CHAPTER - 6

SUMMARY

Limnology is the science of inland water bodies particularly rivers, ponds and lakes, including their biological, physical, chemical and hydrobiological aspects. The main aspect of Limnology is the biogenic material balance of natural waters. Water maintains an ecological balance between various group of living organism and their environment. Limnology has come a long way since the time Forel (1892) in understanding the dynamic of a standing water bodies subsequently, Limnology was studied with reference to the organism specially plankton Hensen (1887) and Fritsch (1907).

Water is not only an economic good but also a social good. Safe water supply and appropriate sanitation are the most essential components for a healthy and prosperous life. The provision of safe drinking water and adequate sanitation facilities. Water is the elixir of life, it is the source of energy and governs the evolution and functions of the universe on the earth. It is a medium of life and necessary component of protoplasmic system and raw material of photosynthetic process. Due to increasing urbanization and industrialization, natural quality of water has changed and deteriorated to a great extent. This as totally disturbed the hydrological cycle, as sufficient time is not available for the nature to regenerate the water from the waste water. Although water is abundant, covering nearly three quarters of the earth; yet is a scarce resource. The total amount of water on the earth is about 1.35 billion cubic meter (Ananthakrishnan, 1982).

Water is a major natural resource, an essential human need and a valuable national asset and hence its use requires proper planning, development and management. The trophic condition of a water body depends on the locality and its geography. Among all renewable resources of earth, water has

...
the exclusive place. It is necessary for survival of all forms of life, food production, economic development and for universal well being. Due to remarkable development of industry and agriculture, the water ecosystem has become audibly changed in several respects in current years and as such they are exposed to all local turbulence despite of where they occur (Venkatesan, 2007).

Water is the elixir of life, it is the source of energy and governs the evolution and functions of the universe on the earth. It is a medium of life and necessary component of protoplasmic system and raw material of photosynthetic process. Due to increasing urbanization and industrialization, natural quality of water has changed and deteriorated to a great extent. This as totally disturbed the hydrological cycle, as sufficient time is not available for the nature to regenerate the water from the waste water. Although water is abundant, covering nearly three quarters of the earth; yet is a scarce resource. The quantity of water present on earth is $1.46 \times 10^9$ cubic kilometer. Out of this 93% is the vast ocean, 4% underground water, 2% stored in the form of ice bergs and less than 1% is available as fresh water. (Lohar 2008)

Rajasthan which is well known as the desert and xerophytic environment, but it has many water resources because the rulers of this state were aware of the water scarcity, therefore constructed a numbers of lakes, ponds and dams. The main purpose behind construction of these water bodies was irrigation, drinking water and recreation. Due to low rainfall in the state, it is important to develop appropriate technology for conserving the rain water which may enrich our ground water resources and form the basis for supporting appropriate aquaculture. Probably because of erratic monsoon in Rajasthan there has been a rich tradition to conserve water especially in the arid area.

In most parts of the state the water table is very low and dependable sources of water are limited. But vast number of small pond and tanks existing in the state which receive rain water during monsoon period and this water is
retained for about 10 to 11 months. These water bodies are known as seasonal ponds.

Temporary ponds (aestival ponds) or Johara present in arid region like CHURU are chief source for drinking water for cattle as well as human beings. These are filled up with rain water and get dry with the arrival of the dry period of the year. In other words the aquatic ecosystem of temporary ponds present an interesting study of wet and dry cycles.

The Churu district is situated in the middle portion of the northeast of Rajasthan at 28°15'N and 74°55’ E. The general topography reveals a succession of dry undulating plain which are covered by loose sand. Climate of Churu city is xeric. This city has few temporary ponds among which pioneers are Sethani Johara, Kalra Johara, Pithana Johara and Johari Sagar (Dakida Johara).

The Sethani Johara is situated in the west of Churu city at triangle of Ratangarh and Sardarshahar roads about 5 Km. away from railway station. This is a man-made seasonal pond which receives rain water during monsoon. It retains water for the whole year. While reviewing the history of water reservoirs in Churu, it becomes clear that with the increasing demand of fresh water, rich people constructed Well, Baori and Joharas in a planned way, for availability of drinking water for local people. About the history of Sethani Johara, it is known that Smt. Brijkunwari constructed this Johara in the agricultural land adjacent to west of Churu city in the memory of her husband Seth Bhagwan Das Bagla in 1886. At that time this Johara was named as “Bhagwan Sagar”. Now it is popular as “Sethani Johara” (Rajasthan Patrika, September 6, 1997).

