- **Ecological Survey**
- **Physico-chemical Assessment**
- **Biomonitoring**
- **Impact Assessment**

- **Ecological Survey**

  Site wise description and survey

  Ritual activity Calendar

Site Wise Discription and Survey:-

Wadi Ratnagiri is one of the important religious attraction for Maharashtra people. It is situated in Kolhapur district of Maharashtra. It is famous by the name of god Jotiba. The God Jotiba is avtaar of Bhairav. As per myth the God Jotiba killed demon Ratnasur who troubled civilians. With this incidence the village became popular as Wadi-Ratnagiri. Instead of this later on public accepted this place by the name of God 'Jotiba'. The temple of Kedareshwar had been built by "Navaji Saya", later on the temple has been rebuilt by Ranojirao Shinde in 1730.

Geographical information is presented below.

Name of locality: - Wadi Ratnagiri (Jotiba)

Taluka : - Panhala

District : - Kolhapur

Distance from Kolhapur: - 23 Km.

Direction from Kolhapur: - North- west

Soil type: - laterite

Average rainfall in mm: - 2110 (1961); 1581 (1971); 1616 (1981); 1034 (1991)

Population: - 4048 (2001 census)

Number of houses: - 680

On the North side of the village there is a temple of 'Yamai'. Besides the temple there are two water sources called as 'Kunda'. Out of these two, one has been by constructed Jijabai in 1743. Other has been built by Ranojirao Shinde which is known as "Jamdagnya Tirtha". There are six more water bodies in the village (Maharastra State Gazzeetier, 1989). The number of water sources include 7 lakes and 16 wells found in village. Out of these resources 3 lakes are useful. These water bodies are Man made. These useful water resources are Gaimukh, Kapurbao and Chavantali. The remaining resources are not used for any specific purpose.

Gaimukh lake is situated below the hill of Wadi-Ratnagiri. It is man made lake and water is used for drinking purpose. The access water of Gaimukh lake is from river "Kasari" nearby Kerli village and stored. The water uptake to Jotiba (Wadi-Ratnagiri) is carried out with the help of pipeline. The distance from Kerli village to Gaimukh is nearly about 4 km. The area of Gaimukh lake is about 400 feet to 700 feet. The water is processed on hill and supplies as drinking water. The water is main source of household use and millions of devotees who visits to this religious place.

Lattitude :- 16^0 47' 09.81 N

Longitude :- 74^0 10' 42.72 E

Altitude :- 2626 fts. (www.googleearth.com)

The second lake known as "Kapurbao" the area of lake is about 750 x 800 feet. The lake is man-made. The lake is situated in central residential area, on the eastern side of the 'Lord Jotoba' temple. The water of this lake is used specifically for washing of cloths.

Lattitude :- 16^0 47' 46.39 N

Longitude :- 74^0 10' 38.30 E

Altitude :- 3078 fts. (www.googleearth.com)

The third lake known as Chavantali. The area of this lake is about 1000 x 800 feet. It is also man-made lake. The lake is situated at western part of hill on to the way cf Jotiba from Danewadi. The water of this lake is used for animals and also for washing the clothes.

Lattitude :- 16^0 47' 57.88 N

Longitude :- 74^0 10' 24.28 E

Altitude :- 3044 fts. (www.googleearth.com)

There is other temple of goddess 'Yamai' on the northern part of hill. Goddess is sister of Jotiba. It is one of the tourist spot on the hill. There is another lake known as "Lake of Yamai". Many local people says that water from this lake is useful for curing skin diseases. The area of lake is about 300 x 300 feet.

Lattitude :- 16^0 47' 56.97 N

Longitude :- 74^0 10' 42.00 E

Altitude :- 3097 fts. (www.googleearth.com)

Besides all these, very large amount of waste water and sewage thrown away from hill in the valley which produced in temple and surrounding localized people.

Ritual Activity Calender

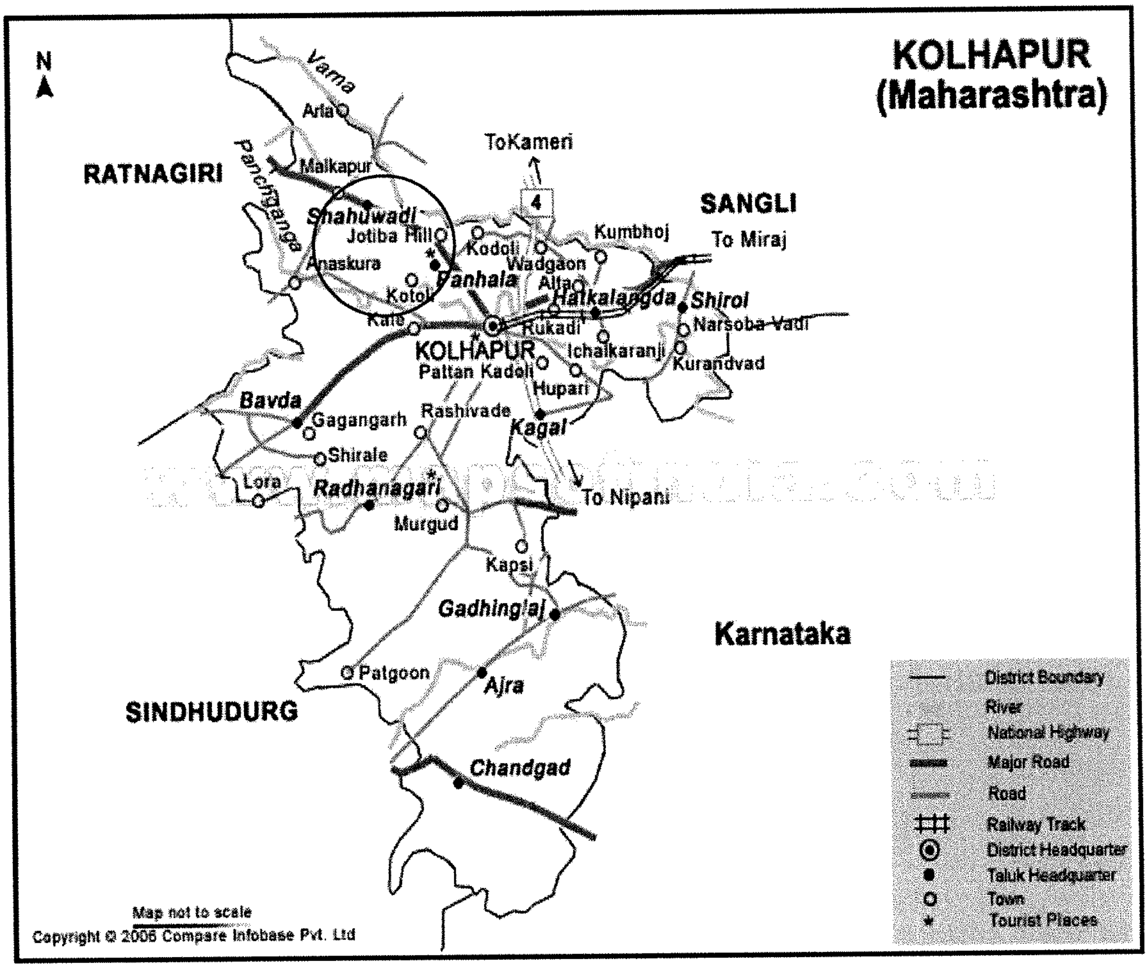
Table no. 1. Annual Ritual activities at Jotiba.

Ritual activity	Chaitra	Vaishakh	Jeshth	Ashadh	Shravan	Bhadrapad	Ashwin	Kartik	Margshirsh	Poush	Magh	Falgun
Yatra	------											
Pakalani		---------										
Dasara							-------					
Khete												------

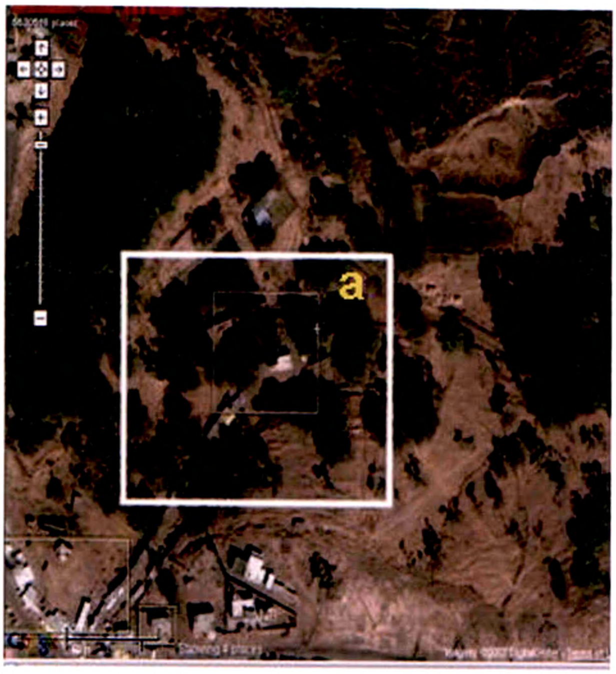
As per the Marathi (Chadramaan) calendar the various ritual activities taking place on the Jotiba hill are shown in table 1. It shows the months of the year when ritual activities take place when large number of devotees visit the place. The major event is the 'Chaitra Yatra'. It takes place in the month of Chaitra (March - April) on the full moon day of the month. During the Yatra more than 2 millions devotees visit this place. Devotees from abroad and various parts of country take part in this procession. In the month prior to the yatra people visit this place only by walk without vehicle this activity is called as 'Khete'. After the Yatra for the next five weeks on Sunday people visit the temple, this act is 'Pakalani'.

During Ashwin (October - November) people goes to the temple to offer their worship on the occasion of Dasara festival. Besides these activity visitors visits the place through out the year especially on the Sunday because Sunday is considered as the day of 'Lord Jotiba'. The number of devotees are not known for regular Sunday visits.

Fig. no.1 Map of Kolhapur District showing location of Wadi Ratnagiri (Jotiba)



Satellite images of Water resources of Jotiba



A

B

C

D

A: Satellite image of Yamai Lake
B: Satellite image of Kapurbao Lake
C: Satellite image of Chavan Tali Lake
D: Satellite image of Gaimukh Lake

Water Resources of Jotiba

A

B

C

D

A :- Lake Yamai　　B:- Lake Kapurbao

C:- Lake Chavantali　　D:- Lake Gaimukh

- **Physico-chemical Assessment**

  Temperature

  pH

  Electrical Conductivity

  Total Solids

  Total Dissolved Solids

  Total Suspended Solids

  Hardness

  Total Alkalinity

  Free CO2

  Dissolved Oxygen

  Chemical Oxygen Demand

  Biological Oxygen Demand

  Inorganic Phosphorus

  Nitrates

  Chlorides

  Minerals

  Oil and grease

II) PHYSICO-CHEMICAL ASSESSMENT

Temperature-

Temperature of water is important factor indicating the quality. A rise in temperature of water leads to the speeding up of chemical reaction in water, reduce the solubility of dissolved gases and amplifies the taste and odour (Shrivastava and Patil, 2002).

Table 2 shows monthly variation in the temperature of four water resources. The present analytical data shows that the temperature of all water resources fluctuates as per the season. The Yamai water resource shows the variation in winter season between 17°C to 25°C with gradual decrease. The lowest temperature recorded in Yamai water body was 17°C in the month of January. In summer season the temperature ranges between 20°C to 26°C. The highest temperature for respective water resource has been recorded in the month of May of 26°C. During rainy season the temperature of Yamai varies between 19°C to 21°C.

In Kapurbao water resource maximum temperature was 25°C and minimum of 20°C. In the winter season with gradual increase respectively from the month of October to January. In summer season from February to May there was gradual increase from 21°C to 29°C. The highest temperature of this lake was 29°C in the month of May while lowest temperature was 20°C in the month of January. In the rainy season the temperature remained nearly constant i.e. 22°C and 23°C. The major cause of this may be heavy growth of Water hyacinth. The growth of water hyacinth interfere the interaction of water surface and atmospheric temperature. This kind of temperature tendency of lake has been reported by Sharma *et al.*, (1978) in the Mansarovar reservoir.

In Chavantali the temperature in winter season varies from 26°C to 19°C. The lowest temperature for Chavantali during the study was 19°C in the month of January. At Chavantali, the temperature of summer season ranges from 23°C to 30°C. The highest temperature for this water body was 30°C in the month of May. In monsoon season the temperature was 20°C to 22°C.

The Gaimukh lake shows variation from 25°C to 21°C in the winter season. In summer season temperature was raised from 24°C to 31°C. The lowest temperature was found in the month of January (21°C) and highest temperature found in the month of May (31°C). In monsoon season the temperature was between 22°C to 24°C.

Hutchinson (1957) suggested that meteorological conditions are responsible for seasonal changes in temperature. The lowest temperature for all the four resources recorded in the month of January in winter season. Similar kinds of observations has been made by Tiwari in 2004 in the river pàndu and in river Yamuna by Singh and Gupta (2004). Higher temperature is observed during summer season because of clear atmosphere, greater solar radiation and due to low water level (Swaranlatha and Rai, 1998). Rainy season showed considerable fall in temperature may due to reduced solar radiation , presence of clouds, while lowest temperature in winter season attribute to the shorter photoperiod and decreased atmospheric temperature (Pailwan, 2005).

Similar kind of seasonal variation was noticed by Patil (2003); Sharma *et al.*, (1978); Devaraju *et al.*, (2005); Roy and Thakuriya (2007); Khare *et al.*, (2007).

The Chavantali has shallow depth which indicate higher fluctuations of temperature in the water resource having more surface of area interacting with solar radiation and atmospheric temperature.

Table no. 2

Monthly variation in the temperature during the year Oct 2006 – Oct 2007

Site ↓	Month →											
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	25	23	20	17	19	20	23	26	19	20	20	21	23
Kapurbao	25	24	21	20	21	24	27	29	22	22	22	23	23
Chavantali	26	24	22	19	23	26	28	30	20	20	21	22	24
Gaimukh	25	24	22	21	24	28	30	32	24	22	22	23	24

All values are expressed in ^{0}C

pH

pH is a measure of intensity of acidity and alkalinity of water and is an important indicator of its quality. In natural water pH ranges from 6.5 to 7.5. But fluctuations may occur seasonally due to load of sewage mixing, degradation of organic and inorganic matter in water body (Patil, 2003).

The table 2 depicts pH values of various sites from October 06 to October 07.

The pH of Yamai water body was quite constant. It ranges in between the 6.78 to 7.12 during the winter season. There was very little fluctuation in the values of pH. During summer season pH shows more fluctuations. The pH in the month of April and May was 5.76 to 5.95 because the ritual activity (Yatra) which held in April. Due to human interference it changes to acidic. During the monsoon season pH values are recorded from 6.61to 6.89. Maximum pH was recorded during the winter season in the month of November while minimum during the summer season in the month of April.

Kapurbao show maximum fluctuations. During winter season pH of water found to be on the higher side reaching upto 8.3 but in January it shows decrease to 7.51 up to the month of March. pH was gradually decreased up to 7.23. In further months fall in pH was recorded upto 5.64 and 5.46 in the month of April and May respectively. During this period the fishes were killed and floating on the surface of water body. According to Barik and Patel (2004) high acidic water affect aquatic flora and fauna. High acidity can cause direct physical damage to skin, gills and eyes of the fishes. The prolonged exposure to sublethal pH level can cause stress, increase mucus production and encourage epithelial hyperplasia. As in same months organic matter goes on increasing the pH turned into acidic nature and lowest value reported at the time of high pollution. Similar kind of results have been recorded by Fadtare and Mane (2007). In rainy season the pH become some what neutral and varies from 7.59 to 6.83. The growth of water hyacinth helps to maintain pH even after high organic sewage discharge. Hallier and Sutton (1973) have recorded similar observations.

The Chavantali do not exhibit much fluctuations the pH of water resource remained in the range of 7.31 to 7.93 for the complete year. Exceptionally the pH in the month of April and May found to be very low about 5.66 to 5.83 because of interference of people as well as organic load due to ritual activity. During the winter season the values range between 7.93 to 7.49. From the summer season onwards comparatively low pH values has been recorded. The reason for lowering of pH may be due to utilization of lake for the cloth washing.

In Gaimukh the range of pH was comparatively higher than the other water resources. During winter season the pH ranges from 7.4 to 7.84. During summer season in February it was 7.18 but in March higher pH was recorded (8.07) because water from river Kasari has added to the water body. In April and May the lowering of the pH reported due to the reservoir has been used as the resting point for the devotees who walks along the road to the hill at the time of ritual activity. During the monsoon pH increases. Kant and Raina (1990) have recorded maximum pH in two ponds of Jammu and coincided with rainfall. Similarly Angadi *et al.*, (2005) in support with Tripathi and Pandey (1990) recorded maximum pH in monsoon than that of rest seasons. The slight alkaline water do not cause any health hazard (Jameel and Hussain, 2003).

Sharma *et al.*, (1978) recorded high pH in unpolluted resources Similar results obtained for Gaimukh water body. The Gaimukh show alkaline pH throughout year except in April and May. Rajurkar *et al.*, (2003 a) have suggested same in Umian lake Meghalaya.

In the month of April and May low pH recorded than the winter and it was attributed to pollution. Similar reports are available from Patil *et al.*, (2003) at polluted sampling points of Tapi river.

Table no. 3

Monthly variation in the pH of water bodies of Jotiba during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	6.81	7.12	6.94	6.78	6.12	6.38	5.76	5.95	6.82	6.89	6.61	6.77	6.52
Kapurbao	8.32	8.21	8.31	7.51	7.44	7.23	5.64	5.46	7.19	7.59	6.92	6.83	6.34
Chavantali	7.72	7.93	7.72	7.49	7.58	7.67	5.66	5.83	7.64	7.43	7.49	7.31	7.39
Gaimukh	7.33	7.23	7.45	7.84	7.18	8.07	6.04	6.42	7.98	7.73	7.44	7.29	7.36

Electrical conductivity

The Electrical conductivity of present study has depicted in the table number 4.

The Yamai lake has electrical conductivity value between 0.26 mhos/ cm to 0.29 mhos/ cm in the winter season with gradual increase. In summer season electrical conductivity ranges from 0.31 mhos/ cm to 0.42 mhos/ cm with increasing pattern. In monsoon electrical conductivity values varies from 0.38 mhos/ cm to 0.17 mhos/ cm. The highest value is recorded in the month of May while lowest during August.

Electrical conductivity of Kapurbao lake in winter season ranges from 0.51 mhos/ cm to 0.58 mhos/ cm. In summer the range is 0.56 mhos/ cm to 0.73 mhos/ cm with fluctuations. The highest values has been recorded in the month of May. In the monsoon season, the value decreases from 0.64 mhos/cm to 0.41 mhos/cm due to rain water dilution.

In Chavantali the maximum value of electrical conductivity is observed in summer (0.51 mhos/ cm). There is negligible difference in the values recorded in winter and summer 0.24 mhos/cm.

There are fluctuations in the electrical conductivity of Gaimukh lake. The values of electrical conductivity in winter season are 0.39 to 0.31 mhos/ cm. The highest EC was documented in the month of December. The electrical conductivity value of summer was lower than the winter because in summer season the water has been taken from river Kasari in the month of March. The value ranges between 0.33 to 0.29 mhos/ cm. In the month of June the EC value remains low. Values vary during monsoon from 0.23 to 0.33 mhos/ cm.

The high electrical conductivity value among all lakes is found in Kapurbao which is exceptionally higher from remaining sites. Higher values of EC are due to the high concentration of ionic constituents present in the water bodies. There is contribution from salinity intrusions as well as pollution by domestic waste. Similar observations were recorded by Abbasi and Vinithan (1999) and Jevakuma *et al.*, (2003). These value may attributed to high evaporation rate due to increased temperature. Lowest in monsoon due to dilution effect of rain water. The similar pattern in summer have been reported by Rajurkar *et al.*, (2003); Barik and Patel (2004); Patil *et al.*, (2003) Kataria *et al.*, (1995). The relation of EC with temperature could be explained on the basis of the fact that solubility of minerals and other inorganic matter increase with the increase in water temperature (Hujare, 2005).

The increased ionic concentration in the water in summer reflects the EC and it can be considered as a parameter that signifies the mineralization in aquatic ecosystem. An increase or decrease in conductivity of water source will result in a similar increase or decrease in other parameter of water such as total dissolved solids. Similar kind of observations were made by Guru Prasad (2005) in canals of Krishna river. Thus the high EC values can be correlated with high total dissolved solids values. Similar results have been obtained by Piska *et al.*, (2004); Arunan *et al.*, (2004); Shivashankara and Sharmila (2004).

The EC was considered as dependent variable and other corresponding chemical ions such as Ca, Mg, Na, K, HCO3, Cl, SO4, NO3 (Gopalasamy *et al.*, 2006). Most of the inorganic salts, acids and bases when dissolved in water make it a good conductor but organic do not change the conductivity (Murali and Indira, 2004). The high value in Kapurbao suggest that it is not only polluted by organic waste but also inorganic substances alongwith domestic waste. Conductivity of polluted lake was higher than that of unpolluted lake (Sharma *et al.*, 1978). Present results are on similar lines.

Table no. 4

Monthly variation in the Electrical conductivity values during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	0.26	0.21	0.28	0.29	0.30	0.33	0.35	0.42	0.38	0.35	0.17	0.22	0.25
Kapurbao	0.51	0.57	0.59	0.58	0.56	0.61	0.56	0.73	0.64	0.47	0.41	0.55	0.57
Chavantali	0.31	0.3	0.24	0.36	0.40	0.43	0.41	0.51	0.33	0.31	0.24	0.31	0.32
Gaimukh	0.34	0.32	0.39	0.31	0.33	0.21	0.27	0.29	0.23	0.24	0.29	0.33	0.34

All values are expressed in mhos.

Total Solids

A high amount of solids in water restrict the use of water for cooking of food, washing of cloths, bathing and agricultural purposes as well as industrial use.

The Total Solids show variations seasonally. The values are given in table 5.

Yamai lake shows variation in the amount of total solids as per season. The seasonal range of total solids is 276 to 306 mg/l. In summer season the values show high fluctuations. In the month of March lower amount (218 mg/l) is observed in the month of Chaitra (Chandrayan Calender) the total solids incredibly increases to 324 mg/l. Later on values again lower down rapidly at the onset of monsoon. In monsoon the range is with least average that resides between 252 to 258 mg/l. The highest value is recorded in the month of May due to offering the of things to God as well as to lake by devotees. The lowest value is found in the month of March due to the cleaning activity as a pre-planning for the Yatra.

For Kapurbao lake Total Solids values are found to be higher than remaining lakes. During winter the values were 308 mg/l to 336 mg/l. The summer values are higher ranging between 396 to 614 mg/l. In monsoon season it ranges from 286 mg/l to 324mg/l. The highest value is recorded in the month of May. The value here is above the permissible limit. The lowest value was observed in the month of July (284 mg/l). This may possibly due to the rain watér as well as heavy growth of water hyacinth.

