer *et al.*, 2007, which could be due to ability of Rotifers to adapt themselves to wide range of habitats and physico-chemical variations (Oie and Olsen, 1993;Viayeh, 2012; Karunakar *et al.*,2013 ; Balakrishna *et al.*,2013; Kielbasa *et al.*,2016).

Maximum Protozoans were found to be coexisting in December (6 species) but were not recorded for the month of January. Among the existing species maximum presence was of *Difflugia lebes* for atleast 9 months and species like *Campanella* and *Euplotes* were recorded for only one time. Protozoan population prefer a temperature range of 16ºC- 25ºC (Kaushik and Saksena, 1995; Sawhney, 2008 and Shafiq, 2004). Quantitatively of maximum was the presence of *Difflugia lebes* and minimum of *Astrsamoeba sps*. (Table-).Cladocera where maximum coexisting in month of March (8 species) and showed complete absence in three consecutive months (Oct, Nov, Dec). Maximum contribution to Cladoceran count was by *Alonella* sps. and minimum by *Simocephalus* sps. Cladocerans prefer clear water , optimum pH and good amount of Dissolved Oxygen. (Uttangi, 2001; *et al*., 2007).

Copepods showing maximum number qualitatively in February, March, June, September (4 species) and minimum in April, October, November (1 species each). (Table-7) Maximum number in summer months could be due to their preference to warm conditions except the month of February. (Langer *et al., 2007).* Quantitative contribution has maximum been by *Cyclops bicolor* . Such coexistence of more than two species at any time particular time was been postulated by Kour, 2002.

Among the two species of Ostracoda both quantitative and qualitative more adaptable to the environment of this station was of *Stredensia* sps.

Qualitative study for **station 2 (Jonu pond)** revealed the hierarchy as
Rotifera > Protozoa > Copepoda > Cladocera > Ostracoda.
Protozoa was represented by (7 Genera) , Cladocera (5 Genera), Rotifera (10 Genera), Copepoda (6 Genera) and Ostracoda (2 Genera). (Table-9, fig: 23)

Rotifera maximum coexistence was seen in the month of June (8 species) where as Protozoa maximum coexisted in May and September (4 species) followed by Copepods in June (9 species), Cladocera in February and December (6 species) and both Genera of Ostracods in July, August and September. The adaptability of Rotifers to wide range of temperature variation supported their growth in summer months (Langer *et al., 2007).* Copepoda increase in summer month was due to their preference to warm temperature (Dar *et al.,* 2009). Cladocerans were high on number when the Dissolved oxygen was in high amount and the water was clear (Langer *et al.*2007; Uttangi, 2001). The summer increase in the zooplankton number can be due to increased availability of food due to increased rate of decomposition (Shinde *et al., 2012*). This Ostracods were recorded in the month of July and August when the temperature is quite high as they prefer warm conditions while they are least affected by the DO concentrations , increase in the pollution level also support their growth (Kulkoyluoglu *et al., 2007*).

But the quantitative contribution to the total zooplankton count at this station was found to be different as Cldocera > Copepoda > Rotifera > Protozoa > Ostracoda (Table-9). Among Cladocera this contribution was maximum by *Daphnia similis* which showed presence for 7 months and minimum was by *Alona monocantha*.

Similarly among Copepods the maximum contributor was *Cyclops bicolor* and minimum was by *Diapotomous* sps. For Rotifers the maximum bulk was contributed by *Platiyas patulus* and minimum by *Brachionus quadridentata.* Among protozoa maximum contribution was of *Diffugia lebes* (8 months) and minimum by *Euplotes* sps. (1 month). At this station among Ostracods *Prinocypris* sps. was contributing more quantitatively.

From Table 3-7, we can conclude that some Protozoans showed their dominance in the winter months (St. 1) while some showed their peak in summers showing their preference to wide range of temperature , thus they can be considered as eurythermal. Rotifers were dominated in the summers with highest densities at both the stations while showed their decline with the arriving of winters, showing their proliferation in warm temperature. Thus temperature playing important role in their life cycles. Both Cladocerans and Ostracods showed their growth in both summers and monsoons where temperature is quite similar. Here along with temperature other factors like oxygen, pH, alkanity, food availability had great enfluence as Cladocerans prefer good amount of oxygen. Copepods at st.1 showed dominance in winter while at station 2 showed in summers. This is due to the difference in species which prefer different ranges of temperature and conditions that were present in two different study stations. Some species survived in cold temperature while some were able to survive in warm conditions.