The catchment area of Sethani Johara has limestone and sandy soil. The plant species which cover the catchment area are *Taphrosia purpurea*, *Boerhaavia hirsute*, *Amaranthus sp.*, *Zizyphus jujuba*, *Prosopis cineraria*, *Dokra pinnata*, *Centunculus spinosus*, *Baccharis halimifolia*, *Calotropis procera*, *Calotropis gigantea*, *Ficus religiosa*, and *Sophora janthina*.
Calotropis procera, Leptadenea pyrotechnic, Aerva tomentosa, Tribulus terrestris, Argemone maxicana, Calligonum polygonoides, Cenchrus ciliaris, Achyranthus aspera, Cleome viscose, Euphorbia hirta, Gisekia sp., Mollugo cerviana, Farsetia hamiltonii, Heliotropium strigosum, Aristida sp., Corchorus sp., and Cyandon dactylon. The dominant species of this area are Cyandon dactylon and Taphrosia purpurea.

This area in northeast of Rajasthan is the hottest region in India. The winter season persists from December to February. December and January are the coldest month of the year. Particularly in this area in the rear of some western disturbances which traverse north India, cold waves occur and temperature some time falls -2°C. In the middle of March temperature increases and the hot season exist from April to June. May and June are the hottest month of the year. Due to dry atmosphere, open sky and sandy soil, quick radiation of heat occurs on earth soon after sunset with the result that the minimum temperature at night in noticeably lower. The burning heat and hot winds make the weather during the day very exhausting. An infrequent dust storms and sand storms bring about a abrupt fall in temperature and a few of the thunder storms of the season, which occur and are accompanied by rainfall, bring reception, though provisional relief from the burning heat. The weather changes with the arrival of monsoon spell of rain. During summer season in the month of May and June the maximum temperature is between 44 and 48°C, While in winter months i.e. December and January the minimum temperature becomes near to zero. On some occasions it becomes below zero i.e. minus. The annual precipitation in this area is between 30-35 cm. The relative average humidity is below 70%.

A number of observations regarding limnological studies related to physico-chemical characteristics of Sethani Johara, Churu were carried out for a period of twelve month (from January 2012 to December 2012). For the purpose of the present study three different stations i.e. A, B and C were fixed for water sampling and collection of phytoplankton. Station A was in the centre
of the pond and was least disturbed and station B was situated on southern side was more disturbed. Station C which was situated on the Western side of this pond was also least disturbed. In this pond the water samples were collected from surface zone as well as from bottom zone of station A. The water samples were usually collected during morning hours (7 AM to 9 AM) on a fixed date during each month.

The samples from surface and bottom zones were collected with sufficient precautions, so as to prevent any disturbance. The water sampler as recommended by Thresh et al. (1949) for collection of water samples was used for the purpose of present work. The detailed description of this sampler has been given by Jain (1978).

For collection purpose bottles made of polythylene were used because bottles made of plastic are unbreakable, light in weight and chemically inert as far as inorganic chemicals are concerned. The bottle were cleaned earlier by soaking these with dilute chromic acid which were washed well with distilled water. To determine the dissolved oxygen, narrow mouthed stoppered bottles of 275 ml capacity were used. Immediately on collection, the water samples were winklered and acidified for oxygen determination.

For analyzing the physico-chemical characteristics of water, standard methods prescribed by Trivedi et al. (1987), APHA (1998) and Kumar and Ravindranath (1998) were followed. The parameters such as water temperature, turbidity, pH, dissolved oxygen and free carbondioxide were measured at the sampling site. Similarly, air temperature and transparency were determined in the field. The collected samples were brought to the laboratory and analysed within 24 hours except the biological oxygen demand which require a period of five days for incubation at a temperature of 20°C. In cases, where delay was unavoidable chloroform was added in samples, so as to prevent the changes to be brought about by bacterial activity. (Schwoerbel, 1970).
Phytoplankton samples were also collected simultaneously with water samples from both the stations. These were collected by means of a conical bolting silk net having a diameter of 15cm and length of 75cm. To the lower narrow end of the net a steel tube of 50ml capacity was fixed. The bolting silk cloth has 50 meshes/cm. Pond water was passed through the net. The samples collected in tube were transferred to the marked bottles. The samples were preserved in modified Lugol’s solution (Vollenweider, 1969). After sedimentation of phytoplankton the supernatant liquid was siphoned off, and the sedimented portion was preserved in 4% formaldehyde.

The methodical detection of phytoplankton was done with the help of standard works (Fritsch 1935, Desikachary 1959, Randhawa 1959, APHA 1998). The Quantitative estimation of phytoplankton and other algae was done with the help of Haemocytometer counting chamber and the values per ml of the original water samples were calculated by the formula as suggested by Welch (1948).