In Chavantali, Total Solids during winter season ranges between 214 and 270 mg/l. The summer value ranges from 222 to 321 mg/l. There is rapid increase in the month of April and May due to summer and open space surrounding to lake is utilized as parking space for transport of buses and vehicles at the time of "Yatra". The rainy season do not show lowering of the TS values. The cause of it may be due to utilization of lake for the purpose of washing of cloths as well as easy runoff from surrounding. The total solid values in the monsoon season ranges between 294 and 318 mg/l. The highest value was in the month of July and lowest value was found during winter. The maxima during summer and minima during winter has been recorded for total solids in this lake. Similar results have been reported by Sathe *et al.*, (2000); Hujare (2005); Sivakumari *et al.*, (2005). The above values may possibly due to contribution of more organic wastes.

The Gaimukh exhibit comparatively low value among four lakes. The values during winter show variations between 204 to 282 mg/l. In summer season the value ranges between 208 and 260 mg/l. The monsoon variation is from 214 mg/l to 248 mg/l. The highest value was found in the month of December. The steep increase in solids was recorded due to Yatra. During this ritual activity, the Gaimukh lake is always utilized for the rest by the devotees who walks along the road to hill.

The amount of solids in water is dependent on the source of water geography and geology of surrounding water body (Patil, 2003). The Kapurbao lake is in the residential area while Yamai lake is near to the temple. Therefore high waste load is possible, Gaimukh has a long way location from the residential area and thus have not much amount of wastes.

High solid load in water resources is due to activities by local people in the form of unwanted material disposal, garbage and further its accumulation in water resources, mixing of sewage by groundwater runoff etc. Similar observation has been made by Patil (2003).

The total solids goes on increasing as summer progresses. The peak total solids has been recorded before the arrival of monsoon and similar kind of observation has been recorded by Tiwari (2004) it is also recorded that the values lows down after monsoon (Khare *et al.*, 2007).

Table no. 5

Monthly variation in the Total Solid content during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	306	276	288	300	234	218	240	324	254	252	244	258	264
Kapurbao	306	304	338	288	396	358	436	614	324	284	286	314	316
Chavantali	204	214	222	222	254	222	308	321	318	326	320	294	302
Gaimukh	204	216	282	272	224	208	216	260	248	214	232	236	240

All values are expressed in mg/l.

Total dissolved solids (TDS)

Monthly variation in Total Dissolved Solid is shown in table 6.

The total dissolved solid shows lot of variation. In Yamai the TDS were fluctuating during the all seasons. The values vary from 90 mg/l. to 134 mg/l. The gradual increase has been recorded as a function of seasons. In summer season the values range from 94 mg/l to 164 mg/l. The highest value of TDS for the same lake was 164 mg/l in the month of May. The Yamai water has shown quite low values. The highest values in April and May attributed to summer as well as ritual activity 'Chaitra- yatra'. In the monsoon season, range of TDS constraints to 88mg/l to 110 mg/l. The least value reported in the month of July.

In Kapurbao the TDS values vary as per change in the season. During winter season the values were in between 170 mg/l and 216 mg/l. During summer season the TDS ranged from 224 mg/l to 488 mg/l. The influence of summer along with ritual activity and domestic sewage was incredibly higher. The TDS maxima for each lake was recorded in the month of May. In monsoon season the TDS values reached to minimum level showing range between 178 mg/l to 126mg/l.

In Chavantali the TDS range between 60 mg/l to 74 mg/l. The lowest value was found in the month of November for the lake. There is a little fluctuation during winter season. In the summer season the values were comprehensively raised and ranged between 85 mg/l to 205 mg/l. The peak was recorded in the month of May. The arrival of monsoon lowered down the values of TDS of the lake. The values recorded during the rainy season were 106 mg/l to 119 mg/l.

The Gaimukh has shown variation of TDS from 108 mg/l to 134 mg/l during the winter season. During summer season the concentration of TDS increased with range in between 112 mg/l to 168 mg/l. As the temp increased in the progressing summer season the TDS values also increased. The TDS values lowered down after the onset of rainy season.

All lakes shows the TDS value bellow permissible limit given by ICMR (1963) i.e. about 500 mg/l.

According to Reid (1961) TDS play an important role in lowering the productivity of aquatic environment. The high concentration of TDS increase the water turbidity. This in turn decreases the light penetration and thus affect the photosynthesis, thereby suppressing the primary producers in the form of algae and macrophytes, which affect the micro and macro invertibrates which are dependant directly or indirectly on plants for food (Pailwan, 2005).

Khatavkar *et al.*, (1989 a) have recorded the range of TDS. It was higher in summer than the monsoon and winter. Similar trend is observed here.

Increase in TDS values from winter to summer and decreased in monsoon is also recorded bySingh and Rai (2003). Definite pattern of seasonal variation in TDS was observed Hujare (2005); Jain *et al.*, (2003); Paka and Rao (1997); Transeau (1916); Holgetts (1921); Behera *et al* (2006).

As the TDS values increases the EC values get increased. This shows that there is positive correlation between these two parameters. Similar kind of positive correlation has been recorded by Maruthi *et al.*, (2004). High EC and TDS signifies the inorganic pollution of any water body (Mor *et al.*, 2003).

According to Guruprasad (2005) higher values of TDS are attributed to the presence of colloidal suspended matters which do not settle readily. The dissolved solids are mainly the minerals. Organic impurities in polluted water also contribute to dissolved solids. These may due to different ion chlorides, bicarbonates, sulphates, calcium, magnesium, etc. In polluted water the concentration of all or some of thses substances are very high (Lomte, 2003). High TDS values due to waste disposal around the water resources has been recorded by Maruthi *et al.*, (2004).

Total dissolved solids is important parameter determining the water quality. Beyond the prescribed limit it imparts a particular objectionable taste to water and reduce its potability.

Table no. 6

Monthly variation in the Total Dissolved Solid content during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	90	104	118	134	94	92	118	164	108	88	108	110	122
Kapurbao	170	176	202	216	224	220	334	488	178	126	130	144	152
Chavantali	78	60	72	74	84	114	170	205	111	106	119	109	115
Gaimukh	108	134	114	128	112	122	150	166	74	64	110	114	128

All values are expressed in mg/l.

Total suspended solids

Total Suspended Solids are given in table. 7 for investigated sites.

The suspended particles in high amount enters into the ecosystem it causes number of difficulties. The sediment when enters into body of aquatic animals like fishes respiration become impaired, plant productivity and water depth get reduced. An aquatic organisms and their environment become suppocated (Guruprasad, 2005). The suspended solids and dissolved solids affect hardness, alkalinity, which ultimately affect the physiological activities of flora and fauna.

According to Singbhal (1973) the increase in concentration of Total Suspended Solids (TSS) would reduce the light penetration into the water and affect the plankon and fishes by decreasing dissolved oxygen level in water. Similar kind of affirmative observation has been made in the present investigation.

The upheld TSS values are observed in summer in Yamai. Similar observations have been made by Kannan (2007); Hujare (2005). The high TSS values were found due to direct sewage discharge with solid waste. The present results are on similar line. The high TSS from Chavantali may due to the surface runoff from catchment area during the rainy season. The observations are also reported by Rao and Mahmood (1995); Hujare (2005).

In Yamai TSS value shows high fluctuations during winter. The values are in the range of 206 mg/l to 166 mg/l with gradual decrease. The TSS values in summer season of the lake resides in the range of 142mg/l to 222 mg/l. The highest values for the lake has been recorded during this period in the month of May when ritual activity i.e. Chaitra – Yatra took place. From the month of May it slowly lowered. In monsoon season the values recorded between 146 mg/l to 162 mg/l. There is no definite pattern found in Yamai for TSS readings. The lake is smaller one and the TSS values get influenced by visitors. The lowest value observed was in the month of September (118 mg/l).

The Kapurbao lake has shown variation in the winter for TSS (84 mg/l to 136 mg/l) with gradual decrease. In summer season, increasing pattern was observed. The monsoon show range from 146 mg/l to 160mg/l. The least value is recorded in the month of January highest peak was recorded in the month of February. The variation in the TSS of Kapurbao attributed to the waste disposal. Monsoon exhibit the increasing TSS pattern due to the luxuriant growth of water hyacinth and further addition of plant parts to the water resource.

In Chavantali water body show the total suspended solids range in between 196 mg/l and 148 mg/l. In summer season the TSS values constraints in between 160 mg/l and 108 mg/l . The lowest value were recorded during summer season in the month of March. In monsoon the increase was recorded due to addition of surface runoff from catchment area. The highest value recorded for chavantali was 220 mg/l. Sah *et al.*, (2000) recorded the higher TSS in rainy season than summer season. It was due to input from the catchment area. Increase in TSS values from monsoon to summer is also recorded by Singh and Rai (2003).

Table no. 7

Monthly variation in the Total Suspended Solids during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	216	172	170	166	140	122	222	160	146	164	136	148	142
Kapurbao	136	128	134	84	172	138	102	126	146	158	156	160	164
Chavantali	126	154	150	148	160	108	138	116	207	220	201	185	187
Gaimukh	96	82	168	144	112	86	66	94	174	150	122	122	112

All values are expressed in mg/l.

Hardness

Unni (1983) has suggested that the total hardness can be used as an indicator for classifying domestic pollution. Fadtare and Mane (2007) stated that the total hardness indicates concentration of Ca^{++} and Mg^{++} ions.

The seasonal variations of hardness are given table 8 .

Total hardness of the Yamai water body ranges from 69.33 mg/l to 81.33 mg/l during winter season. During summer the hardness ranges between 82 mg//l to 111.6 mg/l with gradual increase from February to May. In rainy season hardness varies from 68 mg/l to 98.66 mg/l. The highest value for respective lake was recorded in the month of May and lowest in July.

Hardness of Kapurbao varies during winter i.e from 142.5 mg/l to 178.66 mg/l. In summer season the hardness increases (167.00 mg/l to 177.33 mg/l). Due to dilution effect hardness reduces during rainy season.

The hardness of Chavantali reservoir also fluctuates season wise. Winter range is between 96 mg/l to 108 mg/l. During summer season the increase in hardness is between 107 mg/l to 113 mg/l. The monsoon shows the range of hardness 84.66 mg/l to 103.33 mg/l. The maxima recorded for Chavantali reservoir was in the month of May and minimum in July.

The Gaimukh lake has hardness between 158.66 mg/l to 168.33 mg/l during the winter season. During summer comparatively low values than winter has been found (148 mg/l to 154 mg/l). Hardness during the monsoon varies between 120 mg/l to 144 mg/l . The highest peak and lowest peak for the lake is recorded in the month of January and July respectively.

Maximum hardness was observed in the lake Kapurbao followed by Gaimukh. The least value of hardness was observed for Yamai lake. The values are within the permissible limit of 300 mg/l given by WHO (1984).

Mairs (1996) has found close relation in hardness and alkalinity. He is of opinioned that whenever hardness is lower than alkalinity it is due to carbonates. According to Murugesan *et al* ., (2004) calcium and magnesium and total hardness in water are interrelated. Thomas *et al.*, (2007) have coupled high Ca, Mg and Chlorides with total alkalinity and total hardness.

Iqbal and Katariya (1995) have reported increase in calcium and magnesium hardness of the lake water towards winter and summer due to evaporation and addition of Ca^{++} and Mg^{++} salts from detergents and soaps used in washing and bathing. It may enter through industrial effluents and domestic sewage. Similar situation is found in Kapurbao. High value of hardness may be due to anthropogenic activities. Hujare (2005); Bagde and Verma (1985); Bhadram *et al.*,(2004); Sah *et al.*, (2000) have suggested similar pattern of hardness.

The hardness of water caused by multivalent metallic cations (Guruprasad, 2003). Sakhare (2004); Rath *et al.*, (2000); Fadtare and Mane (2007); Sastry *et al.*, (2003) have indicated that the total hardness concentration is of Ca and Mg ions. Though the hardness values are within the permissible range, all the water resources carry sufficient amount of Ca^{++} and Mg^{++} ions. In general water hardness is moderately hard.

Table no. 8

Monthly variation in the Hardness values during the year Oct 2006 – Oct 2007

Site ↓	Month →											
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	73.33	81.33	69.33	76	82	88.66	108	111.6	98.66	68	74	90	88.66
Kapurbao	142.5	169.33	178.66	161.33	167	174	174	177.33	161.33	158.66	161.33	167	169.33
Chavantali	108	102	96	104.8	107	114	108	113	103.33	93.33	84.66	96	102
Gaimukh	162	158.66	164	158.33	154	148	150	152	126.66	120	126.66	144	148

All values are expressed in mg/l.

Total Alkalinity

Alkalinity itself is not harmful to human being. In large quantities, alkalinity, imparts bitter taste to water. Alkalinity must be present in excess to neutralise the acid released by the coagulant in chemical coagulation process. Total alkalinity is important to know the buffer capacity of water. High alkaline water tend to have high pH after aeration and low alkaline water tend to have low pH after aeration. The alkalinity in water is due to carbonates, bicarbonates and hydroxides.

The results of total alkalinity of four water resources are depicted in the table 9.

The total alkalinity of Yamai lake in winter season remains in the range of 105 mg/l to 120.8 mg/l. Higher alkalinity values are found in the month of may while lowest value in the month of February. There is steep increase in the alkalinity from February onwards. In monsoon season the concentration varies from 88 mg/l to 101.66 mg/l.

The Kapurbao water body shows the total alkalinity range between 171.66 mg/l to 215 mg/l. with constant fluctuations during the winter. In summer season there is gradual increase from 182.5 mg/l to 278.3 mg/l. Highest peak is found during May. The total alkalinity during monsoon season is in between 171.66 mg/l to 190 mg/l. Sah *et al.*, (2000) have suggested the significant high alkalinity at the mixing zone. Higher alkalinity attributes to increased rate of decomposition, during which free CO2 get liberated then reacts with water to form HCO3 increase the alkalinity. Similar suggestions were given by Harshey *et al.*, (1987); Kaur *et al.*, (2000); Devi and Belgali (2005). The high values of total alkalinitymay be due to influx of detergent and soaps in the month of May (Bhardwaj and Sharma, 1999; Patil, 2003).

The total alkalinity of Chavantali total alkalinity remained between 112.5 mg/l and 170 mg/l during winter season. It is noted that here the fluctuation in alkalinity is prominant. In summer the total alkalinity show gradual increase. It ranges between 105 mg/l. and 195 mg/l. The peak value of total alkalinity for each lake was recorded in the month of May.

The Gaimukh water body shows comparatively low total alkalinity (101.66 mg/l and 142.5 mg/l) during winter. The highest value was observed in the month of January. The summer values range between 95 mg/l to 120 mg/l. In monsoon season total alkalinity varies from 86 to 101.66 mg/l. with a gradual increase.

The desirable value of total alkalinity for domestic purpose is 100 mg/l. Among all the lakes the Gaimukh values are within the limit.

A marked seasonal fluctuation in total alkalinity from minimum in monsoon and maximum in summer have been reported by Michael (1969); Ayyappan and Gupta, (1981); Shreenivasan, (1990); Jhingran, (1992). Kaushik and Saksena (1999) have recorded increased total alkalinity attributed to the evaporation rate in certain water resources of India. The dilution effect leads to the low total alkalinity in the monsoon season (Jain *et al.*, 1996 a; Ravikumar *et al.*, 2006).

Alkalinity is greater than hardness due to the presence of basic salts of sodium and potassium in addition to those of calcium and magnesium (Manivaskam, 1984; Rani *et al.*, 2001). In the present study increase in alkalinity coincids with increasing trend of hardness. Similar kind of reports were made by Pailwan (2005).

There is variation in total alkalinity seasonwise and sitewise. The fluctuation may due to dilution effects as well as high values due to evaporation rate in water resources.

Table no. 9

Monthly variation in the Total alkalinity of water of different lakes during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	121.66	120.83	101.66	105	75	120.8	115.8	135	91.66	80	100	101.66	115.8
Kapurbao	171.66	215	203.33	215	182.5	207.5	237.5	278.3	182.5	171.66	181.66	190	182.5
Chavantali	170	114.16	140	112.5	105	165	160.8	195	150	65	70	110	118.33
Gaimukh	101.66	118.33	101.66	142.5	112.5	107.5	95	120	86	91.33	93	101.66	115.8

All values are expressed in mg/l.

Free CO_2

The Free carbon dioxide is one of the essential components of the aquatic ecosystem. It is relatively abundant in natural water and its importance in the photosynthetic activity. No further explanation, since the daily and seasonal carbon flow in the system formed the base of food pyramid (Goldman and Horne, 1983). Dissolution of free CO_2 in water depends on temperature, pressure etc. The polluted water bodies acquire CO_2 by biological oxidation of organic matter (Fadtare and Mane, 2007). In water, persistent high concentration of free CO_2 can be injurious to fishes, due to its toxicity or interference with respiration (Doudoroff, 1957). The free carbon dioxide is the only source of carbon assimilated and incorporated into the body of living aquatic autotrophs.

The values of free Carbon dioxide for different lakes been given in the table 10.

Yamai water body showed a significant value of free CO_2 in summer season than winter season. It has been recorded between 18.33 mg/l and 24.93 mg/l. In summer season it increases up to 27.93 mg/l to 79.56 mg/l. The value minimize during rainy season and it resides between the range of 40.33 mg/l to 24.03 mg/l. The highest value of free CO_2 recorded is 79.56 mg/l in the month of May.

Kapourbao lake has comparatively higher free CO_2 than other lakes. In winter season the free CO_2 was found to be 27.86 mg/l to 48.4 mg/l. In monsoon season the free CO_2 increases steeply. It varies from 92.4 mg/l to 135.66 mg/l. There is comprehensive increase in pre-monsoon to monsoon. The values found to be comparatively higher (106.21 mg/l to 114.4 mg/l) as the anoxious condition or negligible amount of O_2 is present in water. The highest value of Free CO_2 for respective lake was recorded during month of May where as lowest value was found in the month of December. The CO_2 increase coupled with increase in pollution level. Some significant attempts have been made by Fadtare and Mane (2007). The high free CO_2 during the monsoon season may be attributed to above reason. The high level of free CO_2 is due to high anaerobic nature and less photosynthetic activity may due to pollutant.(Martin and Haniffa, 2003; Ellis, 1937).

The free CO_2 fluctuates monthly in Chavantali winter season value ranges from 12.1 mg/l to 18.33 mg/l. The summer values are comparatively higher (33.73 mg/l to 61.6 mg/l). After the arrival of rain values are residing in the range of 18.33 mg/l to 12.1mg/l. The highest values are recorded in the month of May lowest in the month of August, September and January. The average value of Free CO_2 for all lakes was found lowest in rainy season. The respiratory activity of aquatic organisms and decomposition of organic matter are important sources of carbon dioxide in fresh water bodies (Pailwan, 2005).

In Gaimukh the range of Free CO_2 in winter season was between 26.4mg/l to 13.2mg/l. In summer season the value comparatively gets increased and resides between 22.00 mg/l to 28.00 mg/l. But after rainy season the values were decreased to 14.92 mg/l to 11.52 mg/l. The lowest value has been recorded in the month of August while maximum was found in March.

In Gaimukh Free CO_2 values were comprehensively less than the other lake. The Chavantali and Yamai water resources show high fluctuations in the Free CO_2. The maximum Free CO_2 was recorded in Kapurbao. Comparatively monsoon season shows less Free CO_2 except in Kapurbao. The CO_2 concentration was found constantly higher during premonsoon.

Prakash (1982); Lohar and Patel (1998); Hutchinson (1957) have shown an inverse relationship of free CO_2 with dissolved oxygen. In absence of free CO_2 the bicarbonates are converted into carbonates releasing CO_2 which is utilized by autotrophs thus making water more alkaline (Pailwan, 2005). Similar kind of situation was found in Gaimukh, may coupled with the alkaline pH of the water resource. The alkaline pH indicate presence of CO_2 in the form of bicarbonates.

The maximum concentration of free CO_2 was recorded in summer season and least in the monsoon season. During present investigation the water resources like Kapurbao, Yamai and Chavantali show similar pattern of free CO_2. The observations are similar as shown by Pailwan (2005) for Kaneriwadi tank.

According to Munawar (1970), during the oxygen deficiency anaerobic bacteria become more active in decomposition of organic matter. Thus CO_2 released at the bottom gets diffused into the entire waterbody. The high level of CO_2 during summer and monsoon at Kapurbao may possibly coincides with the decline in the water level and increase load of organic matter of autochothonous origin in summer season and allochothonous in monsoon (Pailwan, 2005). Hynes (1970) is of opinion that the free CO_2 values may reach above 50 mg/l in an organically polluted waterbody. Pailwan (2005) has mentioned the concentration of CO_2 results into low pH and high carbonate values. Similar confirmatory results are obtained for polluted waterbodies in the investigated sites i.e. Kapurbao, Chavantali and Yamai.

Table no. 10

Monthly variation in the Free CO_2 during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	24.93	18.33	19.06	18.7	27.13	28.99	50.6	79.56	40.33	24.93	28.89	27.13	28.89
Kapurbao	47.66	40.33	27.86	48.4	92.4	114.4	121.73	135.66	106.21	114.4	114.4	106.33	101.2
Chavantali	18.33	22.36	14.92	12.1	33.73	36.3	57.66	61.6	18.33	14.92	12.1	12.1	18.33
Gaimukh	26.4	23.1	23.83	13.2	22	28	22.73	22.73	14.92	12.1	11.52	13.2	14.92

All values are expressed in mg/l.

Dissolved Oxygen

A great variety of gases are found dissolved in natural water. Out of these gases dissolved oxygen is the most important one because it is a regulator of metabolic processes of organisms and also the community as a whole. Oxygen acts as an indicatior of trophic status and magnitude of eutrophication.The anthropogenic activity becomes a prime source of water pollution. The sewage when influxes the aquatic system cause serious effects on physico- chemical and biological characteristics of the water. The oxygen present in aquatic system destroy the organic part of sewage under natural processes (Kumara and Belagali, 2008).

The status of dissolved oxygen of four water bodies is presented in the table 11.

The range of dissolved oxygen for Yamai water was from 5.54 mg/l to 3.7 mg/l. During summer the values of dissolved oxygen showed variation from 3.1 mg/l to 1.5 mg/l. The lowest value was recorded in April. During monsoon season increased level of dissolved oxygen than the summer (6.081 to 5.243 mg/l) were recorded. The highest value was recorded during monsoon i.e. in the month of June. The average value found to be higher in the monsoon season.

The dissolved oxygen in Kapurbao ranges between 5.54 mg/l and 1.114 mg/l. The highest value is recorded in the month of October. The values later on decrease rapidly. During summer season the waterbody has shown anoxic condition. As monsoon season arrived, the dissolved oxygen values in other lakes were found to be increased. In Kapurbao it was negligible and recorded between 0.40mg/l to 0.10mg/l. Discharge of domestic sewage responsible for decreasing level of oxygen in water, Similar reports are given by Kadam (1990).

The dissolved oxygen was quite higher during winter season in Chavantali. The values were ranging between 0.99mg/l and 4.93mg/l with some fluctuations. The values in summer were lower than that of winter. The range was from 4.96mg/l to 1.35mg/l. Higher level of dissolved oxygen was recorded in the month of July and January. Dissolved oxygen in the month of May was reduced.

In Gaimukh the dissolved oxygen was found to be increased to 6.614mg/l to 7.324mg/l. Increase in dissolved oxygen may possibly related to decrease in temperature.

