FRESH WATER WETLANDS IN ARID ZONE

BY

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"Acknowledgements are many
But lines are few
Gratitude so deep,
That word would not do."

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CONTENTS

1. INTRODUCTION:

Water is not only major component of environment but it is the best solvent, and also medium on which all organisms are dependent for their existence. Even from the narrower practical point of view, a fresh water body provides a variety of human needs, is full of value, only when it is not abused and polluted. Therefore it is important to acquire requisite skills to ensure the conservation of this vital natural resource. The primary concern with water is for drinking, preparation of food and as a means of cleaning. But nowadays, man realized the inherent mysteries of aquatic phenomenon and water is the basis for all life activities. Accumulation of these observations a new branch of science starts to study, the fresh water biology and limnology.

Limnology is the branch of science, which deals with biological productivity of inland waters and which determine all the causal influences, (Welch 1950). Biological productivity includes its qualitative and quantitative features and its actual and potential aspects. The term inland waters include all kinds of water, running or standing fresh, salt or other physicochemical composition. The causal influences involve the various factors such as physical, chemical, biological, meteorological which determine the character and quantity of biological production.

The study of fresh or saline waters which contained within continental boundaries is Limnology (Goldman and Horne 1983). The term hydrobiology was formerly used as more or less equivalent to the limnology. Certain terms were used loosely as more or less equivalent to the term limnology, viz. hydrobiology, fresh water biology, aquatic biology, aquatic ecology and limnobiology, in the past.

At present, limnology plays a role in the decision – making process for problems of dam construction, pollution controls, fish and wild life enhancement. The wealth of current knowledge of limnology is the product of studies on European and American lakes. In India, the hydrobiological studies followed traditional approaches using temperate models (Rao T. Ramakrishna. 1991).

Basic limnological knowledge is essential for a sound management of aquatic resources. Wetlands are valuable resources and their continued degradation and loss involves numerous direct and indirect effects in many dimensions of society. The future of wetlands becomes a global issue in need of global information sharing, co-operation, policy setting and action.

The Ramsar convention (1971) defines wetland as, “area of marshes, fens, peat lands or water whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including area of marine water which at low tide does not exceed six

5meters.” The wetlands are lands transitional between terrestrial and an aquatic system where the water table is usually at or near the surface or the land is covered by shallow water.

The Indian sub- continent spans the latitudinal range from 6^0 N to 37^0 N. This is a part of humid tropics region. Some areas are dry to almost arid. However most of the region is well supplied with both lentic and lotic habitats. Natural lakes are notable for their scarcity only a few occurring in northern most region. However manmade lakes (reservoirs) are quite numerous in all over region.

The reservoirs serve as a source of water for domestic and industrial purposes and also for agriculture and fisheries. The same water resources may also utilize for disposal of wastes. Fresh water reservoirs have long attracted the attention of ecologists, both for their importance as the source of drinking water and in the development of inland fisheries. Fresh water is one of the scarce natural resources, conservation of which is assuming increasing demand in domestic, agricultural and industrial sectors on the one hand and its gross pollution on the other. It is well known that almost all human activities modify the quality of fresh water resources. The urbanization, industrialization, deforestation, agriculture and construction activity lead to the pollution of water bodies. Direct human activities in the form of washing, bathing, cattle and clothes wash ing etc. are effective factors causing the pollution of water bodies.

Considerable literature exists on the limnology of several Indian freshwater lentic ecosystems (Ganpati 1940, Rao and Govind 1964, Sreenivasan 1964, Zafar 1966, Munawar 1970). Pioneer work on plankton of Indian water bodies has been carried out by Ganpati (1940), Philipose *et. al.* (1970)). In India, much work has been done on the algal flora by Gonzalves and Joshi 1946, Philipose 1960, Palmer 1969, Panday and Tripathi 1988.

The study has been designed to understand the hydrobiological features of reservoir, to assess water quality which will state the potability, suitability for fish culture and irrigation purpose.

Prior to initiation of present work all the wetlands were surveyed to know their extent and seasonality. Some are small area wise while, some of them dry up during summer. Therefore, area wise six major perennial wetlands were selected.

The main objective of the work is to study the existing cropping patterns and available water resources in the study area, to identify suitable sites which will meet the requirement of water for existing crops and to recommend suitable pattern.

2. MATERIAL AND METHODS:

- **Survey and Morphometric Features:**

In present study, survey of wetlands of drought prone eastern part of Sangli district was made to observe present status of water storage and availability of water for whole year by survey and with the help of local people.

Morphometric features such as catchment area, total capacity, dead storage, type of dam, length and type of slipway, submergence etc. were studied by obtaining the information through local people as well as through irrigation department. Morphometric features of each reservoir were studied by the methods described by Trivedy *et al* (1998).

- **Physico- chemical Environment of Waterbodies:**

Five reservoirs were visited monthly for the I^{st} of study period (June 2013 to May 2014) and seasonally during next consecutive year (June 2014 to May 2015).Three sampling sites for each reservoir were selected for monthly analysis. The water samples were collected approximately 10–15 meters from border line of each wetland. Therefore, sampling sites were constant through out the annum. Water samples were collected in pre-cleaned five liter plastic cans and immediately brought to the laboratory for various physico-chemical analyses.

Data was gathered on air-water temperature, pH, and free carbon-dioxide and dissolved oxygen etc., these experiments were performed at the respective sites only.

The air and water temperature was recorded by using mercury thermometer; Transparency of water was determined by Secchi disc method. pH by using pH meter (Hanna Model Champ). Electrical conductivity is determined by EQUP - TRONICS – Auto temperature conductivity meter Model – EQ- 661.

The chemical parameters such as dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, calcium, magnesium, chlorides, total dissolved solids, total Kjeldahl nitrogen and total phosphorus were determined by standard methods as described by American Public Health Association (APHA, 1985, 2005) Trivedy *et. al.* (1998).

For the physico-chemical properties and biological parameters of pollution standards by WHO (1993), Goel (2001).

- **Biological Parameters:**

1. **MPN Technique** (Most Probable Number):

The standard test to estimate the number of coliform is carried out by multiple tube dilution technique as described by American Public Health Association (APHA, 1985, 2005) and Trivedy *et. al* (1998).

There are three steps to estimate the coliform group by MPN technique, presumptive test, conformed test and completed tests.

For presumptive test single and double strength Mc Conkey's broth (Himedia) were prepared, sterilized in test tubes containing Durham's tube to show the gas production. Three sets were used, with each set having 5 tubes.

The first set was filled with 10 ml. double strength medium and other two sets with 5 ml single strength medium. 10 ml of water sample was inoculated in the first set and 1 ml and 0.1 ml in the second and third set respectively. Finally all tubes were incubated at 37 ºC for the period of 24 – 48 hours. The tubes were analyzed after incubation for gas production (MPN index of 100 ml of sample).

2. **Biological oxygen Demand (BOD):**

Biological oxygen Demand (BOD) of water samples was evaluated by measuring oxygen concentration before and after incubation for 5 days by Winkler's Idometric Method. The results were expressed in mg/l.

- **PRODUCTIVITY OF WETLANDS:**

1. **Primary Productivity**:

Primary productivity was calculated for the period of second sampling year (May 2014 to May 2015) by employing the light and dark bottle method by Gaarder and Gran (1927). The setting of experiment was done from site II of each reservoir. Oxygen content in light and dark bottles along with initial dissolved oxygen were determined by Winkler's Iodometric method with three replicates.

2. **Aquatic macrophytes:**

During every visit aquatic macrophytes and marginal macrophytes were studied, photographed and collected from reservoirs and kept in polythene bags for further process. In laboratory they were identified by using Cooke's 'The Flora of Presidency of Bombay' (1967), Flora of Kolhapur district (Yadav and Sardesai 2002) and other relevant published literature.

3. **Phytoplankton**:

The phytoplankton were collected using plankton net. It was prepared by using bolting silk No. 125. Total 100 liters of water sample was filtered and concentrate was collected in 200 ml plastic bottle. Two separate sets of concentrate samples were preserved by adding 4% formalin and 1 ml of Lugol's Iodine.

Identification of phytoplankton was made following APHA 2005, Fritsch (1944), Bongale and Bharati (1978) and Prescott (1982) and consulting experts. The qualitative analysis of phytoplankton was performed under Olympus trinocular 20C Hi microscope by focus 10 X 45x with 7.5 mega pixel camera.

IMPORTANCE OF WETLANDS:

1. **Agricultural productivity:**

The study of Agricultural productivity and fishery productivity of all the reservoirs was conducted with the help of questionnaire. (Appendix I and II). The survey was conducted in nearby villages of reservoir. Local people were interviewed by using questionnaire. The data obtained by filling up questionnaire was analyzed in the laboratory. The head of house hold was considered as the unit of analysis. The socio-economic condition of the house is closely related to the family head.

2. **Fishery:**

The fishes captured by fishermen were observed during the regular visits of study period. Fishermen and their family members were interviewed about their whole activity and their profit. Fishes were identified following the state keys of Jhingran (1982, 1991), Jayaram (1999).

An indirect method of quantifying importance value in relation to agriculture, fishery and potability is developed on the basis of the data collected qualitatively and quantitatively primary and secondary hand for the wetlands under study.

This model is based on assigning numerical values for various biological, environmental, and socio-economic risk factors, with the total score indicative of magnitude of either threat potability or importance in relation to agriculture and fishery.

The numerical values based on observed variables were entered in the data sheets in the collection site itself while, numerical values based on analytical work were entered after completion of analysis for all the seasons for all the wetlands.

Based on the survey, productivity with reference to agriculture and fishery was calculated.

3. **Avifauna**:

The birds observed in and around the reservoir were identified by using standard keys of Salim Ali (2002) and Bruce Campbell (1974).

APPENDIX - I

Questionnaire for Agricultural Development or improvement by wetlands

1. Name of family leader :
2. Age :
3. Caste :
4. Address :

5. Total number of family members : Male: Female:

6. Total original land :

    a) Under Irrigation: b) Dry land: c) Useless land :

7. Number of Cattle :

8. Crops cultivated :

    Before construction after construction of wetland
    1
    2
    3
    4

9. Availability of water : Yes / No

    Well: Water tank:
    Water supply scheme: Bore well:

10. Whether the water tank near the village is beneficial or not: Yes /No
    If Yes, How it is helpful?
    1) By Direct supply : Yes / No
    2) Increase in well water level : Yes / No

11. What types of benefits did you receive from the water tank water?

    a) Increase in the land under irrigation.
    b) Increase in gross productivity of yield.
    c) Increase in economic status.
    d) Increase in industries in area.

12. Overall effect of wetland on your family and village area.

* * * * *

APPENDIX - II

Questionnaire for Fish farming Development or improvement by wetlands

1. Name of family leader :
2. Age :
3. Caste :
4. Address :

5. Total number of family members : Male: Female:

6. Since how many years you are doing fishing.

7. Which nets do you use for fishing?

8. Which fishes do you get in this water body?
    1.
    2.
    3.
    4.

9. How much yield of fish do you get per visit?

10. How many days do you do fishing in a month?

11. In which months do you do fishing?

12. Where do you sale these fishes?

13. Approximate cost of fishes per kg.

14. Approximate annual income from fishing.

15. Do you do fishing individually? Or Are you associated with fishing Society?

16. Name of the fishing society.

17. Do you pay some amount to society?

18. Overall effect of this water body on you and villagers.

* * * * *

3. RESULTS AND DISCUSSION:

I. Survey and Morphometric Features:

1. **Survey:**

The present survey covers data available on location, geographical co-ordinates, area, category type etc. Southern Maharashtra includes Sangli, Satara and Kolhapur districts. Out of these three districts, Sangli district is one of the most important district as far as agricultural development is concerned.

Sangli district is situated between 16.46 to 17.1^{o} N and 73.43 to 75.0^{o} E latitudes. The total geographical area of the district is 8601.5 sq. km. having 25, 83,524 population according to the 2001 census. Geographically, Sangli district is divided into two zones viz. area adjoining Krishna river basin and eastern drought prone area away from basin with low rainfall and typical arid geographical set up. The overall water level is up to 6 meters down but varies according to geographical area, strata and location of the particular village. The eastern part of the district shows low fertile soil because of natural set up where man-made reservoirs have become source of irrigation besides the well. This region includes Khanapur, Atpadi, Kavathe- Mahankal, Jath and eastern part of Tasgaon tahsil. This eastern region shows scarcity of water leading to general dry climate. The present work is restricted for the study of man-made reservoirs of the drought prone eastern part of the Sangli district.

All reservoirs (major and minor) are surveyed and total six reservoirs are chosen for the study as a representative of each tahsil. They are 1) Bhakuchi Wadi reservoir from Khanapur tahsil 2) Nimbawade reservoir from Atpadi tahsil, 3) Sidhewadi reservoir from of Tasgaon tahsil, 4) Dudhebhavi reservoir from Kavathe-Mahankal tahsil and 5) Doddanala reservoir from Jath tahsil.

From each tahsil single reservoir is selected. These minor and medium reservoirs store rain water received from adjoining areas through smaller channels. It is being utilized for drinking and irrigation purposes through scheme. These reservoirs are mainly constructed for irrigation purpose. Irrigation is an age old art as old as human utilization. The fishing activity is undertaken by the fishermen community and local inhabitants of adjoining villages have become the source of an additional income. Thus, increasing human activities over the recent past years imposing a greater stress on this ecosystem. It is well known that almost all human activities change the quality of water reservoirs. The causative factors responsible for degradation water quality need to be evaluated so as to take proper steps before the situation becomes uncontrollable.

Thus, in the present investigation an attempt has been made to evaluate the important biological parameters such as plankton, aquatic macro flora of selected water reservoirs. Simultaneously, the productivity of water bodies such as primary productivity, agricultural productivity and fishery related productivity studied to know the status of water reservoirs respectively.

The study has been designed to understand the hydrobiological features of reservoirs to identify water quality which determines potability, suitability for fish culture and irrigation purpose.

Attempts are mostly to collect additional information and update the biological data of untouched water bodies which will be of use in studying and conserving the water reservoirs of our country.

1. Bhakuchi wadi reservoir:

The Bhakuchi wadi is small village located at northern part of Khanapur tahsil and northern part of district 70 km away from district place. The village is known for its minor reservoir. In 1988-91 Irrigation Department has constructed earthen dam riveted with stones. The water is used for irrigation also for washing, batting and fishing activities. The reservoir is much influenced by human activities and weeds.

2. Nimbavade reservoir:

The Atpadi is a tahsil place and it is 105 km away from district place. Nimbavade is well known minor irrigation reservoir. In the period 1981-1988 Irrigation Department has constructed earthen Dam riveted with stones. The purpose of construction of reservoir is irrigation, but it is neglected for many years. Recently it is used for irrigation, for human activities and for fish culture.

3. Sidhewadi reservoir:

This is medium irrigation reservoir near Tasgaon tahsil. It is about 47 km from district place. This reservoir was constructed during the year 1972 to 1977. Irrigation Department has constructed earthen dam riveted with stones. This reservoir is very useful to nearby villagers of Sawalaj, Sidhewadi and Waiphale. The main source of water is used for irrigation purpose and fishery. But now it is used for human activities.

4. Dudhebhavi reservoir:

This is minor irrigation reservoir near Dudhebhavi village about 80 km. away from district place in Kavathe-Mahankal tahsil. It is constructed during 1984 by the Irrigation Department. Purposely it is constructed for irrigation but now-a-days it is used for fishing activities and for other human activities.

5. Doddanala reservoir:

It is major irrigation reservoir in Jath tahsil. It is about 145 km from district place. It is constructed during 1977-80. It is used as a drinking water source for the Jath town. It is also used for the cultivation of fishes.

During rainy season i.e. from mid June, July, August and September the farmers allow their buffallows grazing on lush green grasses in catchment area.Very less macrophyte occur in the reservoir.

All the reservoirs store rain water receiving from adjoining catchment area though small channels. The water of reservoir is used for irrigation purpose by government policies. The reservoirs are leased out to fishermen co-operative societies. The fishermen cultivate fishes. No scientific method is applied for fish farming and indiscriminate fishing is observed frequently.

SAMPLING SITES:

Three sampling sites were selected in each reservoir taking into account various human activities like cloth washing, bathing, cattle washing, fishing etc, inlet and outlet of reservoir, growth of aquatic macrophytes and morphometric features of reservoirs.(Figure i, ii, iii).

Bhakuchi wadi Reservoir :

Site I (B I): This site is located at west side of reservoir near the dam line. It is much influenced by human activities such as bathing, buffalo washing. Vegetation is on the dam line.

Site II (B II): This site is also influenced by all human activities and fishing. It is located nearby centre of reservoir but towards south bank.

Site III (B III): It is located at eastern end of reservoir which collects inflow of water by small channels from adjacent area during rainy season. Site is influenced by aquatic macrophytes.

Nimbavade Reservoir:

Site I (N I): It is shallow and located at northern east side of reservoir near the dam line. Vegetation occurs on dam line. This site is devoid of aquatic macrophytes. This site is much influenced by cattle, sheep interference and fishing activities.

Site II (N II): This site lies at the south bank of reservoir and more influenced by number of anthropogenic activities.

Site III (N III):This site collects rain water and run off from adjoining areas through small streams. From this site the water is lifted for irrigation through pipes. This site is comparatively less influenced by human activities.

Sidhewadi Reservoir:

Site I (S I): This site is located at the east corner of reservoir. It receives rain water from adjacent area during rainy season. It is devoid of macrophytes and it is comparatively less influenced by human activities except fishing.

Site II (S II): It is shallow near the dam line of reservoir. This site is much influenced by human activities like washing, bathing, fishing etc. It is devoid of macrophytes.

Site III (S III): It is also much influenced by human activities. It receives rain water and run off from adjacent catchment area during rainy season. It is infested by growth of macrophytes.

<u>Dudhebhavi reservoir</u>:

Site I (Db I): It is located near the dam line sandva (outlet). The bottom is rocky and muddy (mixed). It is shallow at the eastern side of reservoir. It is much influenced by human and cattle activities and fishing activities.

Site II (Db II): This site lies at southern west corner of reservoir. It is rocky in nature. Near to this site reservoir accepts water inflow and run off from adjacent catchment area. It is devoid of macrophytes. This site is much influenced by human activities, cattle and sheep activities along with fishing.

Site III (Db III): The site is located at Northern west side of reservoir. It is influenced by human activities like cloth washing, cattle washing and fishing. Aquatic macrophytes.

<u>Doddanala Reservoir</u> :

Site I (Dn I): This site lays nearly the dam line at northern side. It is shallow with muddy bottom. This site is full of macrophytes and influenced by human and grazing animals along with fishing activities.

Site II (Dn II):It lies nearly the centre of bank of west side. This site is also infested by macrophytes. It is shallow and muddy. This site shows human influence.

Site III (Dn III):Here the rain water is collected through smaller streams of adjacent catchment area. It shows human influence, animal interference, fishing activities. This site is dominated by several macrophytes.

2. Morphometric Features:

The morphometric features of all reservoirs have been studied during the year 2006 and are represented in Table I and II.

I Morphometric features of Bhkuchiwadi, Nimbwade reservoirs.

Reservoirs → **Morphometric Features ↓**	Bhkuchiwadi	Nimbwade
Longitude	17º 19′ E	17º 25′ E
Latitude	74º 37′ N	74º 52′ 30″ N
Catchment area (Square kilometer)	261.21 sq. miles	108.49
Total capacity (Mcft)	680.30	11.00
Dead storage (Mcft)	59.96	35.35
Length of dam (including slipway) (Meter)	1990	887.50
Type of dam	Earthen	Earthen
Length of Slipway (Meter)	150	183
Type of slipway	Clear overflow	Clear overflow
Submergence area (Hectare)	108.80	66
Bottom	Rocky	Rocky
Height of dam (Meter)	19.70	16.31
Water spread (Hectare)	1207	533
Average rainfall (inches)	17.64	19.56
Construction year	1988 / 1991	1981 / 1988
Ecological category	Fresh water	Fresh water

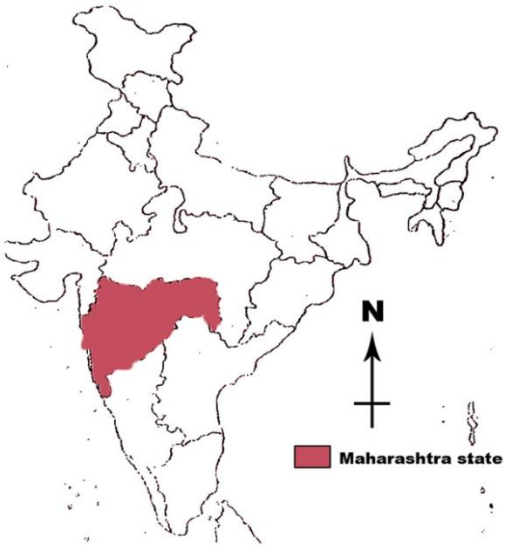
Source: Irrigation department, Sangli.

II Morphometric features of Sidhewadi, Dudhebhavi and Doddanala reservoirs.

. **Reservoirs** → **Morphometric Features** ↓	**Sidhewadi**	Dudhebhavi	Doddanala
Longitude	19º 9′ E	17º 9′ 37″ E	17º 4′ 50″ E
Latitude	74º 6′ N	74º 46′15″ N	75º 36′ N
Catchment area (Square kilometer)	65 Sq. mile	51.76	106.0
Total capacity (Mcft)	302.95	630.90	508.60
Dead storage (Mcft)	87.56	18.63	60.84
Length of dam (including slipway) (Meter)	959	330	5
Type of dam	Earthen	Earthen	Earthen
Length of Slipway (Meter)	216	115	5
Type of slipway	without gated	Clear overflow	Clear overflow
Submergence area (Hectare)	146	152	1000
Bottom	Silted	Rocky	Rocky
Height of dam (Meter)	19	19.33	18.6
Water spread (Hectare)	145	221	256
Average rainfall (mm)	450	551	501
Construction year	1972 / 1978	1984	1977
Ecological category	Fresh water	Fresh water	Fresh water

Source: Irrigation department, Sangli.