The present study suggests and intimate relationship between air and water temperatures since both of them exhibited a similar pattern in regard to fluctuations, however, fluctuation in water temperature was comparatively less. This pond do not show a stable thermal stratification. In the present study water temperature was found ranging between 12.8°C to 32.4°C of which maximum value was recorded during summer season and the minimum value in winter season. In the present study water temperature showed a significant positive correlation with specific conductivity, pH, turbidity chlorides and organic matter. In addition at this pond temperature has also shown an inverse relationship with dissolved oxygen, free carbon dioxide and transparency. Temperature has shown the higher values at surface zone in comparison to bottom zone.

The transparency values were found to be minimum in the months of July (ranging between 0.31 and 0.35m) while maximum in the month of
November (ranging between 0.89 and 0.95 m). The decrease in transparency values and the increase in turbidity values during rainy months were observed to coincide with the mixing of water, silt as well as plankton population. The transparency values were high at station A.

The turbidity values were maximum during July at all the stations in this pond which might be because of the inflow of water due to rains. Turbidity has shown a positive correlation with salt like phosphate ($r = 0.576$). Turbidity has also shown a negative correlation with transparency ($r = -0.913$).

In Sethani Johara specific conductivity values were observed to be comparatively higher at bottom zone and lower at surface zone. The values were observed to fluctuate between 0.13 mMhos to 0.57 mMhos. In this pond conductivity have shown a positive correlations with temperature, pH, sodium, potassium, calcium, total hardness and total alkalinity.

Free carbon dioxide was absent during major part of investigation in this pond. Moreover, free carbon dioxide showed significant inverse relationship with temperature and dissolved oxygen in this pond.

In present study carbonate alkalinity values were observed to fluctuate between 0.0 ppm to 13.62 ppm. The contribution of bicarbonate alkalinity in the total alkalinity was observed to be much higher than that of carbonate alkalinity. In this pond the concentration of bicarbonate was found to be minimum during winter and maximum during the summer season and total alkalinity showed significant positive correlation with pH, specific conductivity and chloride. The total alkalinity value ranged between 57.65 ppm to 110.35 ppm.

The water of Sethani Johara was observed to be alkaline throughout the study period. The pH values fluctuating between 7.10 and 8.32 during the month of January and June respectively. In general the pH values of water were observed to be higher at surface zone and lower at bottom zone. In this
pond pH of water has shown a positive correlation with water temperature, specific conductivity, chloride and total alkalinity.

In this pond concentration of calcium was found to be maximum (32.3 ppm) during rainy season and minimum (12.3 ppm) in winter season. In Sethani Johara magnesium and total hardness were observed to show a similar trend, being maximum during rainy season and minimum during winter season. In addition to this in present study calcium, magnesium and total hardness were observed to have maximum concentration at bottom zone.

The concentration of various nutrients suggests that the pond studied is of eutrophic nature. The high concentration of chloride (24.56 ppm to 86.48 ppm) in indicative of heavy pollution (Arora, 1965) mainly of animal origin.

In Sethani Johara dissolved oxygen contents have been recorded to be maximum during winter (7.6 ppm – December) and minimum during summer (1.2 ppm – June) seasons. Present study have revealed that in this pond the concentration of dissolved oxygen decreases with depth. In this pond an inverse correlation between dissolved oxygen with temperature and free carbon dioxide have been observed.

In this pond the phosphate-phosphorus have been observed to be maximum (0.76 ppm) during rainy season confirms that there source is through run-off water during rains.

In the present study sodium value observed to be minimum (10.20 ppm) during winter and maximum (18.24 ppm) during summer season. While the concentration of potassium were recorded to be maximum (23.6 ppm) during summer and minimum (8.8 ppm) during winter season. Both these element were observed to be higher at bottom zone.

The dissolved organic matter was observed to increase during summer season and has shown positive correlation with water temperature in this pond.
Biological oxygen demand values in the Sethani Johara were observed to range between 3.0 ppm and 9.8 ppm and were maximum during the month of June and minimum during January. In this pond biological oxygen demand values increase with depth.

During the study of Sethani Johara 30 species of phytoplankton and other algae belonging to 27 genera were observed. Out of 30 species, 16 belongs to Chlorophyceae, 8 to Myxophyceae, 5 to Bacillariophyceae and 1 to Euglenophyceae. In addition to these three groups, one other group Euglenophyceae represented by one species has been observed. In respect of density January was the month when all the three stations showed maximum number of individuals in this pond.

In this pond the phytoplankton population depicted a distinct periodicity. Chlorophyceae dominating in the winter, blue greens in summer and Bacillariophyceae during rainy season. The number of species and density at surface zone varies between 826 ind. ml\(^{-1}\) yr\(^{-1}\) (station C) and 1025 ind. ml\(^{-1}\) yr\(^{-1}\) (station A). Average density of the whole phytoplankton population at surface zone was observed to be 930 ind. ml\(^{-1}\) yr\(^{-1}\). The data also suggest that the density at bottom zone was 607 ind. ml\(^{-1}\) yr\(^{-1}\).