Such relation has been reported by Bhave and Borse (2001). In summer months the values lowered down in the range of 3.5mg/l to 1.9mg/l. The fall was occurred in dissolved oxygen values as summer progressed. In rainy season the values of dissolved oxygen were recorded in the range of 6.89mg/l to 5.87mg/l. showing less intensity of pollution. The highest level of dissolved oxygen was racorded in the month of December i.e 7.32mg/l. The lowest was value recorded in the month of April. Among all the lakes dissolved oxygen level was found higher in the Gaimukh lake while, the lowest value was recorded in Kapurbao indicating high intensity of disturbance.

The rate at which atmospheric oxygen passes across the air water interphase and become dissolved in water depends upon temperature, partial pressure of gases in atmosphere concentration of dissolved salts, solubility, pollution, inflowing underground water, photosynthetic activity of plants and respiratory activities of plants and animals in the water (Zutshi and Vass, 1978).

Kaushik and Saksena (1999 b) have recorded high values of dissolved oxygen in monsoon season in the water bodies of central India. It was attributed to circulating and increasing rainwater into these water bodies. Similar conditions was observed by Nair, (2006); Welch, (1952); Rani *et al.*, (2001); Koshoe and Vasudevan (1999); Sivakumari *et al* .,(2005).

Khatavkar *et al.*, (1989 a). have recorded that variation in dissolved oxygen is governed by photosynthetic and decomposition activity in water. In Kapourbao decomposition activity of organic waste is found almost through out the year. It is higher during April and May due to hyacinth growth decomposition of plant parts and elevated temperature

The seasonal fluctuations and sudden variations in the levels of dissolved oxygen at certain instances was recorded. It may be attributed to the factors like temperature, physical and chemical reactions and biological activities occur in the water bodies.

The low temperature enhance the dissolution of oxygen in water. Such seasonal observation are made by Khabade *et al.*, (2002); Pailwan, (2005). Dissolved Oxygen is needed for living organisms to maintain their biological processes. Higher temperature, biological impurities, ammonia, nitrate, ferrous ions and substances such as hydrogen sulphide reduces the levels of dissolved oxygen (Hariharan, 2002). The decreased dissolved oxygen level after the Ganesh idol activity in the Rajaram lake and Kotitirth lake of Kolhapur city was recorded by Patil and Dongare (2006). CPCB (1999-2000) has also recoreded such phenomenon in the lakes of Banglore. Gunale (1981) has reported high dissolved oxygen for non-polluted areas.

It is to be noted here that the dissolved oxygen in any water body is subjected to change daily, monthly and seasonally as a function of environmental fluctuations but pollution adds to it.

Table no. 11

Monthly variation in the Dissolved Oxygen content during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	5.54	5.303	3.71	4.932	3.108	2.837	1.587	2.804	6.081	5.675	5.243	5.675	4.932
Kapurbao	5.54	2.8378	1.7905	1.114	0.7094	0.7094	0.1013	0	0	0.405	0.1013	0.1013	0.1013
Chavantali	6.124	4.932	5.81	6.993	4.054	4.966	3.344	1.351	6.358	7	6.684	4.256	4.966
Gaimukh	6.98	6.614	7.324	7.094	2.837	3.547	1.925	2.027	5.5878	6.89	6.486	6.891	6.358

All values are expressed in mg/l.

Biological Oxygen Demand

Biological Oxygen Demand is the amount of oxygen to measure the amount of biological oxidisable organic matter and decomposition of that organic matter under aerobic condition (De, 1986; Maiti, 2004). It is require for stabilization of waste in water. The biological oxygen demand is useful to assess the self purification capacity of water body. It gives an idea to design the wastewater treatment plants. It is demand of oxygen by biological community present in water for their respiration. Generally dissolved oxygen values fluctuates daily due to light and dark conditions but biological oxygen demand (BOD) values are more influenced by the number of organisms than dark and light conditions. During present investigations it is observed that biological oxygen demand is very high during the summer months and therefore it is recorded on day three. Among the waterbodies studied constantly high BOD is recorded almost for all. But situation at Kapurbao is alarming because sometimes purely anoxic condition may occur.

As compare to all other parameters there is a no much difference in BOD seasonally or monthly. It clearly indicates that there is constant disturbance in water bodies with respect to contamination of water by microbes. It may possibly attributed by the devotees visiting the place every Sunday surface runoff in monsoon and yatra in the summer. Looking towards results it is to be noted that the months from February to May have more disturbance and favorable for luxuriant growth of heterotrophs.

The Biological oxygen demand was highest during the summer and lowest in winter. Similar results are reported by Sah *et al.*, (2000); Khare *et al.*, (2007); Singh and Gupta (2004); Tiwari (2004). According to Devaraju *et al* ., (2005) high BOD indicates the slow eutrophication phase of the lake. Similar kind of observation is recorded in the present investigation.

The higher biological oxygen demand indicates pollution which may attributed to the maximum biological activity. In the present investigation high BOD values are obtained may possibly due to sewage input. The high BOD was found to be restricted in pH between 6.5 and 8.5. Similar results are reported by Bandela *et al.*, (2002).

According to Hines *et al.*, (1977) biological oxygen demand, chemical oxygen demand and other inorganic constituents are primary concern in municipal wastes, urban runoff and animal wastes. The value of COD in conjugation with BOD is helpful in knowing the toxic conditions and presence of biologically resistant organic substances.

In general the water resources of Jotiba are contaminated more during the ritual activities. Kapurbao lake is more disturbed and the situation is alarming.

Table no. 12

Monthly variation in the Biological Oxygen Demand during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	2.702	1.317	2.2301	3.649	1.96	2.566	1.587	2.533	2.23	2.027	1.96	2.603	2.837
Kapurbao	3.581	2.8378	1.7905	1.114	0.7094	0.7094	*	*	*	0.405	0.1013	0.1013	0.1013
Chavantali	2.214	2.635	3.175	4.662	2.027	2.603	1.389	1.148	2.365	2.214	2.8378	2.635	3.175
Gaimukh	2.365	3.311	3.649	3.142	1.419	0.844	1.283	1.79	2.702	2.365	2.027	2.635	2.702

All values are expressed in mg/l.
*** purely anoxic condition therefore in BOD experiment DO was not detected on day 1 also**

Chemical Oxygen Demand

The Chemical oxygen demand (COD) is useful parameters for analysis of domestic and industrial waste water. The COD is the oxygen required for the chemical oxidation of most organic matter and oxidisable inorganic substances with the help of strong chemical oxidants.

The COD values for various sites are depicted in table 13.

Yamai water body shows 206 to 262 mg/l chemical oxygen demand during winter. High fluctuations were observed during this season. The values found to be increased gradually from February to April. The peak value was recorded in the month of April. The values were reported in the range of 264 to 308 mg/l. Then decrease is recorded up to the end of monsoon season between 280 to 276 mg/l.

The Kapurbao lake show substantially higher average values than other lakes. During winter season the values vary from 260 to 286 mg/l. In summer season the COD values remain in between 256 to 296 mg/l. From June onwards constant COD was recorded (i.e. 280 to 286 mg/l). Maximum value was observed in the month of May and lowest in the month of November.

For Chavantali COD value ranges between 224 to 256 mg/l during winter season. In summer months there is increase in COD from 240 to 280 mg/l. The maximum COD was obtzined in the month of May. The minimum was found in the month of November.

Gaimukh water body has COD range from 216 to 244 mg/l during winter season. The least value of COD was recorded in the month of November. The COD values increased from January onwards. In the month of May highest peak was recorded. During summer season COD ranges from 228 to 268 mg/l. The dilution effect occurs as monsoon starts. Due to dilution effect COD was gradually decreased to 256 to 264 mg/l.

In all lakes similar pattern of COD has been recorded. The progressive increase in COD was recorded at the end of summer. High COD was recorded during summer. Similar reports have been given by Sah *et al.*, (2000); Patil *et al.*, (2003); Barik and Patel (2004); Singh and Gupta (2004); Tiwari (2004). Sivakumari *et al.*, (2005) recorded a gradual decrease of COD from summer end to winter season. Similar observations were made in present investigations for all lakes.

Table no. 13

Monthly variation in the Chemical Oxygen Demand for different lakes during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	**Nov**	**Dec**	**Jan-07**	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept.**	**Oct-07**
Yamai	256	244	206	262	264	276	308	288	280	280	276	280	286
Kapurbao	272	260	280	286	292	256	280	296	284	280	286	286	288
Chavantali	232	224	252	256	264	240	272	280	272	268	264	268	270
Gaimukh	220	216	244	242	244	228	248	268	260	260	256	264	262

All values are expressed in mg/l.

Inorganic Phosphorus

Phosphorus bound in rocks is generally insoluble in water. The phosphorus content in water is less as compared to other minerals. Domestic industrial effluent and agricultural runoff are major source of phosphorus in the water. Organic and inorganic phosphorus found in water. But mainly inorganic phosphorus plays dynamic role in an aquatic ecosystem under oxidizing condition. It is precipitated and lost to the sediments resulting in depletion of phosphorus in water. It can be found with soil, organic matter and sediment particles. It controls algal growth and primary productivity because it is fundamental element in metabolic reactions of plants and animals.

The variation in inorganic phosphorus content for various sites depicted in the table 14.

In Yamai lake the inorganic phosphorus fluctuations were observed seasonally. In winter season, inorganic phosphorus was in between 0.08 mg/l to 0.233 mg/l. In summer season there is steep increase in the values from 0.135 mg/l to 0.400 mg/l. While the effect of rainy season starts from June, when inorganic phosphorus lowered down to 0.05 mg/l and 0.075 mg/l for June and July respectively. From the month of August again increase was recorded. The maximum value for the lake was found in the month of October while lowest values found in June 07.

In Kapurbao lake phosphorus content was comparatively higher. During winter season inorganic phosphorus was in the range of 0.584 mg/l to 0.762 mg/l. The extreme increase from 0.635 mg/l to 5.67 mg/l was observed during summer.

Inorganic phosphorus was not much fluctuating in Chavantali. During the winter season it ranges between 0.16 mg/l to 0.41 mg/l. There was two fold increase in the phosphorus in Yamai. During the pre monsoon season values were from 0.284 mg/l to 1.00 mg/l. In monsoon season inorganic phosphorus was ranging between 0.85 mg/l and 0.19 mg/l. The maxima was found in the month of May and the minima in the month of August.

Gaimukh reservoir showed comparatively lowest values among all studied lake. During winter season 0.15 mg/l to 0.216 mg/l of inorganic phosphorus was recorded. In summer season the values increased i.e. 0.335 mg/l to 0.5 mg/l with gradual increase from February to April. From the month of May the decrease in the level of inorganic phosphorus was observed. In further months of monsoon inorganic phosphorus was found in the range of 0.11 mg/l to 0.26 mg/l. The minimum content was observed in the month of August while maximum in the month of June.

Higher concentration of phosphorus in summer season may also be attributed to high turnover in decomposition (Kaushik and Saksena, 1999 b). Dykyjova and Kvet (1978) have recorded main peaks of phosphorus in late May and early June and coincided with intense release either from dying of biotic population (autolysis) or from decaying organic materials. The high phosphorus value in monsoon and winter may be correlated with the entry of organic matter of allochthonous origin in the water bodies.

Jakher and Rawat (2003) have observed significant +ve correlation between phytoplankton and phosphate. Thomas (1969) has pointed out the addition of phosphate - P- that brings an eutrophication mechanism by increasing bacterial content.

Banerjee and Lal (1990) stated that the availability of phosphate in pond water depends upon the organic matter content in the pond bottom and types of organisms present in the system. Release of phosphorus is dependent on the soil reaction. Slightly acidic conditions of the medium favour the release of the available phosphorus in water.

Ruttner (1953); Hujare (2005) have reported smaller amount of phosphate phosphorus in water free which was of contamination by effluents. High PO4 - P values can be attributed to formation of inorganic phosphorus, also to the accumulation of phosphate in water body through agricultural drainage and sewage from surrounding area (Hujare, 2005; Patil, 2003).

Patil (2003) is of opinion that phosphorus level in post monsoon season, higher due to continuous discharge of domestic sewage, detergents, washing, bathing and swimming. The concentration of nitrates and phosphates provide information on the nutrient status and pollution level of the rivers and lakes. Nutrient levels are dependant on runoff from agricultural land and water discharge that carry high loads of phosphorus and nitrogen fertilizers, animal waste and municipal sewage. High nutrients may produce eutrophication of lakes (World resources, 1999; Lalitha *et al.*, 2006; Fadtare and Mane, 2007).

According to Barik and Patel (2004) during summer season phosphate concentration was higher and moderate during rainy season and lowest during winter season. Sharma *et al.*, (1978) have also recorded high phosphate in polluted waterbodies in summer season. Tiwari (2004) has recorded low PO_4 values in the monsoon season. Ravikumar *et al.*, (2006) have recoreded increase in phosphate level in summer season and showed highest reading in monsoon. Kannan (2007), Kiran *et al.*, (2006) have recorded high phosphate level during summer, moderate in winter and lowest in rainy season.

The nutrient elements such as NO_3-N, PO_4 and SO_4 enters into lakes and rivers and encourage the growth of rooted plants algae and thereby cause eutrophication of the lake (Chatterjee and Raziuddin, 2002). Water hyacinth grows in nutrient rich water profusely.

Table no. 14

Monthly variation in the Inorganic Phosphorus content during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	Nd	0.08	0.43	0.233	0.132	0.15	0.4	0.25	0.05	0.075	0.17	0.14	0.09
Kapurbao	Nd	0.67	0.762	0.584	0.635	0.62	1.12	5.67	5.55	4.13	4.32	4.67	4.81
Chavantali	Nd	0.41	0.39	0.166	0.284	0.32	0.55	1	0.85	0.33	0.19	0.35	0.41
Gaimukh	Nd	0.2	0.15	0.21	0.335	0.37	0.5	0.266	0.65	0.15	0.11	0.26	0.293

All values are expressed in mg/l.
Nd – Not detected

Nitrate

The Nitrate variations are given in table 15 .

In Yamai the increased varition of nitrate was observed upto summer from the winter season. The initial nitrate value was 1.1 mg/l in the month of October later on it was increased as winter progresses. In the early summer steep increase was found and then maximum levels were observed. During summer the values were increased upto 8.97 mg/l. During progress of pre-monsoon nitrates were reduced slightly. In the monsoon, the nitrate was reduced rapidly.

In Kapurbao the nitrate content was found to be very high throughout the year. Initially low concentration of nitrate was observed in winter (i.e. 2.52 mg/l to 5.63 mg/l). The lowest value was found in winter season. Higher concentrations of nitrate were observed with steep increase i.e. 9.89 mg/l to 24.48 mg/l. The highest value was recorded in May.

Nitrate concentration in Chavantali was minimum during winter. It was rangeing within the limit of 1.8 mg/l to 3.97 mg/l. The highest value(10.3 mg/l) was found in summer. Values during monsoon were moderate(i.e. 2.8 mg/l to 3.28 mg/l).

In Gaimukh there was quite contrast pattern than other lakes. The lowest value was found in winter i.e. 0.6 mg/l. It may be due to lack of agricultural run off in summer and late winter In monsoon rain water carries salts and again increased values of nitrate were reported. The high values of nitrate were recorded in the summer season by Rajakumar *et al.*, (2006); Ravikumar *et al* (2006). Kiran *et al.*, (2006).

High nitrate concentration is due to domestic organic pollution in Kapurbao lake. Similar observations were reported by Hussain and Hussain (2003); Jameel and Sirajudeen (2003); Kalita *et al.*, (2006); Sharma *et al.*, (1978) for variations other water bodies.

The highest value of nitrate was correlated with high load of organic waste and also due to various human activities such as bathing, washing of cloths and cattle in case of Chavantali. Similar observations are reported by Srivastava and Srivastava (2003); Murali and Indira (2004). Lalitha *et al.*, (2006) have recorded that oxidation of organic nitrogen substances is enhanced by sewage disposals. Devi and Belgali (2005) have shown relation in high concentration of nitrate and agricultural activities. In the month of

June and July the values of nitrate did not shown comprehensive decrease due to heavy runoff of deposited organic matter, from the catchment area (Golterman, 1975). Bahura, (1998) have recorded high nitrate in temple tank of Bikaner. It was attributed to its long term enrichment with animal wastes of nitrogenous nature.

Reid (1961) has observed the average nitrates in unpolluted freshwater i.e. 0.3 mg/l. Ganapathi (1960); Devaraju *et al.*, (2005); Sharma, *et al.*, (1978) have stated that the polluted water body is rich in nitrate content throughout year than the non-polluted waterbodies. Gaimukh water was shown low values than that of remaining water resources.

Higher concentration of nitrates are useful in irrigation but, their entry in to the water resouces increase the growth of nuisance algae and triggers eutrophication and pollution (Trivedy and Goel, 1986).

Table no. 15

Monthly variation in the nitrate content during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	1.1	1.51	3	4.71	8.97	8.501	8.5	8.71	2.32	0.97	1.21	1.68	2.26
Kapurbao	2.52	3.97	4.64	5.63	9.89	9.22	13.76	24.48	14.12	8.69	9.54	9.81	9.94
Chavantali	1.8	1.8	2.52	3.97	8.81	8.3	7.2	10.3	2.67	1.8	2.32	3.28	3.96
Gaimukh	0.6	0.67	1.78	3.28	8.74	7.1	4.9	6	1.73	2.22	3.33	3.21	1.57

All values are expressed in mg/l.

Chloride

Chloride is a major constituent in wastewater. Chloride ions are generally present in natural water and their presence can be attributed to the dissolution of salt deposits, discharge of effluents, sewage discharges, irrigation etc. An increase in the Chloride content in natural water may be caused due to pollution by sewage. The high concentration of chloride imparts a salty taste and sometimes cause laxative effect on human beings (Veera Bhardam *et al.*, 2004). Young children may suffer if they consume water with high Chloride as their delicate kidney tissue may damage sometime higher osmotic pressure brought about by presence of high concentration of salts (Goyal *et al.*, 2006). High chloride content has deleterious effect on the structure of agricultural plants (Sastry, 2003). The excess chloride concentration is present with excess sodium concentration may cause congestive heart failure, (Brooker and Johnson, 1984; Wesson, 1969), hypertension (DNHW, 1978).

The Chloride variation has been shown in the table 16.

The Yamai lake has shown quite considerable changes in the values of Chloride. It shows fluctuation as per the respective season. During the winter, Chloride ranges between 41.65mg/l and 48.28mg/l. In summer season the chloride values are in the range of 47.09 mg/l to 85.32 mg/l with steep increase. As the arrival of monsoon the value decreases. It resides in the rainy season as 63.42 mg/l to 38.34 mg/l. The lowest value has been recorded in the month of September while highest value in the month of May.

The Kapurbao exhibit the higher values in the month of May. The values of Chloride during the winter season have been recorded between 73.84 mg/l and 83.78 mg/l. During pre-monsoon season the recorded values are between 73.13 mg/l and 89.93

mg/l range. The monsoon shows decreased value of Cl residing in the range of 69.58 mg/l to 53.25 mg/l. But later on again increase has been recorded in further months. The lowest value recorded in the month of July and highest value in the month of May.

The chloride of lake chavantali in winter season show values between 31.47 mg/l to 41.18 mg/l. Summer season follows gradual increasing pattern. The values are in the range of 39.05 to 65.32 mg/l. Values decreases in monsoon and varies from 45.44 to 29.82 mg/l.

In Gaimukh water resource the chlorides found to be comparatively low. It resides in the range of 31.47 mg/l to 46.86 mg/l. during the winter season. In the summer season the chloride values lowered due to altered water which was carried from Kasari river. The pre-monsoon season chlorides were in between 30.53 mg/l and 24.85 mg/l. During monsoon the values do not show much fluctuation. Initially decrease has been recorded and increasing trend was observed in monsoon. The values reside in the range of 23.55 mg/l to 35.5 mg/l during this period. The lowest value recorded in the month of July and highest value in the month of December.

Change in chloride content of the reservoir emphasizes that there are two main factor viz. temperature and rainfall lead to alteration in Chloride content. The higher concentration of chlorides is recorded during the summer season due to evaporation nearly at all studied sites except Gaimukh. Similar kind of observations were recorded by Sivakumari *et al.*, (2005); Chourasia and Adoni (1985). During rainy season there is reduction in chloride content (Khare *et al.*, 2007; Ravikumar *et al.*, 2006; Swaranlatha and Rao 1988; Sharma *et al* ., 1978; Patil *et al.*, 2003; Rajakumar *et al* ., 2006).

According to Guruprasad (2005) the chloride concentration is index value of eutrophication as well as indication of pollution caused by potash fertilizers. Similar kind of observations were recorded in case of Gaimukh. The organic pollution show increased amount of Chloride in water (Ziaudduin and Siddiqui, 2007; Vimala *et al.*, 2006; Panda *et al.*, 2004). Man and animal excreta contains high amount of chlorides together with nitrogenous compounds (Kenwood , 1920; Thrash, *et al.*, 1944; Trivedy and Goel, 1986; Hariharan, 2002). The excretory waste of animals and human is a rich source near Kapurbao lake may possibly increasing chloride values.

Table no. 16

Monthly variation in the Chloride content during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	45.55	45.91	41.65	48.28	47.09	53.25	79.58	85.32	63.42	44.02	45.44	38.34	41.18
Kapurbao	73.84	75.26	76.91	83.78	73.13	70.76	78.81	89.93	69.58	53.25	63.42	65.32	62.96
Chavantali	41.18	31.47	35.02	36.12	39.05	48.28	65.32	65.32	45.44	29.82	31.24	31.24	35.5
Gaimukh	41.18	31.47	46.86	45.44	30.53	24.85	29.11	29.82	26.98	23.56	29.82	35.5	34.14

All values are expressed in mg/l.

Sodium

As per the report of HEC (1972) high sodium in drinking water is harmful to the person suffering from cardiac, renal or circulatory diseases. The presence of sodium and potassium content most important for the water used for irrigation (Buddhi *et al.*, 2002). The application of water having undesirable Na^{++} and Mg^{++} , $CO3^{--}$ and $HCO3^{-}$ in agriculture give rise to soil salinity and soil permeability problems (Shrinivas *et al.*, 1984).

The sodium (Na) content variations in the present investigation has been shown in the table 17.

The Na values vary as per the season and site. Yamai lake shows Na content from 8.14mg/l to 9.05mg/l during winter season. During summer season sodium ranges between 8.24mg/l and 1.38mg/l. During April and May sudden increase in concentration was recorded. From the arrival of monsoon lowering in the concentration of Na was observed. In late monsoon months again increased concentration was found. The highest value recorded from the site was in the month of May while lowest value observed in August.

The Kapurbao has shown comparatively high degree of concentration of these ions than that of remaining sites. During winter season the values remained in between 9.84 mg/l and 13.52 mg/l. Arrival of summer caused gradual increase from February to April. The values remained in the range of 14.13 mg/l to 17.92 mg/l. During monsoon decrease in the content recorded and it was varying from 10.19 mg/l to 12.26 mg/l. The highest value recorded in the month of April while lowest value was found in the month of July.

For Chavantali recorded range of Na during winter season was 7.53 mg/l to 8.56 mg/l. During the summer season concentration was increased (10.19 mg/l to 11.84 mg/l). On the onset of monsoon the lowering occurred in between 8.59 mg/l to 11.15 mg/l. The lowest value recorded in the month of July while higher concentration was recorded in the month of May.