Map of India showing Maharashtra. | Map of Maharashtra showing Sangli District



Map of Sangli District showing Study Area

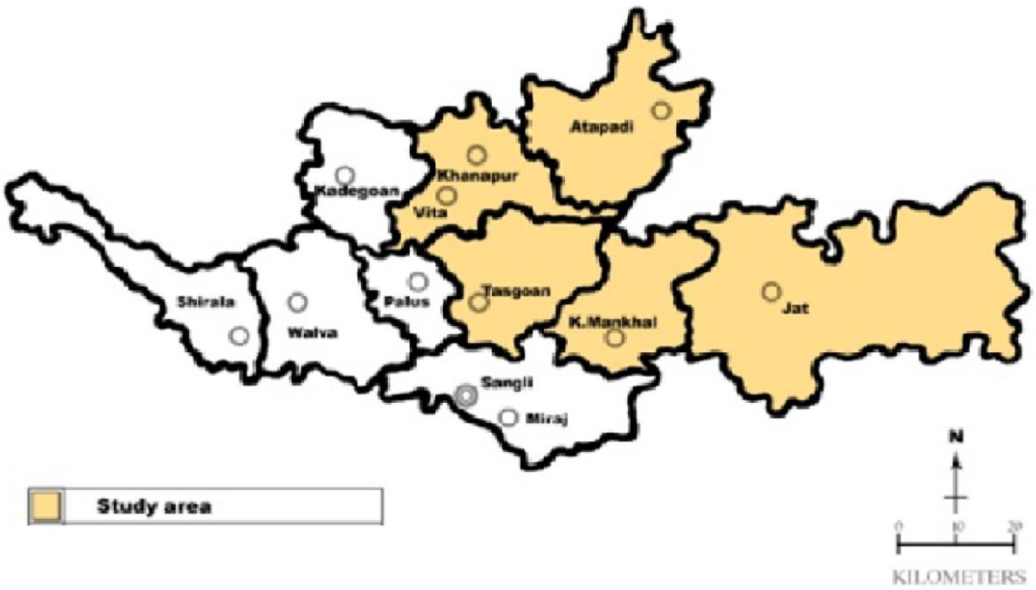


Plate I Map of India, Maharashtra and Sangli District

Plate II   Satallite images of Bhakuchi wadi and Nimbawade water Bodies

Plate III Satallite images of Sidhewadi, Dudhebhavi and Doddanala water Bodies.

II. Physico-chemical environment of water bodies:

a. Physical parameters:

In the present investigation temperature, Secchi disc transparency, pH and electrical conductivity are studied monthly as well as seasonally.

1. Temperature:

The atmospheric temperature does not remain constant on account of change in season; the water temperature also varies seasonally. This leads to the mixing of surface and bottom layers at the time of transition from one season to another. The measurement of water temperature is important basically for its effect on chemistry and biochemical reactions in the organisms. It is also an important in the determination of pH, conductivity and saturation level of gases in water. A steady rise or fall in the water temperature is attributable the corresponding rise or fall in the atmosphere temperature due to the increased or decreased solar radiation.

All organisms including fish possess well define limits of temperature tolerance with optimum lying somewhere in between. All metabolic and physiological activities and life processes such as feeding, reproduction movement and distribution of aquatic organisms are greatly influenced by water temperature (Welch 1952).

The ambient (air) temperature depends upon climate and thus is affected by season, latitude and altitude. The change in temperature can induce changes in species composition of plant community. Certain shallow bodies of water in the tropics are apparently stratified during the day and mixed at night. Sufficient accurate data are important to the limnologist. Temperature directly and indirectly exerts many fundamental effects on limnological phenomenon such as lake stability and biotic metabolism (Lind 1974).

1A. Mean Temperature (Air and water °C) of Bhakuchiwadi, Nimbawade, Sidhewadi Reservoirs from June 2013 to May 2014.

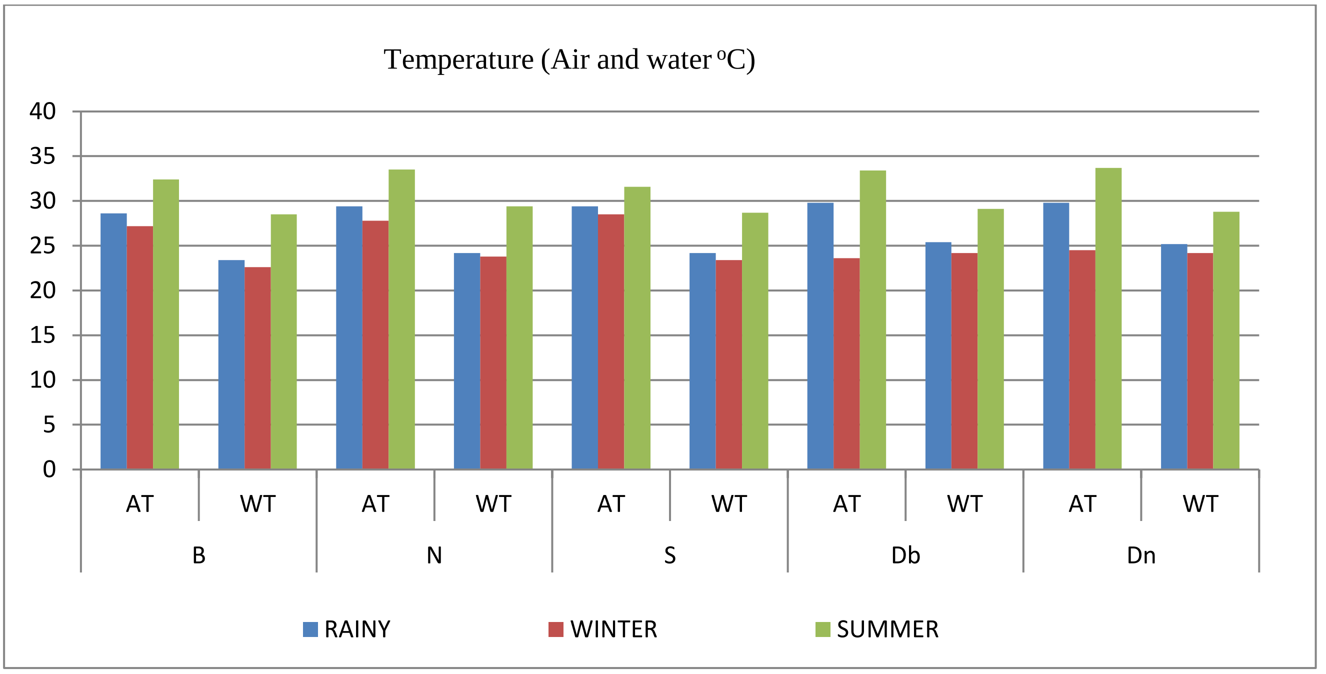
Reservoirs → **Months ↓**	B AT	B WT	N AT	N WT	S AT	S WT
June 2013	32.3	27.1	32.4	27.1	33.2	29.8
July	27.6	24.2	30.4	24.1	27.3	25.6
August	24.7	23.8	25.1	22.3	25.8	24.3
September	27.2	25	27.8	23.8	26.6	25.3
October	31.1	28.8	31.5	25.2	29.3	27.6
November	28.2	25.1	28.8	24.6	28.3	24.1
December	**24.2**	**23.1**	**25.3**	**23.2**	**26.1**	**22.5**
January 2014	26	24.2	27.2	23.4	27.3	24.3
February	27.3	24.1	27.9	24.1	27.5	26.1
March	31.5	25	31.5	26.5	32.7	29.4
April	32.1	25.2	33.1	26.8	33.2	30.5
May	**34.3**	**28.6**	**35.6**	**28.1**	**37.4**	**31.1**

1B. Mean Temperature (Air and water °C) of Dudhebhavi and Doddanala reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	Db AT	Db WT	Dn AT	Dn WT
June 2013	32.8	28.7	32.9	29
July	30.5	24.6	30.8	25.2
August	31.1	25.2	31.5	25.4
September	30.8	26.4	30.9	26.5
October	31.5	28.1	31.7	28.3
November	30.7	25.6	31.2	26.7
December	**28.5**	**23.1**	**29.1**	**24.8**
January 2014	30.2	24.6	30.3	26.2
February	32.4	28.2	33.1	28.3
March	34.8	30.4	35	30.1
April	35.6	30.5	35.2	31.1
May	**37.4**	**32.4**	**37.6**	**32.2**

B	Bhakuchiwadi
N	Nimbawade
S	Sidhewadi
Db	Dudhebhani
Dn	Doddanala

1C Seasonal Temperature (Air and water ^oC) of all reservoirs from June 2014 to May 2015.



The trend of monthly fluctuations in the surface water temperature was similar to the air temperature. This clearly indicates that air and water temperature did not vary to a greater extent.

The season wise analysis reveals that the average air and water temperature was maximum during summer comparatively less during monsoon and least during winter season. The rise and fall in atmospheric temperature was due to increase and decrease of solar radiations.

Many researchers have given the range of temperature of air and water for various water bodies around Maharashtra state. For Rajaram tank the fluctuations in the air temperature has given in the range of 15.5 ^oC to 32 ^oC, while the water temperature range is in 23 ^oC to 29.5 ^oC (Angadi 1985).

Overall there is fluctuation in the water temperature of each water body as the atmospheric temperature locality wise.

2. Transparency: (Secchi disc transparency)

Light is an essential requirement for photosynthesis. Light penetration depends upon the available intensity of the incident light which varies with the geographical location of the water body (Jhingran 1982). The penetration of light rays in water depends upon several factors such as suspended solids, particulate matter, dissolved organic matter present in water and the intensity. The transmission of light is affected by the color and turbidity of water. The former affecting the composition of transmitted light and later the depth to which it penetrates.

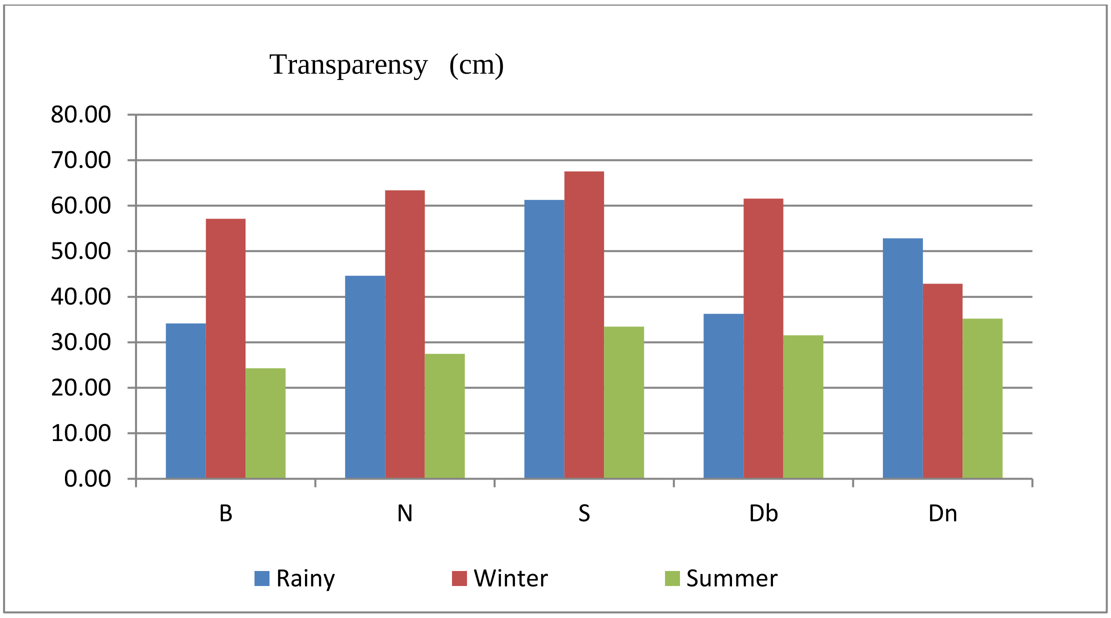
Solar radiation is the major energy source driving the productivity of aquatic system. It is therefore very important to know the extent of light penetration in the natural waters. (Adoni *et.al.* 1985). Transparency has been considered as an important parameter for assessing the primary productivity of the water body.

The lowest transparency was observed during summer and highest values were recorded during winter season, during both the years of study period. Hujare and Mule (2008) reported the lowest transparency during summer season and highest values during rainy season, which support present findings.

2A. Mean variation in **Transparency** (cm) at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	12.5	12.5	59.3	33	33.5
July	21.4	22.45	57.2	41.5	36.8
August	26	36.21	55	45	38.1
September	45.4	39.1	61.1	46.5	41.5
October	**60.1**	58.62	62	51	43.2
November	52.1	**62.12**	61.5	56.5	**45.3**
December	56.5	51.65	**62.1**	**72**	44.5
January 2014	47.1	46.21	55.2	65	39.5
February	48.1	35.27	62.5	60	43
March	45.5	40	58.5	45	41.6
April	22.6	25.14	**51.3**	31.5	40.6
May	**12.4**	**12.35**	60.3	**21.5**	**31.8**

2B Seasonal range in Transparency in all reservoirs from June 2013 to May 2014.



3. pH

The hydrogen ion concentration of natural waters is an important environmental factor. The pH is the logarithm of the reciprocal of the hydrogen ion concentration affects metabolism within the plant cell by affecting the uptake of nutrients and carbon dioxide.

Various species are adapted to different range of pH and thus species composition in water body may be altered by different range in pH (Mitchel 1974). In the sense, every species has its extremes of toleration of acidity and alkalinity.

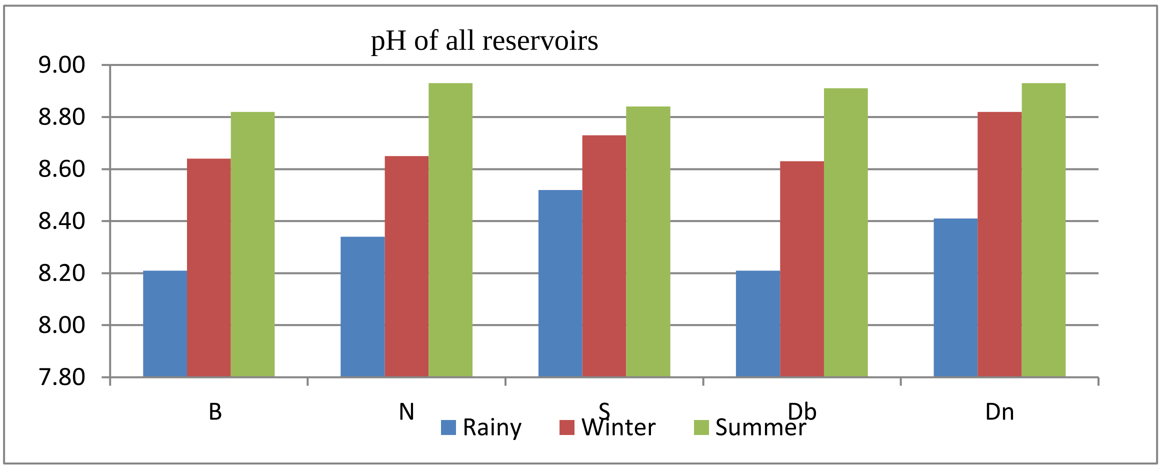
The pH of all reservoirs remained alkaline throughout the study period. The annual fluctuations were negligible, indicating good buffering capacity. The water having pH range of 6.5 to 9.0 are most suitable for pond aquaculture (Jhingran 1982). At pH 6 or above 9.5 for extended periods, fish will not grow well. According to WHO (1993) the desirable pH of drinking water is 7.0 to 8.5.

Hujare. (2008) has given the range of 7.6 to 8.8 in Attigre tank of Kolhapur district. In his observation maximum pH was recorded during summer months and minimum in monsoon. Awasti and Tiwari (2004) have recorded pH range of 7.1 to 8. It was recorded maximum during January and February 2000 while, it was least during rainy season. Rajput *et. al.* (2004) have recorded alkaline status of water of Hatnur reservoir with pH range of 8.1 to 9.1 where low pH during rainy season and high during summer. Solanki *et. al.* (2007) have reported highest values of pH during summer and the lowest values during rainy periods of Khari Nadi water of Agra.

3A. Variation in **pH** at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	8.4	8.6	8.5	8.7	8.7
July	8.2	8.2	8.2	8.3	8.5
August	**7.9**	**8.1**	8.1	**8**	**8**
September	8	8.2	**8**	8.3	8.3
October	8.2	8.2	8.3	8.3	8.2
November	8.3	8.3	8.3	8.1	8.3
December	8.3	8.3	8.1	8.3	8.4
January 2014	8.4	8.4	8.2	8.3	8.5
February	8.4	8.4	8.3	8.5	8.5
March	8.6	8.6	8.4	8.6	8.5
April	8.6	8.8	8.5	8.8	8.6
May	**8.7**	**9.1**	**9.2**	**9.1**	**8.9**

3 B Seasonal range in pH in all reservoirs from June 2013 to May 2014.



4. Electrical conductivity (EC):

The electrical conductivity of water is a measure of its ability to carry the electric current and its various numbers of ions present in the water. It depends on the nature and concentration of ionized salts. It can be expressed in m mhos. Electrolytes in water dissociate into the respective ions and important conductivity to it.

The higher values of electrical conductivity were observed during summer months, where as it lowered down during winter season for both the years at all sites.

The electrical conductivity is used an index to select the suitability of water for agricultural purpose. Deo and Ali (1993) have classified the irrigation water according to the electrical conductivity (m mhos).

<0.250	Excellent
0.250-0.750	Good
0.750-0.2000	permissible
0.2000-0.3000	doubtful
> 0.3000	unsuitable

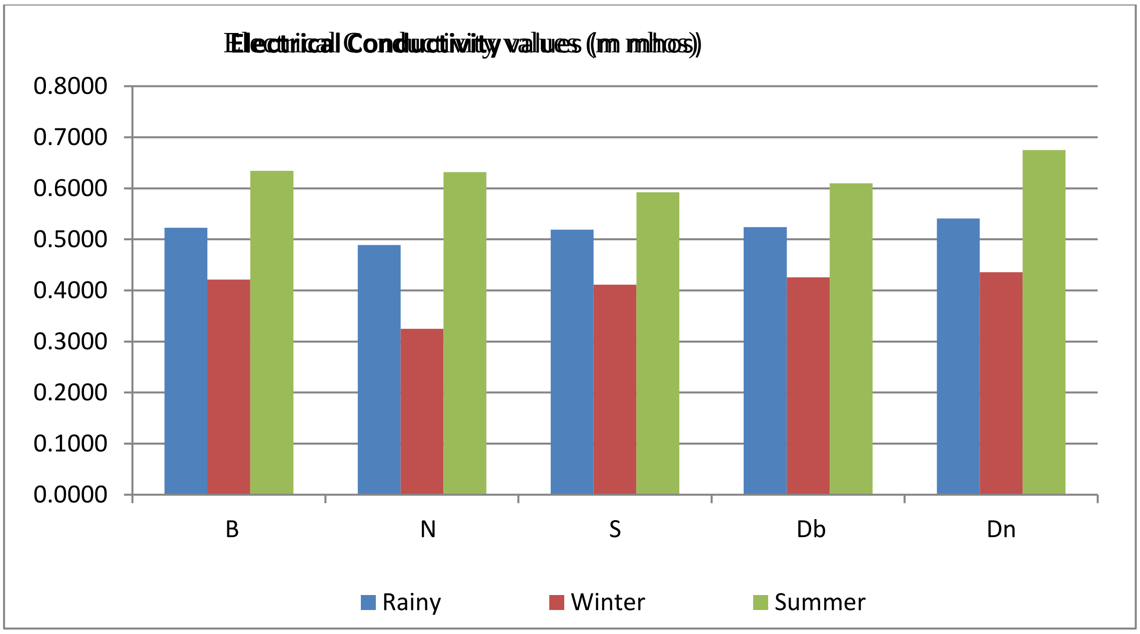
Bhosale *et. al*. (1994) have reported the range of electrical conductivity between 0.332 to 0.729 m mhos for few reservoirs of Sangli district.

As per Deo’s classification all the water resources are good in quality. The water from all reservoirs is suitable for agriculture as well as fishery.

4A. Electrical Conductivity values (m mhos) at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	0.53	0.561	0.585	0.565	0.561
July	0.443	0.472	0.501	0.478	0.465
August	0.489	0.52	0.522	0.54	0.53
September	0.428	0.532	0.501	0.537	0.538
October	0.382	0.442	0.412	0.445	0.441
November	0.341	0.416	0.364	0.426	0.416
December	**0.314**	**0.323**	**0.356**	**0.327**	**0.315**
January 2014	0.346	0.431	0.389	0.434	0.426
February	0.415	0.528	0.422	0.529	0.518
March	0.612	0.535	0.497	0.534	0.536
April	0.668	0.598	0.51	0.604	0.614
May	**0.689**	**0.748**	**0.61**	**0.759**	**0.719**

4 B. Seasonal Electrical Conductivity values (m mhos) at all reservoirs from June 2014 to May 2015.



b. Chemical parameters:

In present investigation dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, calcium, magnesium, chlorides, total dissolved solids, total nitrogen and total phosphorus were determined monthly as well as seasonally for August 2006 to July 2008.

5. Dissolved oxygen:

Among all abiotic factors dissolved oxygen is the most important factor for fresh water life. It is of great limnological significance. It regulates many metabolic processes of aquatic organisms. The main source of dissolved oxygen in water is from the atmosphere through exposed surface directly and other from the chlorophyll i e. via plants through photosynthesis. During day time autotrophs release oxygen while consuming carbon dioxide, but during night, plant consumes oxygen and release carbon dioxide through respiration. The animal community, which is residing in the water body need dissolved oxygen for respiration and release carbon dioxide during daytime as well as in night.

The amount of oxygen in a lake depends on the extent of contact between water and air, circulation of water currents and on the amounts released and consumed by Lake Organism. Therefore, keeping the time scheduled for each reservoir, dissolved oxygen is determined monthly and seasonally.

The minimum dissolved oxygen limit for fish growth is 4.0 mg/l (Jhingran 1982). According to APHA (1985) the lowest dissolved oxygen for maintaining fish in healthy condition is 5.0 mg/l and the critical value is 3.0 mg/l. In present study the range of dissolved oxygen is found optimum for fish growth. The dissolved oxygen content of the reservoirs is favorable for fish production. The major cause of oxygen depletion during monsoon may be reduction in photosynthetic activity.