Chlorophyceae was observed to show a positive correlation with dissolved oxygen and an inverse correlation with water temperature in this pond. In this pond Chlorophyceae was observed to contribute 51.81% (station C) to 62.92% (station A) of the total phytoplankton density at surface zone, while 63.59% at the bottom zone. Taking surface and bottom zones together the data reveal that in respect of phytoplankton density the contribution of this group at station A is 63.17%. In this temporary pond the Chlorophyceae has shown only one peak in the month of January. Beyond February there was a decrease in its concentration upto July at stations A and B.
On the basis of density the characteristic species of this group are *Chlamydomonas* sp and *Eudorina elegans*, at all the stations including different zones. *Tetraspora* sp. and *Pediastrum simplex* exhibited minimum density at the surface and bottom zones respectively of station A. At station B the species having minimum density was *Cosmarium reneiforme*, at station C was *Pediastrum duplex*, while *Tetraspora* had minimum density at station A.

In the present study diatoms have been found to show negative correlation with phosphate-phosphorus and turbidity and positive correlation with dissolved oxygen. In this pond Bacillariophyceae was observed to be represented by 5 species belonging to 5 different genera. Its contribution at the bottom zone was 5.60%; while at surface zone it ranged between 5.75% (station A) and 9.09% (station B). The maximum density of this class was observed during the months of December (station C) or January (surface and bottom zones of station A and station B), while the minimum density was observed during the months of February (station C) or March (bottom zone of station A and station B) or May (surface zone of station A). The data reveal that the surface and bottom zones of station A have maximum number of species (2) and the maximum density (19 ind. ml\(^{-1}\) at surface and 13 ind. ml\(^{-1}\) at bottom) occur during the month of January.

In respect of seasons the dominating species of Bacillariophyceae at the surface and bottom zones of station A was *Nitzschia palea* during summer and winter season and Fragilaria sp. during winter season. While this class not represented in rainy season. At stations B the dominant species was Navicula viridis during winter season and at station C Pinnularia viridis was dominant during rainy season.

In the present study Myxophycean population was observed to be maximum during summer season and exhibited positive correlations with temperature, pH, specific conductivity, total alkalinity and sodium and negative correlation with dissolved oxygen and phosphate. In this pond Myxophyceae
was represented by 8 species from 7 different genera. Its contribution at the bottom zone was 27.67%; while at surface zone it ranged between 27.12% (station A) and 34.38% (station C). This class exhibited only one peak during the month of June while its concentration was minimum in the months of July (surface zone of station A and station C); January (station B); February (bottom zone of station A). In respect of stations its concentration was minimum at station A and maximum at station B.

*Microcystis aeruginosa* species contributed towards the maximum density while the minimum density in this blue greens was contributed by *Rivularia* sp. (surface and bottom zones of station A and station B), and *Nostoc* sp. (station C). In respect of zones the concentration of Myxophyceae was always observed to be decrease at the bottom zone. The density of myxophyceae observed to be maximum during the month of June at all the stations and bottom zone.

Euglenophyceae in this pond was poorly represented both in respect of number of species and concentration. Euglenophyceae was represented by only one species viz. *Euglena viridis*. In this pond this class was observed to be represented by only one species i.e. *Euglena viridis*. This species was observed to grow in this temporary pond for a period of 3 to 6 months from August to October (bottom zone of station A), July to October and December (station C), July to November (station B) and July to December (surface zone of station A). In respect of stations the concentration of this species was minimum at station B and maximum at station C. In respect of zones the performance of *Euglena viridis* was observed to be comparatively higher at the surface zone.

The gross primary production on an annual average basis has been found to be maximum (2.940 gC m$^{-3}$ day$^{-1}$) during January. In the present study the values for respiratory rate (ranging between 1.129 gC m$^{-3}$ day$^{-1}$ and 2.262 gC m$^{-3}$ day$^{-1}$) were observed to be maximum in the month of December.
(stations A and C) and January (station B). The annual gross primary production values of phytoplankton population in this pond were observed to vary between 895.34 gC m\(^{-3}\) yr\(^{-1}\) and 953.74 gC m\(^{-3}\) yr\(^{-1}\). Similarly the values for net primary production ranged from 354.78 gC m\(^{-3}\) yr\(^{-1}\) to 413.18 gC m\(^{-3}\) yr\(^{-1}\) were observed.

In this pond the biomass of plankton population was maximum in the month of December (34 mg l\(^{-1}\), station A) and January (36 mg l\(^{-1}\), station C). The chlorophyll content and energy status show an intimate relationship being maximum in the month the January and minimum in the month of July.