VARIATION IN SUMMER LIMNOLOGICAL CHARACTERISTICS OF BOD-SAR WET LAND OVER A PERIOD OF MORE THAN TWO DECADES

Raina (Wanganeo), R *, Wanganeo, A, Fozia, S. and Pramod, K**
*Sadhu Wasvani College, Bairagarh, Bhopal-462026, India.
** Department of Limnology, Barkatullah University Bhopal-462026, India.
Email: wanganeo_a@yahoo.com, pramodlimno2004@yahoo.com, fozia_sanaullah@yahoo.co.in

ABSTRACT

Present study was conducted on Bod-Sar wet land, Srinagar Kashmir in order to assess the changes in various limnological characteristics over a period of more than two decades. On comparing the results obtained during the summer months only, a considerable variation in various physico-chemical and biological parameters was observed. An enhancement in the values of Specific conductivity, Total alkalinity, Total hardness, Calcium hardness, Magnesium hardness, Chloride, Nitrate nitrogen and Phosphate phosphorus was obtained during the current study. A considerable decline in Dissolved oxygen was recorded.

Present investigation revealed reduction in phytoplankton and Zooplankton species by 15 and 25 organisms respectively over the period. Among phytoplankton, class Cyanophyceae was found to be dominant followed by class Chlorophyceae during present investigation where as, Raina (1981) recorded dominance of Chlorophyceae followed by Bacillariophyceae. Among Zooplankton species Class Rotifera continued be the dominant.

Primary Production also recorded an enhancement by 950 mgC m^3day^{-1} over a period of more than two decades.

Key Words: - Bod-Sar Wetland, Plankton, Physico-chemical parameters and Primary production.

INTRODUCTION

The lentic bodies are more complex and fragile ecosystem in comparison to the lotic ecosystems as, they lack self-cleaning ability on account of high hydraulic detention time. In recent years, increasing anthropogenic activities in and around the aquatic ecosystems and their catchment areas have contributed to a large extent towards the deterioration of the water quality leading to the accelerated eutrophication.

The present study was conducted on the Bod-Sar wetland, situated at an altitude of 1580 m a.s.l. and about 13 kms towards the South of Srinagar. It lies within the geographical co-ordinates of 34°00'50.02"N and 74°56'14.98"E. The catchment area of the wetland is quite variable. Towards North-East, it has rural settlements while on the two sides (South-West and South-East) the karewal belt is laden with saffron fields and orchards.

Enhancement in the nutrient level over decades has considerably changed the plankton community besides reducing its physical dimensions.

STUDY AREA

Bod-Sar wetland is one of the major and biologically rich water body of Kashmir Himalayan region situated 13 Km away from

Srinagar in Pampore. The wetland has considerably shrunk in size due to erosion from its Catchment area where around 300 hundred houses (hosting nearly 2000-2500 persons) have been constructed along the shore of the wetland. Some important morphometric features of Bod Sar wetland are given in Table 1. At present this water body is used for irrigation and fish production.

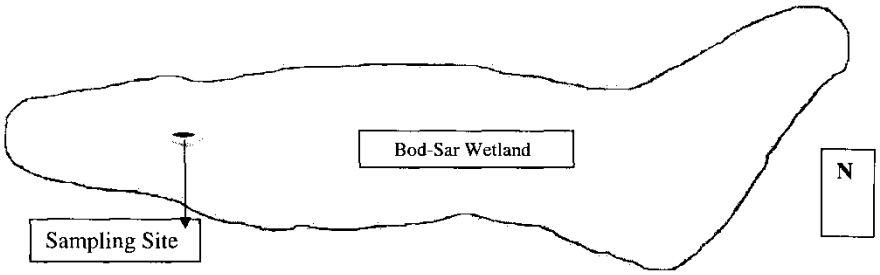


Fig. 1 Map of Bod-Sar Wetland with Sampling Site

MATERIALS AND METHODS

The present investigation was carried out during summer, 2007. Physico-chemical characteristics of the samples have been analyzed following the methodology as given in APHA (2000). Water for plankton analysis was filtered through the plankton net made of bolting silk of mesh size 20μ and the concentrated samples were preserved with Lugol's solution simultaneously. The concentrated samples were analyzed under the inverted microscope for the identification of plankton with the help of following standard keys: APHA (2000), Adoni (1985), Desika-charya (1958), Edmondson (1992), Needham and Needham (1962) Sharma (1986), Sinha and Naik (1997) and Prescott (1973). Primary production measurements have been carried out following the method given by Gaarder and Gran (1927) and dissolved oxygen concentrations were determined by the un-modified Winkler method.