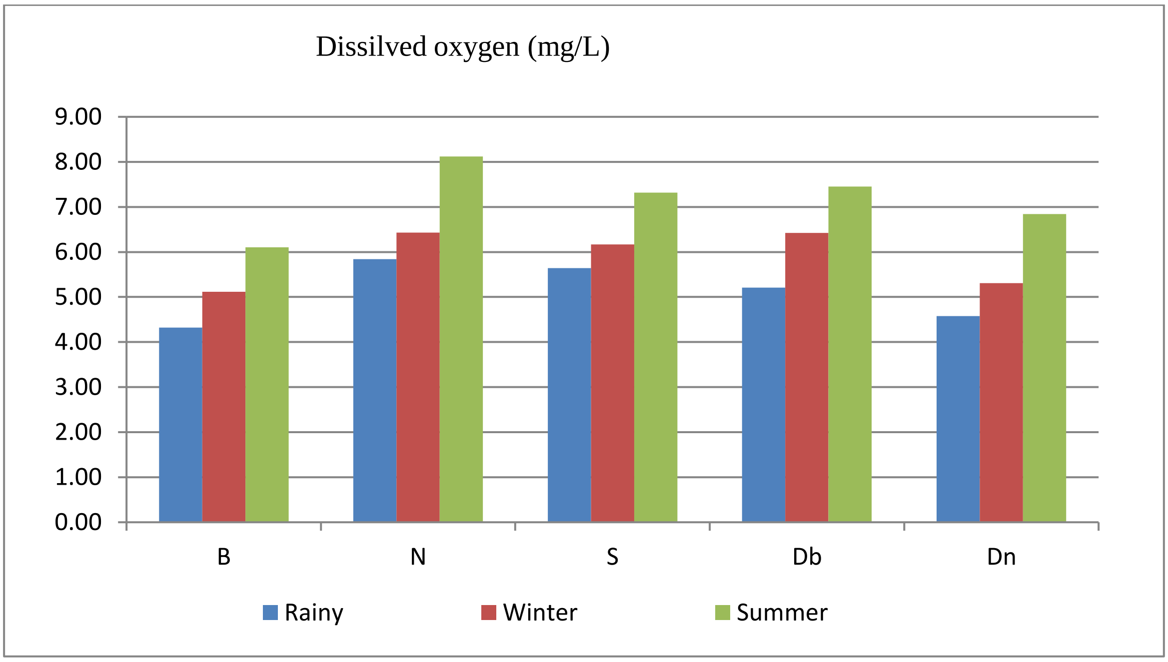
Relatively higher values of dissolved oxygen during summer probably as a result of photosynthetic activity (Solanki *et.al.*2007). Similar type of observation made by Khare *et. al.* (2007).The similar seasonal trend in dissolved oxygen was observed by Hujare and Mule (2008). Jain *et. al.* (2005) observed peak of dissolved oxygen in spring season. Lowest values of dissolved oxygen during onset of monsoon have recoded by Vijay Kumar *et.al.* (2005). Sawant and Telave (2009) have noticed increasing values of dissolved oxygen during summer and decreasing trend during monsoon in Nool reservoir of Gadhinglaj tahsil of Kolhapur district.

It is interesting here to note that, dissolved oxygen rises appreciably during summer and decreases in monsoon months. However, very little variation is observed during summer and monsoon for all the reservoirs.

5A. Values of **Dissolved Oxygen** (mg/l) at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	5.01	7.53	6.84	7.14	7.52
July	4.54	6.24	5.16	6.32	6.31
August	**4.04**	**4.22**	**4.29**	**4.11**	**4.13**
September	4.12	4.38	4.38	4.32	4.3
October	4.44	5.1	5.02	5.12	5.02
November	4.85	5.48	5.21	5.21	5.24
December	5.15	6.01	5.27	5.44	5.4
January 2014	5.18	6.41	5.57	6.38	6.35
February	5.34	7.24	5.89	7.25	7.35
March	5.53	7.94	5.96	7.64	7.44
April	6.24	8.07	6.19	8.41	8.21
May	**8.34**	**8.54**	**7.17**	**9.32**	**8.51**

5 B Seasonal **Dissolved Oxygen** (mg/l) at all reservoirs from June 2014 to May 2015.



6. Free carbon dioxide:

Carbon dioxide is the product of decomposition of organic matter by bacteria and through respiration of lake community. It adds to water by inflow of ground waters, which seep into water bodies. It depends on the decomposition of top soil and chemical nature of underlying rocks containing carbonates. Its solubility varies inversely with temperature. It reacts with water to form weak acid i.e. carbon acid which in turn reacts with hydroxide to form bicarbonates and carbonates.

The carbon dioxide content in water is an important single index for fish culture (Jhingran 1982). The amount of free carbon dioxide present in natural water is generally low and its concentration maintained by diffusion from the atmosphere, respiration of living organisms, and bacterial decomposition of organic matter and seepage of inflowing groundwater.

Free carbon dioxide in water forms carbonic acid which after dissociation gives H^+ ions thus, decreasing pH values. The free carbon dioxide is essential for photosynthesis. Well aerated waters with very little pollution usually have no or very little free carbon dioxide (Goel and Chavan 1991, Hujare 2005).

Temperature have an influence on percentage of soluble gases particularly oxygen and carbon dioxide. The intense sunlight during winters and summers seem to accelerate photosynthesis by phytoplankton there by utilizing carbon dioxide and giving off oxygen. During rainy months dilution effect reduces the phytoplankton population remarkably; more over diffused sunlight due to cloudy atmosphere the rate of photosynthesis seem to decreases (Ahmed and Krishnamurthy (1990). The monsoon rains brought a fresh supply of free carbon dioxide causing reduction in pH. Low amount of free carbon dioxide has been recorded in the pre monsoon by Jhingran (1982) in non polluted resources. Jadhav *et. al.* (2009) have observed similar trend in Gaimukh of Jotiba water resources.

Vijay Kumar *et. al.* (2005) have noted that when pH is higher than 8.0 free carbon dioxide is usually less or absent.

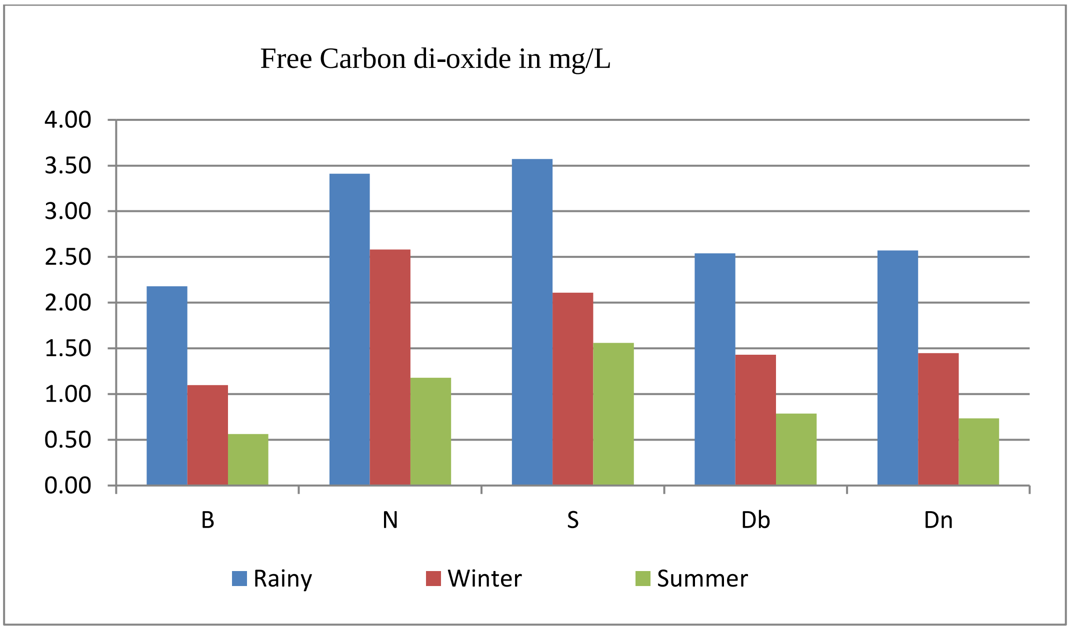
Chow (1958) is of opinion that free carbon dioxide ranging from 3.0 to 4.0 mg/l affects the fish breath with difficulty and the fishes die if exposed to 30.0 mg/l. Similar views have also been given by Gupta *et. al.* (2008), Devi (1993), Kumar *et. al.* (1996) and Mishra *et. al.* (1999).

The present values of free carbon dioxide thus well aerated water bodies as well as the oligotrophic nature.

6A. Analysis of **Free Carbon-dioxide** (mg/l) at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	0.4	0.6	0.6	**0.1**	**0.1**
July	0.4	0.7	1.2	1.6	1.4
August	**1.8**	**2.4**	**3.8**	**2.2**	**2.1**
September	1.1	1.3	2.7	1.7	1.4
October	0.8	0.6	2.6	0.8	0.8
November	0.6	0.4	2.1	0.4	0.4
December	0.5	0.5	1.9	0.2	0.2
January 2014	0.6	**0.2**	1.2	0.2	0.2
February	0.3	0.6	1	0.1	0.2
March	0.3	0.3	0.8	0.1	0.2
April	0.3	**0.2**	0.7	**0.1**	**0.1**
May	**0.2**	0.4	**0.3**	**0.1**	**0.1**

6 B Analysis of **Free Carbon-dioxide** (mg/l) at all reservoirs from June 2014 to May 2015.



7. Total alkalinity:

Total alkalinity of water is the ability to accept protons. It is the quantity and kinds of compounds present in water which shift the pH to alkaline nature. It is caused by cations viz. Ca, Mg, Na, Fe, and NH_4 combined either as carbonates or bicarbonates or occasionally hydroxides. Three kinds of alkalinities are indicated such as hydroxyl (OH), carbonates (CO_3) and bicarbonates (HCO_3); all three are summed as total alkalinity. The carbonates and bicarbonates are common in water because carbonates are abundant in nature and hydroxides are rare in natural water.

In all reservoirs, during rains total alkalinity declines while, rises up to summer season.

Moyle (1949) have classified water into nutrient status based on alkalinity as follows,

1 to 15 mg/l	nutrient poor
16 to 60 mg/l	moderately rich
More than 60 mg/l	nutrient rich

Based on the above classification all reservoirs show nutrient rich status.

Jackson (1961) has suggested that the alkalinity below 50 mg/l indicates low photosynthetic rate. Based on this all reservoirs have higher photosynthetic rate. Comparatively high total alkalinity in summer season may be due to influx of detergent and soaps rich in alkalinity Hujare and Mule (2008) have given similar suggestion

Alkalinity reduces in monsoon and maximize in summer. Many workers have observed similar pattern of variation in total alkalinity which support present findings (Shrivastava (2005), Hujare (2008), Sukhija (2007), Sharma and Jain (2000), Chatterjee and De (2008), Jadhav *et. al.* (2009) and Sawant and Telave (2009).

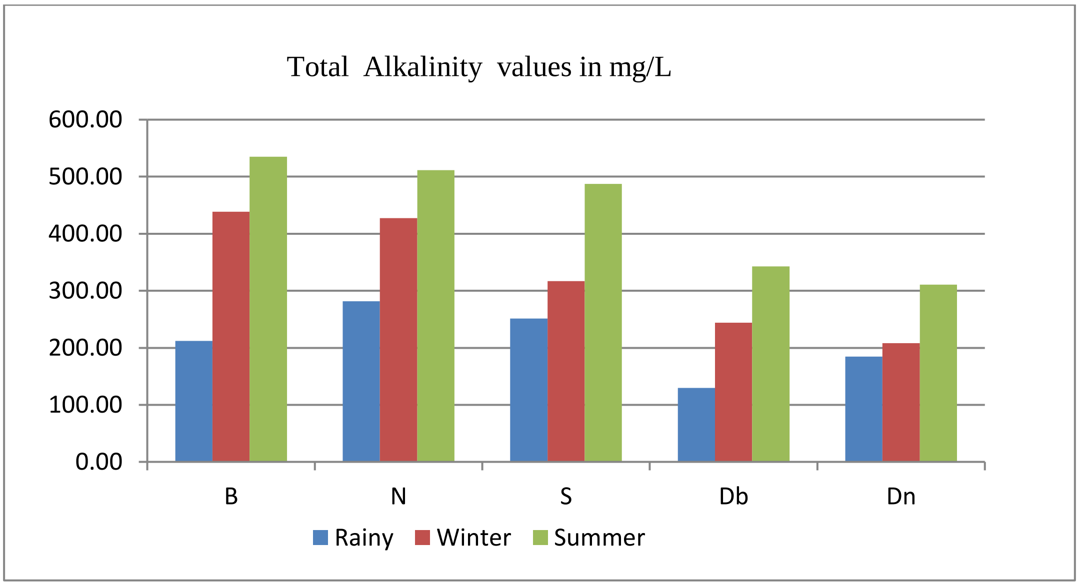
Due to rainfall alkalinity value reduces. Similar trend is noted by Jadhav *et.al*. (2009).The higher alkalinity in summer may be attributed to increased rate of decomposition during which carbon dioxide is liberated which reacts with water to from HCO_3 increasing the total alkanlinity in summer (Hujare and Mule 2008 and Awasti and.Tiwari 2004, Kaur *et.al.*2000).

Total alkalinity value shows positive correlation with pH, dissolved oxygen and primary productivity of reservoirs. Vijaykumar *et. al*. (2005) noted that high values of total alkanlinity during summer may be due to increasing rate of decomposition. When water temperature was high and the water level was low, there is an increase in the productivity. Many results support the present findings.

7A Annual range of **Total Alkalinity** (mg/l) at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	178	385	365	183	335
July	138	233	245	151	161
August	**114**	**152**	**164**	**122**	**114**
September	117	182	198	126	118
October	136	201	207	131	131
November	134	256	231	140	148
December	148	320	237	146	163
January 2014	161	340	398	164	195
February	173	369	312	179	214
March	191	375	385	193	261
April	216	416	417	259	311
May	**252**	**478**	**459**	**289**	**353**

7 B Seasonal range of **Total Alkalinity** (mg/l) at all reservoirs from June 2014 to May 2015.



8. Total Hardness:

The total hardness in water is the total of concentration of alkaline earth metal cations (e.g. Ca^{++}, Mg^{++}). In most fresh waters the hardness is imparted by calcium and magnesium ions which are in combination with carbonates and bicarbonates apart from sulphate, chlorides and nitrates. Many workers seem to consider hardness the same as total alkalinity since when both are expressed as $CaCO_3$, their values may be a approximately equal. However hardness in principle is the total of soluble Ca and Mg salts present in the water, expressed as its $CaCO_3$ equivalent (Jhingran 1982).

The hardness may be temporary, caused by soluble calcium and magnesium bicarbonates, carbonates. Total hardness is used to classify water as “hard” or “soft”. The hardness is the property of water which prevents froth formation with soap and increase the boiling point of water (Trivedy *et. al.* 1998).

Definite pattern of seasonal variation was noticed for all reservoirs. i. e. maximum during summer of two consecutive sampling years and minima was noticed during winter.

Among all reservoirs, lowest values of hardness are obtained for Lengre and highest at Borgaon. Higher values of total hardness during summer season can be attributed to increased rate of evaporation.

Vijaykumar *et. al*. (2005), have reported maximum values during summer, it may be attributed to high temperature, low water level and addition of Ca and Mg salts from detergents and soaps used for cloth washing by the surrounding villagers, which is in agreement with present study.

The higher hardness values in summer season are mainly attributed to rising temperature thereby increasing the solubility of calcium and magnesium salts (Garg 2003).

Singh and Gupta (2004) observed minimum values of hardness during November and maximum during April. Maximum values during summer months may be due to scarcity of rainfall. Khabade and Mule (2005), Jadhav *et. al.* (2009) have noticed the maximum hardness during summer months, which is in agreement with present findings. Mathivannan *et. al.* (2005) also reported similar pattern of variations at Mettur Dam.

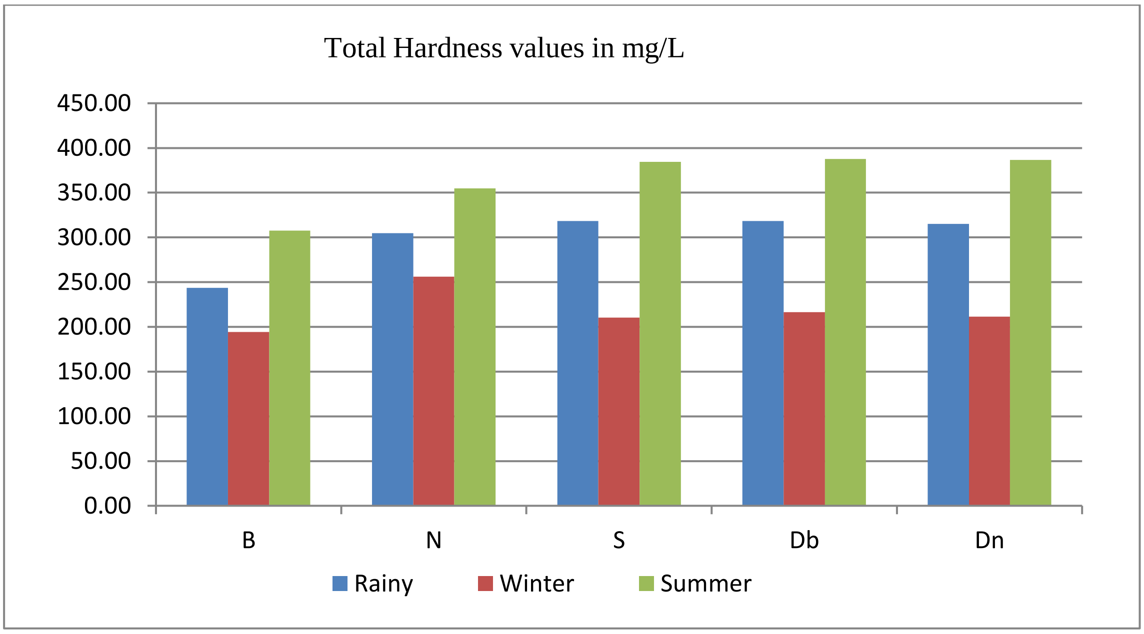
Hardness values showed direct relationship with temperature, EC similar relationship was observed by Hujare (2008), Kaur *et. al*. (2000).

The permissible limits prescribed by both WHO (1993) and Bureau of Indian Standards (1991) is 300 mg/l. The hardness of reservoir lies beyond the limit and hence the water is not suitable for drinking as it is hard. Hardness of water is correlated with both heart and kidney problems.

8A Variations in **Total Hardness** (mg/l) at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	318	304	267	371	361
July	200	258	285	304	344
August	156	232	236	282	260
September	138	245	249	251	257
October	138	240	215	250	248
November	134	234	164	238	231
December	**106**	**226**	**115**	**214**	**201**
January 2014	152	265	165	228	224
February	216	292	205	287	241
March	260	298	315	311	262
April	262	318	340	384	308
May	**336**	**332**	**388**	**395**	**379**

8 B Variations in **Total Hardness** (mg/l) at all reservoirs from June 2014 to May 2015.



9. Calcium:

Calcium is one of the most abundant substances of the natural waters. Being present in the roots, it is leached from there to contaminate water. The quantities in natural waters vary from 10 to 100 mg/l.

In animals and some plants calcium is the main skeletal component. It plays important role in buffering the lake water (Goldman and Horne 1983). Calcium and magnesium are the most abundant ions in fresh water. Calcium mainly occurs in combination with carbonate ions. Calcium can be leached practically from all rocks. Calcium is essential to all green plants except lower algae in proper translocation of carbohydrates. It is an integral component of plant tissue. It is facilitating the availability of other ions. Calcium reduces the toxic effects of single salt solutions of sodium, potassium and magnesium. The calcium is important to the biological productivity of waters (Lind 1974).

Calcium is an important ion in imparting the hardness to the waters. The calcium appears to have several physiological roles such as relation to the proper translocation of the carbohydrates.

The levels of calcium of all reservoirs at three sampling sites are studied monthly and seasonally. In all reservoirs calcium content is found to be minimum during winter and maximize in summer in both monthly and seasonally.

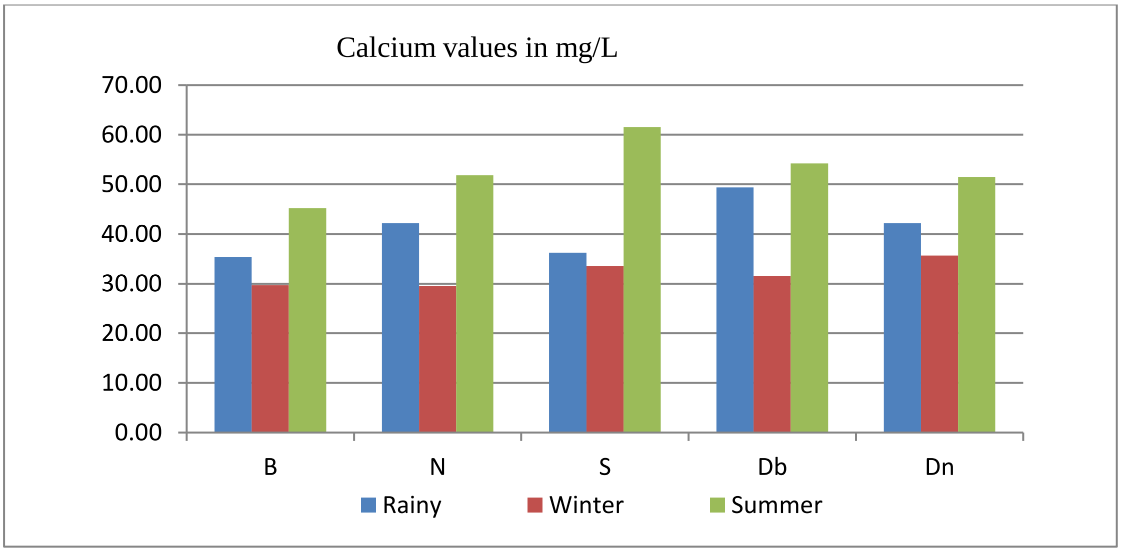
The maximum desirable limit of calcium in drinking water is 75 mg/l (WHO, 1993 and BIS, 1991). The calcium content in all reservoirs is below the desirable limit. It is an essential constituent in human life. Deficiency of calcium may cause rickets and defective teeth. It is an essential component for nervous system, cardiac function and in coagulation of blood (Hujare 2005).

Calcium shows positive correlation with temperature, total hardness, electrical conductivity, chlorides, total dissolved solids, magnesium, total nitrogen and total phosphorus, this view has also been supported by the findings of Awasti and Tiwari (2004). Increasing minerals like calcium and magnesium was the cumulative effect of summer season as well as decreasing water level in the reservoir. Many workers have suggested the highest range of calcium during pre monsoon. (Hujare 2005, Jadhav *et. al*. 2009, Shrivastava and Alam 2007, Sawant and Telave 2009).

9A. Values of **Calcium** (mg/l) at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	53.15	52.16	57.18	45.14	46.35
July	49.23	52.03	56.47	41.27	42.58
August	43.78	51.64	52.15	41.23	40.78
September	43.08	50.14	48.75	41.18	40.11
October	42.61	38.15	41.85	35.66	36.85
November	41.59	35.64	41.33	34.29	36.5
December	**41.21**	**32.54**	**39.11**	**31.23**	**35.21**
January 2014	42.14	36.12	41.28	33.06	35.81
February	46.84	45.32	43.78	37.89	39.15
March	48.65	49.75	54.29	41.62	46.38
April	58.18	51.35	55.24	43.78	47.55
May	**58.26**	**53.26**	**58.54**	**45.86**	**48.23**

9 B Values of **Calcium** (mg/l) at all reservoirs from June 2014 to May 2015.



10. Magnesium:

Magnesium also occurs in all kinds of water with calcium, but its concentration remains generally lower than the calcium.