There is no seasonal pattern for Gaimukh. During winter season the value found in between 5.64 mg/l to 7.30 mg/l while for pre-monsoon period higher concentration in between 2.28 mg/l to 7.08 mg/l was recorded. The monsoon period showed lowest value ranging in the limit of 4.19 mg/l to 2.11 mg/l. The highest peak recorded during winter period in the months of December & January. The lowest peak was recorded in the July.

Higher Sodium content observed during summer season may be attributed to decreased water level. Sidana and Karim (1984) have reported the maximum sodium content in dry season. Higher Na values during summer and decrease during rainy season is reported by Prasad *et al.*, (2005); Rajakumar *et al.*, (2006); Meenakumari and Hosmani (2004); Sah *et al.*, (2000); Singh *et al.*, (2002); Singh and Gupta (2004).

Here sodium is more in concentration than potassium. The observation is also shown by the report of Kannan and Ramasamy (1993). According to Suthar *et al.*, (2005); Parker *et al* (1987), the domestic waste contributes in increase of the sodium.

Table no. 17

Monthly variation in the Sodium content during the year Oct 2006 – Oct 2007

Site ↓	Month →											
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	Nd	8.75	8.14	9.05	8.55	8.24	12.28	15.38	10.08	7.28	5.91	8.15	9.57
Kapurbao	Nd	9.84	12.5	13.52	14.13	16.8	17.92	17.28	10.61	10.19	11.71	12.26	11.96
Chavantali	Nd	8.56	8.31	7.53	10.19	10.52	10.9	11.84	9.04	8.597	10.277	11.15	13.67
Gaimukh	Nd	5.64	7.3	7.3	5.62	2.28	4.46	7.08	4.19	2.114	2.756	2.591	4.59

All values are expressed in mg/l.
Nd – Not detected

Potassium

The potassium (K) variation during the present investigation is depicted in Table 18.

Present results clearly indicate that, potassium differs in different water bodies as per the season. In water source of Gaimukh significant values of potassium were recorded. During the winter season concentration remains in the range of 1.91 mg/l to 2.02 mg/l. During the pre-monsoon season it remained in between 1.03 mg/l and 2.85 mg/l. From the month of March K concentration goes on decreasing. As the monsoon arrives, K concentration falled down from June. The concentration during monsoon season was in between 0.98 mg/l to 1.23 mg/l. The peak recorded in the month of march during pre-monsoon season. The lowest value was recorded in the month of July during monsoon .

Yamai water showed higher concentration of potassium content than that of Gaimukh and Chavantali. Potassium content varied from 5.81 mg/l to 7.34 mg/l. The average value was increased during the summer season and the concentration ranged between 6.47 mg/l and 8.63 mg/l. The peak value was recorded during summer. Rainfall reduces the concentration of 'K' due to dilution. The lowest value is recorded in the month monsoon.

The Kapurbao water exhibited highest concentration of potassium. During winter season the range was from 6.90 mg/l to 7.58 mg/l. The lowest concentration was recorded in the month of December. As the summer progressed the concentration was increased in the range of 7.08 mg/l to 10.28 mg/l. The rain causes reduction in the potassium concentration. The values ranged between 8.16 mg/l and 9.23 mg/l.

The K level of Chavantali during winter season was in the range of 3.36 mg/l to 4.86 mg/l. During summer season higher content was observed varying from 2.96 mg/l to 7.78 mg/l. The highest concentration was observed in the month of May. The values during monsoon season varied from 6.297 mg/l to 4.39 mg/l. The highest peak was recorded during summer in the month of May.

The results reported by Goyal *et al.*, (2006); Prasad *et al.*, (2005); Singh and Rai (2003) indicates high concentration of potassium during pre-monsoon season than the monsoon and post monsoon season. Similar kind of trend is recorded in all lakes during present investigation. There are no specific standards of the potassium for either drinking water or effluent sample (Maiti, 2004).

The higher concentration of potassium is generally associated with increased level of pollution (Sathe *et al.*, 2000 and Hujare, 2005).

Table no. 18

Monthly variation in the Potassium content during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	Nd	6.26	5.81	7.34	6.62	6.47	8.63	6.48	5.41	4.73	5.17	6.09	6.57
Kapurbao	Nd	7.21	6.9	7.58	7.08	7.42	9.9	10.28	8.54	8.16	8.96	9.23	7.68
Chavantali	Nd	3.36	3.45	4.86	2.96	5.53	7.34	7.78	6.297	4.397	4.812	5.51	6.346
Gaimukh	Nd	1.91	2	2.02	1.03	2.95	2.79	2.2	1.05	0.98	1.15	1.232	2.094

All values are expressed in mg/l.
Nd – Not detected

Calcium

The calcium (Ca) is an essential constituent for human being. Low content of calcium in drinking water may cause rickets and defective teeth. It is essential for nervous system, cardiac function and in Coagulation of blood (Khurshid *et al.*, 1997). It is an important constituent of the skeletal structure of organisms. (Thilaga *et al.*, 2005). Calcium is most abundant element in human body. Higher calcium content in drinking water causes encrustation in water supply structures and adversely affects on domestic use (Raghvendran, 1992). Water with high concentration of Ca is not desirable in washing, laundering and bathing owing to its suppression of formation of lather with soap. The quantities of calcium in natural water vary depending upon the types of the rocks (Guru Prasad, 2003). Ca^{++} and Mg^{++} occurs in water mainly due to the presence of lime stone, gypsum and dolomite material. Ca and Mg are the major constituents in raw water.

Variation in the concentration of calcium during present study (October 06 to October 07) is depicted in Table 19 .

Yamai water body was showing Calcium range in between 16.81 mg/l and 17.53 mg/l during summer season. During summer season the values found to be higher than winter. The values have been remaining in range of 18.6 mg/l to 28.86 mg/l. During rainy season the values of calcium vary from 19.26 mg/l to 23.11 mg/l. From late monsoon calcium found to be slightly increased in gradual manner upto the last record. The highest value recorded for present site was in the month of may while lowest in the month of November.

The values of calcium concentration during winter season ranged from 28.8 mg/l to 31.97 mg/l. During summer season calcium in Kapurbao resided in between 29.8 mg/l to 42.8 mg/l. The highest value was found in the month of may. During summer calcium level went down probably due to growth of water hyacinth.

The Chavantali lake water was showing quite significant variation in calcium values with a specific seasonal pattern. During winter season the variation recorded was 21.24 mg/l to 27.89 mg/l. In the summer season the values were found to be increased than winter. But from late summer slow decrease was observed. Thus in monsoon lowering of values recorded in between the range of 10.78 mg/l to 26.87 mg/l. The highest value was noted in the month of March. The lowest value recorded in the month of August.

The Gaimukh lake water was showing a gradual increase in calcium amount in the water during the winter season. The values were found to be in between 17.53 mg/l and 23.87 mg/l. During the summer season the values recorded in between 20.6 mg/l to 23.76 mg/l. The values are not higher than that of winter. It may be due to addition of water from river Kasari to lake. As the monsoon arrived in rainy season the values got lowered from 21.79 mg/l to 19.08 mg/l. The highest value was recorded in the month of January (23.87 mg/l). The lowest value was recorded in the month of July (19.08 mg/l).

The maximum desirable limit of calcium in drinking water is 75 mg/l. and maximum permissible limit is 200 mg/l. (ISI 1983). The concentration of calcium ions in present water bodies is within the desirable limit for all sites.

Iqbal and Katariya (1995) have reported increased in Calcium and Magnesium from winter to summer may be due to evaporation. Hujare (2005) recorded that the Ca^{++} may reach the maxima in summer season for Vadgaon reservoir. Rajakumar *et al.*, (2006); Kannan and Ramasamy (1993); Sah *et al* (2000); Singh *et al*; (2002); Sharama *et al.*, (1978); Singh and Rai (1988); Goyal *et al.*, (2006) recorded higher Ca in summer months and decreasing pattern in monsoon months.Similar trend has been observed for Jotiba lakes.

Kant and Raina (1990) has given that less Ca^{++} may be due to utilization of Ca^{++} by macrophytic vegetation during winter and monsoon.

Table no. 19

Monthly variation in the Calcium in the water content during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	17.53	16.81	17.43	17.4	18.6	23.26	21.06	28.86	21.95	19.26	22.54	23.11	24.53
Kapurbao	31.97	28.8	31.54	30.59	29.8	37.35	32.75	42.8	31.12	26.78	28.55	29.12	27.31
Chavantali	21.44	24.74	21.14	27.89	30.43	31.53	21.66	13.92	12.11	12.52	10.78	26.87	19.26
Gaimukh	17.53	19.5	23.57	23.87	21.79	20.6	21.46	23.76	20.49	19.68	20.14	21.79	20.94

All values are exprcssed in mg/l.

Magnesium

The Magnesium is essential for all living organisms and especially for chlorophyll bearing organisms, since it is important constituent of chlorophyll. High concentration of Mg^{++} reduces utility of water as domestic use. It also imparts unpleasant taste. High concentration also proves to be as diuretic (Trivedy and Goel, 1986). Magnesium is moderately toxic element if its concentration in drinking water is high. If high concentration of magnesium is combined with sulphate results laxative effect. It is also found that the persons living in area containing water reservoir with higher hardness; magnesium and potassium are significantly increased in heart muscles (Khurshid *et al.*, 1997).

Magnesium variation during present investigation from October 06 to October 07 is depicted in the Table 20 .

Yamai lake water showed gradual increase in Magnesium during winter season. The range was in between 8.24mg/l and 9.39mg/l. During summer season it showed high values of Magnesium than the winter varied from 9.15mg/l to 11.73mg/l. The monsoon arrival impartsed lowering in concentration. In the late monsoon season increase in the values was again observed. The highest value was recorded in the month of March during summer & lowest value was recorded during December.

For Kapurbao the magnesium found to be in the range of 12.62mg/l to 17.71mg/l. During pre-monsoon season the values of Magnesium recorded from 14.14mg/l to 23.62mg/l. In the late summer month i.e.May steep decrease in Magnesium level was recorded. The highest value recorded in the month of March while lowest value was recorded in May. During monsoon season low was recorded concentration than that of summer and winter.

For the lake Chavantali comparatively low amount of Magnesium was recorded than the Kapurbao. Chavantali lake showed variation of Magnesium during winter from 7.41mg/l to 12.02mg/l. The summer season could not show much more increase in the values and remained in the range of 8mg/l to 12.14mg/l. The monsoon season showed quite low values than the winter & Monsoon season. They reside in between 7.96mg/l to 4.51mg/l. The minimum value was recorded in the month of July while maximum value was recorded in the month of May.

Gaimukh lake showed the values between 8.24mg/l and 15.9mg/l. with increasing pattern in winter season. The increase in values continued towards summer season and reside from 11.03 to 17.15 mg/l. The peak value was recorded in the month of March. Due to the monsoon effect magnesium concentration lowered down and varied from 12.6 mg/l to 8.09 mg/l. The least value was recorded in the month of August.

Hujare (2005) reported maximum magnesium during summer season than other season. The observation is also recorded by Kataria *et al.*, (1995); Naik and Purohit (1996); Patil *et al.*, (2003); Meena kumari and Hosmani (2004). Kannan and Ramasamy (1993). All the authors have recorded higher Mg in summer months and decreasing pattern in monsoon months. Similar trend has been recorded by Sah *et al.*, (2000); Singh *et al.*, (2002); Sivakumari, *et al.*, (2005). Sharma *et al.*, (1978) also.

Magnesium occurs in all kinds of natural water resources alongwith calcium. Principal sources in natural water are rocks and sewage. Industrial waste also contributes to magnesium Guruprasad, (2003). Suresh *et al.*, (1986), have reported high concentration of calcium and magnesium in Ganga river, attributed to discharge of sewage mixed effluents. In Kapurbao heavy discharge of domestic waste may be the cause for Magnesium.

Murugesan *et al.*, (2004) have recorded the decreasing pattern of Magnesium from monsoon to winter with lowest value in winter is season. Ravikumar *et al.*, (2006); Shatri (2000) have stated that when the rainfall is high it depletes magnesium quantity in water.

Table no. 19

Monthly variation in the Magnesium content during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	**Nov**	**Dec**	**Jan-07**	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept.**	**Oct-07**
Yamai	8.24	9.39	9.07	9.34	9.46	11.73	9.15	10.94	10.09	9.23	10.4	10.12	11.09
Kapurbao	12.62	17.71	15.86	14.78	14.14	23.62	16.59	8.58	10.38	9.78	11.42	10.97	13.53
Chavantali	12.02	8.62	10.11	7.41	8	9.69	9.63	12.14	7.64	4.51	5.48	7.96	10.55
Gaimukh	8.24	14.56	15.9	15.54	11.03	17.15	13.88	15.1	12.6	10.08	8.09	10.73	12.33

All values are expressed in mg/l.

Copper

Copper (Cu) is an essential trace element in nutrition of plant and animals including human being. It is required for the function of several enzymes and is necessary in biosynthesis of chlorophyll (Chatterjee, 1984). Copper is strongly bound to organic matter and sulphide fraction in water (Smies, 1983). Up to 2 mg/l copper ions are essentially required for healthy adult human being. Copper in water in large quantity irritate stomach cause neuralogical complaints, liver and kidney disfunction, cancer and accelerate aging (Pfeiffer and Mailloux, 1987); whereas deficiency of Cu can lead to high serum cholesterol and an increased risk of cardiovascular diseases (Singh, 2003).

The copper variation during present analysis from October 06 to October 07 is presented in the Table 21.

Copper variation shows a specific pattern in case of Yamai water body. During winter season the copper content ranged in between 0.009 mg/l and 0.019 mg/l. In the month of March it reaches to its peak (0.03 mg/l). The presence of Cu was found only upto the month of May. During further months Cu concentration was found to be zero in the lake. During late monsoon negligible content of copper was observed.

Kapurbao lake water showed the different kind of pattern for Cu than Yamai. During winter, Cu concentration remained in the range of 0.012 mg//l to 0.019 mg/l. The sudden increase was recorded in the month of March (0.026 mg/l). Cu was found in the lake upto the month of April.

In Chavantali copper content was found to be increasing during the winter, ranging from 0.002 mg/l to 0.011 mg/l. In summer high values between 0.015 mg/l and 0.024 mg/l were recorded. Cu was not detected during rainy season. The maximum value was recorded in the month of April.

The Gaimukh water showed similar trend like Chavantali. The range of copper was in between 0.007 mg/l to 0.016 mg/l during winter. The increase can be seen from winter to summer (0.019 mg/l to 0.061 mg/l). Highest value was reported in the month of March. May onwards no copper was detected.

World Health Organisation (1971) has indicated that the highest desirable level of copper in drinking water is 0.05 mg/l and maximum permissible level is 1.5 mg/l. In present investigation the copper concentration is recorded below the permissible limit in all water bodies.

Sah *et al.*, (2000); Singh and Gupta (2004); Kannan and Ramasamy (1993) have reported high content of Cu in the summer season, suggested that fluctuation in concentration may be due to bioaccumulation in flora and fauna.

Table no. 21

Monthly variation in the Copper content during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	0.009	0.012	0.01	0.019	0.007	0.03	0.013	0.01	Bdl	Bdl	Bdl	0.002	0.004
Kapurbao	0.015	0.019	0.014	0.012	0.011	0.026	0.019	Bdl	Bdl	Bdl	Bdl	0.013	0.009
Chavantali	0.002	0.002	0.007	0.011	0.015	0.019	0.024	Bdl	Bdl	Bdl	Bdl	0.005	0.008
Gaimukh	0.009	0.008	0.007	0.016	0.019	0.061	0.032	Bdl	Bdl	Bdl	Bdl	Bdl	0.006

All values are expressed in mg/l.
Bdl – Below detectable limit

Iron

The iron (Fe) is one of the abundant transition element and well known metal in biological system. Under reducing condition, iron exists in ferrous state. In the absence of complex forming ions ferric ion is not significantly soluble unless the pH of water is low. Iron in the water can cause staining of laundry and porcelain and also a bitter sweet astringents test detectable by some persons at level above 1-2 mg/l (Pandey and Corney, 1989). Hemoglobin in the blood of all vertebrates, the oxygen carrying protein molecule is regarded as the complex consisting of globin proteins with four heme units attached to it. Shapiro (1963; 1964) has noted a close correlation between the metal and the concentration of yellow organic acid in the water. Lamar (1968) suggested that iron probably as ferric hydroxide or oxide, forms colloidal solutions with organic water (polymeric hydroxyl carboxyl acid) in natural surface water. According to Sholkovitz *et al.*, (1978) more than half of the total quantity of iron in the natural water is transported with organic acids. Fe is a constituent of cytochrome and nonheme iron proteins involved in photosynthesis, nitrogen fixation and respiratory linked dehydrogenase (Noggle and Fritz, 1986). Heavy metals have deleterious effect at low level in the drinking water (Khurshid and Zaheeruddin, 2000;Tyagi and Buddhi, 2000).

The iron content from various water bodies are given in the Table 22. The table shows variation of iron in all water resources of Jotiba. The pattern is season dependant.

The Yamai water body has of 0.019 mg/l to 0.047 mg/l iron content during winter . During summer very high concentration was found. The average maximum value was recorded March (0.031 mg/l to 0.059 mg/l). The Iron concentration was lowered down to the range of 0.026 mg/l to 0.036 mg/l in monsoon. The minimum iron content was reported in the month of October during the winter season.

The Kapurbao water resource exhibit iron content with the range of 0.011 mg/l and 0.032 mg/l in winter. In summer the content of Fe increased and values are from 0.013 mg/l to 0.068 mg/l. The values lowered down in rainy season due to dilution effect (0.051 mg/l to 0.019 mg/l). Higher concentration of Fe content was found in summer (May) and lower concentration of Fe in the winter.

For Chavantali a definite pattern is observed with gradual increasing Fe content from winter to summer. The values in winter varies from 0.01 mg/l to 0.07 mg/l. Where as the summer values are from 0.088 mg/l to 0.09 mg/l.

The Gaimukh water body show maximum amount of iron during summer. In winter season, the range is 0.012 mg/l to 0.022 mg/l. The values greatly increased in summer may be due to water import process from the river with the help of iron pipe. The values recorded in the range of 0.03 mg/l to 0.057 mg/l in February. In the monsoon season minimum values were obtained (0.003 mg/l to 0.014 mg/l) i.e. in the month of June.

It is interesting note about the Fe sources here. There are two possibilities of sources of iron. It may come from the various geological strata through which water passes in which it is stored. Secondly, it may come from corrosion of iron pipes used (Bhosale, 2004). Similar kind of observation for Gaimukh is made. In this lake, iron pipes are utilized for water import as well to export from lake.

During summer months iron content was higher than the other seasons. Similar kinds of reports were given by Kannan and Ramasamy (1993); Murugesan *et al.*, (2004); Sah *et al.*, (2000); Rajurkar *et al.*, (2003 b); Singh and Gupta (2004); Khare *et al.*, (2007); Goyal *et al* ., (2006). The present finding also focuses on the anthropogenic incorporation of the metals from the vehicle services/repairing as well as from household and agriculture waste products.

Table no. 22

Monthly variation in the Iron content during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	0.019	0.022	0.032	0.047	0.057	0.031	0.045	0.059	0.026	0.021	0.036	0.026	0.041
Kapurbao	0.011	0.014	0.024	0.032	0.041	0.013	0.013	0.068	0.051	0.029	0.017	0.019	0.031
Chavantali	0.01	0.019	0.032	0.071	0.088	0.075	0.09	0.029	0.014	0.009	0.006	0.025	0.045
Gaimukh	0.019	0.018	0.012	0.022	0.03	0.572	0.029	0.076	0.003	0.004	0.005	0.014	0.034

All values are expressed in mg/l.

Manganese

Manganese occurs widely in nature. Biologically it is an essential micronutrient for most organisms. Excess amount of Manganese affects the animals adversely, causing cramps, tremors and hallucination, manganetic pneumonia and renal degeneration. Manganese dissolved in natural water as divalent state (Ramteke and Moghe, 1986). The solubility of Mn in natural water is largely a function of the pH and the oxidation reaction potential (Bowen, 1966). Mn is least toxic among the essential metals. At the concentration greater than maximum permissible limit Mn is toxic to animals and man. It cause growth retardation, fever, sexual impotence, mascular fatigue and eye blindness (Chatterjee, 1984). Mn poisoning is sometimes found as an occupation disease, but as with many other trace elements, it is essential in small amount for life processes (Pandey and Carney, 1989).

The variation in the Manganese content during the present investigation has been shown in the table 24.

The table clearly indicates that the Mn differs in different water bodies as per the season. The waterbody Gaimukh has shown significant values of Mn content. During the winter season the concentration has been recorded 0.003 mg/l in early months i.e. October and November while later months the range was below dectable limit or absency of the element. During summer season the substencially rich concentration of Mn was found. The highest value was recorded in the month of March (0.0496 mg/l). It was slowly decreased in further months. In May the value recorded is 0.0194 mg/l. But after the monsoon the range goes down below detectable limit and recored as absent. Mn was not detected in Monsoon and late winter.

The Yamai lake has substancially enriched content of Mn than other lakes. In winter season Mn concentration varies from 0.0021mg/l to 0.0145 mg/l with gradual increase.The average value increased in the pre-monsoon months (0.0131 mg/l to 0.0411 mg/l). The maximum content was 0.041 in the month of April. The rainfall affects the concentration of Mn and results into the decreased content. The value ranges from

0..0074 mg/l to 0.0031 mg/l. The lowest value was found to be 0.0021 mg/l in the month of November. The Kapurbao exhibit Mn content to the significant level during the pressent work. The winter season range was from 0.0012 mg/l to 0.0043 mg/l with gradual increase. As summer season progresses increases (0.0037 mg/l. to 0.177 mg/l). The highest Mn was in the month of May. As the monsoon add the water to waterbody the concentration slowly decreases and the value varies from 0.064 to 0.006 mg/l. The lowest value was recorded in the month of November.

In Chavantali the concentration of Mn during winter season ranges between 0.001 mg/l to 0.012 mg/l. The summer season shows higher concentration of Mn content and it varies from 0.007 to 0.022 mg/l. During premonsoon period Mn was not detected. The highest value was in the month of March. Singh and Gupta (2004); Kannan and Ramasamy (1993) have reported the higher Mn values in premonsoon season , similar trend has been recorded during present piece of work for all sites.

Table no. 23

Monthly variation in the Manganese content during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	0.003	0.0021	0.007	0.0145	0.013	0.0268	0.0411	0.015	0.00741	0.00311	0.00372	0.0063	0.0084
Kapurbao	0.0013	0.0012	0.0031	0.0043	0.0037	0.0052	0.025	0.177	0.064	0.012	0.007	0.006	0.031
Chavantali	0.001	0.001	0.008	0.012	0.007	0.022	0.0079	0.008	Bdl	Bdl	Bdl	0.00282	0.0041
Gaimukh	0.003	0.003	Bdl	Bdl	Bdl	0.0496	0.0039	0.0194	Bdl	Bdl	Bdl	Bdl	Bdl

All values are expressed in mg/l.
Bdl – Below detectable limit

Oil and Grease

The oil and grease content of various water bodies of Jotiba is depicted in the Table 24.