RESULT AND DISCUSSION

The physico-chemical characteristics as given in Table 2 and Fig's. 1, 2 depict a considerable variation during more than two decades which is supported by its productive nature. pH of the said water body was found to be alkaline (7.7 units) during the present study period. This finding coincided with the findings of Raina (1981). The electrical conductivity recorded a

value of 470µS at 25 °C (on an average basis) in the Bod-Sar wetland (Raina, 1981) during the year 1980, whereas, an increase in specific conductivity values by 490 µS was recorded in the present investigation (Table 2).

Total Alkalinity (515 mg/l) of the Lake during the present study period was found to be 265mg/l more than reported by Raina (1981). The high alkalinity values reveal the high pollution load of the water body as has also been reported by Bath and Kaur (1999) and Sivagurunathan and Dhinkaran (2006). According to Philipose (1960) a water body having alkalinity values > 100 mg/l is nutritionally rich.

Table 1. Morphometric Features of Bod-Sar Wetland (Raina, 1981)

Features	Units	Bod - Sar Wetland
Latitude		34°00'50.02"N
Longitude		74°56'14.98"E
Elevation	ft	5205
Catchment area	Km^2	7.897
Total Area	Km^2	0.1025
Max. Length	Km^2	0.875
Max. Breadth	Km^2	0.25
Max. Depth	M	2.75
Total Volume	m^3x10^6	0.123

Table 2. Variation in various parameters during the month of August in Bod Sar Wetland

Parameters	Units	1980 (Raina, 1981)	2007 Present study
Atm. Tem.	°C	36	26
Wat. Tem.	°C	29-28	22
pH	units	7.3-8.8	7.7
Cond.	µS 25 °C	470	960
DO	mg/l	18	6.6
TA	mg/l	250	515
TH	mg/l	267	330
Ca har.	mg/l	45	89.25
Mg.har	mg/l	19.94	58.502
Cl	mg/l	78	112.38
NO_3-N	mg/l	5	8.9
PO_4-P	mg/l	44	59
Production	mg Cm^3/day	2500	3450

The dissolved oxygen content during the study period was 6.6 mg/l. Raina (1981), observed a value of 18 mg/l in the year 1980. During the current study the D.O. was found to be less by 11.4 mg/l from that of the results recorded by Raina. Low content of dissolved oxygen is a sign of organic pollution. In general the solubility and availability of nutrients is affected by oxygen content of water and therefore the productivity of an aquatic ecosystem (Wetzel, 1983).

Raina (1981) reported Total hardness value of 267 mg/l in the Bod-Sar Lake during the year 1980, whereas, during the present study a value of 330 mg/l has been recorded, which is 63 mg/l more than the previous results reported by

Raina. The chloride content recorded during the present study was 112.38 mg/l which was much higher than the results depicted by Raina (1981) during her study. The high chloride concentration indicates that the water body is eutrophic. Dhamija and Jain (1994) and Bath and Kaur (1999) also support the same phenomenon. High level of Chloride clearly points out the excessive human interference in the water body (Goel *et. al.*, 1980). The Nitrate-nitrogen and Orthophoshorus content was 3.9 mg/l and 15 mg/l more than the findings of Raina (1981). The enhancement in the nutrient content recorded during the present study in Bod-Sar wetland is on account of increased anthropogenic pressure.