The source of magnesium in natural water is through leaching of igneous and carbonates rocks. It is related to water hardness. It is an important and essential natural element for plant growth and development. It is a component of chlorophyll molecule. The magnesium appears to act as carrier phosphorus (Welch 1952).

The magnesium content in all reservoirs showed definite seasonal pattern. Maximum magnesium content was observed in summer season. The concentration of magnesium was minimum than concentration of calcium possibly due to lesser occurrence of magnesium minerals in bottom strata of reservoir.

According to WHO (1993) and BIS (1991) the permissible limit for drinking water magnesium content for permissible is 50 mg/l. The present results of all reservoirs are within the permissible limit.

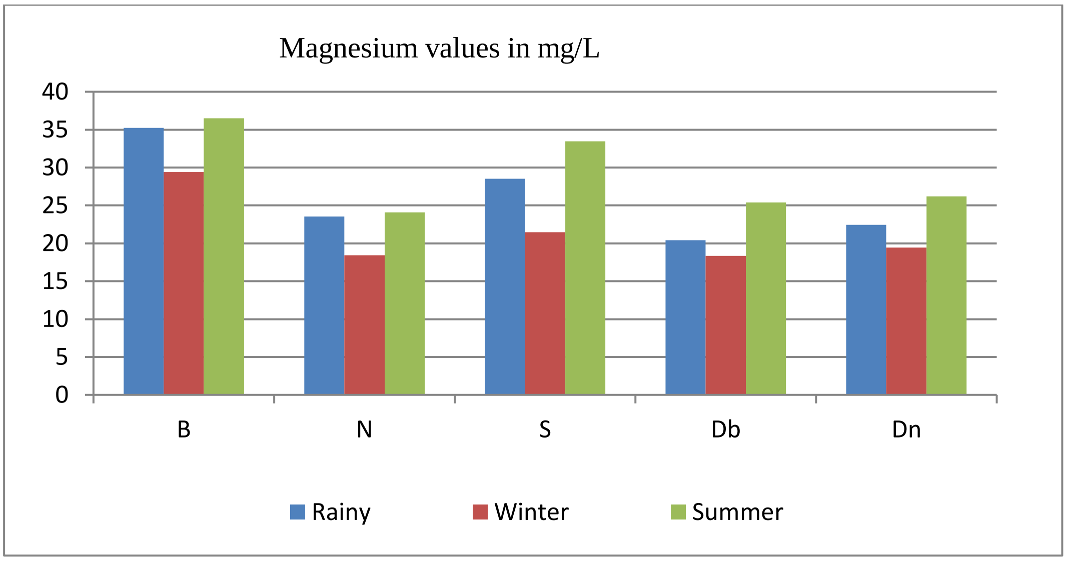
Numbers of workers have pointed out similar trend of fluctuation in magnesium. Sobha and Harilal (2005) have recorded similar observation at Ampalthara. Similar pattern of changes were also recorded by Khare *et. al*. (2007), Subhashini and Saradhamani (2005), Sawant and Telave (2009). Shrivastava and Alam (2007) have recorded the highest values of magnesium in pre monsoon season. Deshmukh and Pingale (2007) have reported higher values in April and lowest during December at Wiscon dam water.

The content of magnesium were found increased with increase in total hardness, electrical conductivity, temperature, chlorides, calcium, total dissolved solids, total nitrogen and total phosphorus.

10 A. Magnesium (mg/l) at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	33.61	22.89	32.48	18.35	21.25
July	30.42	21.92	31.89	16.44	20.49
August	31.66	18.61	27.94	13.52	20.07
September	33.61	18.59	25.82	12.11	20.5
October	33.56	17.53	23.68	12.34	19.1
November	31.18	17.2	23.07	**12.15**	18.12
December	**30.12**	**16.56**	**22.48**	12.92	**16.88**
January 2014	30.69	18.51	23.68	13.19	16.92
February	31.66	20.53	28.45	14.92	18.03
March	32.64	21.43	28.82	15.88	21.22
April	34.59	23.38	30.14	17.59	22.74
May	**35.07**	**25.82**	**33.24**	**19.67**	**23.18**

10 B **Magnesium** (mg/l) at all reservoirs from June 2013 to May 2014.



11. Chlorides:

Chlorides are usually present in low concentrations in natural waters and play metabolically active role in photolysis of water and photophosphorylation reactions in autotrophs. But in salt lakes chloride may be dominant anions. Their high concentrations are considered to be the indicators of pollution, which is either due to organic wastes of animal origin or industrial effluents. The most important source of chloride in natural waters is the discharge of sewage. In very high concentration it gives a salty taste to the water. The salts in solution also affect taste and general suitability of drinking water. The chloride may appear in fresh waters as a result of salt deposits in the ground dissolving in to the fresh water, or as salt left after evaporation, particularly in irrigation water (Michael Kaill and Frey John 1973).

In present investigation, chloride values in all reservoirs are found to be increased during summer and decreased in winter of two consecutive sampling years.

According to WHO (1993) and BIS (1991) permissible limit of chloride is 200 mg/l for drinking water. The water from all reservoirs is below limit. Therefore, it is to be noted that the water is fit for drinking.

Goel (2001) has categorized the status of water based on chloride content for irrigation purpose as follows.

0 to 142 mg/l **:** excellent to good.

142 to 355 mg/l **:** good to injurious and harmful to sensitive crop

> 355mg/l **:** unfit for irrigation.

Based on the values it is suggested that water from all studied reservoir can be used for irrigation purpose.

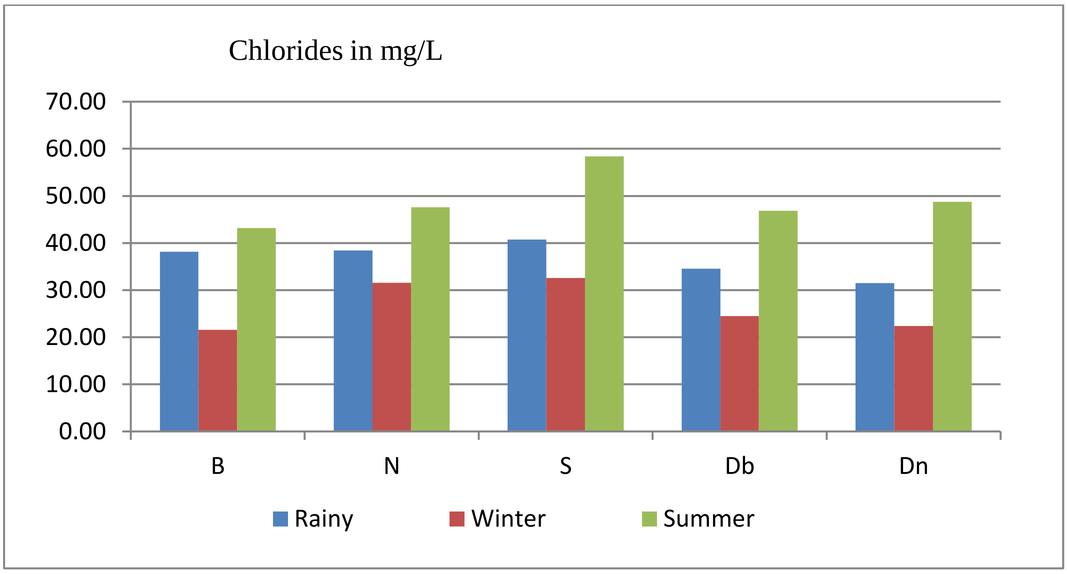
The chloride concentration reached maximum during summer, as the level of reservoir attained low level. However, this may be one of the reasons the values decreased steadily through monsoon and reached minimum in winter due to dilution. Similar condition was observed by Anand and Sharma (2000), Sharma and Jain (2000), Sathe *et. al.* (2001), Vijay Kumar *et.al*. (2005), Khare *et.al*. (2007), Raveen *et. al.* (2008), Hujare and Mule (2008) and Sawant and Telave (2009). Rise in the level of chlorides may also due to increased temperature and evapo-transpiration. Similar observations were reported by Chatterjee and De (2008), Khabade and Mule (2005) and Jadhav *et. al*. (2009).

In general, concentration of chlorides is affected by several factors. Such as increased human and cattle activities. This also indicates the organic load of animal origin.

11A. Values in **Chloride** (mg/l) at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	36.55	49.7	56.37	32.24	32.35
July	31.66	46.86	50.31	30.64	31.52
August	35.18	42.05	37.46	28.43	27.31
September	27.87	44.12	38.21	25.64	24.54
October	25.44	39.76	36.97	**23.14**	**21.1**
November	24.24	**35.05**	36.98	23.35	22.54
December	**23.21**	35.5	**36.27**	24.44	23.62
January 2014	27.98	42.6	46.28	24.83	23.69
February	33.24	42.6	51.64	27.32	25.51
March	35.95	47.12	55.36	39.23	39.63
April	48.18	51.26	57.46	43.54	44.33
May	**48.34**	**53.96**	**58.17**	**43.64**	**45.41**

11 B Values in **Chloride** (mg/l) at all reservoirs from June 2013 to May 2014.



12. Total dissolved solids (TDS):

Water is the universal solvent, have a large number of salts dissolved in it, which changes its physico-chemical properties and indirect effects on the organisms.

The highest total dissolved solids values are observed during summer while there is drop in the range at three sites during winter.

It is interesting to note here the total dissolved solids positive correlate with temperature, electrical conductivity, total hardness, calcium magnesium, chlorides and negative correlate with free carbon dioxide.

The total dissolved solid indicates the general nature of water quality. The water containing 500 mg/l total dissolved solids is the desirable limit for potable water (WHO 1993, BIS 1991). Beyond the limit may cause gastrointestinal disorders. It is evident that the total dissolved solids values are beyond the desirable limit with onset of summer. In rainy and winter season reservoir water is within the limit. The values exceed due to number of activities and also due to evapotranspiration.

In the present investigation highest total dissolved solids values are obtained during summer, which can be attributed to high rate of evaporation and consequently decreased water level leading to accumulation of dissolved solids.

As per the classification given by Goel (2001) with respect to total dissolved solids.

Class-1 (0 to 700 mg/l)	**:** excellent,
Class- II (700 to 2000 mg/l)	**:** harmful to sensitive crops,
Class -III (>2000mg/l)	**:** not suitable for irrigation

Accordingly water from all reservoirs is suitable for irrigation purpose.

On the basis of concentration of total dissolved solids water is classified by Wilcox (1955), ICMR (1975) as

Up to 500 mg/l	:	desirable for drinking
Up to 1000 mg/l	:	permissible for drinking
Up to 2000 mg/l	:	useful for irrigation
Up to 3000 mg/l	:	not useful for drinking and irrigation

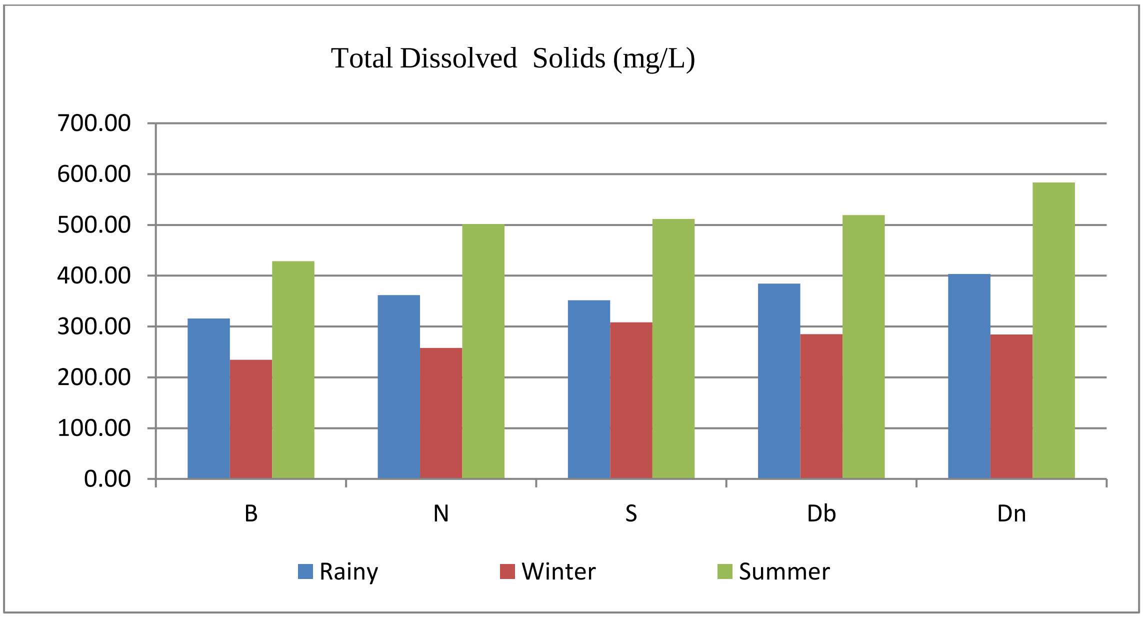
Based on above classification water from all reservoirs are only desirable in rainy and winter and permissible during summer.

Many researchers observed the increasing pattern of total dissolved solid value during summer and decreasing during winter. Paka and Rao (1997), Singh and Gupta (2004), Sobha and Harilal (2005), Khabade and Mule (2005), Shrivsastava (2005), Mathivanan *et. al.*(2005) and Chatterjee and De (2008) support the present findings.

12A. Range of **Total Dissolved Solids** (mg/l) at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	338	421	739	**986**	434
July	257	342	524	657	270
August	248	291	426	456	306
September	251	282	421	348	311
October	242	**264**	435	**274**	**246**
November	232	290	435	301	348
December	**212**	301	**365**	389	376
January 2014	248	308	389	397	303
February	272	531	527	504	417
March	393	554	624	625	526
April	461	566	712	824	618
May	**526**	**601**	**834**	945	**636**

12 B Range of **Total Dissolved Solids** (mg/l) at all reservoirs from June 2014 to May 2015



13. Total Nitrogen (Kjeldahl):

Nitrogen is an essential nutrient for plant growth, but in aquatic systems nitrogen is limited because a range of organisms can obtain nitrogen gas from the atmosphere. Many of nitrogen fixers in the water are blue green algae. Sources of nitrogen to streams include sewage, animal wastes, fertilizers, and natural sources such as organic matter. Thus levels of nitrogen can be used to indicate the impact of human settlement and land use on natural environment.

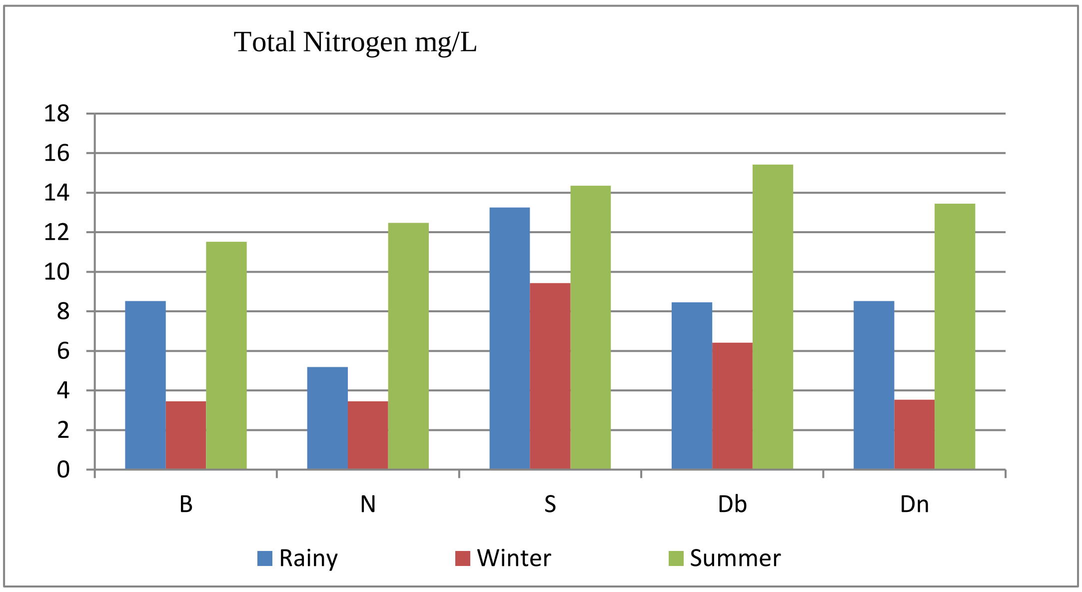
The concentration of soluble organic nitrogen may vary seasonally and a measure of its occurrences is available indication of the productivity of water.

In all reservoirs similar pattern is observed. Maximum values of total nitrogen are noticed during summer and minimum in winter. According to Omana and Mohan (2008) the range of total nitrogen is between 0.17 mg/l to 4.04 mg/l. highest values were observed during summer. However, Kosygin and Haobijam (2005) and Jain *et.al*. (2005) described the highest range of total nitrogen in March with decreasing range in monsoon to winter.

13A. Total Nitrogen (mg/l) at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	13.23	8.41	19.1	14.65	10.22
July	9.73	8.1	12.36	8.37	9.46
August	8.1	5.61	7.24	7.91	9.76
September	6.12	4.32	5.32	6.31	7.01
October	5.76	4.21	3.12	5.11	6.12
November	2.6	**3.51**	**3.6**	2.48	**3.82**
December	**2.52**	3.72	3.78	**2.1**	5.01
January 2014	6.55	4.62	6.55	5.34	4.78
February	10.19	6.33	7.24	7.38	9.12
March	12.05	8.17	11.17	9.45	10.01
April	12.27	9.24	14.2	12.18	12.51
May	**15.65**	**13.68**	**18.71**	**15.42**	**11.98**

13 B Total Nitrogen (mg/l) at all reservoirs from June 2014 to May 2015.



14. Total Phosphorus:

Phosphorus in water bodies occurs mainly in orthophosphate, condensed phosphates and organically bound phosphates. The microbial degradation of organic matter releases the phosphorus in phosphate form.

The natural non polluted waters have insignificant quantities of phosphorus, because most of the minerals containing phosphorus are quite insoluble in water. Also phosphates are strongly bound to soil particles. Thus not easily leached out by run off or percolation waters. The natural waters can get enriched with phosphorus only after receiving phosphorus rich waste waters like domestic sewage, effluents, agricultural run off etc.

Much of the environmental significance of phosphorus like in its ability to cause eutrophication of water in presence of nutrients like nitrogen. The quality criteria for phosphorus in water are to check the unwanted algal growth. According to standards of CPCB (1995, 1999) the dissolved phosphates as P should not exceed 5 mg/l in waste waters those are intended to the discharged in inland surface water bodies. As per U. S. EPA (1976) the phosphorus concentration should not exceed 50 mg/l in any tributary river or lake and 25 mg/l within these main bodies of water.

This term corresponds to the total dissolved and filterable phosphorus in all of its forms in solution including organic phosphorus. The total phosphorus concentration correlates well to other water quality parameters particularly algal growth and chlorophyll. Organic phosphorus affects the algal growth; therefore it may be more appropriate to evaluate total phosphorus. Phosphorus and phosphorus containing compounds act as energy conveyers for living organisms. Once the organism dies, phosphorus will be reintroduced to soil and water where, it is taken up again by another organism. The most common source of phosphate pollution is poor management of agricultural irrigation and run off.

Phosphorus is an essential nutrient for plant growth, but too much phosphorus cause excessive growth of algae and weeds. Hence it is used as an indicator of the pollution for algal growth in fresh water ecosystem.

The main source of phosphorus is from the naturally occurring phosphorus contained in soil material transported in to water as a result of erosion. Other source include run off from rural and urban catchments where fertilizers are used, soil loss in construction areas, run off contaminated by litter and domestic animal faces and sewage waste water. For this reason, total phosphorus can be used as an indicator of the impact of human settlements and agricultural land use on aquatic ecosystem. The rocks in which most of the phosphorus is bound are generally insoluble in water and hence the phosphorus content of natural fresh water is low and biological growth is limited due to this fact.

In the reservoirs, total phosphorus levels were recorded maximum during summer of two consecutive sampling years. The minima is observed during winter and then in monsoon of both the years.

Similar observations have reported by Anand and Sharma (2000), Sobha and Harilal (2005) and Kosygin Haobijam (2005).

The fluctuations and increase in the content is possibly are to temperature, electrical conductivity, total hardness, calcium, magnesium, chlorides and total dissolved solids.

The presence of high concentration of phosphorus in water may lead to pollution. Lee *et. al.* (1981) have classified the water bodies on the basis of phosphorus content.

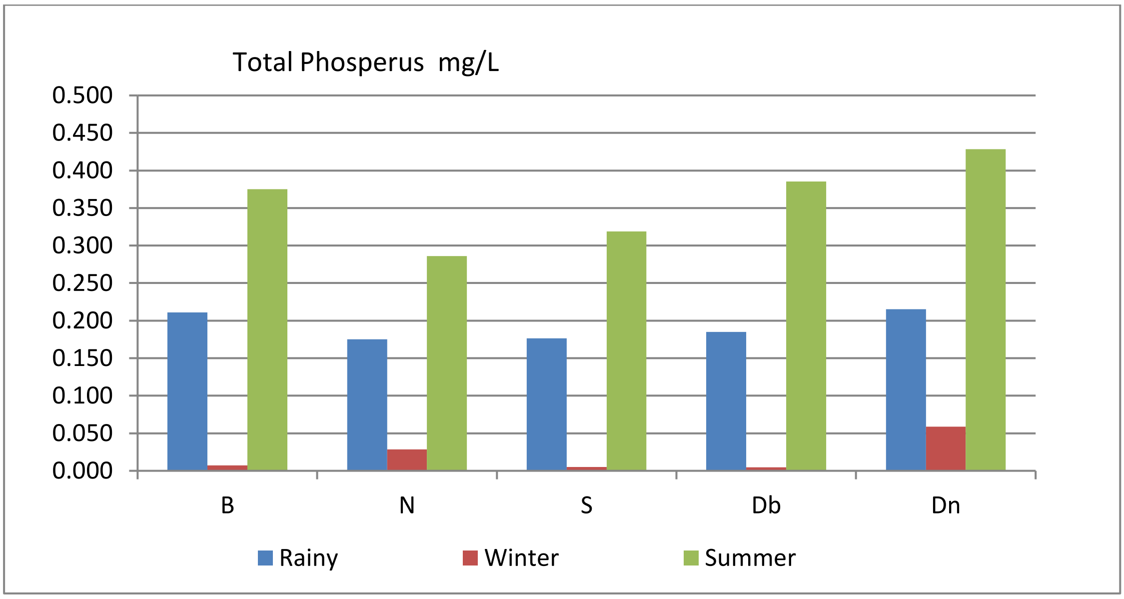
< 0.0079 mg/l	: Oligotrophic
0.008 to 0.011 mg/l	: Oligomesotrophic
0.012 to 0.027 mg/l	: Mesotrophic
0.028 to 0.039 mg/l	: Meso-eutrophic
> 0.040 mg/l	: Eutrophic

According to above criteria, all reservoirs may be placed under the category of oligotrophic in winter season.