The oil and grease content of the lake Yamai was greater. The table shows a specific pattern of oil and grease content. The oil and grease content during winter season was recorded in between the range of 0.0637 mg/l and 0.0815 mg/l. Sudden increase in the oil and grease content in the month of November may be attributed to 'Dashara' when visitor comes to visit the God and offer oil in temple. During summer season the values showed great increase. This may be due to increase in the number of devotees to the site. The month march is the month of 'Chaitra' as per the 'Chandramaan Calender'. In this month visitors come every Sunday as a ritual activity. At the end of the month on full moon day (Poornima), a grand fair held known as 'Chaitra-Yatra'. On this occasion nearly about 40-50 lakh devotees come to visit the hill. Devotees offer oil to temple as well as to lake directly. These activities leads to increase in value during summer specifically in the month of April. It is above the permissible limit ranging from 0.0741 mg/l to 0.1893 mg/l. Surprisingly the value lowered down in the next month due to outlet utilization of lake to remove waste held by lake during ritual activity. Still the values were remained above permissible limit. During monsoon the after effect of Yatra were ended. The values came to minimum limit. The peak concentration of oil and grease for the lake was recorded in the month of April in summer. The least value found to be recorded in the month of August.

Kapurbao water resource showed the presence of oil and grease. But the concentration of oil and grease was not high as recorded in Yamai. The human interaction, use of soaps and detergents sometimes leads to higher concentration. During the winter season contents resided in the range from 0.0416 to 0.0443 mg/l. During summer the high increase was recorded specifically in the month of April and May due to heavy washing as well as domestic sewage. The values found in between 0.0379 mg/l and 0.593 mg/l. In monsoon season it was observed due to rain water addition. The content was lowered to 0.0312 mg/l to 0.0284 mg/l. The highest peak was recorded in the month of April while least value in July.

In Chavantali the oil and grease concentration was low than that of Yamai and Kapurbao. The value during winter season recorded were 0.0228 mg/l to 0.0263 mg/l. During the pre-monsoon season concentration vary from 0.0242 mg/l to 0.0347 mg/l. During monsoon the values were greatly reduced and remained in between 0.0262 mg/l to 0.0103 mg/l. The maximum concentration for Chavantali was recorded in the month of April and the minima was observed in the month of August.

The Gaimukh water exhibited lowest concentration of oil and grease among the all investigated site. The investigation of Gaimukh revealed that concentration of oil and grease in the range of 0.0137 mg/l to 0.0123 mg/l . During the summer season increase was recorded due to the lake site utilization for by resting spot for the devotees who walks to hill by road. The concentration during summer season was from 0.0139 to 0.0287 mg/l. In rainy season the oil and grease content was limited to the range of 0.0142 mg/l to 0.0091 mg/l. The highest values was recorded in the month of April. While lowest was found in the month of August.

As per the International Standards (1991) the 0.03 mg/l of oil and grease is permissible to any water body. For currently investigated sites the values found to be within the permissible limit for Gaimukh. Remaining lakes shows the concentration of oil and grease content above permissible limit during the summer season. But as monsoon arrives the values reduce to the permissible limit except Yamai.

Table no. 24

Monthly variation in the Oil and Grease content during the year Oct 2006 – Oct 2007

Site ↓	Month →												
	Oct-06	Nov	Dec	Jan-07	Feb	March	April	May	June	July	Aug	Sept.	Oct-07
Yamai	0.0637	0.0815	0.0691	0.0741	0.0807	0.1129	0.1893	0.1042	0.0858	0.0416	0.0312	0.0428	0.0369
Kapurbao	0.0439	0.0416	0.0443	0.0419	0.0434	0.0563	0.0598	0.0379	0.0312	0.0284	0.0288	0.0304	0.0316
Chavantali	0.0253	0.0263	0.0242	0.0228	0.0242	0.0307	0.0347	0.0293	0.0262	0.0119	0.0103	0.0121	0.0156
Gaimukh	0.0137	0.0123	0.0137	0.0131	0.0139	0.0255	0.0287	0.0178	0.0142	0.0093	0.0091	0.0114	0.0147

All values are expressed in mg/l.

- ## Biomonitoring

  Introduction

  Bacteriological Study

  Phytoplankton Monitoring

Introduction

For any ecological work monitoring is very important. Monitoring gives an idea about temporal changes of any parameter. From aquatic ecosystem point of view biomonitoring is important as good as physico-chemical monitoring. Biological community is influenced by or dependant upon physical situations of its environment. On the other hand relative occurrence of organisms speaks more or throw the light on physical situation.

In case of pond ecosystem, water is a major component and bacteria as well as phytoplankton are organisms which can monitor the study of changes in physical situation. Generally the growth of bacteria is parallel to the organic matter and nutrients present in water body. High bacterial count is indication of sewage pollution. In natural water phytoplankton are abundant with specific balance. Physical alteration of water may cause disturbance in this balance and therefore one can evaluate this change by studying phytoplankton indices.

In the present work two biological parameters are worked out as biomonitoring. In case of bacteria Standard Plate Count (SPC) is studied seasonally while the phytoplankton were collected and identified seasonally. Different indices are also studied.

Study of coliforms is the important tool for monitoring of faecal pollution. Coliforms may added from soil but the major source is fecal matter coming directly or from sewage. Its presence indicates probable occurrence of human pathogenic organisms in water body.

Bacterial study

The recent decision of WHO emphasizes that water given to people should meet requirements to modern hygiene and it must be free from toxic substances and pathogenic organisms. Water sanitation and health are closely related, poor hygiene, inadequate quantity and quality of drinking water and lack of sanitation facilities cause millions of the world's poorest people to die from preventable disease each year and women and children are main victims (Ssemakula, 2002). A serious source of contamination can also be subsurface disposal of domestic wastewater (Hammer and Hammer, 2002). Natural water receive significant microbial load through domestic sewage, animal excreta and industrial wastes.(Indrabai and George, 2002). According to WHO (1984) the greatest pollution hazards to which drinking water is exposed , recent contamination by sewage or faeces of human and animal origin. Organisms used as indicator of faecal pollution include the coliform group of organisms. Presence of such indicators even in treated water system make it inevitable to screen the potability of water (Geldreich, 1976).

The results of total bacterial count has been presented in table 25. The total bacterial count found high in rainy season in all lakes. Comparatively among the lakes Kapurbao shows highest bacterial presence followed by Yamai and Chavantali respectively . In Gaimukh lowest total bacterial count for monsoon season has been recorded.

During winter season the moderate SPC has been found as compare to remaining seasons. The values recorded in winter shows high bacterial presence in Chavantali lake than other sources while Gaimukh shows least count.

In summer season lowest bacterial presence has been found in comparison with other season. High bacterial growth was recorded in Yamai lake during summer while lowest found in Gaimukh.

In present investigation it is recorded that the high average bacterial population in monsoon than summer and winter. Similar type of reports have been documented by Bahodor *et al.*, (2004; 2005); Sobsey (1999); Royee and Prakasam (2003); Prajapati and Mathur (2005). Various water sources may contain not only the natural and the soil bacteria but also large number of organisms derived from sewage. The different types of bacteria present within drinking water network exhibit very heterogenous and complicated pattern (Chrstian and Pipes, 1983).

The results of coliform studies has been presented in table 26. The total coliform show maximum presence in monsoon season lowest in summer. In monsoon high coliforms recorded from Kapurbao followed by Yamai and Chavantali. The lowest value was observed in Gaimukh. During winter moderate faecal pollution was observed. In summer season overall lowest value for faecal coliform shown by Gaimukh. The occurrence of faecal coliforms in microbial examination of water is an important because presence of faecal contamination indicates domestic sewage, human or animal excreta addition and its extend of risk to human health similar records observed by Moriniga *et al.*, (1992); Ramteke *et al.*, (1992); Rajurkar *et al.*, (2003). The faecal coliforms are abundant in monsoon than winter. Faecal disposal near the waterbody which can contaminate the water. This phenomenon happen especially during the monsoon season and winter season and because of the rainfall microorganisms enter in the waterbody and then contaminate the water at Kapurbao, Yamai and Chavantali lakes. Similar pattern has been recorded by Bahador *et al.*., (2004). Coliforms are above permissible limit may also due to domestic sewage run through improper drainage, open fields defecation and improper methods of disinfection of water (Agarkar and Tombre, 2005).

Singhal and Mahto (2004) reported that the water hyacinth stabilize the water quality and substantial support to bacterial density. Similar kind of observations were recorded in Kapurbao lake, that the water hyacinth growth and inadequate sanitationary measures leads to decay of plant parts in water body providing flourishing environment for bacterial growth.

Curriero *et al.*, (2001) investigated and showed that relationship between outbreaks of water born diseases and heavy rainfall events in a more systematic fashion. Heavy rainfall leads to water runoff into surface water sources which has high count of bacteria as well as potential pathogens (Doran and Linn, 1979; O'Shea and Field, 1992; Tunnicliff and Brickler, 1984). The observation may true in case of present work.

Table no 25. Total bacterial number recorded in studied sites seasonally.

Season ↓	**Site →**			
	Yamai	**Kapurbao**	**Chavantali**	**Gaimukh**
Winter	290	215	320	25
Summer	180	125	103	16
Monsoon	318	356	231	64

Values are expressed in $X10^{-2}$ per ml.

Table no 26. Comparative occurrence of total faecal coliform in different waterbodies.

Season ↓	Site →			
	Yamai	Kapurbao	Chavantali	Gaimukh
Winter	29	41.5	20.5	10
Summer	70	83	45	6.5
Monsoon	176	182	164	16

Values are expressed in $X10^{-1}$ per ml.

Phytoplankton Monitoring

The term plankton was I[st] time used by Vector Henson in 1887, comes from Greek word meaning as wonderers. It consists of floating plants and animal components. One of the important aspect of the plankton is the productivity in aquatic ecosystem. By this term aquatic ecosystem consists quality and quantity of microscopic plants and animals i.e. phytoplankton and Zooplankton. Phytoplankton plays a vital role in the biological treatment of organic wastes in water. These phytoplankton supply the oxygen. Therefore the evaluation of population, density, periodicity and succession, biomass and productivity of phytoplankton is very important in monitoring of a water body (Pailwan, 2005).

Table 27 depicts the phytoplankton recorded from Yamai lake. The Yamai lake shows 37 species of phytoplankton from the various group. The group wise distribution of phytoplankton is represented by Chlorophyta- 17; Chrysophyta- 4; Euglenophyta- 7; Pyrrophyta- 1; Cyanophyta- 8 with total of 37species (17 + 4 + 7 + 1 + 8 = 37). This 'numerical sequential index' indicates the dominance of group Chlorophyta followed by Cyanophyta> Euglenophyta> Chrysophyta> Pyrrophyta. The Chlorophyta, the various species recorded are *Ankistrodesmus sp., Characium limneticum, Chlorella sp.1, Chlorellidiopsis saparabilis, Chlorococcum sp., Closterium spp, Cosmarium sp. Crucigenia tetrapedia, Kirchneriella sp., Scenedesmus acuminatus, Tetraedron spp., Ulothrix sp., Westella linearis, Spirogyra sp.* The Pyrrophyta group has been represented by single species *Ceratium huridenella.* The second highest group is Cyanophyta comprising 8 species including *Chrococcus sp., Spirulina sp., Merismopedia spp.,* *Microcystis spp., Oscillatoria sp.*. Euglenoids are represented by *Trachelomonas spp., Phacus spp., Euglena spp.* From group Chrysophyta *Synedra acus, Pinularia sp., Cyclotella sp., Fragellaria sp.*

The seasonal diversity of phytoplankton is shown in Yamai table 28. It represents high frequency distribution in summer season with 34 species followed by 28 species in winter . In monsoon season diversity of planktons recorded to 20 species.

Table 29 shows the species diversity of phytoplankton from Kapurbao. The Kapurbao lake has total 35 species. The numerical sequential index is 17 + 7 + 6 + 0 + 5 = 35. The Chlorophyta group is dominant followed by Chrysophyta> Euglenoids> Cyanophyta. The Chlorophyta group is included by *Monoraphidium copricornutum, Ankistrodesmus spp., Characium limneticum, Chlorella sp., Chlorochytrium sp., Chlorococcum sp., Closterium spp., Cosmarium sp., Crucigenia tetrapedia, Elakatothrix biplex, Scenedesmus sp.,Spirogyra sp., Tetraedron spp.* The Pyrrophyta members are absent. The Chrysophyta group is represented by *Synedra acus, Pinularia spp., Navicula spp., Dinobryon sp., Cyclotella sp.* The Euglenophyta comprises about 6 species of *Euglena spp., Phacus acuminatus, Trachelomonas sp.* The Blue Green Algae (BGA) group is represented by 5 species *Oscillatoria sp., Microcystis spp.,* and *Chroococcus sp.*

The seasonal variation of phytoplankton is represented in Kapurbao table 30. The table indicates higher species diversity in the winter while lowest diversity is observed in summer season. The winter season exhibits 34 species while 16 species are present in monsoon and 8 in summer.

Table 31 exhibits the species of phytoplankton recorded from Chavantali lake. The Chavantali is rich in phytoplankton in comparison with other lakes. Sixty five species have been recorded. The numerical sequential index is 34 + 18 + 5 + 1 + 7 =65. This indicates group wise dominance as Chlorophyta> Chrysophyta > Euglenophyta> Cyanophyta > Pyrrophyta. This indicates dominant group is Chlorophyta with 34 spp including *Ankistrodesmus spp., Chlorella sp., Chlorochytrium sp., Chlorococcum sp., Chlamydomonas sp., Closterium spp., Coelastrum spp., Cosmarium sp., Crucigenia tetrapedia, Dictyosphaerium spp., Gloeocystis sp., Koliella sp., Microactinum pusillum, Monoraphidium copricornutum, Ourococcus sp., Pediastrum duplex, Scenedesmus spp., Spirogyra sp., Spondylomorum sp., Straurastrum muticum, Tetraedron sp., Westella* *linearis.* The second largest group is of Chrysophyta represented by 18 species including *Synedra acus, Spinoclosterium sp., Pinnularia spp., Navicula sp., Nitzschia spp., Fragillaria spp., Dinobryon sp., Cyclotella sp.,* and *Chrysocapsa sp.* The BGA has represented by 7 species comprises *Calothrix sp., Chrococcus sp., Gloeotrichia sp., Merismopedia spp., Microcystis spp.* Euglenophyta group is represented by *Trichelomonas spp., Phacus spp., Euglena proxima.* The pyrrophyta group has a single species *Ceratium hirudinella.*

The seasonal diversity of phytoplankton is shown in table 32. It represents that the phytoplankton species exhibit fluctuation with 29 species in monsoon while 53 species are observed during winter season. In summer season 42 species are found in this lake.

Table 33 indicates total phytoplankton species from Gaimukh lake. The Gaimukh lake shows least number of phytoplankton in comparison with other lakes. The numerical sequential index recorded is 6 + 5 + 4 +1 + 3 =19. The Chlorophyta group is dominant followed by Chrysophyta > Euglenophyta> Cyanophyta > Pyrrophyta. The Chlorophyta group includes *Cosmarium sp., Scenedesmus spp., Spirogyra sp., Tetraedron spp.* The other group includes *Synedra acus Tribonema sp., Trachelomonas spp., Pinularia spp., Phacus spp., Oscillatoria sp., Navicula sp., Microcystis spp., Euglena acus, and Cyclotella sp.* The pyrrophyta represented by *Ceratium hirudinella.*

The seasonal diversity of phytoplankton in the Gaimukh lake is shown in table 34. Gaimukh exhibits higher frequency of distribution in summer. Frequency of phytoplankton is moderate during winter while frequency is lowest in monsoon.

Algal abundance was noticed in the summer season and its declining state observed in monsoon due to turbidity, current velocity, runoff water, precipitation causing dilution effect, loss of water through outlet, fluctuating water level affect algal abundance and diversity (Crayton and Sommerfeld, 1979; Tiwari, 2004, Berner, 1951; Chandler and Weeks, 1954; Kannan and Job, 1980; Mustafa and Ahamed, 1997). Similar kind of pattern has been observed in present wok.

Some heavy metals are require for the algal growth and development (Rai *et al.*, 1981) but in monsoon the heavy metal amount found to be low may affect the algal growth.

Mc Combie (1953); Bharadwaja (1940) has pointed out that the temperature and light factor may responsible for higher population of phytoplankton. In the same way blooming of phytoplankton in summer season has been observed in case of Chavantali. Similar reports are made by Shreenivasan *et al.*, (1974); Arumugon and Furtado (1980) in some temperate and tropical reservoirs. The dominance of chlorophyta has been recorded in summer season also observed by Hujare (2005); Vyas and Kumar (1968).

When aeration is satisfactory the effect of sewage by adding nutrients is that of enrichment. The recycling of nutrients is essential for the proper functioning of biological system, but excess amount of sewage load to a decline in the phytoplankton population density (Perkins 1974). Similar kind of observation recorded in Kapurbao lake. According to Ganapati (1975) organic material such as domestic sewage and food processing wastes finds a common dumping place in water bodies, however it gets rapidly decomposed and often enrich the elements essentials for plant nutrition and productivity.

According to Stevenson (1984) species diversity can be greater in polluted water than that of nonpolluted areas. Thus indicating extent of pollution in Chavantali.

Palmer (1969) suggested that some phytoplankton genera are tolerant to organic pollution these are *Euglena sp., Oscillatoria sp. Nitzchia sp., Navicula sp., Synedra sp., Spirogyra sp., Pediastrum sp., Fragellaria sp., Ulothrix sp., Pinularia sp., and Cosmarium sp.* According to standard IS 10500: 1991 the species *Coelastrum, Oocystis, Scenedesmus, Zygnema, Chlymadomonas, Chlorella, Spirogyra, Tribonema, Closterium* are found in polluted water. These species are recorded from nearly all water resources but the frequency of these species in studied lake proves to be on the line of observation.

Synudeen Saheb (2004) recorded maximum phytoplankton during November to April and minimum during June to September. Again he stated that rise in turbidity from May onwards related to higher velocity of water resulting from greater rainfall leading to silting, consequently it inhibit the photosynthesis of phytoplankton. (Welch, 1952).

Nayak *et al.*, (2004) has correlated increase in pH, high photosynthetic activity and high nutrients with phosphate depletion are due to phytoplankton utilization. Similarly pH, phosphate depletion observed in the present lake.

Kapurbao recorded water hyacinth growth results poor health of lake which is characterized by low species diversity, fast shallowing, dominance of detritus food web and the water unsuitable for human consumption also recorded by Singhal and Mahto (2004). Natural eutrophic lake can accommodate the growth of algae and aquatic plants at such level that the herbivore community can not consume them all. The excess eventually becomes organic matter that is decomposed by bacteria. This decomposition is an aerobic process that may leads to depletion of O_2 in lake water.

Similarity Index (S)

Sullivan and Carpenter (1982); Gunale (1991) have suggested that, instead of mere presence or absence of indicator species, density of these taxa may prove better way for accessing the degree of pollution. This can be easily marked by using species similarity index. According to Linton and Warner (2003) stress is generally thought to induce both quantitative and qualitative changes in the structure and functioning of communities. Structural changes are usually assessed by analyzing species diversity or composition.

The Similarity Index (S) show similarity between two sites. Similarity indices compare the two sites and are very useful in detecting point source of pollution.

The species similarity index (S) among various sites has been shown in table 35. The value tending towards zero shows comparatively high pollution level (Shrivastava and Shrivastava, 2006).

The lowest similarity index recorded is 0.38 between Gaimukh and Chavantali lakes. It indicates that Chavantali show high pollution level than that of Gaimukh. While the similarity index between the Kapurbao and Yamai with Gaimukh lake is 0.436 and 0.500 respectively. These values of index are tending towards zero exhibit more polluted nature as compare to Gaimukh lake. The similarity index between yamai and Chavantali is 0.490. This indicates that pollution level of chavantali is higher than Yamai. The Yamai and Kapurbao exhibit highest similarity index i.e. 0.602. this represents having same point of source of pollution. The similarity index between Chavantali and Kapurbao exhibit 0.435 value which tends towards zero showing high pollution level.

The observations indicate that for different sites for different seasons similarity index varies greatly with respect to phytoplankton distribution and abundance. This is in response to the physico-chemical changes at concern sites and season. The phytoplankton may directly influenced by the microenvironment. Similar kind of observations were made by Supate (1992). Riznyk (1973) has shown difference in the phytoplankton community structure due to differing physico- chemical and biological parameters to which the organism are exposed.