The list of plankton species is given in Tables 3 and 4. During the present period of investigation a total of 108 phytoplankton and 62 zooplankton species were recorded. Out of 108 phytoplankton species, 32 species belonged to class Cyanophyceae (29%), 30 to class Chlorophyceae (28%), 28 to class Bacillariophyceae (26%) and 18 to class Euglenophyceae (17%) Fig.3. Class Dinophyceae and Class Chrysophyceae were found to be absent in the present study (Table 5 and Fig. 3). The sequence of dominance of phytoplankton during the present investigation was

Table 3. Qualitative variation in the Phytoplankton during August in Bod-Sar Wetland

Taxa	1980*	2007
Chlorophyceae		
Actinastrum sp.	+	+
Ankistrodesmus sp.	-	+
Ankistrodesmus falcatus	+	+
Ankistrodesmus spiralis	+	+
Arthrodesmus convergens	+	-
Chlorella sp.	+	-
Chodatella sp.	+	-
Closteriopsis sp.	-	+
Closteriopsis longissima	+	-
Closterium sp.	+	+
Closterium pronum	+	+
Closterium moniliforum	+	-
Coelastrum microporum	+	+
Coelastrum sphaericum	+	-
Cosmarium sp.	+	-
Cosmarium granatum	-	+
Cosmarium subprotumidum	-	+
Crucigenia crucifera	+	-
Crucigenia tetrapedia	+	-
Desmidium sp.	+	-
Elkatothrix sp.	+	+
Euastrum sp.	+	-
Gonatozygon sp.	+	-
Gonium sp.	+	-
Gonium pectorale	+	-
Kirchneriella obesa	+	-
Microasterias pinnatifida	+	-
Oedogonium sp.	+	+
Onychonema sp.	+	-
Pandorina sp.	+	-
Pediastrum sp.	+	+
Pediastrum boryanum	+	-
Pediastrum duplex	+	+
Pediastrum simplex	+	-
Pediastrum tetras	+	-
Pediastrum tetras var. tetradon	-	+
Pediastrum tetras var. excisum	-	+
Pleurotaenium sp.	+	-
Scenedesmus sp.	+	+
Scenedesmus acuminatus	+	-

Scenedesmus arcuatus	+	-	*Diatoma* sp.	-	+
Scenedesmus armatus	+	-	*Diatoma elongatum*	+	-
Scenedesmus armatus var. bicaudatus	-	+	*Epithemia* sp.	-	+
			Epithemia turgida	+	-
Scenedesmus bijugatus	+	+	*Eunotia* sp.	+	+
Scenedesmus bijugatus forma parvus	-	+	*Eunotia pectinalis*	+	-
			Fragillaria sp.	+	+
Scenedesmus carinatus	+	+	*Fragillaria arcus*	+	-
Scenedesmus dimorphus	+	+	*Fragillaria capucina*	+	-
Scenedesmus obliquus	+	+	*Fragillaria crotonensis*	+	-
Scenedesmus ovialterans	+	-	*Fragillaria intermedia*	-	+
Scenedesmus protuberans forma minor	-	+	*Gomphonies herculeana*	+	-
			Gomphonema sp.	+	+
Scenedesmus quadriquada	+	-	*Gomphonema acuminatum var. coronata*	+	-
Selenastrum sp.	+	+			
Sphaerozosma sp.	+	-	*Gomphonema augur*	+	-
Spirogyra sp.	+	+	*Gomphonema constrictum*	+	-
Staurastrum sp.	+	+	*Gomphonema geminatum*	+	-
Staurastrum frucigerum	+	-	*Gomphonema lanceolatum forma turris*	-	+
Staurodesmus cuspidatus	+	-			
Tetraedron sp.	+	+	*Gomphonema montanum*	-	+
Tetraedron minimum	+	+	*Gomphonema olivaceum*	+	-
Tetraedron muticum	+	+	*Gyrosigma* sp.	+	+
Tetraedron pusillum	+	-	*Hantzschia* sp.	+	+
Tetraedron trigonum	+	-	*Melosira* sp.	+	+
Tetrastrum sp.	+	-	*Navicula* sp.	+	+
Treubaria sp.	+	-	*Navicula cincta*	-	+
Triploceras sp.	+	-	*Navicula confervaceae*	+	-
Volvox sp.	+	-	*Navicula cuspidata*	+	+
Xanthidium sp.	+	-	*Navicula laterostata*	-	+
Zygnema sp.	+	-	*Navicula radiosa*	+	+
Bacillariophyceae			*Neidium* sp.	+	+
Achnanthes sp	+	+	*Nitzschia accicularis*	+	-
Achnanthes minutissima	+	-	*Nitzschia amphibia*	-	+
Achnanthes lanceolata	+	-	*Nitzschia angustata*	+	-
Amphora sp.	+	-	*Nitzschia apiculata*	+	-
Amphora bitumida	+	-	*Nitzschia lacunarum*	+	-
Amphora ovalis	+	+	*Nitzschia palea*	-	+
Calonies sp.	-	+	*Pinnularia* sp.	+	+
Cocconies sp.	-	+	*Rhizosolenia* sp.	+	-
Cocconies placentula	+	-	*Rhopalodia gibba*	+	-
Cyclotella sp.	+	+	*Surirella* sp.	+	+
Cymatopleura solea	+	-	*Surirella ovalis*	+	-
Cymbella ventricosa	+	-	*Synedra ulna*	+	-
Cymbella tumida	-	+	**Cyanophyceae**		
Cymbella turgida	-	+	*Anabaena* sp.	+	+