14A. Variation in **Total Phosphorus** (mg/l) at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	0.41	0.077	0.078	0.058	0.431
July	0.162	0.056	0.051	0.059	0.226
August	0.062	0.041	0.022	0.038	0.126
September	0.039	0.019	0.012	0.021	0.08
October	0.011	0.009	0.005	0.007	0.071
November	0.006	0.002	0.004	0.005	0.068
December	**0.003**	**0.001**	**0.003**	**0.002**	**0.063**
January 2014	0.015	0.007	0.006	0.018	0.073
February	0.061	0.015	0.053	0.036	0.091
March	0.091	0.048	0.064	0.057	0.12
April	0.262	0.093	0.08	0.083	0.31
May	**0.557**	**0.182**	**0.083**	**0.087**	**0.523**

14 B Variation in **Total Phosphorus** (mg/l) at all reservoirs from June 2014 to May 2015.



III Biological Parameters:

1. **Most Probable Number (MPN):**

Determination of most probable Number (MPN) for coli forms in water is an effective ecological tool to assess quality of an aquatic environment. It is indicated as MPN/100 ml. The coliform group of bacteria is the principle indicator of suitability of water for domestic uses. The presence of coliform in water is an indicator of contamination by human or animal excreta (Jain 2005). It is probably due to human and animal activities during rains when reservoirs were full of water.

Many workers have observed similar trend (Wavade and Shaikh 2008, Prajapati and Raol 2008, Lakshmi *et .al*. 2000, and Prajapati and Raol 2007, Jain *et. al.*2005). Chatterjee and De (2008) recorded range of MPN from 4 (May) to 6 (November) in dug well water and 4 to 6 MPN/100ml randomly in bore-well samples.

According to WHO (1993) and BIS (1991) coliforms should be absent for drinking purpose and if present the permissible limit is 10. As compared to standard all water bodies are beyond the permissible limit except Atpadi and Borgaon. Therefore water is bacteriologically unsafe for drinking.

MPN is more during monsoon. It may be due to accumulation of bacterial cells from surface run off. Actually the origin of coliform in water bodies is from soil.

15. Coliform in terms of Most Probable Number at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	N	2	N	1	4
July	N	2	N	N	18
August	N	3	10	N	41
September	25	5	40	5	52
October	20	2	40	N	65
November	22	2	40	3	35
December	20	1	40	1	31
January 2014	10	2	15	2	15
February	2	2	10	N	18
March	N	2	10	2	11
April	N	1	N	N	9
May	N	N	N	N	N

2. Biological Oxygen Demand (BOD):

The total amount of oxygen consumed by micro-organisms in decomposing the organic waste is called Biological oxygen demand of water, popularly abbreviated as BOD. Generally, BOD test is conducted to assess the organic load in the water body and to know the water quality. On an average basis, the demand for oxygen is proportional to the amount of organic waste to be degraded aerobically. Hence the BOD value can be used as a measure of waste strength. The BOD is useful in stream pollution control management and in evaluating the self purification capacities of streams.

The complete degradation of the organic matter may take as long as 20 to 30 days. Simple organic compounds like glucose are almost completely oxidized in 5 days; therefore BOD test has designed for 5 days at 20 ºC.

BOD of all water bodies show definite pattern of seasonal variation.

WHO (1993) specify that the drinking water should be devoid of BOD. Accordingly the present values for all reservoirs suggest the contaminating status. It may be due to human and cattle activities in and around the reservoirs.

As per irrigation standards, the permissible limit of BOD is 30 mg/l; even for aquaculture the limit is 30 mg/l. According to standards, all water bodies are suitable for irrigation and aquaculture purpose.

Many investigators have observed similar patterns of BOD values Singh and Gupta (2004), Raghuwanshi (2005), Sudeep *et.al*. (2008) and Agrawal *et. al*. (2004) explained that, the highest values of BOD during summer were attributed to biological activity, due to high organic decomposition during summer. In winter, microbial activity lowers hence values of BOD decreases.

Similar fluctuations in BOD values were reported by Subhashini and Saradhamani (2005), Vijay Kumar *et. al.* (2005), Khare *et. al.* (2007), Chatterjee and De *(*2008), Shivesh *et. al.* (2002) and Sobha *and* Harilal (2005).

In present investigation BOD values are directly correlated with water temperature, electrical conductivity and total hardness. Similar observations were reported by Deshmukh and Pingale (2007) which supports present observations.

Overall high temperature during summer and organic load during rainy season accelerate the BOD.

16. Biological Oxygen Demand (mg/l) at all reservoirs from June 2013 to May 2014.

Reservoirs → **Months ↓**	**B**	**N**	**S**	**Db**	**Dn**
June 2013	3.61	3.61	2.93	3.74	3.67
July	3.21	3.5	2.67	3.21	3.52
August	3.12	3.45	2.62	3.02	3.09
September	2.11	3.41	2.51	2.91	2.93
October	1.92	2.8	2.31	2.43	2.64
November	1.81	2.51	**2.12**	2.1	2.23
December	**1.62**	**2.04**	2.18	**2.05**	**2.02**
January 2014	1.72	2.09	2.59	2.16	2.26
February	2.1	2.13	2.63	2.54	3.31
March	3.15	3.12	2.71	2.95	3.37
April	3.35	3.52	2.87	3.22	3.49
May	**3.79**	**3.82**	**3**	**3.79**	**3.63**

IV. Productivity of the reservoirs:

1. **Primary productivity** (GPP, NPP and CR):

In nature the primary production is the most important biological phenomenon. It is the process by which the inorganic material of the environment is converted into the organic matter of cell material. In natural water the primary production is entirely depends on photosynthesis. The rate of primary production is known as primary productivity.

In fresh waters the primary production on three types of organisms.

1) Macrophytes 2) Phytoplankton 3) Periphyton

Out of which phytoplankton is universal in occurrence and account for maximum primary production in most water bodies. In some shallow lakes, macrophytes may be most important.

Oligotrophic lakes are poor in quantity of plankton while, eutrophic lakes are very rich (Welch 1952).

In the present investigation Net Primary productivity (NPP), Gross primary productivity (GPP) and community respiration (CR) of five reservoirs have studied seasonally during May 2014 to May 2015.

Primary productivity is an important biological phenomenon in nature on which the entire array of life depends directly or indirectly. The importance of primary productivity in aquatic ecosystem is useful to maintain tropic levels and availability of energy for secondary producers.

The evaluation of primary production of an ecosystem is one of the important factors to estimate the potential fish yield (Singh 1998).

Assessment of the amount of fixed carbon which has been converted into organic material through photosynthesis is the total or gross primary production. Net production is the amount of organic substance remaining in plant bodies after respiration.

Figure No. 20 to 24 depicts the Gross primary productivity (GPP), Net primary productivity (NPP) and community respiration (CR) of all reservoirs.

Singh (1990) and Khan (1980) observed highest GPP values during summer season and minimum during rainy season for similar type of ecosystem.

GPP, NPP and CR values decline in rainy season and attains peak during summer.

In present investigation comparatively higher rate of primary productivity was recorded in Sidhewadi reservoir. During present study definite trend of seasonal variation in primary productivity was observed in all reservoirs and bimodal pattern of increased productivity was noticed. The primary peak of production was observed during summer season, the secondary peak was noticed in winter and the lowest rate was recorded during rainy season.

The decline in the productivity during rainy season may be due to dilution of reservoir and subsequent reduction in phytoplankton density. Moreover the cloudy weather in monsoon might have resulted in low production.

Prasad and Nair (1963), Mandal *et.al*. (2005), Sreenivasan (1964), Khan and Siddiqui (1971), Singh *et.al*. (1996), Synudeen Sahib (2002), Vijay Kumar (1994) observed similar results. According to them increase in water temperature and alkalinity from March onwords accelerate primary production. Present findings are similar to that. Bisral (1996) obtained the productivity of Supa reservoir at Addi maximum in April and May and minimum during September. According to classification modified by Krishnamurthy and Abdulappa (1972) Supa reservoir is oligotrophic in status. Singh (1998) observed maximum rate of production in April.

Figure 20: Seasonality of GPP, NPP and Community Respiration at Bhakuchi wadi.

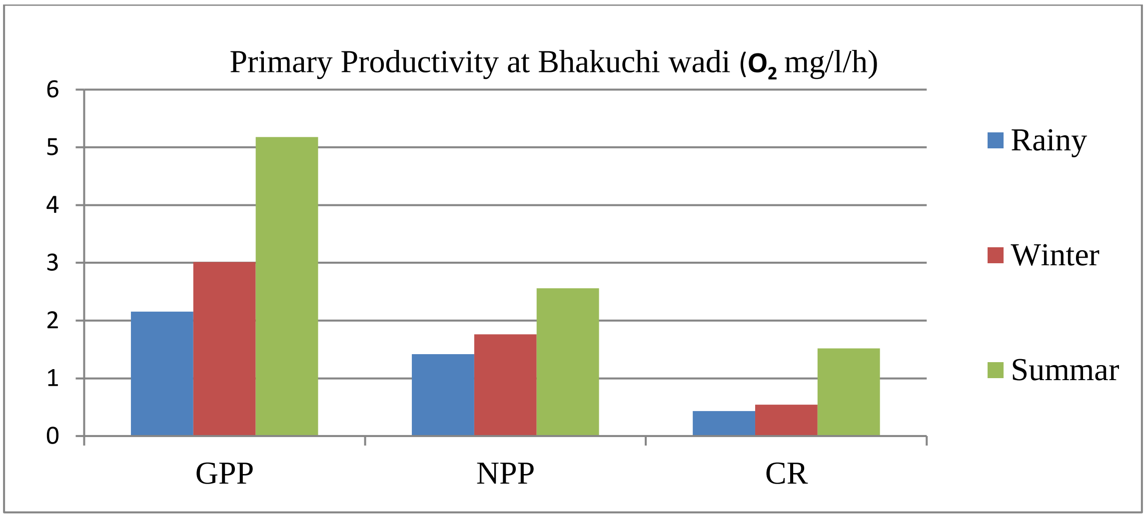


Figure 21: Seasonality of GPP, NPP and Community Respiration at Nimbavade.

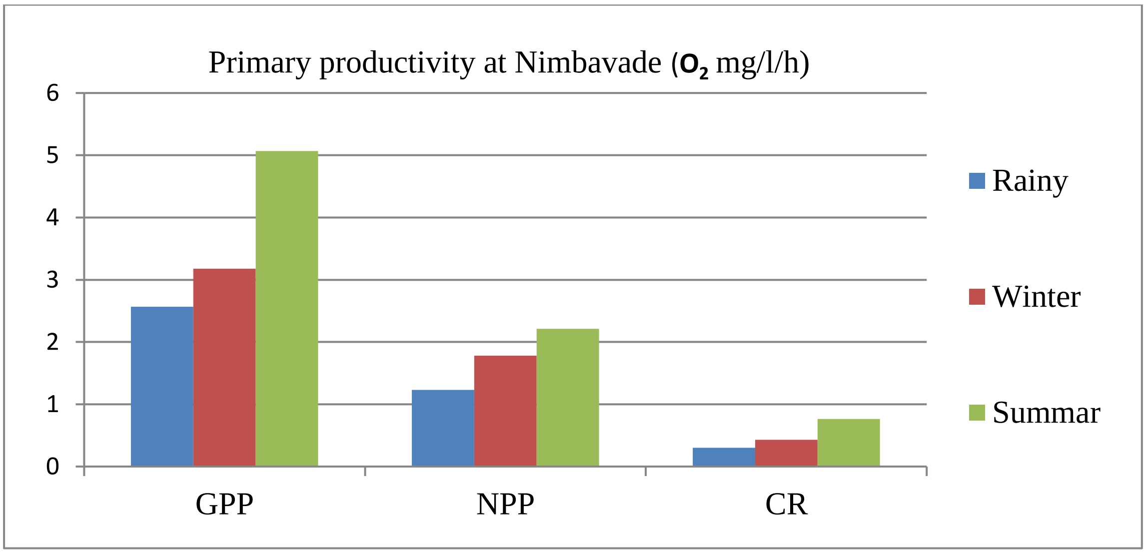


Figure 22: Seasonality of GPP, NPP and Community Respiration at Sidhewadi.

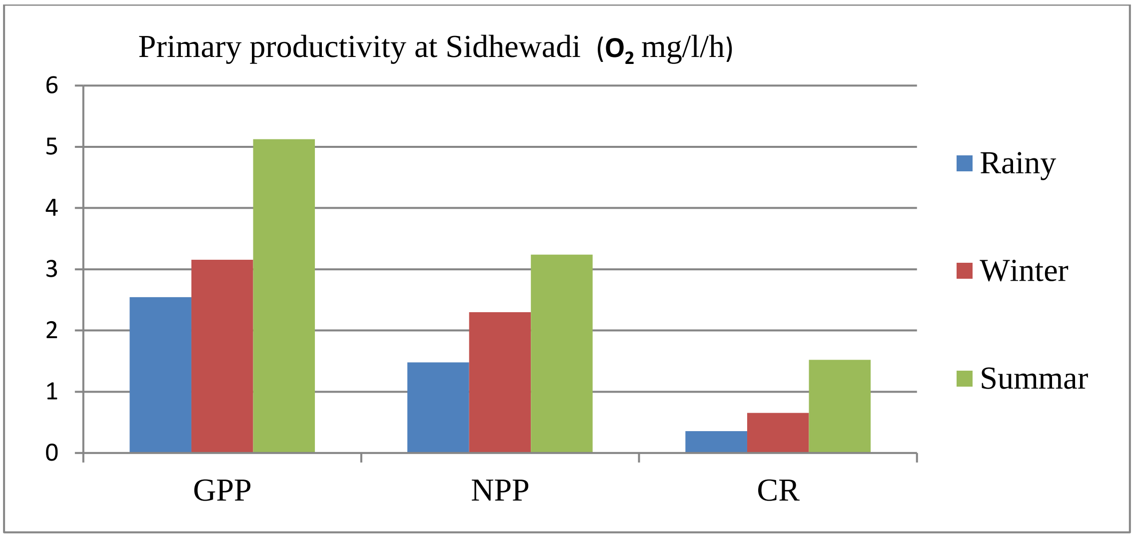


Figure 23: Seasonality of GPP, NPP and Community Respiration at Dudhebhavi.

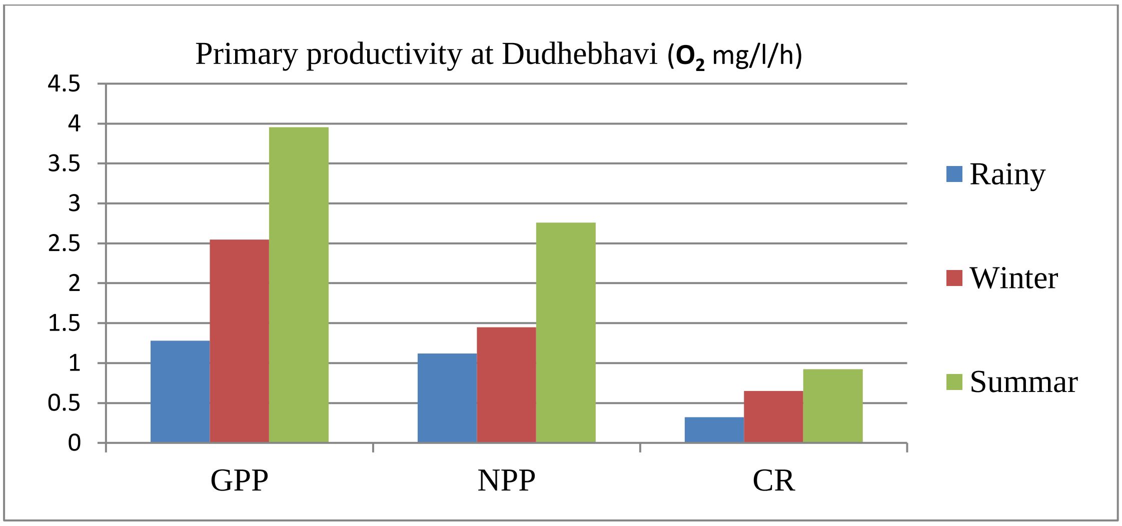
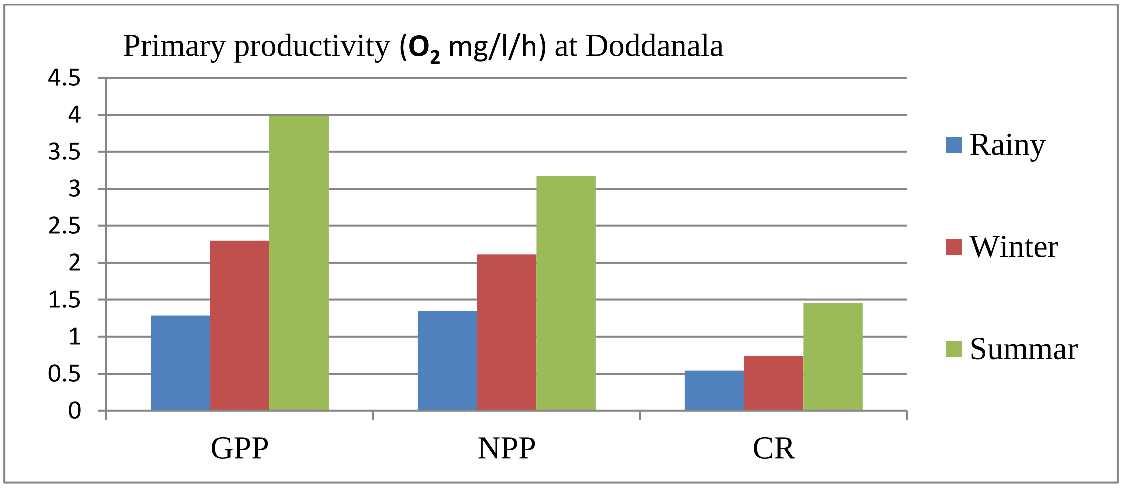


Figure 24: Seasonality of GPP, NPP and Community Respiration at Doddanala.



2. **Aquatic Macrophytes:**

The aquatic macrophytes are large, predominant angiosperms, inhabiting various sections of aquatic ecosystems and are of considerably significant from the productivity point of view in shallow water bodies in the littoral zones of the deep-water bodies. They play an important role in providing food to fish and other aquatic animals; provide support to algae and shelter and habitat to some animals. Also play an important role in cycling of nutrients in the given water body (Trivedy *et. al.* 1998). According to Biswas and Calder (1936) in perennial ponds and tanks four zones of aquatic vegetation are distinguished as bottom zone of vegetation, zone of submerged rooted aquatics, zone of unattached submerged free – floating vegetation and zone of surface vegetation.

The study on aquatic macrophytes is important to limnologist in order to understand functioning of aquatic ecosystem. Most of the aquatic macrophytes may become nuisance who growing profusely. Then these plants termed as aquatic weeds.

The poor growth of aquatic macrophytes in studied reservoirs may be attributed to its rocky bottom. The type of bottom is very important for growth of hydrophytes.

Chemical nature of water is most important factor for distribution of aquatic plants. Physical nature of water, bottom of reservoir, fluctuations in water temperature and water level affect the distribution of aquatic plants.

The occurrence of *Ipomoea carnea* Jacq. subsp *fistulosa*, *Najas minor* sensu Hoook. f. might be because of partial contamination by human and cattle washing and bathing.

The perennial *Ipomoea carnea* Jacq. subsp *fistulosa* grows abundantly throughout the year in all water bodies. Hujare (2008) has observed similar observation. The *Ceratophyllum demersum* L. appeared during September to December.

The area around water reservoirs is occupied by many weeds. They represent original natural set up with typical xerophytes. These are *Argemone maxicana* L., *Tridex procumbens* L., *Parthenium hysterophorus* L., *Calotropis procera* (Ait.) R. Br., *Calotropis gigantean* L. R. Br., *Euphorbia hirta* L., *Euphorbia microphylla* Heyne., *Celosia argentea* L., *Cassia tora* L., *Acacia arabica* (Lamk.) Wild., *Acacia nilotica* (L.) Wild., *Tephrosia purpurea* (L.) Pers., *Lantana camara* L.var aculeate (L.) Moldenke, *Pongamia glabra* Vent., *Azadirachta indica* Juss. etc. surround the water body and on dam line also.

The dicotyledons are dominated over monocotyledons.

17 Occurrence of Aquatic macrophytes in reservoirs.

Sr. No	Reservoirs → Aquatic Macrophytes ↓	B	N	S	Db	Dn
*	**Emergent**					
1	*Phyla nodiflora* (L.) Greene (Verbenaceae)	+	-	+	+	-
2	*Ipomoea carnea* Jacq. subsp *fistulosa* (Marf. ex. Choisy) Austin *(*Convolvulaceae)	+	+	+	+	+
3	*Typha angustata* Bory & Chaub. (Typhaceae)	+	+	+	+	+
4	*Cyperus rotundus* L.ssp. *rotundus* (Cyperaceae)	+	+	+	+	-
5	*Fimbristylis dichotoma* Vahi (Cyperaceae)	-	+	+	+	+
6	*Fimbristylis aestivalis* (Retz) vahi (Cyperaceae)	-	-	+	+	+
7	*Caesulia axilaris* Roxb. *(Asteraceae)*	+	-	-	-	-
8	*Bacopa monniera* (Linn) (Scrophulariaceae)	+	+	+	+	-
9	*Hygroyza aristata* (Nees) (Gramineae)	-	-	+	+	+
10	*Rotalia aquatica* Lour. (Typhaceae)	+	-	-	-	+
*	**Submerged**					
11	*Chara sps.* (Characeae)	+	+	+	+	-
12	*Vallisneria spiralis* L. (Hydrocharideae)	-	+	+	+	-
13	*Ceratophyllum demersum* L. (Ceratophyllaceae)	+	+	+	+	+
14	*Hydrilla verticillata* (L.f.) Royle (Hydrocharitaceae)	+	+	+	+	-
15	*Najas minor* sensu Hoook. f. (Hydrocharitaceae)	+	+	+	+	-
	Total	11	10	13	13	07

3. Phytoplankton:

The horizontal distribution of plankton in the lake is irregular due to the current of waters. However, vertical distribution is the peculiar feature. The light requiring green algae and zooplankton depending up on it are always found abundant in upper layers of lake. Vertical distribution of plankton varies widely. Almost all phytoplankton show vertical variation in distribution through out the euphotic zone (Welch 1952). The hydrobiological investigations mainly take into account their spatial and temporal growth, seasonal succession and periodicity, biomass and productivity etc. and interaction as well as interrelation with physico-chemical, environmental and meteorological conditions. The depth wise and diurnal studies of plankton coupled with information on ecological pathways provide the much desired and reliable data from the management viewpoint.