When correlation applied on the zooplankton number and the physico-chemical parameters water temperature both at station1 and 2 , showed a positive correlation for Rotifers (significant at 0.5 level, r=0.604*) and Ostracods while showed a negative correlation with the Protozoans and Cladocerans. At station 1 Copepods showed negative corelation with water temperature while positive at station 2.(Table)

Conclusions:-

From the above discussions it is concluded that zooplankton variation is not independent but depends on various factors like pH, alkanity, food availabity, decomposition rate and other required nutrients which ultimately depends on the water temperature that determines their available to the growing zooplankton colonies. Thus temperature can be considered as the controlling factor for the nutrient availability as well as the pattern of life cycle growth of zooplankton.

Table 1:- Showing mean values of all the studied physico-chemical parameters at station 1 and 2

Months / Parameters	**Units**	**Mean at station 1**	**Mean station 2**
Air Temp.	^{0}C	27.08	25.75
Water Temp.	^{0}C	20.41	18.12
Depth	cm	60.42	71.875
pH		7.21	6.75
DO	mg/l	3.83	4.6
FCO_2	mg/l	6.33	3.25
CO_3^{2-}	mg/l	00	12
HCO_3^-	mg/l	51.98	72.59
Ca^{2+}	mg/l	21.44	34.21
Mg^{2+}	mg/l	140.14	82.71
Cl^-	mg/l	19.58	20.08
PO_4^{2-}	mg/l	0.2224	0.1147
$SO4^{2-}$	mg/l	0.0260	0.00514
NO_3-	mg/l	0.5727	0.5721

Table 2:- Showing list of zooplankton recorded during the study period at station 1 and 2

List of zooplankton	Station-1	Station-2
PROTOZOA		
1. Arcella sps.	+	+
2. Astramoeba sps.	+	+
3. Centropyxis aculeata	+	+
4. Campanella sps.	+	-
5. Diffugia lebes	+	+
6. Diffugia acuminate	+	+
7. Euplotes sps.	+	+
8. Paramecium aurelia	-	+

9. Vorticella sps.	+	+
ROTIFERA		
1. Asplanchna sps.	+	+
2. Brachionus plicatilus	+	+
3. Brachionus falcatum	+	-
4. Brachionus quadridentata	+	+
5. Colurella obtusa	+	+
6. Euchlanis sps.	+	+
7. Keratella cochlearis	+	-
8. Lecane luna	+	+
9. Lepadella sps	+	+
10. Monostylla bulla	+	+
11. Mytillina sps.	+	+
12. Philodina sps.	+	+
13. Platiyas patulus	+	+
14. Trichotria sps.	+	-
CLADOCERA		
1. Alona sps.	+	+
2. Alona monocantha	+	+
3. Alonella sps	+	+
4. Chydorus sps.	+	+
5. Chydorus ovalis	+	+
6. Ceriodaphnia sps.	+	+
7. Daphnia longiremis	+	-
8. Daphnia similis	+	+
9. Daphnia pulex	+	+
10. Simocephalus sps.	+	-
COPEPODA		
1. Cyclop sps	+	+
2. Cyclop bicolor	+	+
3. Cyclop scutifer	+	+
4. Diaptomous sps.	-	+
5. Eucyclop agilis	+	+
6. Halicyclop sps.	+	+
7. Mesocyclop sps.	-	+
8. Mesocyclop tenius	+	+
9. Mesocycop leukarti	+	+
10. Tropocyclop prasinus	+	+
11. Nauplius larvae	+	+
OSTRACODA		
1. Prinocypris sps.	+	+
2. Stredensia sps.	+	+

Table 3:- Showing comparative account of Protozoan abundance at station 1 and 2.

No./Liter	Station 1	Station 2
Summers	7.66	6.06
Monsoons	3.14	5.79
Winters	12.58	3.37
Total	**23.88**	**15.22**
Mean	7.79	5.07
Std.deviation	± 4.72	± 1.48

Table 4:- Showing comparative account of Rotifera abundance at station 1 and 2

No./Liter	Station 1	Station 2
Summers	60.12	24.4
Monsoons	41.81	15.78
Winters	17.56	5.40
Total	**119.49**	**45.58**
Mean	39.83	15.19
Std.deviation	± 21.34	± 9.10

Table 5:- Showing comparative account Cladoceran abundance at station 1 and 2

No./Liter	Station 1	Station 2
Summers	1.58	23.02
Monsoons	18.24	9.86
Winters	6.32	21.08
Total	**26.14**	**53.96**
Mean	8.71	17.98
Std.deviation	±8.58	± 7.10