Anabaena naviculoides	-	+
Anabaenopsis sp.	+	+
Aphanocapsa sp.	+	+
Arthrospira sp.	+	-
Chroococcus sp.	-	+
Chroococcus disperses var. minor	-	+
Coelosphaerium sp.	+	+
Coelosphaerium kuetzingianum	-	+
Cylindrospermum sp	-	+
Lyngbya sp.	-	+
Lyngbya ventricosa	-	+
Merismopedia elegans	+	+
Merismopedia glauca	-	+
Merismopedia punctata	+	+
Merismopedia convoluta	-	+
Microcystis aeruginosa	+	+
Nodularia sp.	-	+
Nostoc sp.	+	+
Oscillatoria sp.	+	+
Oscillatoria articulata	-	+
Oscillatoria perornata	-	+
Oscillatoria perornata forma attenuata	-	+
Oscillatoria pseudogeminata	-	+
Oscillatoria putrida	-	+
Oscillatoria subbrevis	-	+
Phormidium sp.	-	+
Rivularia sp.	-	-
Sphaerocystis schroeteri	-	+
Spirulina sp.	+	+
Spirulina labyrinthiformis	-	+
Spirulina subtilissima	-	+
Synechocystis sp.	-	+
Synechocystis aquatilis	-	+
Euglenophyceae		
Euglena sp.	+	+
Euglena acus	+	+
Euglena gracilis	-	+
Euglena proxima	-	+
Euglena tripteris	-	+
Euglena vagans	-	+
Euglenomorpha sp	-	+
Phacus sp.	+	+
Phacus acuminatus	-	+
Phacus anomalus	-	+
Phacus caudatus	-	+
Phacus ephippion	-	+
Phacus helikoides	-	+
Phacus longicauda	-	+
Phacus pleuronectus	-	+
Phacus pseudoswirenkoi	-	+
Phacus sesquitortus	-	+
Trachelomonas sp.	-	+
Dinophyceae		
Ceratium hirudinella	+	-
Gymnodinium sp.	+	-
Peridinium sp	+	-
Chrysophyceaea		
Dinobryon sp.	+	-
Synura sp.	+	-

Cyanophyceae > Chlorophyceae > Bacillariophyceae > Euglenophyceae

Where as, the sequence of dominance of phytoplankton during 1980 as reported by Raina (181) was:

Chlorophyceae > Bacillariophyceae > Cyanophyceae > Euglenophyceae > Dinophyceae > Chrysophyceae

Among class Cyanophyceae, most dominant species were *Oscillatoria* sp., *O. perornata,* and *Microcystis aeruginosa. Scenedesmus* sp., *Pediastrum tetras* and *Ankistrodesmus falcatus* were found to be dominant among class Chlorophyceae. Among class Bacillariophyceae, *Navicula radiosa, Fragillaria* sp. and *Nitzschia* sp., were dominant while among class Euglenophyceae, *Euglena* sp. and *Phacus* sp. were dominant. The Bod-Sar wetland supported more Cyanophyceae owing to its high nutrient

status on account of high hydraulic and nutrient residence time (Wanganeo and Wanganeo, 1991). According to Prescott (1973) the Oligotrophic waters were characterized by the Chlorophyceae flora with a conspicuous desmid element, where as, the eutrophic lakes were characterized by the dominance of class Cyanophyceae. Dominance of *Nitzschia* sp., *Fragillaria* sp. and *Navicula radiosa* among the Bacillariophyceae indicates the nutrient rich and polluted waters (Dickman, 1975). Dominance of *Merismopedia elegans*, *M. punctata, Microcystis aeruginosa* and *Oscillatoria* sp. depicts eutrophic nature of the said water body as also reported by Wanganeo and Wanganeo (1991).