The Phytoplankton are chlorophyll bearing suspended microscopic organisms consisting of algae with representatives from all major taxonomic groups. The majority of members belong to Chlorophyceae, Cyanophyceae and Bacillariophyceae. Their unique ability to fix inorganic carbon to build up organic matter through primary production makes their study a subject of prime importance.

The phytoplankton community on which whole aquatic population depends is largely influenced by the interaction of number of physico-chemical factors (Jana 1973, Sankala *et. al.* 1981).

The quality and quantity of phytoplankton and their seasonal succession patterns have been successfully utilized to assess the quality of water and its capacity to sustain heterotrophic communities. Virtually all the dynamic features of lakes such as colour, clarity, tropic state, animal plankton and fish production depend to a large degree on the phytoplankton (Goldman and Horne 1983).

In the present investigation phytoplankton study has been undertaken to study the trophic status and to obtain the base line data (Table 18, 19 and Photoplate IV, V and VI).

Bhakuchi wadi reservoir:

The phytoplankton members represent the families viz. Chlorophyceae, Cyanophyceae, Bacillariophyceae and Dinophyceae. The Chlorophyceae members are found to be dominant through out the study period (Table 18).

During rainy season phytoplankton diversity was less, while in summer it increases. The total number of species was 24, 32 and 36 in rainy, winter and summer season respectively.

Pediastrum biradiatum, Tetraedron muticum var *punctulatum, Scenedesmus quadricauda* var *longispina, Ankistrodesmus spiralis, Ankistrodesmus falcatus* var *mirabilis, Chlorella vulgaris,* *Chlorococcum hunicola, Tetraspora gelatinosa, Microspora spp, Spirogyra spp, Cosmarium depressum, Gloeocapsa aeruginosa,* were absent during rainy season. Whereas, *Sperocystis spp., Pediastrum duplex* var *glacilimum, Pediastrum simplex, Dictyosphaerium pulchellum, Zygnema spp., Chlorella ellipsoidae, Haematococcus lacustris, Asterococcus superbus, Dinobryon sociale, Chorococcus turgidus, Anabaena spp, Lyngbya aestuaril, Oscillatoria spp., Phormidium spp., Cyclindrospermim doryphorum, Ceratium cornutum, Ceratium hirundinella* and *Peridinium polonicum* observed during all seasons of investigation.

Nimbavade reservoir:

During the rainy season the number of species were found minimum (17) where as, it was maximum in the season of summer. The lowest species diversity was during rainy, moderate in winter and the highest diversity was recorded during summer.

Sidhewadi reservoir:

In this reservoir maximum numbers of species were reported during summer season (38) and the minimum numbers were recorded during rainy (25) of study period.

Dudhebhavi reservoir:

Higher numbers of species were recorded during summer (33) and lower in the rainy season (16).

Doddanala reservoir:

During seasonal study, minimum species were recorded during monsoon season, moderae in winter and maximum species observed in summer season (20, 39 and 43 respectively).

Higher phytoplankton in summer season has been reported by Sreenivasan *et.al*. (1974), Arumugon and Furtado (1980) in some tropical lakes. Bharadwaja (1940) also pointed out that the temperature and light as factors responsible for higher phytoplankton population. Temperature is one of the factors which control the abundance of phytoplankton in lentic ecosystem (Nazneen 1980). Mustafa and Zubair (1997) recorded minimum number of phytoplankton in monsoon months. Besides temperature, high pH during summer may be one of the important factors responsible for summer maxima of phytoplankton (Venkteshwaralu 1969). Verma *et. al*. (2001) have recorded similar observation. Tripathi and Pandey (1990) reported similar trend of pattern. Pundhir and Rana (2002) have reported Chlorophyceae as dominant group. Maximum phytoplankton were recorded during summer and minimum during monsoon which is similar to present findings. This is in agreement with the finding of Laxminarayana (1965), Pahwa and Mehrotra (1966) also.

Phillipose (1960) mentioned that diatoms are usually abundant in alkaline water. All reservoirs were found to be alkaline during summer.

According to Hujare (2008) mainly Euglenophyceae members are less and maximum occurs during monsoon and minimum during summer. The response of species to aquatic environment seems to depend upon different parameters rather than any one, even though Cyanophyceae and Diatoms. (Kavitha *et.al.* 2005).

The Chlorophyceae found to be dominant over other groups Goel *et.al* (1986), Vijaya Bhaskar *et.al* (2009) have reported the highest species diversity of Chlorophyceae in fresh water bodies of south west Maharashtra. Veerendra *et. al.* (2006) have reported in all 34 species of phytoplankton amongst Chlorophyceae with 13 species, Bacillariophyceae with 11 species, Cyanophyceae with 7 and Euglenophyceae with 3 species. Significant positive co-relation between Chlorophyceae and alkalinity was observed by Mathew *et. al.* (2007). Bhosale *et.al.* (2010) have reported dominancy of Chlorophyceaen members in the lakes of Kolhapur city and in water bodies of Kavathe Mahankal tahasil. It holds true for the present study.

The excess of carbon dioxide during rainy season coincides generally with decrease in population of phytoplankton. Similar observations have been made by Pundhir and Rana (2002), Das and Srivastava (1956), Rana (1991, 1996).

Algal abundance was noted during summer and its declining state during rainy season due to turbidity, current velocity, water runoff causing dilution effect, loss of water through outlet and fluctuating water level. Similar observations are reported by Tiwari (2004) and Jadhav and Chavan (2009).

Verma and Mohanthy (1995) are of opinion that higher pH values promote the growth of algae. Higher concentration of dissolved oxygen favors the dominance of Chlorophyceae (Venkateshwaralu 1969). This is also in agreement with the finding of Khatri (1987). The variation in periodicity may be because of fluctuations observed in these physico-chemical factors. Similar studies on Chlorophyceae population in the ponds of Dharwad made by Hosmani (1988) and Thirugnanamoorthy Selvaraju (2009). Naik *et. al.* (2005) stated that higher pH and nitrogen supports the growth of Cyanophyceae. This observation is in agreement with present findings. The growth of Bacillariophyceae in the pond was influenced by the presence of high dissolved oxygen and high total dissolved solids. Similar investigation on the distribution and periodicity of Bacillariophyceae members in fresh water bodies were made by Jose and Patel (1991), Chitra and Meena (2004) from lakes of Kerala.

18. Seasonality of the phytoplankton species occurring in Bhakuchi wadi, Nimbawade and Sidhewadi reservoirs.

S. N.	Name of the species	Bhakuchi wadi			Nimbawade			Sidhewadi		
		R	**W**	**S**	**R**	**W**	**S**	**R**	**W**	**S**
	Chlorophyceae									
1	*Sperocystis spp.*	+	+	+	-	+	+	-	+	+
2	*Pediastrum biradiatum* Meyen	-	+	+	+	+	+	+	+	+
3	*Pediastrum duplex* var *glacilimum* West & West	+	+	+	-	-	+	-	-	-
4	*Pediastrum simplex* Meyen	+	+	+	-	-	-	-	-	+
5	*Pediastrum tetras* var *tetradon* (Corda) Rabenhorst	-	-	-	+	+	+	+	+	+
6	*Tetraedron muticum* var *punctulatum* (Reinsch) De Toni	-	-	+	-	+	+	-	-	-
7	*Dictyosphaerium pulchellum* Woood	+	+	+	+	-	+	-	-	-
8	*Westella botryoides* (W. West) de Wildmann	-	-	-	-	-	-	-	+	+
9	*Scenedesmus quadricauda* var *longispina* (Chod.) G.M. Smith	-	+	+	-	+	+	+	+	+
10	*Scenedesmus acuminatus* (Lag.) Chodat	-	-	-	+	+	+	-	-	+
11	*Tetrastrum triangularae* Komarek	-	-	-	-	-	-	-	-	-
12	*Ankistrodesmus spiralis* (Turner) Lemmermann	-	+	+	+	+	+	+	+	+
13	*Ankistrodesmus falcatus* var *mirabilis* (West & West) G.S. West	-	+	+	-	-	+	-	-	-
14	*Zygnema spp.*	+	+	+	-	-	-	+	+	+
15	*Volvox spp.*	-	-	-	+	-	+	+	+	+
16	*Chlorella ellipsoidae* Gerneck	+	+	+	-	-	-	-	-	-
17	*Chlorella vulgaris* Beyerineck	-	-	+	-	-	+	-	-	-
18	*Chlorococcum hunicola* (Naeg.)		+	+	-	+	+	+	+	+

	Rabenhorst									
19	*Tetraspora gelatinosa* (Vauch.) Desvaux	-	+	+	+	-	+	-	-	-
20	*Microspora spp.*	-	+	+	-	-	-	+	+	+
21	*Telimgia granulata* Bourrelly	-	-	-	-	-	-	-	-	+
22	*Haematococcus lacustris* (Girod.) Rostaf.	+	+	+	-	-	-	+	+	+
23	*Palmella mucosa* Kuetzing	-	-	-	+	+	+	-	-	-
24	*Asterococcus superbus* (Cienk.)Scherffel	+	+	+	-	-	-	-	-	-
25	*Kirchneriella obese* var. *Aperta (*Teil.) Brunnthaler	-	-	-	-	-	-	+	+	+
26	*Spirogyra spp.*	-	+	+	+	+	+	+	+	+
27	*Cosmarium depressum* Lundell	-	+	+	-	-	+	+	+	+
28	*Cosmarium tetraphtalmun* Brebission	+	-	+	-	-	-	+	+	+
29	*Dinobryon sociale* Eherenberg	+	+	+	+	+	+	-	-	-
	Cyanophyceae									
30	*Chorococcus disperses* var *minor* G.M.Smith	-	-	-	-	-	-	+	+	+
31	*Chorococcus limneticus* var *subsalsus* Lemmermann	-	-	-	-	-	-	+	+	+
32	*Chorococcus turgidus* (Kuetz.) Naegeli	+	+	+	-	-	-	-	-	+
33	*Merismopedia tenuissima* Lemmermann	-	-	-	-	+	+	-	+	+
34	*Merismopedia Trolleri* Bachmann	-	-	-	-	-	-	-	+	+
35	*Merismopedia elegans* var *major* G.M.Smith	-	-	-	-	-	+	-	-	-
36	*Anabaena spp.*	+	+	+	-	+	+	+	+	+
37	*Aphanizomenon spp.*	-	-	-	+	+	+	-	-	-
38	*Gloeocapsa aeruginosa* (Carm.) Kuetzing	-	-	+	-	-	-	-	-	-

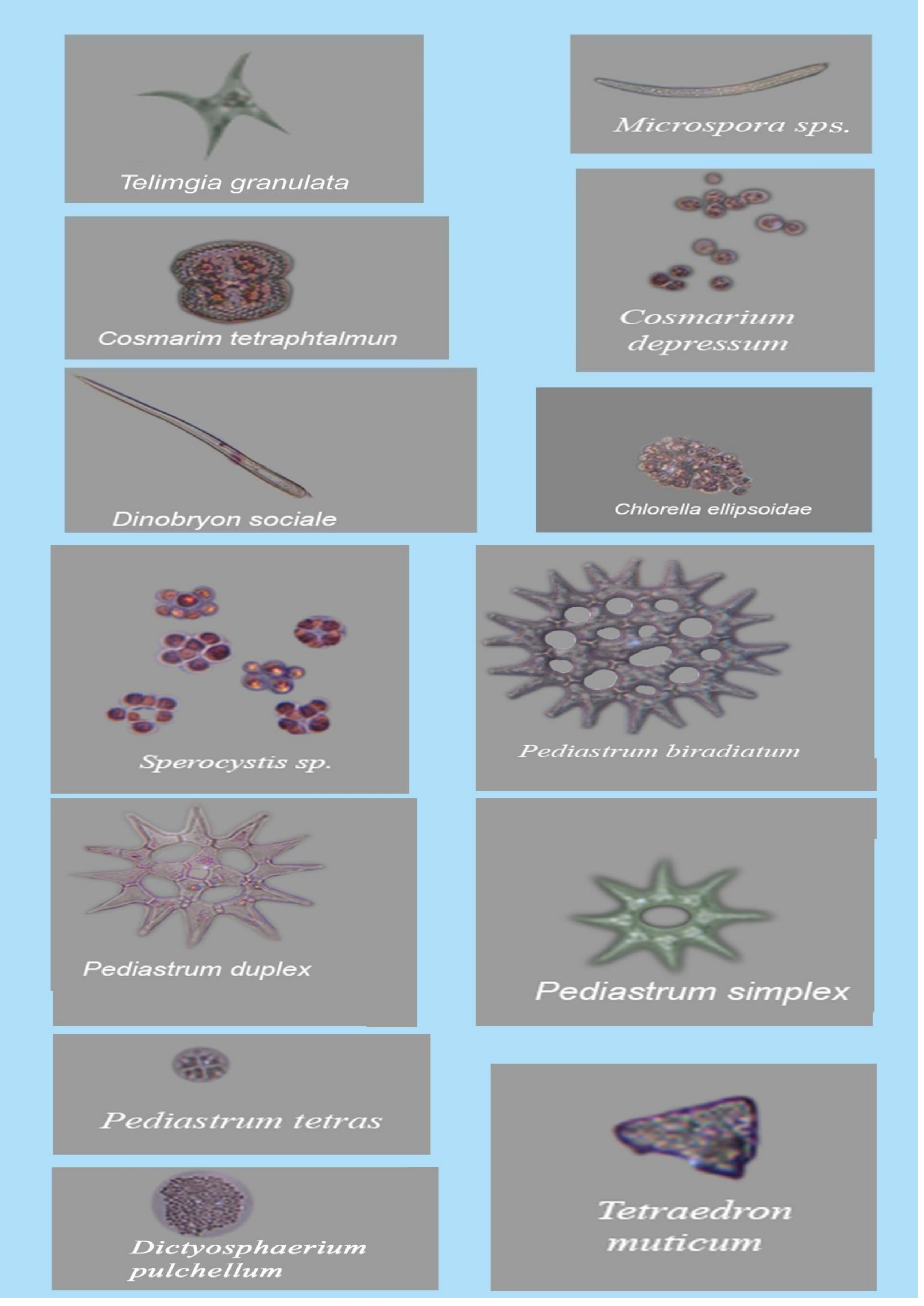
39	*Lyngbya aestuaril* (Mert.) Liebmann	+	+	+	-	-	-	+	-	+
40	*Oscillatoria spp.*	+	+	+	+	+	+	+	+	+
41	*Spirulina major* Kuetzing	-	-	-	-	-	-	-	+	+
42	*Phormidium spp.*	+	+	+	-	-	-	+	+	+
43	*Cylindrospermum spp.*	-	-	-	-	-	-	-	-	-
44	*Microcystis spp.*	-	-	-	-	-	-	-	-	-
45	*Cyclindrospermim doryphorum*	+	+	+	-	+	+	-	+	+
46	*Gleotrichia natans*	-	-	-	-	+	+	-	+	+
	Bacillariophyceae									
47	*Cymbella spp..*	+	+	+	-	-	-	-	-	-
48	*Cocconeis spp.*	-	-	-	-	-	-	+	+	+
49	*Gomphonema spp.*	-	-	-	-	-	-	-	+	+
50	*Melosira granulate* Ralfs	+	+	+	-	-	-	-	-	+
51	*Melosira varians* Agardh	+	-	+	-	-	-	+	+	+
52	*Navicula spp.*	+	+	+	+	+	+	+	+	+
53	*Synedra capitata* Ehrenberg	-	-	-	-	-	+	-	-	-
54	*Synedra acus* Kuetzing	-	-	-	+	+	+	-	-	-
55	*Cyclotella comta* Kuetzing	+	+	+	+	+	+	-	-	-
	Euglenophyceae									
56	*Euglena acus* var *rigida* Huebner	-	-	-	+	+	+	+	+	+
	Dinophyceae									
57	*Ceratium cornutum* (Ehrenb.) Claparede & Lachmann	+	+	+	+	+	+	-	-	-
58	*Ceratium hirundinella* (O.F.Muell.) Dujardin	+	+	+	-	-	-	+	+	+
59	*Ceratium carolinianum (*Bailey) Jorgensen	-	-	-	-	-	-	-	-	+
60	*Peridinium polonicum* Woloszynska	+	+	+	-	-	-	+	+	+
	Total	24	32	36	17	22	31	25	31	38

19. Seasonality of the phytoplankton species occurring in Dudhebhavi and Doddanal reservoirs.

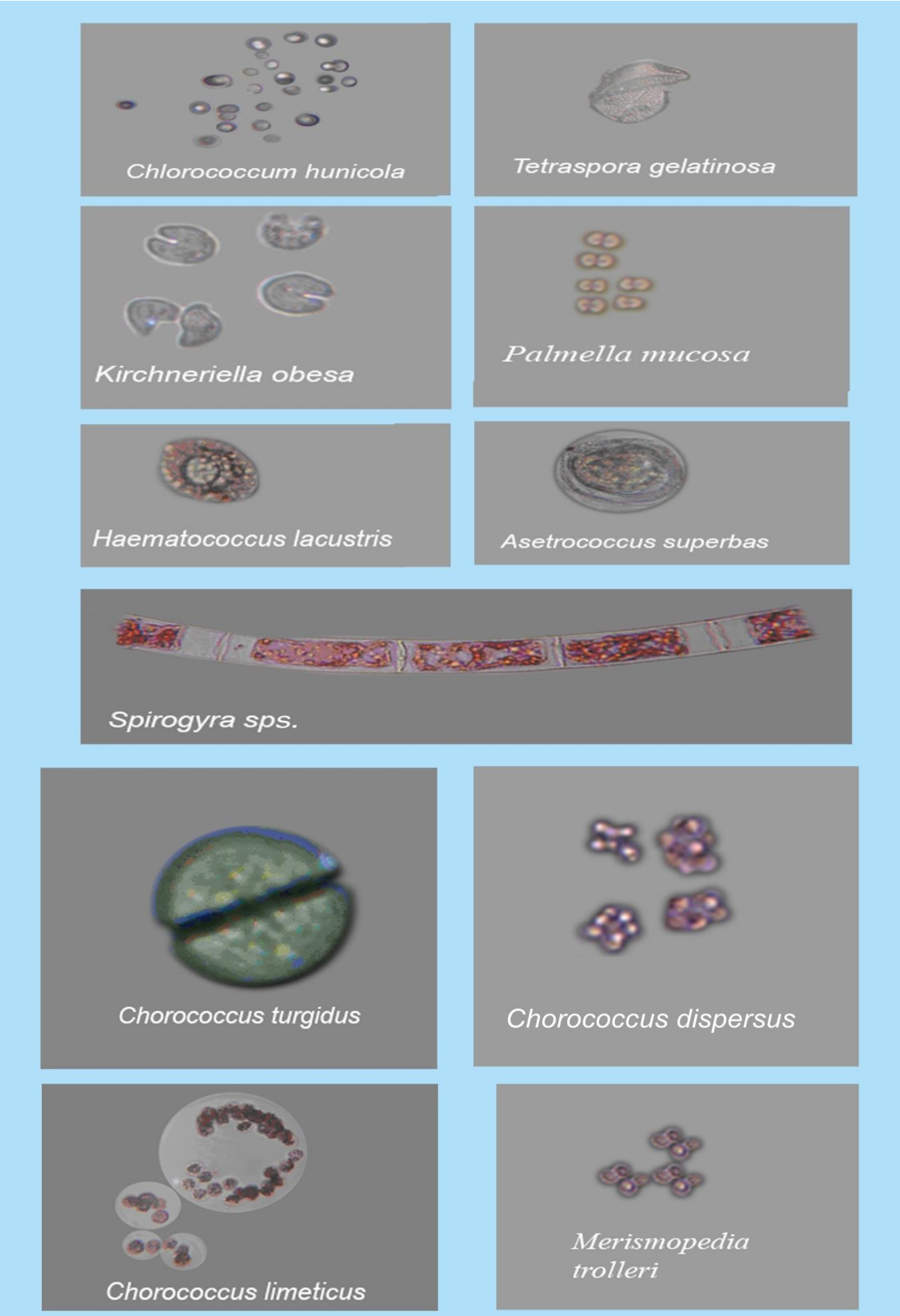
S. N.	Name of the species	Dudhebhavi			Doddanala		
		R	W	S	R	W	S
	Chlorophyceae						
1	*Sperocystis spp.*	-	+	+	+	-	+
2	*Pediastrum biradiatum* Meyen	-	+	+	-	+	+
3	*Pediastrum duplex* var *glacilimum* West & West	-	+	+	-	+	+
4	*Pediastrum simplex* Meyen	+	+	+	-	-	+
5	*Pediastrum tetras* var *tetradon* (Corda) Rabenhorst	-	+	+	-	+	+
6	*Tetraedron muticum* var *punctulatum* (Reinsch) De Toni	+	+	+	-	-	+
7	*Dictyosphaerium pulchellum* Woood	-	+	+	+	+	+
8	*Westella botryoides* (W. West) de Wildmann	-	-	-	-	+	+
9	*Scenedesmus quadricauda* var *longispina* (Chod.) G.M. Smith	-	+	+	-	-	-
10	*Scenedesmus acuminatus* (Lag.) Chodat	+	+	+	+	+	+
11	*Tetrastrum triangularae* Komarek	+	+	+	-	-	-
12	*Ankistrodesmus spiralis* (Turner) Lemmermann	-	-	+	-	+	+
13	*Ankistrodesmus falcatus* var *mirabilis* (West & West) G.S. West	-	+	+	-	+	+
14	*Zygnema spp.*	-	-	-	+	+	+
15	*Volvox spp.*	-	+	-	-	-	-
16	*Chlorella ellipsoidae* Gerneck	-	+	-	-	+	+
17	*Chlorella vulgaris* Beyerineck	-	-	-	-	+	+
18	*Chlorococcum hunicola* (Naeg.) Rabenhorst	-	+	+	+	+	+
19	*Tetraspora gelatinosa* (Vauch.) Desvaux	+	+	+	-	-	-
20	*Microspora spp.*	-	+	+	+	+	+
21	*Telimgia granulata* Bourrelly	-	-	-	-	+	+
22	*Haematococcus lacustris* (Girod.) Rostaf.	-	-	-	-	+	+
23	*Palmella mucosa* Kuetzing	+	+	+	-	-	-