Table no. 27. Phytoplankton recorded in Yamai lake

Sr. No.	**Name of sp.**	Family	**Group**
1	*Ankistrodesmus sp.*	Oocystaceae	Chlorophyta
2	*Ceratium huridenella*	Ceratiaceae	Pyrrophyta
3	*Characium limneticum*	Characiaceae	Chlorophyta
4	*Chlorella sp.1*	Oocystaceae	Chlorophyta
5	*Chlorellidiopsis saparabilis*	Botryochloridaceae	Chlorophyta
6	*Chlorococcum sp.*	Chlorococcaceae	Chlorophyta
7	*Chrococcus sp.*	Chrococcaceae	Cyanophyta
8	*Closterium sp.1*	Desmidiaceae	Chlorophyta
9	*Coelastrum sp. 1*	Desmidiaceae	Chlorophyta
10	*Cosmarium sp.*	Desmidiaceae	Chlorophyta
11	*Crucigenia tetrapedia*	Scenedesmaceae	Chlorophyta
12	*Cyclotella sp.*	Coscinodiscaceae	Chrysophyta
13	*Spirulina sp.*	Oscillatoriaceae	Cyanophyta
14	*Euglena acus*	Euglenaceae	Euglenophyta
15	*Euglena sanguinea*	Euglenaceae	Euglenophyta
16	*Fragellaria sp.*	Fragilariaceae	Chrysophyta
17	*Kirchneriella sp.*	Oocystaceae	Chlorophyta
18	*Merismopedia elegans*	Chrococcaceae	Cyanophyta
19	*Merismopedia tenuissimma*	Chrococcaceae	Cyanophyta
20	*Microcystis sp. 1*	Chrococcaceae	Cyanophyta
21	*Microcystis sp. 3*	Chrococcaceae	Cyanophyta

22	*Microcystis sp.2*	Chrococcaceae	Cyanophyta
23	*Oscillatoria sp.*	Oscillatoriaceae	Cyanophyta
24	*Phacus acuminatus*	Euglenaceae	Euglenophyta
25	*Phacus arbiscularis*	Euglenaceae	Euglenophyta
26	*Phacus sp.*	Euglenaceae	Euglenophyta
27	*Pinularia sp. 1*	Naviculaceae	Chrysophyta
28	*Scenedesmus acuminatus*	Scenedesmaceae	Chlorophyta
29	*Synedra acus*	Fragilariaceae	Chrysophyta
30	*Tetraedron sp.*	Oocystaceae	Chlorophyta
31	*Tetraedron minimum*	Oocystaceae	Chlorophyta
32	*Tetraedron regulare*	Oocystaceae	Chlorophyta
33	*Trachelomonas sp.1*	Euglenaceae	Euglenophyta
34	*Trachelomonas sp. 2*	Euglenaceae	Euglenophyta
35	*Ulothrix*	Ulotrichaceae	Chlorophyta
36	*Westella linearis*	Oocystaceae	Chlorophyta
37	*Spirogyra sp.*	Spirogyraceae	Chlorophyta

Chlorophyta- 17; Chrysophyta- 4; Euglenophyta- 7; Pyrrophyta- 1; Cyanophyta- 8
Total species- 37

Table no. 28. Seasonal variation in phytoplankton in the Yamai lake

Sr. No	Name of species	Monson	Winter	Summer
1	*Ankistrodesmus sp.*	P	P	P
2	*Ceratium huridenella*	A	P	P
3	*Characium limneticum*	A	P	A
4	*Chlorella sp.1*	P	P	P
5	*Chlorellidiopsis saparabilis*	A	A	P
6	*Chlorococcum sp.*	A	P	P
7	*Chrococcus sp.*	P	P	P
8	*Closterium sp.1*	P	P	P

9	*Coelastrum sp. 1*	A	P	A
10	*Cosmarium*	P	P	P
11	*Crucigenia tetrapedia*	P	P	P
12	*Cyclotella sp.*	P	P	P
13	*Spirulina sp.*	A	A	P
14	*Euglena acus*	P	P	P
15	*Euglena sanguinea*	P	P	P
16	*Fragellaria sp.*	P	P	P
17	*Kirchneriella obesa*	A	P	P
18	*Merismopedia elegans*	A	P	P
19	*Merismopedia tenuissimma*	A	A	P
20	*Microcystis*	P	P	P
21	*Microcystis sp.*	P	P	P
22	*Microcystis sp.2*	A	A	P
23	*Oscillatoria sp.*	P	P	P
24	*Phacus sp.*	A	P	P
25	*Phacus arbiscularis*	P	A	P
26	*Phacus acuminatus*	A	A	P
27	*Pinularia*	A	P	P
28	*Synedra acus*	P	P	P
29	*Tetraedron*	P	P	P
30	*Tetraedron minimum*	P	P	A
31	*Tetraedron regulare*	A	P	P
32	*Trachelomonas sp. 1*	P	P	P
33	*Trachelomonas sp.2*	A	A	P
34	*Scenedesmus acuminatus*	P	P	P
35	*Spirogyra sp.*	P	P	P
36	*Ulothrix*	A	A	P
37	*Westella linearis*	A	A	P

	Total no. of Species occurred	**20**	**28**	**34**

Table no. 29 Phytoplankton recorded in Kapurbao lake

Sr. No	Kapurbao	Family	Group
1	*Ankistrodesmus sp.*	Oocystaceae	Chlorophyta
2	*Ankistrodesmus sp.1*	Oocystaceae	Chlorophyta
3	*Characium limneticum*	Characiaceae	Chlorophyta
4	*Chlorella sp.*	Oocystaceae	Chlorophyta
5	*Chlorochytrium sp.*	Endosphaeraceae	Chlorophyta
6	*Chlorococcum sp.*	Chlorococcaceae	Chlorophyta
7	*Chlymadocapsa sp.*		Chlorophyta
8	*Chroococcus sp.*	Chrococcaceae	Cyanophyta
9	*Closterium sp.1*	Desmidiaceae	Chlorophyta
10	*Closterium sp.2*	Desmidiaceae	Chlorophyta
11	*Cosmarium sp.*	Desmidiaceae	Chlorophyta
12	*Crucigenia tetrapedia*	Scenedesmaceae	Chlorophyta
13	*Cyclotella sp.*	Coscinodiscaceae	Chrysophyta
14	*Dinobryon*	Ochromonadaceae	Chrysophyta
15	*Elakatothrix biplex*	Coccomyxaceae	Chlorophyta
16	*Euglena*	Euglenaceae	Euglenophyta
17	*Euglena acus*	Euglenaceae	Euglenophyta
18	*Euglena proxima*	Euglenaceae	Euglenophyta
19	*Euglena sanguinea*	Euglenaceae	Euglenophyta
20	*Microcystis sp. 3*	Chrococcaceae	Cyanophyta
21	*Microcystis sp.1*	Chrococcaceae	Cyanophyta
22	*Microcystis sp.2*	Chrococcaceae	Cyanophyta
23	*Monoraphidium copricornutum*		Chlorophyta
24	*Navicula*	Naviculaceae	Chrysophyta
25	*Navicula minima*	Naviculaceae	Chrysophyta

26	*Oscillatoria sp.*	Oscillatoriaceae	Cyanophyta
27	*Phacus acuminatus*	Euglenaceae	Euglenophyta
28	*Pinularia sp.1*	Naviculaceae	Chrysophyta
29	*Pinularia sp. 2*	Naviculaceae	Chrysophyta
30	*Scenedesmus quadricauda*	Scenedesmaceae	Chlorophyta
31	*Spirogyra sp.*	Spirogyraceae	Chlorophyta
32	*Synedra acus*	Fragilariaceae	Chrysophyta
33	*Tetraedron minimum*	Oocystaceae	Chlorophyta
34	*Tetraedron regulare*	Oocystaceae	Chlorophyta
35	*Trachelomonas sp. 2*	Euglenaceae	Euglenophyta

Chlorophyta- 17; Chrysophyta- 7; Euglenophyta-6; Pyrrophyta- 0; Cyanophyta- 5
Total species- 35

Table no. 30. Seasonal variation in phytoplankton in the Kapurbao lake

Sr. No	Name of species	Monson	Winter	Summer
1	*Ankistrodesmus sp.*	P	P	A
2	*Ankistrodesmus sp.1*	A	P	A
3	*Characium limneticum*	A	P	A
4	*Chlorella sp.*	A	P	A
5	*Chlorochytrium sp.*	A	P	A
6	*Chlorococcum sp.*	A	P	A
7	*Chlymadocapsa sp.*	P	P	A
8	*Chroococcus sp.*	P	P	A
9	*Closterium sp.1*	P	P	A
10	*Closterium sp.2*	P	P	A
11	*Cosmarium*	A	P	A
12	*Crucigenia tetrapedia*	A	P	A
13	*Cyclotella*	P	P	P
14	*Dinobryon*	P	A	P

15	*Elakatothrix biplex*	A	P	A
16	*Euglena acus*	A	P	A
17	*Euglena*	A	P	A
18	*Euglena proxima*	A	P	A
19	*Euglena sanguinea*	A	P	A
20	*Microcystis sp. 1*	A	P	A
21	*Microcystis sp. 2*	P	P	P
22	*Microcystis sp. 3*	P	P	P
23	*Monoraphidium copricornutum*	P	A	A
24	*Navicula*	P	P	P
25	*Navicula minima*	A	P	A
26	*Oscillatoria sp.*	P	P	A
27	*Pinularia sp.1*	P	P	P
28	*Pinularia sp.2*	A	P	A
29	*Spirogyra sp.*	A	P	A
30	*Tetraedron minimum*	A	P	A
31	*Tetraedron regulare*	A	P	A
32	*Trachelomonas sp. 2*	P	P	P
33	*Scenedesmus quadricauda*	A	P	A
34	*Synedra acus*	P	P	A
35	*Phacus acuminatus*	A	P	A
	Total no. of species occurred	16	34	8

Table no.31 Phytoplankton recorded in Chavantali lake

Sr. no	**Chavantali**	**Family**	**Group**
1	*Ankistrodesmus sp.*	Oocystaceae	*Chlorophyta*
2	*Calothrix sp.*	Rivulariaceae	*Cyanophyta*
3	*Ceratium hirudinella*	Ceratiaceae	Pyrrophyta
4	*Chlorella*	Oocystaceae	*Chlorophyta*
5	*Chlorochytrium sp.*	Endosphaeraceae	*Chlorophyta*
6	*Chlorococcum humicola*	Chlorococcaceae	*Chlorophyta*
7	*Chlorococcum sp.*	Chlorococcaceae	*Chlorophyta*
8	*Chlamydomonas sp.*	Chlamydomonadaceae	*Chlorophyta*
9	*Chrococcus sp.*	Chrococcaceae	*Cyanophyta*
10	*Chrysocapsa sp.*	Chrysocapsaceae	*Chrysophyta*
11	*Closterium sp.*	*Desmidiaceae*	*Chlorophyta*
12	*Coelastrum scabrum*	Coelastraceae	*Chlorophyta*
13	*Coelastrum sp. 1*	Coelastraceae	*Chlorophyta*
14	*Coelastrum sp. 2*	Coelastraceae	*Chlorophyta*
15	*Cosmarium sp.*	*Desmidiaceae*	*Chlorophyta*
16	*Crucigenia tetrapedia*	Scenedesmaceae	*Chlorophyta*
17	*Cyclotella sp.*	Coscinodiscaceae	Chrysophyta
18	*Dictyosphaerium sp.1*	Oocystaceae	*Chlorophyta*
19	*Dictyosphaerium sp. 2*	Oocystaceae	*Chlorophyta*
20	*Dinobryon*	Ochromonadaceae	*Chrysophyta*
21	*Euglena proxima*	Euglenaceae	Euglenophyta
22	*Fragellaria construens*	Fragilariaceae	Chrysophyta
23	*Fragillaria spp*	Fragilariaceae	Chrysophyta
24	*Gloeocystis sp.*	Palmellaceae	*Chlorophyta*
25	*Gloeotrichia sp.*	Rivulariaceae	*Cyanophyta*
26	*Kirchneriella sp.*	Oocystaceae	*Chlorophyta*

27	*Koliella*		*Chlorophyta*
28	*Merismopedia elegans*	Chrococcaceae	*Cyanophyta*
29	*Microactinum pusillum*	Scenedesmaceae	*Chlorophyta*
30	*Microcystis sp. 1*	Chrococcaceae	*Cyanophyta*
31	*Microcystis sp.2*	Chrococcaceae	*Cyanophyta*
32	*Microcystis sp.3*	Chrococcaceae	*Cyanophyta*
33	*Monoraphidium copricornutum*		*Chlorophyta*
34	*Nitzschia sp.*	*Bacillariaceae*	Chrysophyta
35	*N. palea*	*Bacillariaceae*	Chrysophyta
36	*N. radicula*	*Bacillariaceae*	Chrysophyta
37	*N. recta*	*Bacillariaceae*	Chrysophyta
38	*N. subcicularis*	*Bacillariaceae*	Chrysophyta
39	*Nitzschia desipata*	*Bacillariaceae*	Chrysophyta
40	*Nitzschia intermedia*	*Bacillariaceae*	Chrysophyta
41	*N. archibaldii*	*Bacillariaceae*	Chrysophyta
42	*Navicula*	Naviculaceae	Chrysophyta
43	*Oedezia sp.*		*Chlorophyta*
44	*Ourococcus sp.*	*Coccomyxaceae*	*Chlorophyta*
45	*Pediastrum duplex*	Hydrodictyaceae	*Chlorophyta*
46	*Phacus macrostigma*	Euglenaceae	Euglenophyta
47	*Phacus sp.*	Euglenaceae	Euglenophyta
48	*Pinnularia sp.3*	Naviculaceae	Chrysophyta
49	*Pinnularia sp.4*	Naviculaceae	Chrysophyta
50	*Scenedesmus acuminatus*	Scenedesmaceae	*Chlorophyta*
51	*Scenedesmus denticulatus*	Scenedesmaceae	*Chlorophyta*
52	*Scenedesmus quadricauda*	Scenedesmaceae	*Chlorophyta*
53	*Scenedesmus sp.*	Scenedesmaceae	*Chlorophyta*
54	*Shaerocystis sp.*	Palmellaceae	*Chlorophyta*

55	*Spinoclosterium sp.*	--	Chrysophyta
56	*Spirogyra*	Spirogyraceae	*Chlorophyta*
57	*Spondylomorum sp.*	Volvacaceae	*Chlorophyta*
58	*Straurastrum muticum*	*Desmidiaceae*	*Chlorophyta*
59	*Synedra acus*	Fragilariaceae	Chrysophyta
60	*Tetraedron minimum .*	Oocystaceae	*Chlorophyta*
61	*Tetraedron regulare*	Oocystaceae	*Chlorophyta*
62	*Tetraedron trigonum*	Oocystaceae	*Chlorophyta*
63	*Trichelomonas sp.1*	Euglenaceae	Euglenophyta
64	*Trichlomonas sp.2*	Euglenaceae	Euglenophyta
65	*Westella linearis*	Oocystaceae	*Chlorophyta*

Chlorophyta- 33; Chrysophyta- 17; Euglenophyta- 5; Pyrrophyta- 1; Cyanophyta- 7
Total species- 63

Table no. 32 Seasonal variation in phytoplankton in the Chavantali lake

Sr. No.	Name of species	Monson	Winter	Summer
1	*Ankistrodesmus sp.*	P	P	P
2	*Calothrix sp.*	A	P	A
3	*Ceratium hirudinella*	A	P	P
4	*Chlorella*	P	P	P
5	*Chlorochytrium sp.*	A	A	P
6	*Chlorococcum humicola*	A	A	P
7	*Chlorococcum sp.*	P	P	P
8	*Chlymadomonas sp.*	A	P	A
9	*Chrococcus sp.*	A	P	P
10	*Chryocapsa sp.*	P	P	P
11	*Closterium sp.*	P	P	P
12	*Coelastrum sp. 1*	A	P	P
13	*Coelastrum sp. 2*	A	A	P
14	*Coelastrum scabrum*	A	P	A

15	*Cosmarium sp.*	P	P	P
16	*Crucigenia tetrapedia*	P	P	P
17	*Cyclotella sp.*	P	P	P
18	*Dictyosphaerium sp. 1*	A	P	A
19	*Dictyosphaerium sp. 2*	A	P	A
20	*Dinobryon sp.*	P	P	A
21	*Euglena proxima*	P	P	P
22	*Fragillaria spp*	P	P	P
23	*Fragellaria construens*	A	P	A
24	*Gloeocystis sp.*	A	P	A
25	*Gloeotrichia sp.*	A	P	A
26	*Kirchneriella sp.*	A	A	P
27	*Koliella*	A	P	A
28	*Merismopedia elegans*	P	A	P
29	*Microactinum pusillum*	P	P	P
30	*Monoraphidium copricornutum*	A	P	P
31	*Microcystis sp.3*	P	P	P
32	*Microcystis sp.2*	P	P	P
33	*Microcystis sp.*	P	P	P
34	*Navicula*	P	P	P
35	*Nitzschia desipata*	A	P	A
36	*Nitzschia intermedia*	A	P	A
37	*N. archibaldii*	P	P	P
38	*N. palea*	A	P	A
39	*N. radicula*	A	P	A
40	*N. subcicularis*	A	P	A
41	*N. recta*	A	P	A
42	*Nitzschia sp.*	P	P	P
43	*Oedezia sp.*	A	P	A

44	*Ourococcus sp.*	A	P	A
45	*Pediastrum duplex*	A	A	P
46	*Phacus macrostigma*	P	P	P
47	*Phacus sp.*	P	A	P
48	*Pinularia sp. 3*	A	P	A
49	*Pinularia sp.4*	P	A	P
50	*Scenedesmus sp.*	P	P	P
51	*Scenedesmus quadricauda*	A	P	A
52	*Scenedesmus denticulatus*	A	P	A
53	*Scenedesmus acuminatus*	A	A	P
54	*Straurastrum muticum*	A	A	P
55	*Shaerocystis sp.*	P	P	P
56	*Spirogyra*	P	P	P
57	*Sinoclosterium sp.*	A	P	A
58	*Spondylomorum sp.*	A	P	A
59	*Synedra acus*	P	P	P
60	*Tetraedron minimum*	P	P	P
61	*Tetraedron regulare*	A	A	P
62	*Tetraedron trigonum*	A	A	P
63	*Trichelomonas sp.1*	P	P	P
64	*Trichlomonas sp.2*	P	P	P
65	*Westella linearis*	A	P	P
	Total no. of species	29	53	42

Table no. 33 Phytoplankton recorded in Gaimukh lake:-

Sr. No	Name of Species	Family	Group
1	*Ceratium hirudinella*	Ceratiaceae	Pyrrophyta
2	*Cosmarium sp.*	Desmidiaceae	Chlorophyta
3	*Cyclotella sp.*	Coscinodiscaceae	Chrysophyta
4	*Euglena acus*	Euglenaceae	Euglenophyta
5	*Microcystis sp.1*	Chrococcaceae	Cyanophyta
6	*Microcystis sp.3*	Chrococcaceae	Cyanophyta
7	*Navicula sp.*	Naviculaceae	Chrysophyta
8	*Oscillatoria*	Oscillatoriaceae	Cyanophyta
9	*Phacus sp.*	Euglenaceae	Euglenophyta
10	*Pinularia sp.4*	Naviculaceae	Chrysophyta
11	*Scenedesmus sp.*	Scenedesmaceae	Chlorophyta
12	*Scenedesmus denticulatus*	Scenedesmaceae	Chlorophyta
13	*Spirogyra*	Spirogyraceae	Chlorophyta
14	*Synedra acus*	Fragilariaceae	Chrysophyta
15	*Tetraedron minimum*	Oocystaceae	Chlorophyta
16	*Tetraedron regulare*	Oocystaceae	Chlorophyta
17	*Trachelomonas sp. 2*	Euglenaceae	Euglenophyta
18	*Trachelomonas sp.1*	Euglenaceae	Euglenophyta
19	*Tribonema*	Tribonemaceae	Chrysophyta

Chlorophyta -6; Chrysophyta-5; Euglenophyta-4; Pyrrophyta-1; Cyanophyta-3
Total species - 19

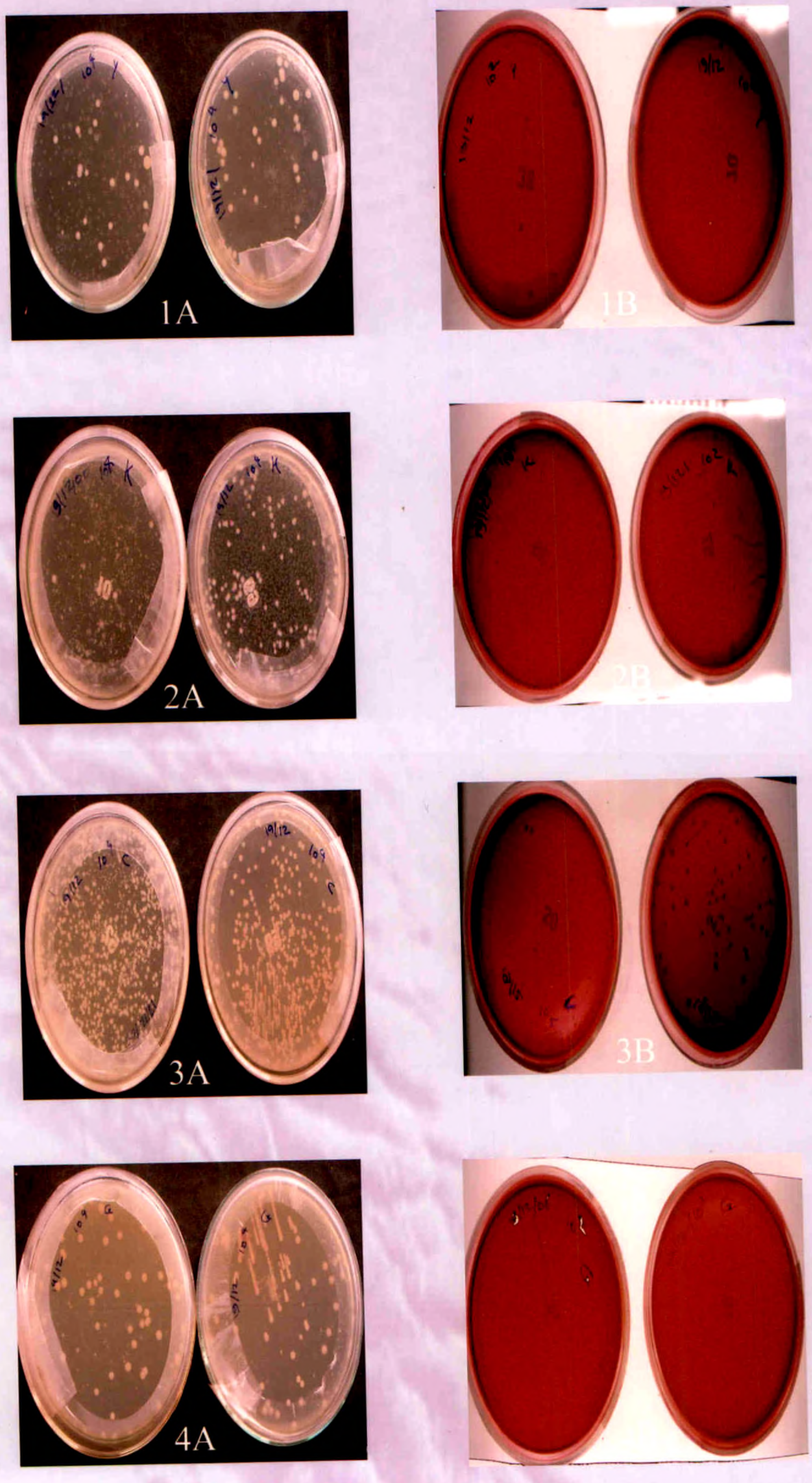
Table no. 34 Seasonal variation in phytoplankton in Gaimukh lake

Sr. No	Name of species	Monson	Winter	Summer
1	*Ceratium hirudinella*	P	P	P
2	*Cosmarium*	P	P	P
3	*Oscillatoria*	A	A	P
4	*Cyclotella*	P	P	P
5	*Euglena acus*	P	P	P
6	*microcystis sp. 1*	P	P	P
7	*Microcystis sp. 3*	P	P	P
8	*Phacus sp.*	P	P	P
9	*Scenedesmus denticulatus*	A	A	P
10	*Synedra acus*	P	P	P
11	*Scenedesmus*	P	P	P
12	*Tetraedron minimum*	A	P	P
13	*Spirogyra*	P	P	P
14	*Tribonema*	A	P	A
15	*Trachelomonas sp. 2*	A	P	P
16	*Trachelomonas sp.1*	P	P	P
17	*Tetraedron regulare*	A	P	P
18	*Pinularia sp. 4*	A	P	p
19	*Navicula sp.*	P	P	p
	Total No. of Species Occurred	12	17	18

Table no. 35 Species similarity Index between lakes:

Sr. No.	Yamai	Kapurbao	Chavantali	Gaimukh
Yamai	-	0.602	0.490	0.50
Kapurbao	-	-	0.4356	0.436
Chavantali	-	-	-	0.380
Gaimukh	-	-	-	-