Out of 62 species of Zooplankton, 54 species belonged to class Rotifera (87%), 7 species to class Cladocera (11%) and 1 to class Cyclopoida (2%). During the present study Class Calanoida was found to be absent where as during 1980, the class Calanoida was represented by *Diaptomus* sp.

The sequence of dominance of zooplankton during more than two Decades remains same but during the present investigation class Calanoida was absent (Table 6 and Fig. 4). The sequence of dominance among zooplankton population was as:

Table 4. Qualitative variation in the Zooplankton during August in Bod-Sar Wetland

Taxa	1980	2007
Rotifera		
Anuraeopsis fissa	+	+
Anuraeopsis coelata	-	+
Ascomorpha sp.	+	+
Asplanchna sp.	-	+
Asplanchna priodonta	+	+
Asplanchnopus multiceps	+	-
Brachionus sp.	+	+
Brachionus angularis	+	+
Brachionus bidentata	+	+
Brachionus bidentata crassispenius	-	+
Brachionus budapestinensis	-	+
Brachionus calcyflorus	+	-
Brachionus caudatus	+	+
Brachionus patulus	+	-
Brachionus plicatlis	+	-
Brachionus quadridentatus	+	+
Brachionus urceus	+	-
Cephalodella sp.	+	+
Cephalodella gibba	+	+
Chromogaster sp.	+	+
Collotheca sp.	+	-
Colurella sp.	-	+
Colurella bicuspidata	+	-
Colurella obtusa	-	+
Diplois sp.	+	-
Epiphanes sp.	+	-
Euchlanis sp.	+	+
Euchlanis dilatata	+	-
Filinia sp.	-	+
Filinia longiseta	+	+
Filinia opoliensis	+	+
Filinia terminalis	+	-
Gastropus stylifer	+	-
Hexarthra sp.	-	+
Hexarthra mira	+	-
Keratella sp.	-	+
Keratella cochlearis	+	+
Keratella quadrata	+	+
Keratella tropica	+	+

Keratella valga	+	+
Lecane sp.	+	+
Lecane bulla	+	+
Lecane closterocerca	+	-
Lecane crepida	+	-
Lecane depressa	+	-
Lecane inopinata	-	+
Lecane ludwigi	-	+
Lecane luna	+	+
Lecane lunaris	+	+
Lecane ohionensis	+	+
Lecane signifera ploenensis	-	+
Lecane quadridentata	+	+
Lecane sympoda	+	-
Lepadella sp.	-	+
Lepadella ovalis	+	+
Lepadella patella	+	-
Macrochaetus sp.	+	+
Macrochaetus collinsi	+	-
Manfredium eudatylotum	+	-
Monommata sp.	+	-
Monostyla sp.	-	+
Monostyla bulla	+	+
Monostyla closterocerca	+	-
Monostyla furcata	-	+
Monostyla lunaris	+	+
Monostyla quadridentata	+	-
Monostyla ventralis	+	-
Mytilina sp.	-	+
Mytilina mucronata	+	-
Mytilina ventralis	+	+
Notholca sp.	+	+
Notholca acuminate	+	-
Phyllodina sp.	+	+
Platyias patulus	+	-
Platyias quadricornis	-	+
Polyarthra sp.	-	+
Polyarthra vulgaris	+	+
Proalidas verrucosus	+	-
Scardium longicaudum	-	+
Squatinella mutica	+	-
Synchaeta sp.	+	-
Testudinella sp.	-	+
Testudinella patina	+	+
Trichocerca sp.	+	+
Trichocerca cylindrica	+	-
Trichocerca longiseta	+	-
Trichocerca porcillus	+	-
Trichocerca similis	+	-
Trichotria tetractris	+	-
Cladocera		
Acroperus harpae	+	-
Alona sp.	+	-
Alona intermedia	-	+
Allona affinis	+	-
Bosmina sp.	-	+
Bosmina longirostris	+	+
Camptocercus sp	+	-
Camptocercus rectrostris	+	-
Chydorus sp.	-	+
Chydorus sphaericus	+	-
Diaphanosoma sp.	-	+
Diaphanosoma brachyurum	+	-
Graptoleberis testudinaria	+	-
Macrothrix sp.	+	+
Macrothrix rosea	+	-
Moina sp.	+	+
Pleuroxus sp.	+	-
Pleuroxus denticulatus	+	-
Cyclopoida		
Cyclops sp.	-	+
Cyclops vicinus	+	-
Calanoida		
Diaptomus sp.	+	-