24	*Asterococcus superbus* (Cienk.)Scherffel	+	+	+	-	-	-
25	*Kirchneriella obese* var. *aperta (*Teil.) Brunnthaler	-	-	-	+	+	+
26	*Spirogyra spp.*	-	-	-	+	+	+
27	*Cosmarium depressum* Lundell	-	-	-	-	+	+
28	*Cosmarium tetraphtalmun* Brebission	-	-	-	-	+	+
29	*Dinobryon sociale* Eherenberg	+	+	+	-	-	-
	Cyanophyceae						
30	*Chorococcus disperses* var *minor* G.M.Smith	-	-	-	+	+	+
31	*Chorococcus limneticus* var *subsalsus* Lemmermann	-	-	-	+	+	+
32	*Chorococcus turgidus* (Kuetz.) Naegeli	-	-	-	+	+	+
33	*Merismopedia tenuissima* Lemmermann	-	-	-	+	+	+
34	*Merismopedia Trolleri* Bachmann	-	-	-	-	+	+
35	*Merismopedia elegans* var *major* G.M.Smith	-	-	-	-	+	+
36	*Anabaena spp.*	+	+	+	-	-	-
37	*Aphanizomenon spp.*	-	-	-	-	+	+
38	*Gloeocapsa aeruginosa* (Carm.) Kuetzing	+	+	+	-	-	-
39	*Lyngbya aestuaril* (Mert.) Liebmann	-	-	-	+	+	+
40	*Oscillatoria spp.*	+	+	+	-	+	+
41	*Spirulina major* Kuetzing	-	-	+	+	+	+
42	*Phormidium spp.*	-	-	-	-	-	-
43	*Microcystis spp.*	+	+	+	+	+	+
	Bacillariophyceae						
44	*Cymbella spp..*	-	-	+	-	+	+
45	*Cocconeis spp.*	+	+	+	-	-	-
46	*Gomphonema spp.*	+	+	+	-	-	-
47	*Melosira granulate* Ralfs	-	-	-	-	+	+
48	*Melosira varians* Agardh	-	-	+	-	+	+
49	*Navicula spp.*	+	+	+	-	-	-
50	*Synedra capitata* Ehrenberg	-	-	+	+	-	+
51	*Synedra acus* Kuetzing	-	-	+	-	-	-

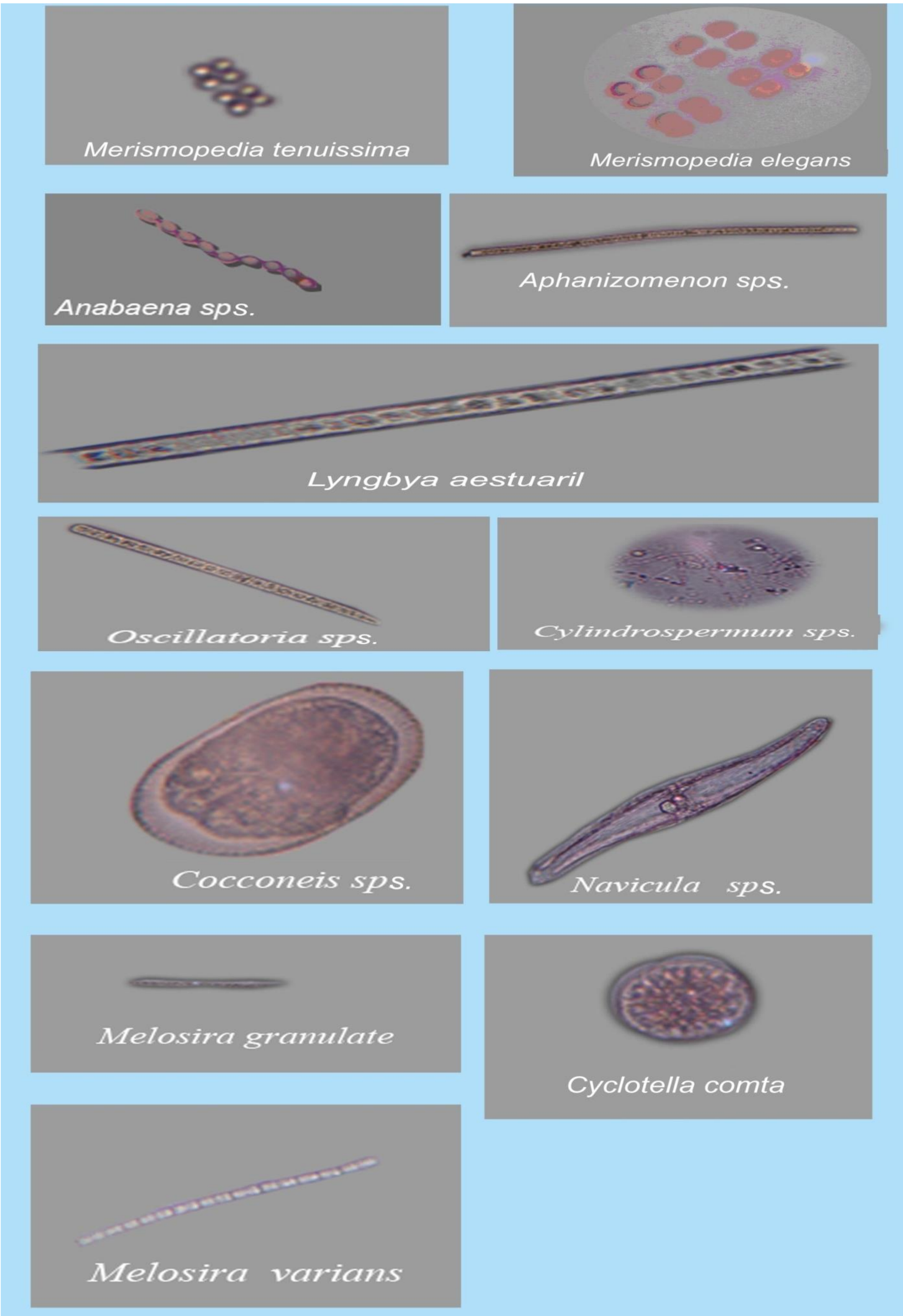
52	*Cyclotella comta* Kuetzing	+	+	+	+	+	+
	Euglenophyceae						
53	*Euglena acus* var *rigida* Huebner	-	-	+	+	+	+
	Dinophyceae						
54	*Ceratium cornutum* (Ehrenb.) Claparede & Lachmann	-	-	+	-	+	+
55	*Ceratium hirundinella* (O.F.Muell.) Dujardin	-	-	-	+	+	+
56	*Ceratium carolinianum (*Bailey) Jorgensen	-	-	-	+	+	+
57	*Peridinium polonicum* Woloszynska	-	-	+	-	+	+
	Total	16	27	33	20	39	43



Photoplate IV Photographs of Phytoplankton :1



Photoplate V Photographs of Phytoplankton :2



Photoplate VI Photographs of Phytoplankton :3

V. IMPORTANCE OF WETLANDS:

1. Agricultural productivity:

Water is one of the important inputs in agriculture. Agriculture plays more vital role for economic stability of the area and country. Therefore, there is a vital need for irrigation and agricultural development to keep the rapidly multiplying population adequately fed.

It is necessary to bring more and more land under irrigation and to adopt improved methods of agricultural practices such as use better seeds, high yielding varieties of crops, more fertilizers etc., but the prime necessity would be assured supply of quality water to have high yields.

An efficient cropping pattern may be defined as the sequence of crops to be raised in an area in accordance with the type of soil, quality of water and climatic conditions of the area and other available irrigation resources. It looks quite simple, but needs a comprehensive knowledge of all water management aspects (Sankara 1976, Jensin 1967, Doorenhos and Pruitt 1975, Richards and Richards 1957, Thornwaite and Mather 1955 and Yadava 1972).

The factors which affect the water requirement are the soil, plant and environment. The total quantity of water that is essential for raising a successful crop has been given by different scientists, Baier (1962), Balanaey and Criddle (1950), Anand and Jain (1978), Kuppa (1978) and Zimmerman (1966).

There are two main crop growing seasons, Kharip and Rabi. The kharip crops are sown with onset of monsoon and harvested in September – October. The rabbi crops are sown in October-November and harvested in February- March. There are some crops like jowar, cotton, which are grown in both the seasons. Also sugarcane stands in the field for 12 to 14 months spread over both the seasons. Rain fed crops are grown in jirayat or unirrigated land. Here the farmer is entirely dependent on the nature for crop productivity.

Bagayat in contrast is an irrigated land where labour and water intensive farming is practiced. Some crops like sugarcane are entirely dependent on irrigation.

Agricultural productivity is very complex phenomenon dependent on various physical, edaphic, socio-economical and technological factors. It is expressed in terms of output per unit of input. It is a measure of agriculture efficiency depending upon the man made framework to exploit the resources. In general, the irrigation is key factor in the agricultural production.

In Maharashtra 13 % agricultural land is under irrigation. There are 14 districts come under drought prone situation, Sangli is one of them.

The stored rain water in the reservoirs is used for drinking, irrigation as well as for domestic purpose. Irrigation is an age old art from human civilization, to increase the crop production. The government policies encouraged the farmers to utilize surface water, ground water resources by providing financial support. Doshi and Pujari (1997) reported that in the drought prone districts of Maharashtra, there is changing crop pattern and crop yield. The quantity and quality of human efforts modify the farm practices at farm as well as regional level.

In the present investigation, it has been noticed that constructed reservoirs are found more beneficial to marginal land owners and farmers. Land ownership and cropping pattern along the adjoining villages are studied. It is found that farmers have 1-20 acres of land at maximum.

Singh and Dhillon (1984) reported the significance of the use of water resources. Irrigation system is regional economic development. Any future planning of irrigation depends upon the basic and essential aspect of supply of agricultural water from ground and surface resources

In Bhakuchiwadi village, farmers are cultivating sugarcane, wheat, gram, grapes and jowar on a larger scale and banana, cotton, turmeric on a small scale. It is evident from the data that crop pattern has changed from rain fed to cash crops.

In the survey of village Nimbwade, majority farmers are cultivating pomegranate, cotton and side by side wheat and jowar on large scale while, sugarcane and gram on small scale.

At Sidhewadi after construction of Sidhewadi reservoir, majority of the farmers are cultivating export quality grapes, wheat, and gram. Comparatively sugarcane and vegetable growers are very less.

Dudhebhavi villagers were earlier growing only the rain fed crops and cereals. But currently, those farmers are cultivating wheat, sugarcane, gram, grapes on a large scale, while vegetables and betel leaf on small scale. The scenario has been changed totally in the studied area.

After construction of the Doddanala reservoir, the farmers started cultivation of crops like wheat, sugarcane, gram and cotton. Some farmers are cultivating grapes, vegetables etc. The farmers were initially cultivating rain fed crops only jowar, maize, tur and urid before construction of reservoir.

All surveyed villages were initially cultivating rain fed crops like *Sorghum bicolor* (L.) Moench var *bicolor*, *Cajanus cajan* (L.) Millsp. , *Vigna mungo* (L.) Hepper, *Vigna unguiculata* (L.) Walp. Subsp. *cylindrica* (L.) Eseltine, *Vigna radiate* (L.) Wilczek, *Vigna aconitifolia* (Jacq.) Morechal, *Eleusine coracana* (L.) Gaertn., *Pennsetum americanum* (L.) K. Schum, etc. but now they are shifted to fruit crops and cash crops. Because the water supply was low especially, during March, April and May due to dead storage of water in reservoir.

Datye *et. al.* (1988) have noticed similar type of changes in drought prone region of Sangli district. Sathe *et. al.* (2006) have reported changing pattern of rain fed crops to sugarcane, wheat and grapes in Ped, Pundi, Morale villages of Tasgaon tahsil. Doshi and Pujari (1997) have also observed that farmers are shifted to cultivate fruit crops like ber, pomegranate, mango and grapes depending up on nature of land and water resources. The changing crop pattern and further economy is entirely based on available water resources.

Thus, based on the studies it can be suggested to recharge, to maintain and to increase the water resources in drought prone areas is the need. Further, their management and conservation will lead to sustainability.

Niranjan Kumar *et. al.* (2008) have reported the ground water of Gajwel is excellent for agriculture purposes.

Figure 15 Cropping pattern of Bhkuchi wadi

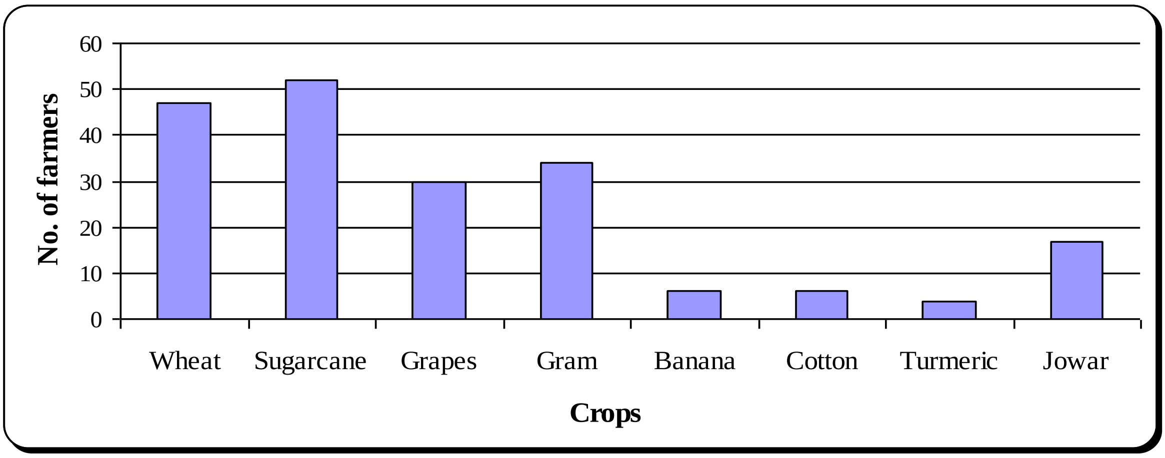


Figure 16 Cropping pattern of Nimbavade.

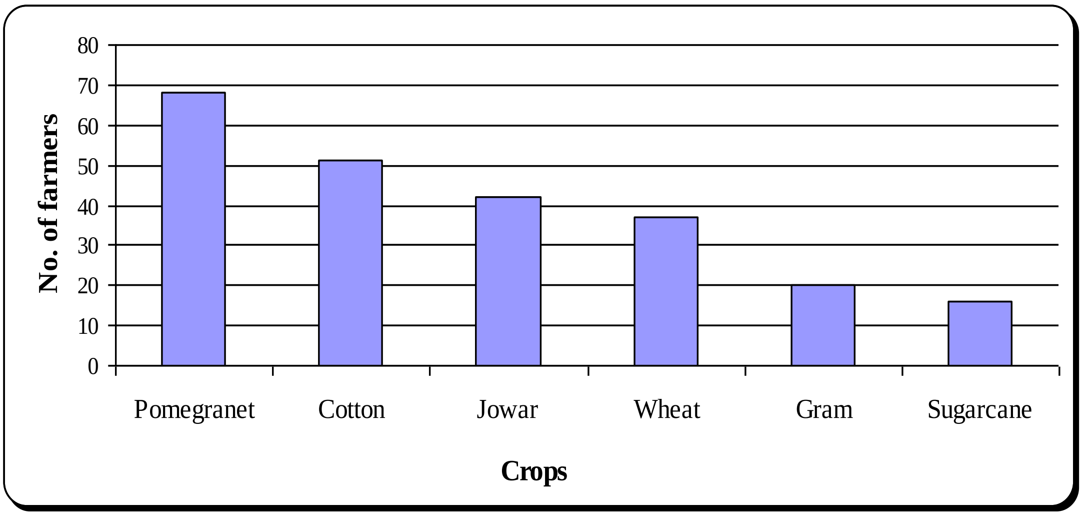


Figure 17 Cropping pattern of Sidhewadi.

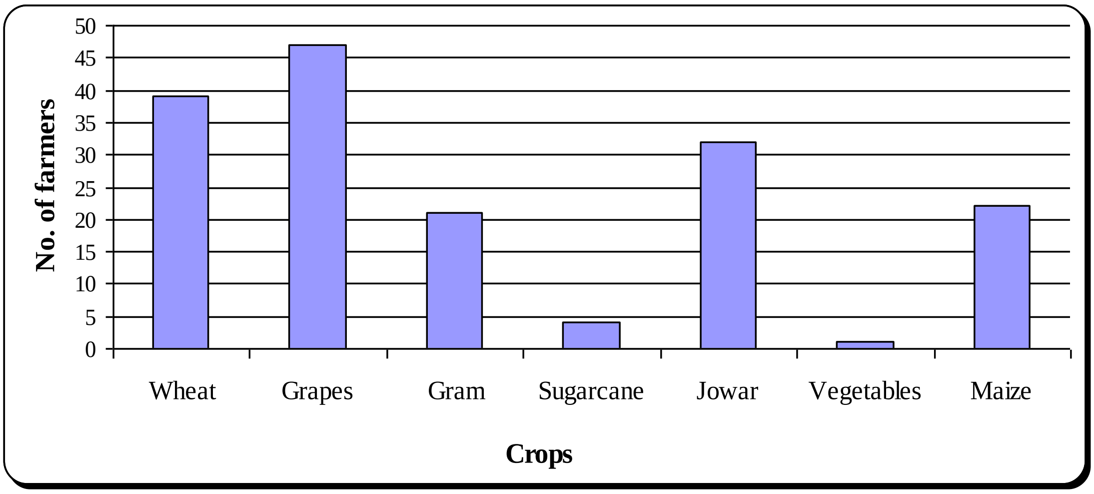


Figure 18 Cropping pattern of Dudhebhavi.

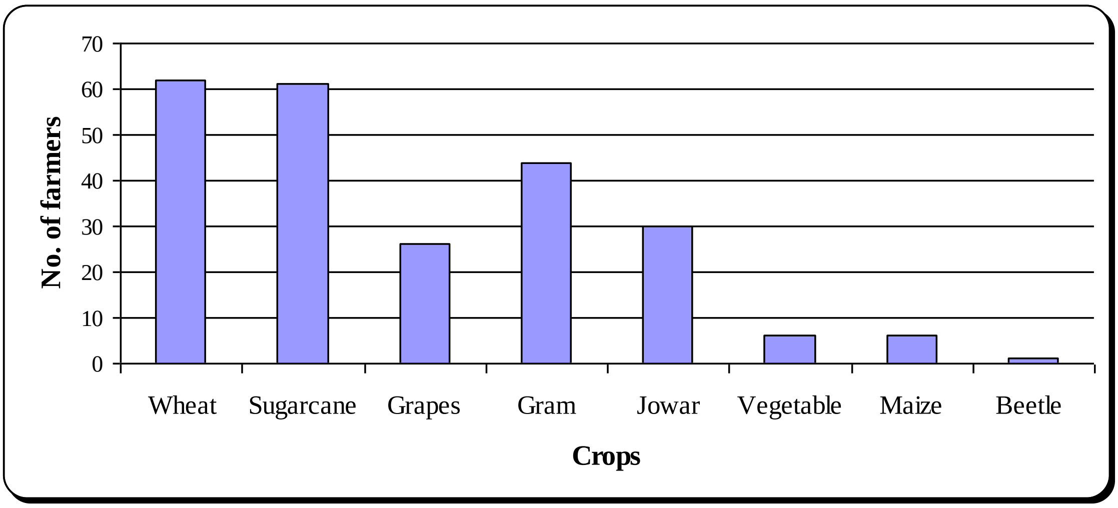
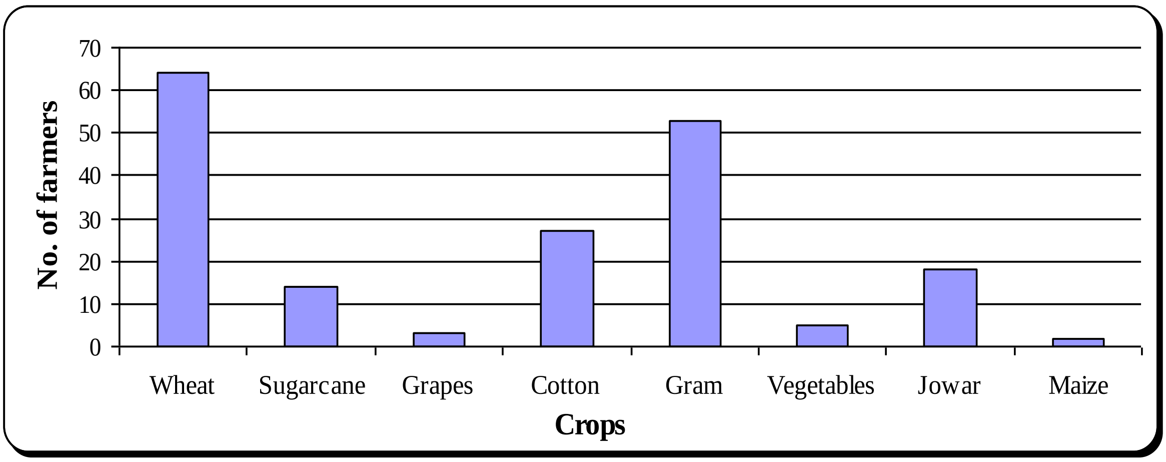


Figure 19 Cropping pattern of Doddanala.



2. Fishery productivity:

Fishes constitute economically a very important group. The nutritional and medicinal value of fishes has already been recognized by Hora and Pillay (1962), David (1969), Mishra (1952) and Jhingran (1982). Fish is an important food resource in fresh waters as well as marine waters as it is rich in proteins, carbohydrates and other nutritional constituents (Singh 2007).

In India, especially during last four decades fishery is adding considerably to the already existing rich water potential for the development of country's fishery resources. Fish fauna of various reservoirs have been reported by David (1969), Dey (1978), Jhingran (1982), Sharma *et. al.* (2004), Hujare (2005) and Dakhad *et. al.* (2008).

In the recent past much literature has been generated about pollution effects of various chemicals on different organs of different fishes (Saksena 1987, Sadhu 1993, Banarjee and Bhattacharya 1995, Gautam and Ritesh 1995, Nagrajan and Yuvarani 2006).

Water pollution affects different biota in general and fishes in particular and later causing health hazards to humans through food chains (Basak and Konar 1976).

These reservoirs are secondarily being used for reservoir capture fishery. After one year of stocking, fishing activities carried out by traditional methods by using traditional nets, crafts etc. Similar observations have been made by Chavan *et. al.* (2005).

Fishermen were not aware of any conservation strategy for the local and any species of fish due to illiteracy and poor education. Similar trend was reported by Chavan *et. al.* (2005).

Fishery and Lively hood:

Basically, these reservoirs were constructed for irrigation. Earlier, fishery was neglected, but developments related to fishery were initiated last few years.

Fishermen community of Bhoi, Bagadi and Koli races and also muslim people generally, do the fishing at all reservoir. Nearly 10 -12 families of fishermen migratory community located along the bank of Sidhewadi reservoir for three – four months. All the fishermen communities are poor and uneducated. The new generation has got 3-4 years of basic education. The involvement of children in fishing is often noted. These children are withdrawn from schools and are involved in fishing.

At all villages local Hindu people do the fishing from last fifteen years.

Sreekantha and Ramachandra (2005) have reported the very poor fishermen community permanently located along the banks of Linganamakki reservoir of Sharavati River.