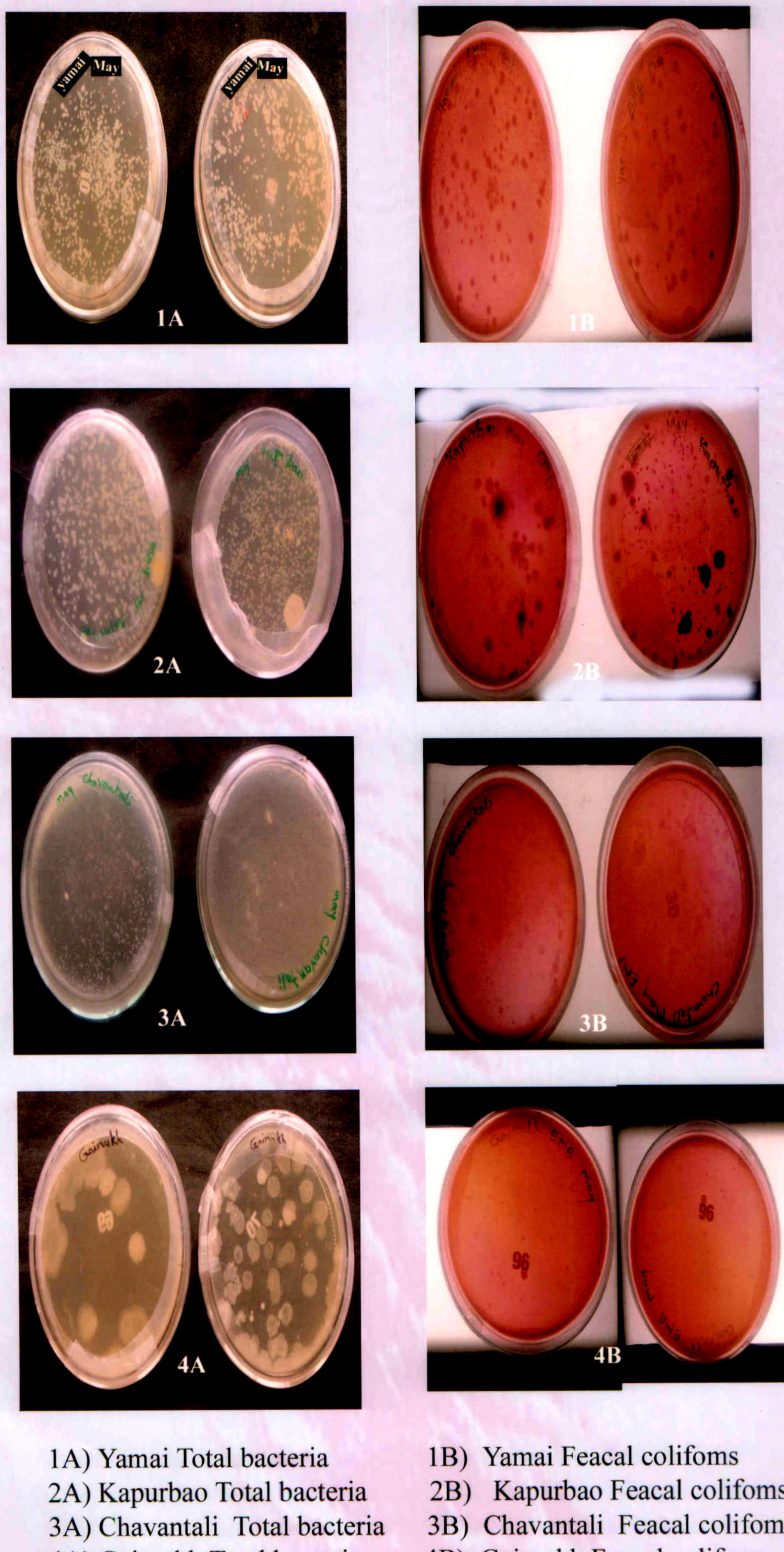
Bacterial study during winter



1A) Yamai Total bacteria
2A) Kapurbao Total bacteria
3A) Chavantali Total bacteria
4A) Gaimukh Total bacteria

1B) Yamai Feacal colifoms
2B) Kapurbao Feacal colifoms
3B) Chavantali Feacal colifoms
4B) Gaimukh Feacal colifoms

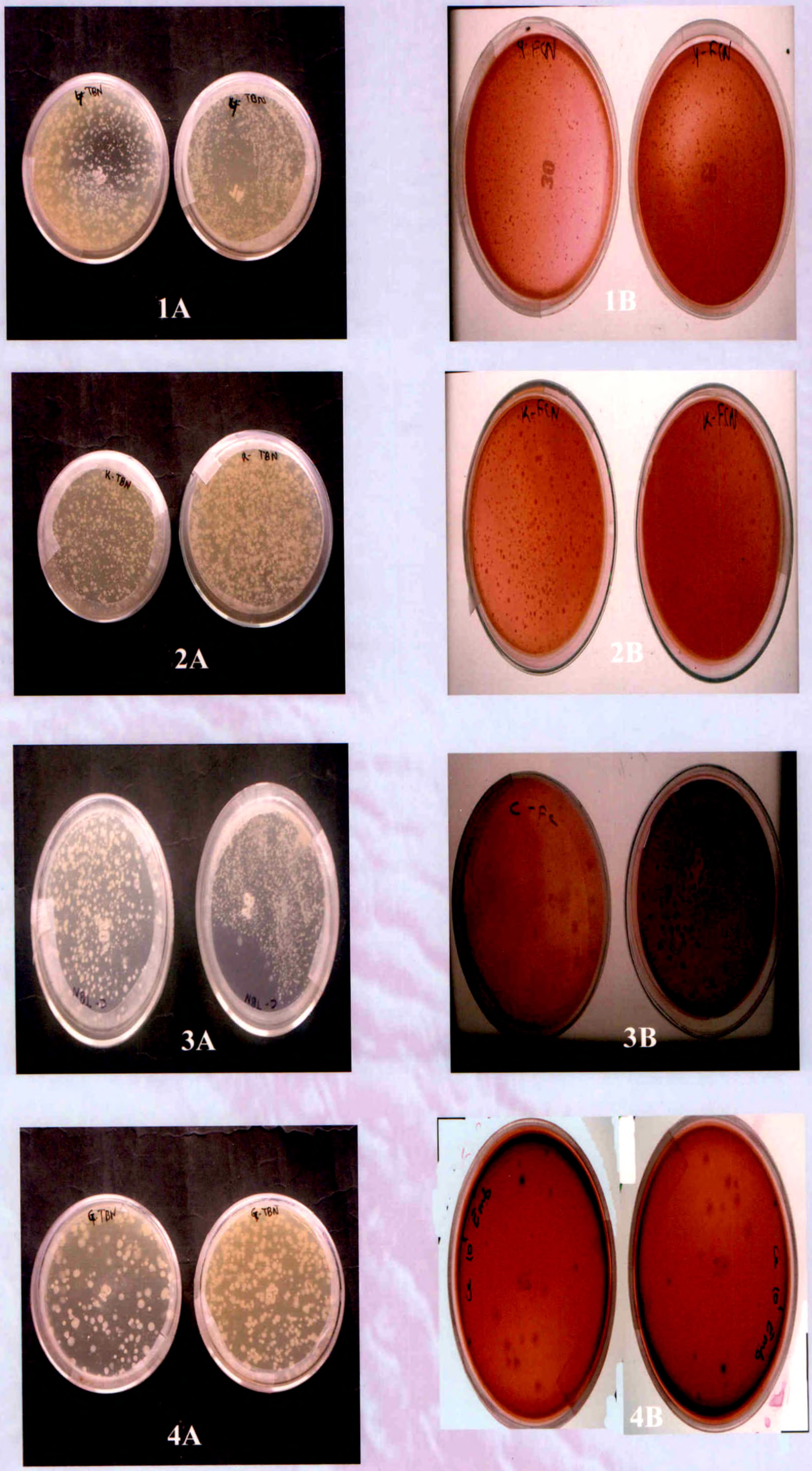
Bacterial study during Summer season



1A) Yamai Total bacteria
2A) Kapurbao Total bacteria
3A) Chavantali Total bacteria
4A) Gaimukh Total bacteria

1B) Yamai Feacal colifoms
2B) Kapurbao Feacal colifoms
3B) Chavantali Feacal colifoms
4B) Gaimukh Feacal colifoms

Bacterial study during Rainy season



1A) Yamai Total bacteria
2A) Kapurbao Total bacteria
3A) Chavantali Total bacteria
4A) Gaimukh Total bacteria

1B) Yamai Feacal colifoms
2B) Kapurbao Feacal colifoms
3B) Chavantali Feacal colifoms
4B) Gaimukh Feacal colifoms

PHYTOPLANKTON PLATE I

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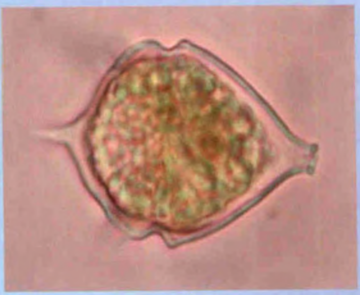

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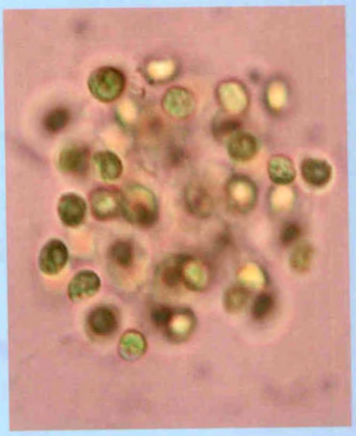

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1) *Ankistrodesmus sp.* 2) *Ankistrodesmus sp.1* 3) *Calothrix sp.*
4) *Ceratium hirudinella* 5) *Characium limneticum* 6) *Chlorella sp.*
7) *Chlorellidiopsis saparabilis* 8) *Chlorochytrium sp.* 9) *Chlorococcum humicola*
10) *Chlorococcum sp.* 11) *Chlymadocapsa sp.* 12) *Chlymadomonas sp.*
13) *Chroococcus sp.*

PHYTOPLANKTON PLATE II

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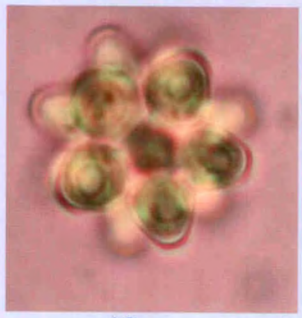

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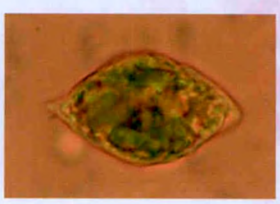

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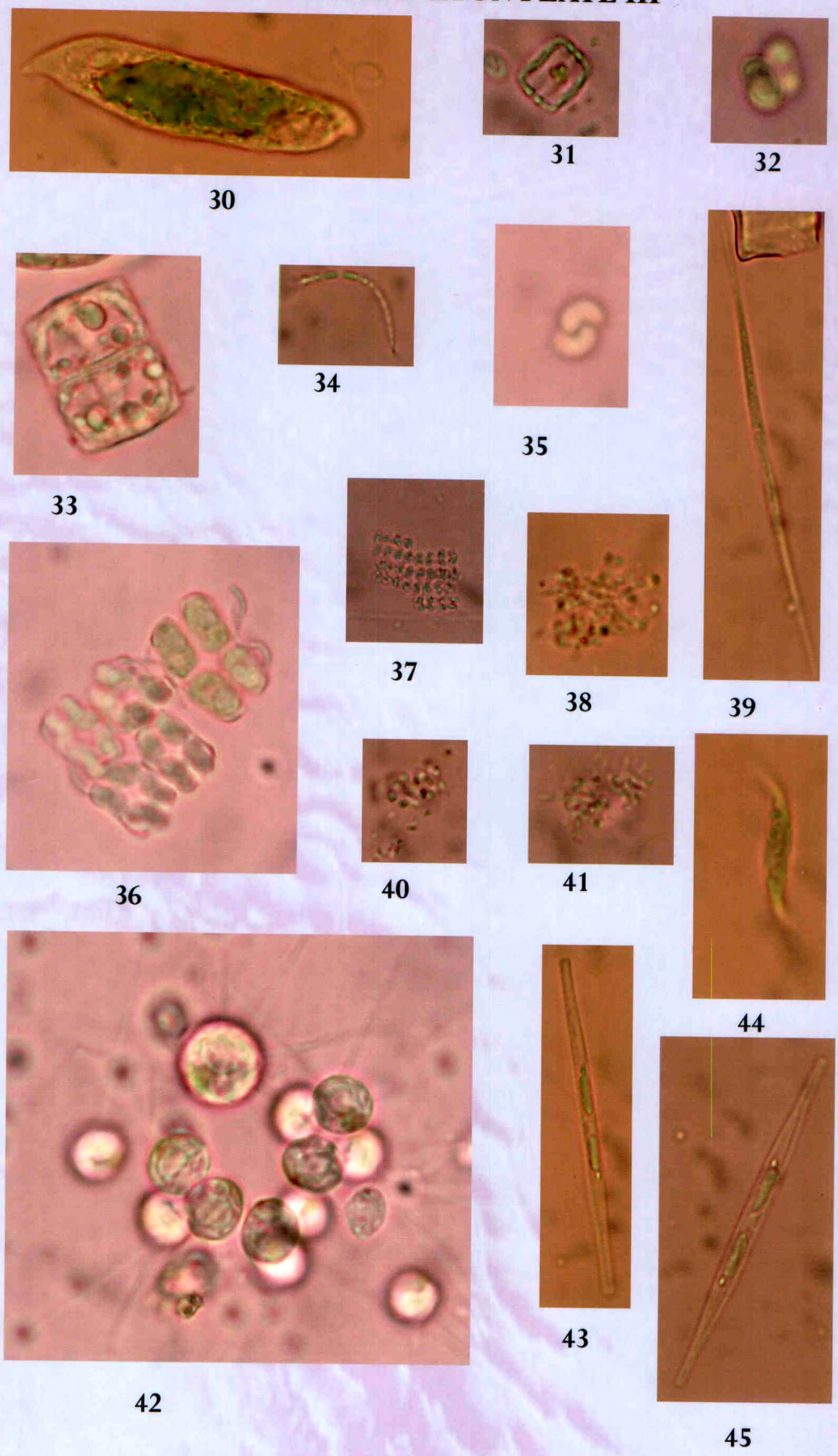
14) *Chryocapsa sp.* 15) *Closterium sp.1* 16) *Closterium sp.2* 17) *Coelastrum scabrum*
18) *Coelastrum sp.1* 19) *Coelastrum sp. 2* 20) *Cosmarium sp.* 21) *Crucigenia tetrapedia*
22) *Euglena proxima* 23) *Cyclotella sp.* 24) *Dictyosphaerium sp.*
25) *Dictyospharium sp.2* 26) *Dinobryon sp.* 27) *Elakatothrix biplex*
28) *Euglena acus* 29) *Euglena sanguinea*

PHYTOPLANKTON PLATE III



30) *Euglena sp.* 31) *Fragellaria construens* 32) *Gloeocystis sp.*
33) *Fragillaria sp.2* 34) *Gloeotrichia sp.* 35) *Kirchneriella sp.*
36) *Merismopedia elegans* 37) *Merismopedia tenuissimma* 38) *Microcystis sp.1*
39) *Koliella sp.* 40) *Microcystis sp.2* 41) *Microcystis sp.3*
42) *Microactinum pusillum* 43) *Nitzschia archibaldii*
44) *Monoraphidium copricornutum* 45) *Nitzschia palea*

PHYTOPLANKTON PLATE IV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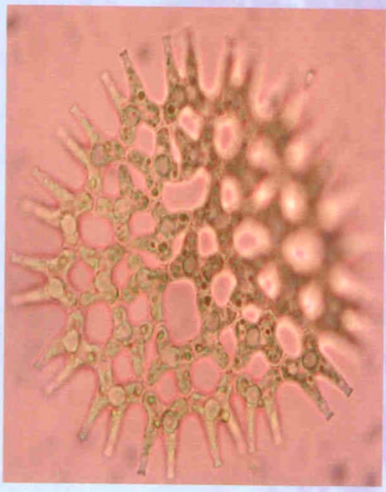
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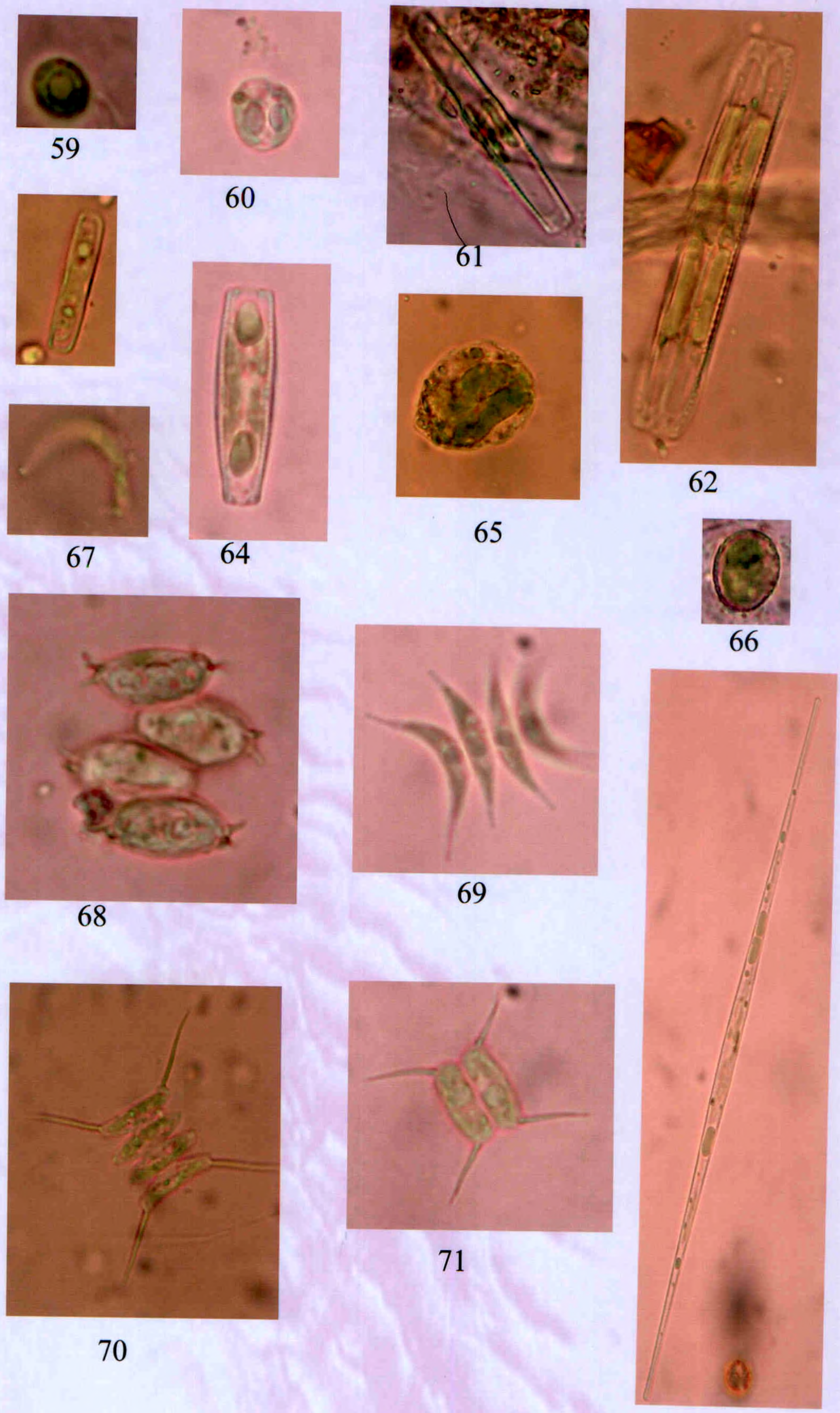
46)*Nitzschia radicula* 47) *N. recta* 48) *N. subcicularis*
49) *Navicula sp.* 50) *Navicula minima* 51) *Nitzschia desipata*
52) *Oedezia sp.* 53) *Nitzschia intermedia* 54) *Nitzschia sp.*
55) *Oscillatoria sp.* 56) *Ourococcus sp.* 57) *Pediastrum duplex*
58) *Phacus acuminatus*

PHYTOPLANKTON PLATE V



59) *Phacus arbicularis* 60) *Phacus macrostigma* 61) *Pinularia sp.3*
62) *Pinularia sp.1* 63) *Pinularia sp.2* 64) *Pinularia sp.4* 65) *Phacus sp.*
66) *Shaerocystis sp.* 67) *Sinoclosterium sp.* 68) *Scenedesmus denticulatus*
69) *Scenedesmus acuminatus* 70) *Scenedesmus quadricauda*
71) *Scenedesmus sp.* 72) *Synedra acus*

PHYTOPLANKTON PLATE VI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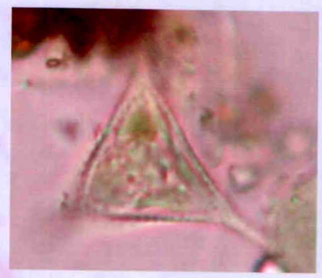
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73) *Spirogyra sp.* 74) *Ulothrix sp.* 75) *Tribonema sp.*
76) *Tetraedron trigonum* 77) *Spirulina sp.* 78) *Trachelomonas sp.*
79) *Straurastrum muticum* 80) *Tetraedron minimum* 81) *Spondylomorum sp.*
82) *Trachelomonas sp. 2* 83) *Tetraedron sp.* 84) *Westella linearis*
85) *Tetraedron regulare*

Impact Assessment

Introduction

General Observations

Impact of Ritual Activity on Water Quality

Pollution Intensity Index

Introduction:-

In case of conservation of any wetland or pond ecosystem monitoring of water quality is first and foremost .activity to be under taken. Parallel to monitoring, identification of threats and impacts is equally essential. Some of the impacts are direct while some are hidden. These are having definite effects on water quality. It is already stated that Jotiba is holy place at which ritual activity is held mainly during April and May. The devotees come to this place through out the year but the number and frequency is far more during Yatra. Primafacie it is observed that the yatra create tremendous pressures on these wetlands and here it is the attempt to show the impacts of yatra scientifically. The data on water quality was gathered throughout the year and for the present purpose it is anlysed statistically and presented in the form of histogram. These histograms are developed from the average values before yatra, during yatra and after yatra. Along with the routing monitoring some additional observations were made here for each parameter. Some of the general observations on activities which are harmful from water quality point of view are listed under general observations.

General observations:-

1) **Cattle houses and Cattle washing:-**

   Many cattle houses are observed on the hill near Chavantali lake. Cattle washing is common in this lake. Near Gaimukh also few cattle houses are present. The waste water of which reaches to Gaimukh. Cattle washing is not done in the Kapurbao and Yamai. But the sheep and goats usually reach to the water of Kapurbao easily.

2) **Cloth Washing:-**

   Kapurbao is commonly utilized for cloth washing. But due to luxuriant growth of water hyacinth in summer season the cloth washing activity was shifted to Chavantali. Occasionally the cloth washing activity can be seen at Yamai also .

3) **Vehicle Washing:-**

   Vehicle washing is often seen at Chavantali, while it is not found at any other lake.

4) Swimming and Bathing:-

The water of Yamai is considered as holy water and supposed to have the ability to cure the skin diseases. Hence, swimming and bathing is commonly observed. In Chavantali this activity was seen occasionally. People avoid the use of Kapurbao water as the lake is more polluted. Gaimukh is the only source of potable water and hence swimming and bathing is strictly prohibited. The lake is protected by constructing the compound wall around it.

5) Anna Chhatra yojana:-

The 'Anna chhatra Yojana' (i.e. providing food for devotees at the time of yatra) is carried out at the open space near the Gaimukh lake every year. Some of the devotees throw the waste food material as well as the 'Nirmalya', the sacred material in the lake.

Impact of Ritual activity on water quality-

Temperature (Fig. 2)

Though there is average increase in the temperature during yatra. It may be attributed by increasing environmental temperature due to summer. It will be hasty if it is concluded that it is only due to human interference. No doubt there is slight increase in the temperature due to increased biological activities.

pH

Without any exception water of all lakes show low pH during yatra. If the pH before yatra is considered as average, increase in pH up to average requires comparatively higher period.