Rotifera> Cladocera > Cyclopoida

Among all the three classes recorded during the present study class Rotifera was dominant and frequently represented by *Brachionus* sp., *Brachionus angularis, Brachionus bidentata, Brachionus budapestinensis, Keratella* sp., *and Keratella cochlearis*. Class Cladocera during the present study was represented by *Macrothrix* sp. that has wide food selection and can with stand high levels of pollution. Besides this, most probably they are not eaten up by the predators (Wanganeo and Wanganeo, 2006). The said Wetland has rich planktonic population as total 181 Phytoplankton and 110 Zooplankton were recorded during the both investigation years thus indicating its productive nature (Table 7).

Primary production of 2500 mgC m^3/day recorded by Raina (1981) in the year 1980 also showed enhancement during the present study by 950 mgC m^3/day on an average basis (Table 2 and Fig. 5). On the basis of primary production values the lake can be categorized among the high productive lakes (Wanganeo, 1980).

Table 5. Variation in Phytoplankton species for more than Two decades

Class	1980 *	2007	Reduction in species	Increase in Species
Chlorophyceae	61	30	31	Nil
Bacillariophyceae	43	28	15	Nil
Cyanophyceae	11	32	Nil	21
Euglenophyceae	3	18	Nil	15
Dinophyceae	3	0	3	Nil
Chrysophyceae	2	0	2	Nil

* = (Raina 1981)

Table 6. Variation in Zooplankton species for more than Two Decades

Class	1980*	2007	Reduction in species
Rotifera	71	54	17
Cladocera	14	7	7
Cyclopoida	1	1	Nil
Calanoida	1	0	1

*= (Raina, 1981)

Table 7. Present Trophic Status of Bod Sar Wetland on the basis of different indices

Physico-chemical parameters	Indices		Reference	Bod Sar Wetland
	Trophicstatus	Range		
Transparency (cm)	Oligotrophic	>460	Lee et.al.(1981)	80 (Eutrophic)
	Mesotrophic	370		
	Eutrophic	<170		
pH	Acidobiontic	<5.5	Venkateswarlu (1983)	7.7 (Alkaliphilous)
	Acidophilous	5.5-6.5		
	Alkaliphilous	7.5-9.0		
	Alkabiontic	>9.0		
Alkalinity (mg/l)	Medium hard	>10-35	Spence (1964)	515 (High productive water)
	Hard	>35-200		
	Nutrient poor	1.0-15.0		
	Moderately rich	16.0-60.0		
	Nutrient rich	>60		
	Productive water	>100	Alkikunhi (1957)	
Conductivity	Eutrophic	>200	Lee et.al.(1981)	960 (Eutrophic)
Hardness (mg/l)	Soft	<75.0	Sawyer (1960)	330 (Hard)
	Moderate hard	57.0- 150		
	Hard	150-300		
	Very hard	>300		
Calcium (mg/l)	Poor	<10	Ohle (1934)	89.25 (Rich)
	Medium	10-25		
	Rich	>25		
Nitrate (mg/l)	Oligotrophic	0.2	Wetzel (1975)	8.9 (Eutrophic)
	Mesotrophic	0.2-0.4		
	Eutrophic	0.5-0.1.5		
Phosphate (mg/l)	Oligotrophic	0.005	Wetzel (1975)	59 (Eutrophic)
	Mesotrophic	0.005-0.01		
	Eutrophic	0.03-0.1		