Table 6:- Showing comparative account of Copepoda abundance at station 1 and 2

No./Liter	Station 1	Station 2
Summers	7.66	6.06
Monsoons	3.14	5.79
Winters	12.58	3.37
Total	**23.38**	**15.22**
Mean	7.79	5.07
Std.deviation	±4.72	±1.48

Table 7:- Showing comparative account of Ostracoda abundance at station 1 and 2

No./Liter	Station 1	Station 2
Summers	8.24	0.10
Monsoons	0.82	6.44
Winters	0.40	0
Total	**9.46**	**6.54**
Mean	3.15	2.18
Std.deviation	±9.46	±3.68

Table 8:- Showing the seasonal variation in Zooplankton community at station 1

Station 1												
months / grps.	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Protozoan	-	0.12	4.92	0.48	0.48	1.78	0.7	0.16	0.44	1.84	3.6	8.53
Rotifera	0.7	3.06	2.86	1.54	1.5	22.068	23.31	7.6	2.88	8.02	11.28	4.44
Copepoda	-	6.08	4.53	2.36	1.02	9.04	1.56	0.24	3.0	0.94	0.56	3.28
Cladocera	2.68	9.64	8.88	8.78	0.6	0.58	0.58	0.58	0.42	-	-	-
Ostracoda	-	-	-	0.10	0.84	6.7	0.16	0.06	0.60	-	-	0.50

Table 9:- Showing the seasonal variation in Zooplankton community at station 2

Station 2												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Protozoan	-	-	0.76	4.2	0.9	0.2	0.55	1.67	1.89	1.76	0.81	2.16
Rotifera	-	-	1.26	1.16	1.2	2.8	4.8	2.16	3.92	0.38	4.1	1.3
Copepoda	0.26	0.8	5.68	4.02	2.4	12.66	4.38	5.92	2.96	2.52	4.24	5.36
Cladocera	0.8	4.6	15.08	3.8	2.04	1.38	0.84	6.72	2.3	-	1.34	15.06
Ostracoda	-	-	-	-	-	0.10	4.46	1.74	0.24	-	-	-

Table 10:- Showing values for correlation among physico=chemical parameters and zooplanktonic groups for station 1(Talpad)

	PROTOZOA	CLADOCERA	ROTIFERA	COPEPODA	OSTRACODA
AIR TEMP.	-0.184	0.342	0.180	0.405	0.495
WATER TEMP.	-0.354	-0.181	0.604*	-0.154	0.465
PH	0.169	0.145	-0.648*	0.072	-0.433
DO	0.301	0.566	-0.638*	0.628*	-0.332
FCO	0.302	0.015	0.260	0.444	0.792**
CO_3^-	0	0	0	0	0
HCO_3^-	0.256	-0.328	0.334	-0.081	0.225
Ca	0.539	-0.637*	0.564	-0.415	0.205
Mg	-0.244	0.433	-0.654*	0.370	-0.307
Cl	0.130	0.530	0.436	0.474	0.347
PO_4	0.004	0.379	0.090	0.376	0.697*
NO_3	-0.075	0.908**	-0.480	0.815**	-0.277
SO_4	0.135	-0.284	0.166	-0.222	-0.075

Table 11:- showing values for correlation among physico=chemical parameters and zooplanktonic groups for station 2 (jonu)

	PROTOZOA	CLADOCERA	ROTIFERA	COPEPODA	OSTRACODA
AIR TEMP.	0.091	0.327	0.312	0.485	0.383
WATER TEMP.	-0.057	-0.435	0.494	0.184	0.517
DEPTH	0.102	0.056	0.034	-0.260	-0.193
PH	-0.108	-0.288	-0.412	-0.279	-0.597
DO	0.207	0.022	0.267	0.484	0.289
FCO	0.714**	0.606*	-0.218	0.413	0.167
CO_3^-	-0.229	-0.271	-0.425	-0.433	-0.127
HCO_3^-	-0.644*	-0.358	-0.082	-0.226	0.120
Ca	-0.182	-0.218	0.072	0.129	-0.107
Mg	0.189	0.032	-0.343	-0.490	-0.330
Cl	-0.193	-0.218	0.166	0.807**	-0.073
PO_4	0.623*	0.053	0.053	0.092	-0.199
NO_3	0.191	0.118	-0.322	0.173	-0.286
SO_4	0.229	0.271	0.425	0.432	0.127

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