Electrical Conductivity

Electrical conductivity is the indirect measure of soluble salts present in water. Electrical conductivity also increases during yatra in the lakes except Gaimukh. Gaimukh showed low electrical conductivity during yatra only due to dilution by river water. Depending upon observations it can be stated that increase in EC is attributed by urination, bathing, cloth washing and offering the 'Nirmalya' and 'Naivadya'.

Solids

There is increase in total solids due to ritual activity. Total solids is the summation of total dissolved solids and total suspended solids. Total dissolved solids are affected by some of the climatic factors. Most important climatic factors are temperature and humidity at the time of yatra.

Summer season which allows evapotranspiration at very higher rate decreasing the quantity of water and thereby increase in concentration of dissolved solids. The suspended solids are humus or humic material or fine biological material which remains suspended in water. Generally this material gets settle at the bottom but during mechanical disturbances it mixes throughout the water column. Increase in suspended solids is observed after yatra at Chavantali, Kapurbao and Gaimukh. It may considered as after effects of yatra. Monsoon rain and surface runoff may be one of the reason behind it. Higher values of total suspended solids in all lakes before Yatra i.e. during winter season may be attributed by faster rate of biological degradation of litter and organic matter at the bottom.

Hardness and Alkalinity (Fig 3)

Hardness and alkalinity is increased during yatra for the lakes except Gaimukh. The intensity of increase is comparatively higher in case of alkalinity. The effects of these parameters can be decreased only after dilution of water by the rain.

Free CO_2

It is the major of aerobic respiration in water and respiration is directly proportional to number of organisms in the water. If there is sufficient number of autotrophs they use free CO_2 for photosynthesis. But if heterotrophs are more, CO_2 may remain free in water. Increase in free CO_2 during yatra is indication of dominance of heterotrophs than autotrophs.

Dissolved Oxygen

Dissolved oxygen is less during yatra for all the lakes. It also indicates dominance of aerobic heterotrophs. Less DO may also attributed by high water temperature because at high temperature gases loose their stability in water.

Biological Oxygen Demand

It is already stated that the average values presented in this chapter are dependent upon annual data as well as some additional observations. During yatra it was observed that water was purely anoxic at some sites. Similarly BOD was so high that on the second day it is observed that there was zero oxygen present in the experimental bottles. Sometimes BOD was calculated on the third day therefore data is not presented.

Chemical Oxygen Demand

In case of all the lakes there is increase in COD during yatra and for the lakes except Yamai it continues after yatra also. It is due to residence of oxidizable organic and inorganic substances for long time. Basically COD of Gaimukh is least among all the lakes before yatra but it increases during and after yatra. It is the indication of addition of oxidizable material from river water.

Inorganic Phosphorus and Nitrate (Fig 4)

There is many fold increase in inorganic phosphorus and nitrate during yatra and in case of Kapurbao it is continued after yatra i.e. in the rainy season also. Therefore it is definitely attributed by addition of domestic waste in lake water.

Minerals

Without any exception there is increase in concentration in all the minerals during yatra. As stated previously it may be due to evapotranspiration and reduction in water level. But there is sufficient ground to state that it is due to human activity looking towards many fold increase in the concentration of Fe, Cu, Mn during yatra.

Oil and Grease (Fig 5)

There is increase in oil and grease in water for all the lakes and this increase is notable for yamai water.

It is to be noted here that all these lakes are lentic in nature without permanent water flow therefore dilution of water is very difficult and occur only by rain water. All the physico-chemical parameters are interconnected and interdependent. Only for Gaimukh there is facility to receive water from river by pumping therefore effects of yatra are not conspicuous.

Along with all these physico chemical parameters biological parameters i.e. bacteria and phytoplankton are also worked out. It is the Standard Plate Count (SPC) for bacteria where, there is no scope to study variation and occurrence of different species. This gap is filled in case of phytoplankton where seasonal occurrence of individual species at different sites of all the lakes is studied. The impact of yatra on relative occurrence of phytoplankton is already discussed in biomonitoring.

Pollution Intensity Index (PII):-

The process of drgradation and pollution is complex one. By considering or evaluating a single or few parameters individually it is very difficult to comment upon the intensity of pollution. It requires collective consideration of parameters to find out concrete conclusions. Number of organizations have given water quality standards and by considering these standards arbitory pollution intensity index is determined. For instance two different indices are calculated for physico-chemical properties and biological properties. The formulations of arbitory units and formulae for calculations is given as appendix –I.

Table no. 36. Pollution Intensity Index (Physico-chemical)

	Winter (Before)	Summer (During)	Monsoon (After)
Yamai	61	64	61
Kapurbao	63	87	55
Chavantali	54	76	45
Gaimukh	54	87	45

Table no. 37. Pollution Intensity Index (Biological)

	Winter (Before)	Summer (During)	Monsoon (After)
Yamai	28	21	44
Kapurbao	19	19	37
Chavantali	34	18.5	41
Gaimukh	-3.5	-7.0	2

Table 36 indicates the pollution intensity indices seasonally for all water bodies, specially for physico-chemical nature. It is interesting that the index is higher for all water bodies during summer when ritual activity takes place. Lowest values are recorded for monsoon i.e. after ritual activity. It clearly indicates dilution effect of rain water and its major role in reduction of pollutants. Kapurbao waterbody is showing higher intensity of pollution throughout the year. While higher intensity is also recorded for Gaimukh during the summer. Primafacie, Kapurbao appears as highly polluted water body and Gaimukh appears comparatively fresh one, but unfortunately intensity index of physico-chemical pollution recorded same. It is to be noted here that the water of river Kasari is lifted and stored in Gaimkh whenever necessary. There are number of objectionable activities on the bank of Kasari river in the upstream region. This is the probable cause for higher value of minerals in Gaimukh water body.

Table 37 describes the pollution intensity indices specifically for biological parameters. It is to be noted here that high values are recorded after activity i.e. during monsoon. It is mainly attributed by the collection of surface runoff nearby the region of in the waterbodies. Among the biological parameters bacterial pollution is major problem. The biological dominance is observed during the monsoon and requires comparatively long period for decrease. Therefore during winter also slightly higher values are recorded. As per these biological indices it can be stated that Yamai, Kapurbao as well as chavantali are more polluted than Gaimukh. Biologically the water of Gaimukh is clean. It may possibly due to its location away from inhabitation.

Based on both indices i.e. physico-chemical and biological it can be stated that Kapurbao is highly polluted and Gaimukh is less polluted waterbody.

Fig no. 2 Impacts of Ritual Activity on Various Parameters

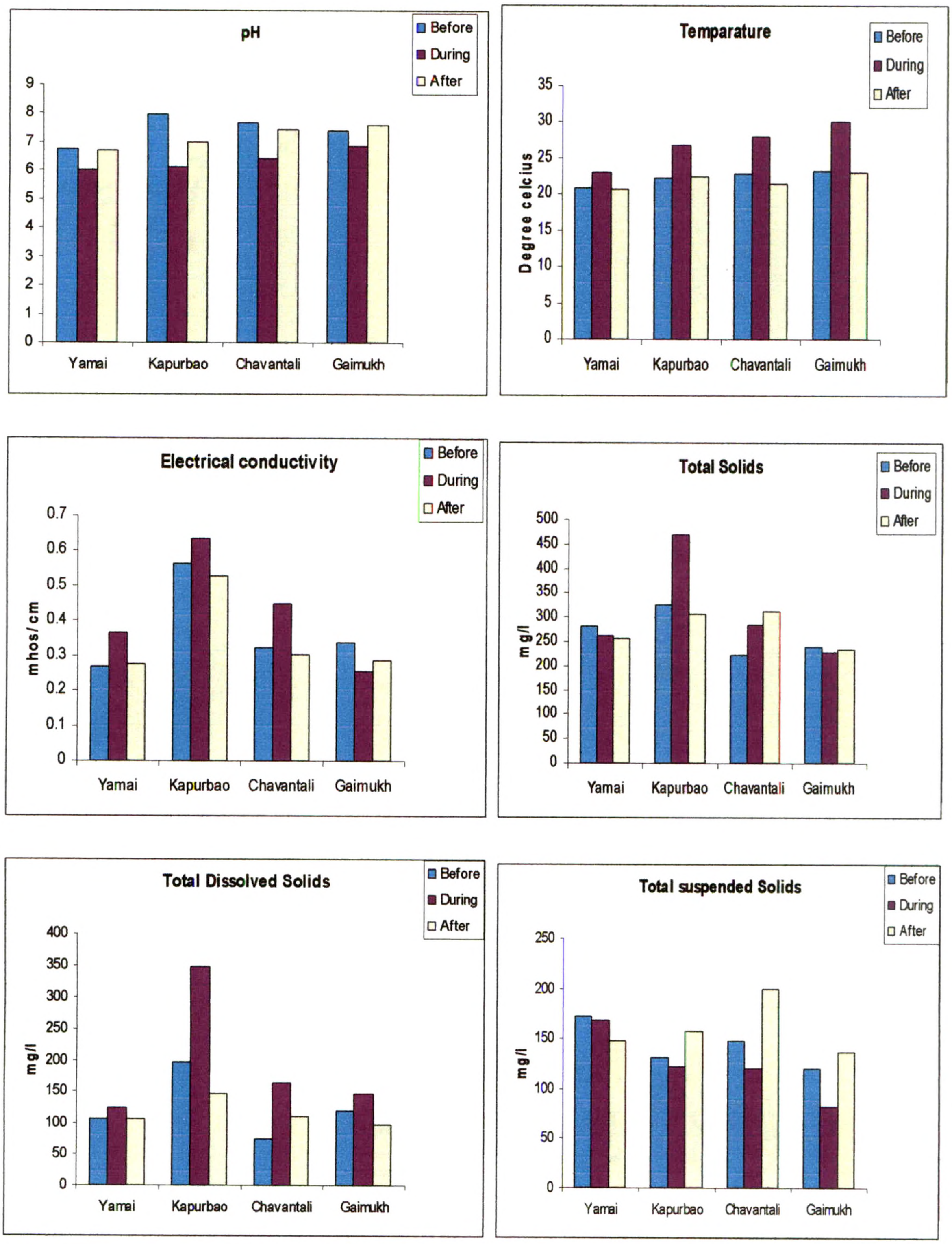


Fig No. 3 Impacts of Ritual Activity on Various Parameters

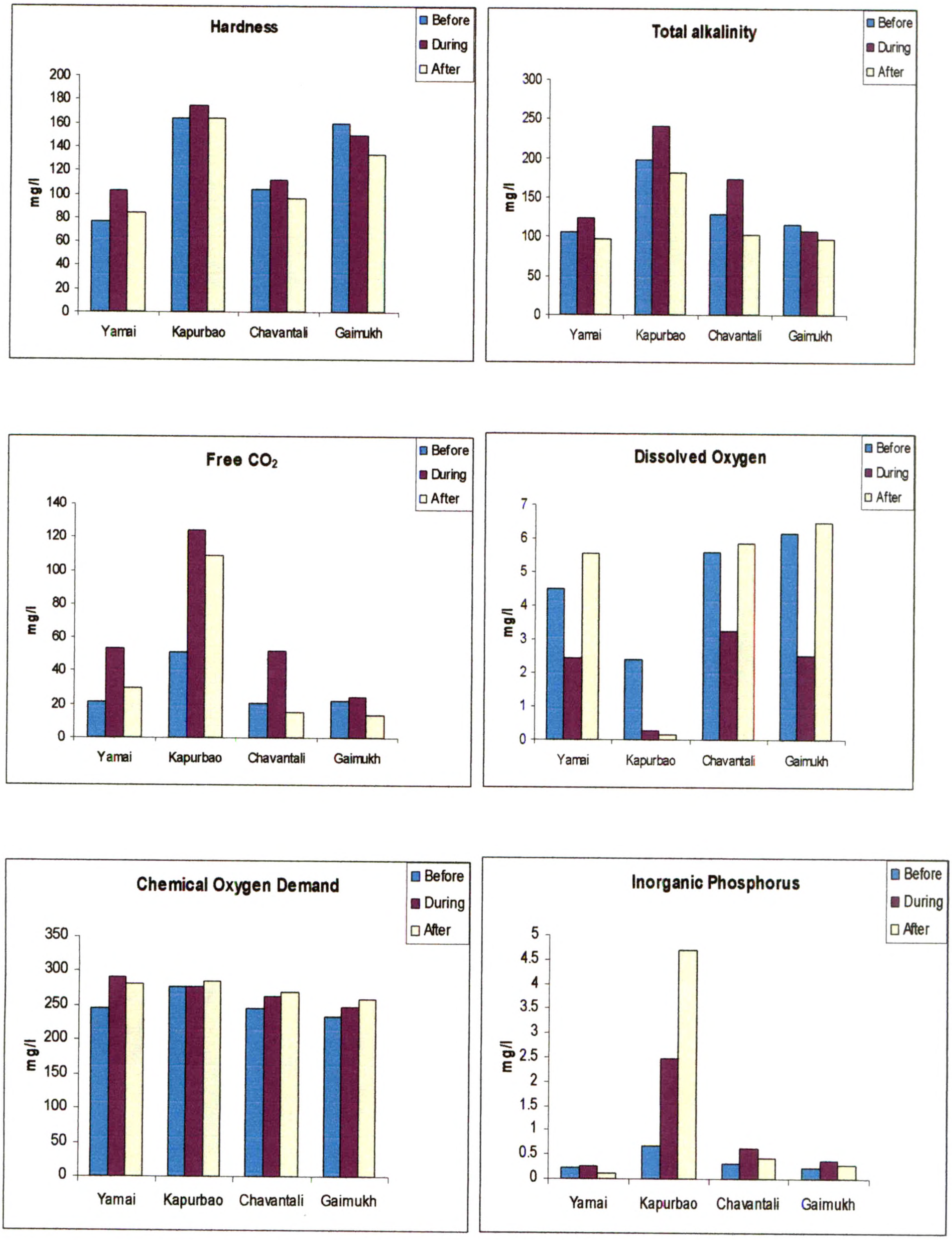


Fig No.4 Impacts of Ritual Activity on Various Parameters

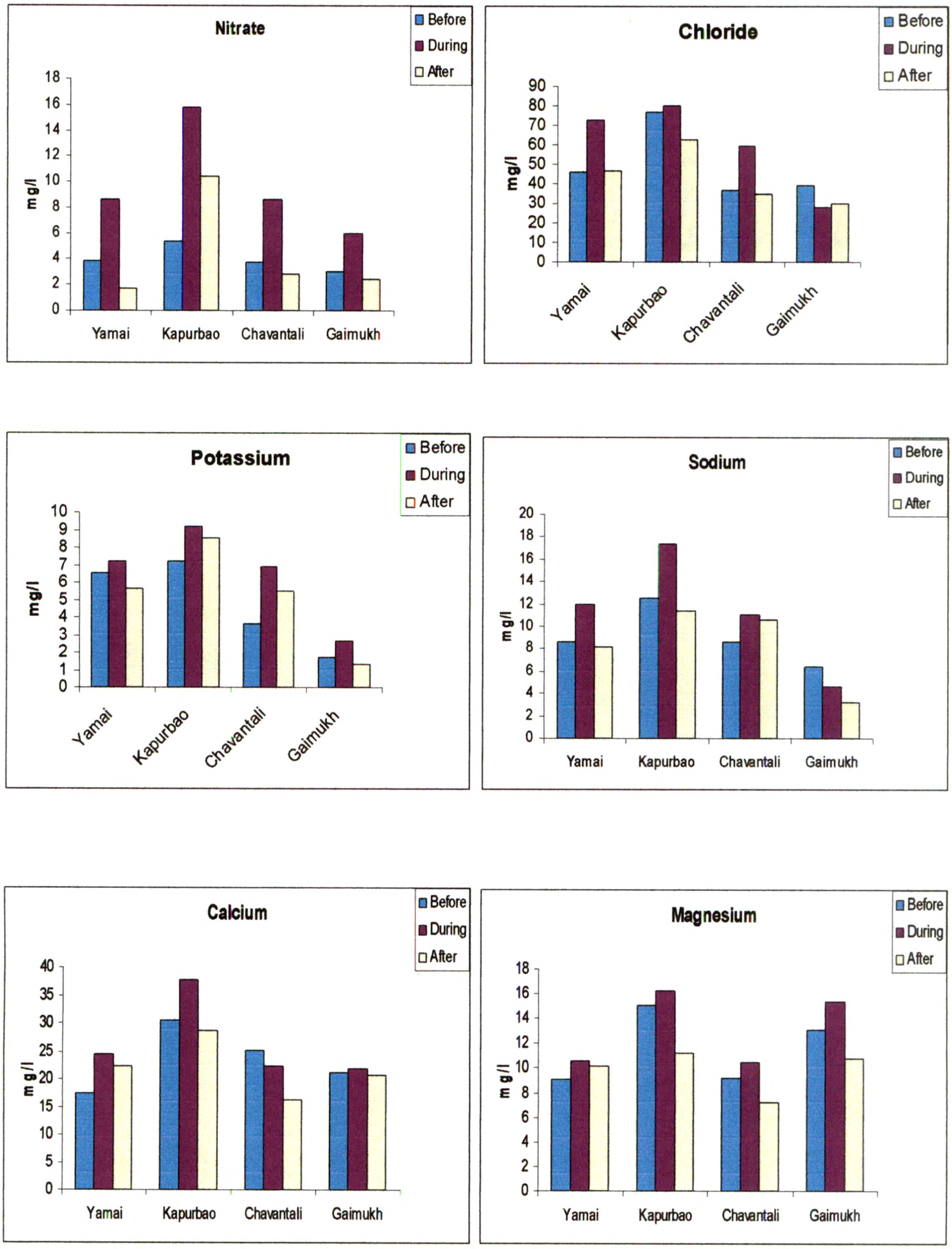
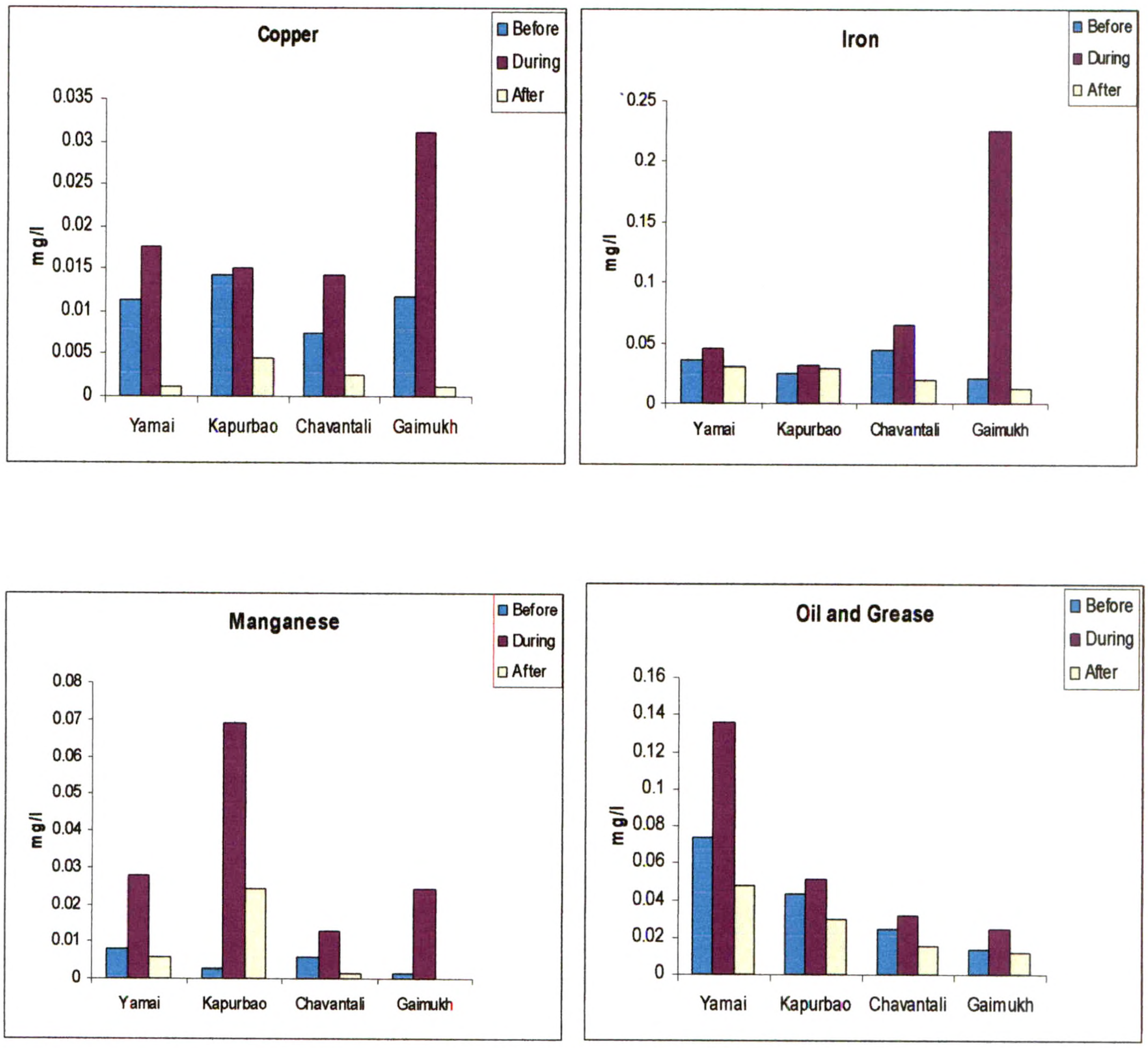


Fig No. 5 Impacts of Ritual Activity on Various Parameters



Anthropogenic activities in water resources of Jotiba

A- Holy bath at Yamai
B- Oil offerd to Yamai lake during yatra
C- Sewage mixing at Kapurbao
D- Water hyacinth growth in Kapurbao
E- Cloth wasing at Kapurbao
F- Cloth washing at Chavntali
G- Cattle washing at Chavantali
H - Garbage disposal at Chavantali
I- Cultivation near Gaimukh
J- Ritual activity chaitra yatra

Appendix –I

Pollution intensity index (Physico-chemical)

Sr. No.	Parameter	Highest desirable limit (As per WHO, 1984)	Arbitory Unit
1	pH	7.0 - 8.5	0.5 = ± 1
2	Total Solids	500 mg/l	50 = ± 1
3	Alkalinity	200 mg/l	25 = ± 1
4	Hardness	100 mg/l	10 = ± 1
5	Dissolved Oxygen	6 mg/l	0.5 = ± 1
6	Magnesium	30 mg/l	10 = ± 1
7	Iron	0.1 mg/l	0.01 = ± 1
8	Manganese	0.05 mg/l	0.05 = ± 1
9	Copper	0.05 mg/l	0.01 = ± 1
10	Chloride	200 mg/l	50 = ± 1
11	Nitrate	45 mg/l	5 = ± 1
12	Oil	0.01 mg/l	0.01 = ± 1

Formula for calculation

Pollution intensity index (Physico-chemical) = 100- (1+2+3+4+5+6+7+8+9+10+11+12)

Pollution intensity index (Biological)

Sr. No.	Parameter	Highest desirable limit	Arbitory Unit
1	Total bacterial count	Zero	$10 \text{ X } 10^2 = \pm 1$
2	Coliform	Zero	10 = ± 1
3	Phytoplankton (Indicated as per Palmer, 1969)		1 indicator genus = ± 1

Formula for calculation

Pollution intensity index (Biological) = (1+2+3)