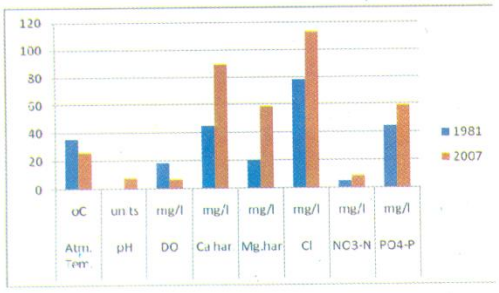


Fig. 1 Variations in some physic-chemical parameters in Bod Sar Wetland

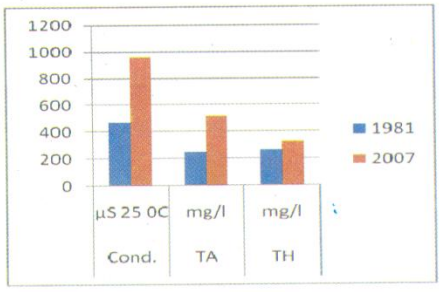
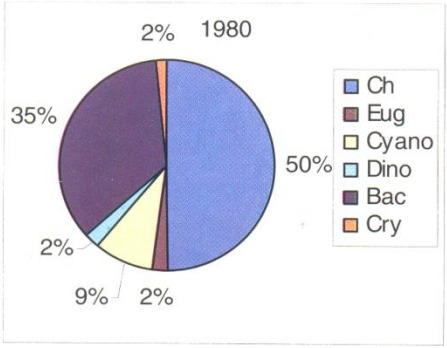


Fig. 2 Variations in Conductivity, Total Alkalinity & Total Hardness in Bod Sar Wetland



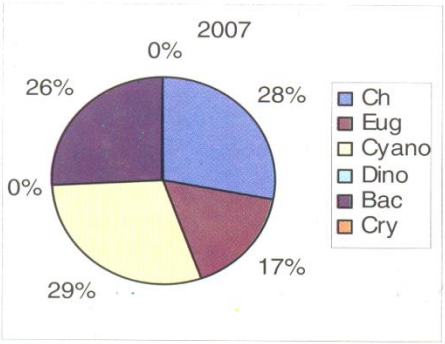
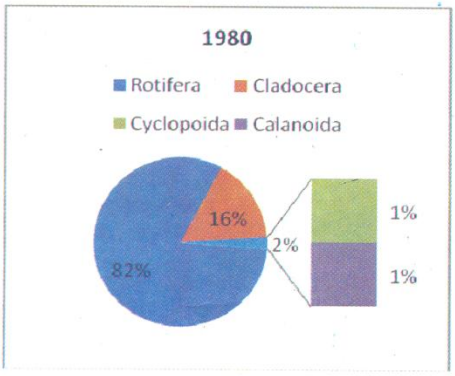


Fig.3 Variation in percentage composition of Phytoplankton population in Bod Sar Wetland



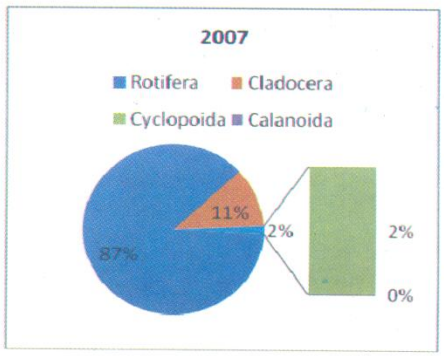


Fig.4 Variation in percentage composition of Zooplankton population in Bod Sar Wetland

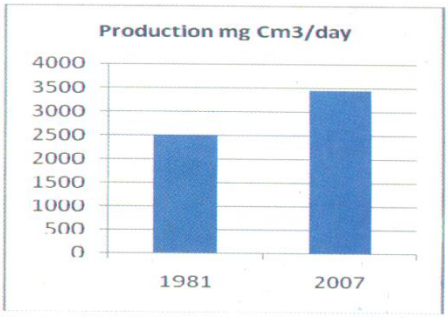


Fig.5 Variation in primary production in Bod Sar Wetland

CONCLUSION

The wetland under consideration has attained maturity to such an extent that it is impossible to reverse it's earlier condition under conservation programme yet, present investigation emphasizes the need to protect this water body from further degradation as this is one of the major resources of water for general house hold chorus

for the local inhabitants besides acting as one of the sources of ground water recharge.

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