Fishermen co-operative society:

The fishermen have established the co-operative societies. These societies obtain the right of fishing from government authorities for a period of five years on lease. If a tank is on lease by person or supported by co-operative society then, fisherman has to pay 10 Rs. per kg per day to lease man or co-operative society. The collected amount is used to purchase the seed of carp. The societies are actively engaged in fishing as follows:

Sreekantha and Ramachandra (2005) have observed fishermen co-operative society located at Sagar taluk of Shimoga district in Karnataka.

Occurrence and Diversity:

Fishes make up most of the abundant classes of vertebrates, both in terms of number of species and number of individuals. 21723 species of fish under 4044 genera, 445 families and 50 orders has been recorded in the world (Hora 1921).

During this study 5 species of cultivated carps have been identified. Table 20 shows some important carps occurred in reservoirs there are about 12 local fish species found in the reservoir along with a crab variety.

Table 21 highlights the occurrence of fish narities as per water body. The local fish varieties like (Tambir) *Labeo fimbricatus*, (Kanas) *Labeo calbasu*, *Chana gachua* (Dokrya), *Chana marulius* (Murel), *Mastocembelus* (Vam), *Ompok bimaculatus* (Khaprya), *Glossogbius girris* (Putia), *Barbus minor* (Singi), *Mystus malbaricus* (Shingati), *Ambasis ranga* (Kanchki), *Rosbara daniconius* (Dandi) and *Garra mullya* (Mallya) and Crabs *Barytelphusa spp.* found only in Sidhewadi.

Labeo rohita is commonly occurring fresh water major carp fish, available in the local ponds and rivers.(Saradhamani *et. al.* (2007) Chavan *et. al.* (2005) have reported that *Mastocembelus armatus* species was already enlisted in the threatened checklist of Ichthyofauna from Marathwada region of Maharashtra. *Cirrhinus mrigala, Catla catla, Labea calbosu, Labeo rohita, Ompok, Mastocembelus armatus* were recorded in the 11 water bodies of Assam by Kar *et. al.* (2009).

The present investigation reveals that a slightly seasonal variation occurs in physico-chemical parameters which can thrive well in environmental conditions and towards conservation of valuable fish resources.

Productivity:

In rainy season (July–August) about 5 thousand fingerlings per year of carps are released in each reservoir by co-operative societies.

The fishing season initiates in the month of January and extends up to May. Nearly 200 days out of 365 days are used for fishing.

Fishing activities usually done by gill nets locally known as kandimini, besides these the cast nets are also used for fishing.

Average weight of single fish ranges between 250 g to 500 g. A team of fishermen collect about 10 to 20 kg fishes per day.

Marketing and Income:

Collected fishes brought to the shore and sorted according to the species and size of fish. Small and medium sized fishes got better demand and market value. The fishes were sold at the rate of 40-50 Rs/kg in the market.

The fishes were purchased by the merchants or whole salers at lower prices. Sometimes, the fishermen would do the retail selling of fishes and gain the profit of 20 to 40 %.

Approximate fish catch and profit of fisherman and lease man or co-operative society is represented in Table 22.

20 Checklist of fishes from reservoirs.

Sr. No.	Varieties	Local name	Scientific name	Family
1	Major Carps	Rohu	*Labeo rohita*	*Cyprinidae*
		Catla	*Catla catla*	*Cyprinidae*
		Mrigal	*Cirrhinus mrigala*	*Cyprinidae*
2	Common carps	Cyprinus	*Cyprinus carpio*	*Cyprinidae*
3	Chinese carp	Silver carp	*Hypoplithalimichthys molitrix*	*Cyprinidae*
4	Local varieties	Tambir	*Labeo fimbricatus*	*Cyprinidae*
		Kanas	*Labeo calbasu*	*Cyprinidae*
		Dokrya	*Chana gachua*	*Cyprinidae*
		Murrel	*Chana marulius*	*Cyprinidae*
		Vam	*Mastocembelus armatus*	*Mastacembelidae*
		Khaprya	*Ompok bimaculatus*	*Siluridae*
		Putia	*Glossogbius girris*	*Cyprinidae*
		Singi	*Barbus minor*	*Saccdsranchidae*
		Shingati	*Mystus malbaricus*	*Bagridae*
		Kanchki	*Ambasis ranga*	*Centropomidae*
		Dandi	*Rosbara daniconius*	*Cyprinidae*
		Mallya	*Garra mullya*	*Cyprinidae*
5	Macrocrustacean	Crabs	*Barytelphusa spp.*	

21 Diversity of Fishes from reservoirs.

Local name	Scientific name	B	N	S	Db	Dn
Rohu	*Labeo rohita*	+	+	+	+	+
Catla	*Catla catla*	+	+	+	+	+
Mrigal	*Cirrhinus mrigala*	+	+	+	+	+
Cyprinus	*Cyprinus carpio*	+	+	+	+	+
Silver carp	*Hypoplithalimichthys molitrix*	+	+	+	+	+
Tambir	*Labeo fimbricatus*	+	+	+	-	-
Kanas	*Labeo calbasu*	+	+	+	-	-
Dokrya	*Chana gachua*	+	+	+	-	-
Murrel	*Chana marulius*	+	+	+	-	-
Vam	*Mastocembelus armatus*	+	+	+	+	-
Khaprya	*Ompok bimaculatus*	+	+	+	-	-
Putia	*Glossogbius girris*	+	+	+	-	-
Singi	*Barbus minor*	+	-	+	-	-
Shingati	*Mystus malbaricus*	-	+	+	-	-
Kanchki	*Ambasis ranga*	-	-	+	-	-
Dandi	*Rosbara daniconius*	+	-	-	+	+
Mallya	*Garra mullya*	-	+	+	-	-
Crabs	*Barytelphusa sp.*	-	-	+	-	-
Total		14	14	17	07	06

22 Average fish catch and profit of fisherman and lease man.

Duration	Fish catch	Profit of fisherman (Rs)	Profit of leaseman (Rs)
		40- 50 Rs / kg	**10 Rs / Kg**
1 Day	10- 20 kg.	400-1000	100-200
3 Days of week	30- 60 kg.	1200 – 3000	300 - 600
1 Month	120- 240 kg	4800 – 12000	1200 - 2400
5 Months	600 -1200 kg.	24000 – 60000	6000 - 12000

3. Avifauna :

The ecology of all wetlands is naturally subjected to wide and frequent fluctuations due to tropical semiarid climatic conditions of Deccan plateau to South India (Makanna *et. al.* 2007).

The water bodies apart from supporting diverse varieties of flora and fauna are known to be an ideal ground for the occurrence of different species of avifauna.

The surrounding flora of reservoir provides food to aquatic birds. The aquatic birds feed on plant and animal material.

Aquatic vegetation, bank side flora, trees in catchment area attracts the birds in reservoir. Even though birds are not aquatic in the real sense but they are dependent on aquatic habitat for food. (Table 23).

At Bhakuchi wadi 23 species were recorded. On Nimbavade reservoir 24 species of birds were observed during survey. Along Sidhewadi reservoir 24 species were recorded whereas 20 species from Dudhebhavi and 17 species were observed from Doddanala reservoir.

Malkanna *et. al.* (2007) have observed large egret, Black Ibis, Shovellar, Brahmini duck, coot in the wetland areas of Raichur.

Physicochemical Characteristics of Lonar Lake effects on Biodiversity studied by Shinde and More (2013).

23. Birds recorded in vicinity of reservoirs.

Sr. No.	**Reservoirs→ Aquatic birds ↓**	**B**	**N**	**S**	**Db**	**Dn**
1	Little cormorant ***Phalacrocorox niger***	+	+	+	-	-
2	Large egret ***Casmerodius albus***	+	+	+	+	+
3	Grey Heron ***Ardea cinera***	+	+	+	+	+
4	Painted Stork ***Mycteria leucophala***	+	+	+	+	-
5	Black Ibis ***Peeudibis papillosa***	+	+	+	-	+
6	Graylag Goose ***Anser anser***	+	+	+	+	-
7	Brahminy shelduck ***Tandorna ferruginea pall***	+	+	+	-	+
8	Lesser whitling duck ***Dendrocygna javanica***	-	+	+	+	-

9	Nothern shoveller ***Anus clypeata***	+	+	+	-	+
10	Garganey ***Anas querquedula***	+	+	+	+	-
11	Common coot ***Fulica atra***	+	+	+	+	+
12	Bronz winged jacana ***Metopidius indicus***	+	+	+	+	-
13	Common sandpiper ***Actitis hypoleucas***	+	+	+	+	+
14	House crow ***Corvus splendens***	+	+	+	+	+
15	Median egret ***Mesophoyx intermedia***	+	+	+	+	-
16	Indian pond Heron, ***Ardeola grayii***	+	+	+	+	+
17	Cattle Egret, ***Bubulcus ibis***	+	+	+	+	+
18	Little Egret, **Egretta garzetta**	+	+	+	+	+
19	Common Quail, ***Coturnix coturnix***	+	+	+	+	+
20	Indian peafowl , ***Pavo cristatus***	+	+	+	+	+
21	Indian grey Hornbill, ***Oclyceros birostri***	+	+	+	+	+
22	Plumheaded Parakeet, ***Psittacula cyanocephala***	+	+	+	+	+
23	Common Hoopoe **U*pupa epops***	+	+	+	+	+
24	Rock Bush Quail , ***Perdicula argoondah***	+	+	+	+	+
	Total	23	24	24	20	17

4. SUMMARY AND CONCLUSION:

Now these days are of '**conservation**'. It may be species conservation, habitat conservation, fresh water management and conservation, aquatic biodiversity conservation.

As stated in **Introduction** the wetlands are deteriorating due to population pressure, increased inflow of pollutants, anthropogenic activities in and around the catchment area of wetland region of Sangli.

The present investigation aims to study the significance of wetlands of drought prone region of Sangli district. Major five aspects are studied. The first aspect is the **Survey of wetlands** in relation to availability of water through out the year due to drought prone region of the district. This aspect is supplemented with survey and significance of nearest farmers and villagers.

Second aspect is study of **Physico-chemical environment of water bodies**. It includes water analysis of reservoirs at three sampling sites of each reservoir.

Temperature, pH, electrical conductivity, dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, calcium, magnesium, chlorides, total dissolved solids, total nitrogen and total phosphorus in water are studied and discussed in detail.

Third aspect is **Productivity of wetlands**. In which aquatic macrophytes and phytoplankton are studied reservoir wise.

Importance of wetlands is the last chapter. Economic importance of wetlands in relation to agricultural productivity, fishery productivity is carried out with the help of questionnaire. Farmers and fishermen were interviewed to obtain the data significantly. Birds visited to reservoirs and in the vicinity of them are recorded during every visit.

Studies on hydrobiology and productivity of Bhakuchi wadi, Nimbavade, Sidhewadi, Dudhebhavi and Doddanala reservoirs were carried out during May 2013 to May 2015. In this study the substantial data has been collected. By considering and correlating all above aspects of present work.

The findings of the present investigations are as follows.

1) Morphometrical data shows that Sidhewadi and Doddanala reservoirs are larger and medium irrigation reservoirs. Bhakuchi wadi, Nimbavade and Dudhebhavi are comparatively smaller and shallow reservoirs. All are much influenced by anthropogenic activities, especially for fishing.

2) The physical parameters like temperature, transparency, pH and EC are important. The transparency lies in moderate range. The pH of all reservoirs is alkaline throughout the study period. The range of EC suggests good quality water for agricultural productivity.

3) The concentrations of chemical parameter of the reservoirs are well under the prescribed limits of surface water.

The level of dissolved oxygen is favorable for fish culture. Free carbon dioxide level is comparatively very low, which shows well aerated waters of reservoirs. The range of total alkalinity indicates their productivity. Nutrient richness of reservoir is good. The total hardness of reservoirs is beyond the permissible limit only in late summer; otherwise it is in moderate indicating suitability for domestic use. Chloride values are higher in Sidhewadi and Nimbavade than other reservoirs. Chlorides are within the range in all reservoirs indicating suitability of water for domestic as well as for irrigation purpose. The low concentration of total nitrogen and total phosphorus affects the productivity of reservoir.

The values of total dissolved solids are maximum at Sidhewadi, Dudhebhavi and Doddanala reservoirs as compare to others. All reservoirs show higher total dissolved solids with onset of summer which are beyond the level. The water of all the reservoirs is suitable for irrigation purpose.

BOD values indicate cattle and human interference in and in the vicinity of reservoir. The result suggests that with proper management, water can be also utilized for drinking purpose.

Water from all reservoirs is suitable for irrigation as well as aquaculture. MPN for coliforms are observed during rainy and winter which suggest the quality of water i. e. unsafe for drinking purpose.

4) Sidhewadi and Doddanala reservoirs are rich in phytoplankton diversity.

5) The occurrence of aquatic macrophytes is very less. The vegetation is typical xerophytic around reservoirs.

6) Sidhewadi reservoir is more productive than other reservoirs.

7) All reservoirs are oligotrophic in nature.

8) The stored water from reservoirs is utilized for agricultural irrigation. Cropping pattern is changed in nearby villages. Majority of farmers have shifted from dry land agriculture to horticulture and commercially important cash crop cultivation. The reservoirs are found more beneficial especially to marginal land owners. Majority of farmers have improved their financial status.

9) The reservoirs are significant for in land fishery. The fisherman community is dependent on these water bodies for fish catch as income source.

10) Few local fishes are identified from the water bodies i e. local diversity of aquatic ecosystem has maintained well.

For the purpose of management of any wetland ecosystem monitoring is essential. It may be biological or physico-chemical. It is very difficult to evaluate each and every parameter regularly. The occurrence of *Spirulina* indicates constant anthropogenic activities and higher range of physico-chemical parameters with alkaline pH. Increased phytoplankton diversity indicates high intensity of organic pollutants.

High BOD, total hardness and electrical conductivity indicate organic pollution. Following suggestions can be drawn.

Natural and man made reservoirs should be maintained for sustainable development of our nation. Steps towards increasing catchments and recharge without disturbance are important. Socio-economic approach is more helpful in developing future plans related to the education of local people as well as conservation of water body.

4. BIBLIOGRAPHY:

Adoni A. D., G. Joshi, K. Ghosh, S. K. Chourasia, A. K. Vaishya, M.Yadav And Verma (1985): Workbook on limnology. *Pratibha Publ. Sagar (M.P.) pp. 216.*

Agrawal Manisha, Desmukh and M.C. Kanchan (2004): Studies on physico-chemical variation in 'Pani ki Dharmshala' reservoir, Jhansi, India. *Eco. Env. and Cons.10 (3):287-284.*

Ahmed Masood and R. Krishnamurthy (1990): Hydro biological studies of Wohar reservoir Aurangabad (Maharashtra State) India. *J. Environ. Biol. 11(3)335-343.*

Anand Reddy K. and Jain T. C. (1978): A simple and practical approach for estimating water requirement of crops. *Proc. Of Seminar on Irrigation Water Management in drought prone areas. Osmania University, Hyderabad. Pp V- 31-34.*

Anand V.K. and Suman Sharma (2000): Physico-chemical characteristics of the bottom sediment of Lacustrine Habitats of Jammu II. Lake Mansar: *Ecol. Env and cons.6 (4):419-428.*

Angadi S.M. (1985): Hydrobiological studies of Rajaram Tank. *M.Phil.Thesis, Shivaji University,Kolhapur (India).*

APHA, AWWA and WPCF (1985): Standard Methods for examinationof water and waste water. 14th Ed., New York.

APHA, AWWA and WPCF (2005): Standard Methods for examinationof water and waste water. 21st Ed., New York.

Arumugon P.T. and Furtado J.I (1980): Physico-chemistry Desertification And nutrient budget of a low land eutrophicated Nalayasian reservoir and its limnological implications. *Hydrobiologia 70:11-24.*

Awasti U.and Tiwari S. (2004): Seasonal trends in abiotic factors Lentic habitats,Govidgarh lake, Rewa, M.P.,India.:*Ecol. Env and cons 4 (2):165-170.*

Baier W.(1962): Studies on estimating potential evapotranspiration from empirical relationships. *South Africa J. Agri. Sc. 6. 455-474.*

Balanaey H. F. and Criddle W. D. (1950): Determining waterrequirements in irrigated areas from climatological and irrigation data. *U.S. Department Agri. Sc. S.pp- 96.*

Banerjee S. and Bhattacharya S. (1995): Histological change by chronic non-lethal levels of elson, murcury and ammonia in the small intenstlane of channa puntatus (Bloch). *Ecotox Environmental Safety: 3(1) 62-68*.

Basak P.K. and Konar S.R. (1976): Pollution of ater by pesticides and Protection of fishes. *Proc. Sc. Ind. 46B: 332-392*.

Bharadwaja Y. (1940): Some aspects of the study of myxophyceae.*Proc.Twent seventh Indian*

Sci. Congress Madras P.168.

Bhosale L.J., Sabale A.B. and Mulik N.G. (1994): Survey and status report on some wetlands of Maharashtra. *Final report submitted to Shivaji University, Kolhapur India.*

Bhosale L. J., Patil S. M., Dhumal S. M. and Sabale A. B. (2010): Occurrence of phytoplankton in the lakes in and around Kolhapur city. *Indian Hydrobiology, 12(2): 133-142.*

BIS (1991): Specifications for drinking water IS: 10500:1991. *Indian standard institution, New Delhi.*

Bisral N.B. (1996): The primary productivity of Supa reservoir during its filling phase. *J. Environ Biol 17(2):127-132.*

Biswas K. and Calder C.C.(1936): Handbook of common water and marsh plants of India and Burma. *Govt. of India Publication Calcutta.*

Bongale U. D. and S.G. Bharati (1978): Fresh water algae of Davangere and Raichur of Karnataka state, India. *J. Bombay Nat. Hist.Soc.77 pp.6-11.*

Bruce Campbell (1974): The Dictionary of Birds in colour *Published by Peerage Books, London WI.*

Chaterjee C. and De A. (2008): Impact of Anthropogenic activitieson drinking water quality : A case study of Raniganj coalfield area(W.B) *Nature, Environment and Pollution Technology.: 7(3) 451-459.*

Chavan S.P, Kadam M.S and N.E. Ambore (2005):Conservation needs for a fresh water Spiny eel. M. armatus frop Marathawada Region of Maharashtra, India:. *Eco. Env. Cons..11(3-4): 5173-519.*

Chitra P. and Meena S. (2004): Flora of temporary water bodies along with the semi coastal line Chachai to Shagusham in Thiruvananthapuram, India. *Hydrobiologia 7(1 and 2) 47-51.*

Chow T. (1958): Study of water quality in the fish pond of Hongkong. *Hongkong Univ. Fish J.* (*2) 7-28.*

Cooke T. (1967): The Flora of Presidency of Bombay, BSI, Calcutta.Cowrdin L.

CPCB (1975, 1999): Pollution Control Acts, Rules and Notification Issued There under, Central Pollution Control Board, New Delhi.

CPCB. Delhi. Nic. In/ Annual report 1999- 2000.: Impact assessment due to immersion of Ganesha idol in the lakes of Banglore city.

Dhakad N. K., Deepak Shinde and Preeti Choudhary (2008): Fish fauna of Mod Sagar reservoir of Jhabua district, M.P. *Nature, Environment and Pollution Technology.: 7(1) 159-161.*

Das S. M. and Srivastava V. K. (1956): Quantitative studies on fresh water plankton II. Corelation between plankton and hydrobiological factors. *Proc. Nat. Acad, Sci. India(B). 26 (4): 243-254.*

Datye K. R., S. Paranjape and S. Ghatage (1988): Economical sustainable system of water resource management: An Environmental Perspective Seminar. *16, 17.*

David A. (1969):Limnology & fisheries of Tungabhadra reservoir. *Bull. Cent. Inland Fish Res. Inst 13( ) 1-118.*

Deo N. and Manzoor Ali (1993): Water quality of a mining area in Keonjhar district for drinking and agriculture. *I. J.E.P. 13(9) 652-658.*

Deshmukh B.S. and S.D. Pingale (2007): Hydrobiological study of Wilson Dam water,District Ahmednagar(MS), India.:*Eco. Env. .and Cons.13(4):709-712.*

Devi O. I. (1993): Distribution, primary production and nutrient tatus of macrophytic communities in Waithou Lake, Manipur. *Ph. D. Thesis, Manipur Univ. Imphal.*

Dey F. (1978): Fresh water fishery. *Biology.W.M.C. Brown Co. Deerburque.*

Directory of wetlands (1990): Minister of Environment and Forest, Governmen. of India.

Doorenhos J. and Pruitt Woo. (1975): Crop water requirements. *Irrigation and Drainage paper No. 24 F A. O.*

Doshi R. and Pujari A. (1997): Arthsanwad- Maharashtra irrigation Special Issue (Marathi). *Vol. 2, July- September. 113-118.*

Doudoroff P. and Shumway (1970): Dissolved oxygen requirement of fresh water fishes. *FAO. United Nation Fish Tech. Paper86: 29.*

Fritsch F.E. (1944): The present day classification of algae. *Bot.Rev.10.*

Gaarder T. and Gran H.H. (1927): *Rappet, Proc. Verb cons. Expl Mer, 42,1-48.*

Ganapati S.V. (1940): The ecology of a temple tank containing permanent bloom of *Microcystis acculoginosa* (Kutz). *J. Bom. Nat. Hist. Soc. 42: 65-67.*

Garg S. S. (2003): Water quality of wells and borewell of 10 selected locations of Chitrakoot region. *Indian J. Env. Protec.23(9). 966-974.*

Gautam R. K. and Ritesh P. (1995):Enzymological alteration in kidney and liver of a fresh water teleost.H. fossilis after toxication with lead and mercury. *Bull. Pure App. Sc. 14(2) 101-104*.

Goel P.K., Khatavkar S.D., Kulkarni A.Y. and Trivedy R.K. (1986): Limnology studies of few freshwater bodies in south western Maharashtra with special reference to chemistry and phytoplankton. *Poll. Res. 5(2): 79-84.*

Goel P.K. and V.R. Chavan (1991): Studies on the limnology of a polluted fresh water tank. *Gopal B. and Asthana V(editors) Aquatic sciences in India 51-64. Indian Association for Limnology and Oceanography.*

Goel P. K. (2001): Water pollution, Causes, Effects and Control, *New Age International (p) Limited Publishers, New Delhi.*

Gonzalves, E.A. and D.B.Joshi (1946): "Fresh water algae near Bombay I. The seasonal succession of the algae in tank at Bandra", *J. Bom. Nat. Hist. Soc. 46, 144-176.*

Gupta S.K., N.P. Tiwari and Md Noor Alam (2008): Studies on the physico-chemical status of two water ponds at Patna in relation to growth of fishes.: *Nature, Environment and pollution Technology.: 7(4) 729-732.*

Hanan H. H. (1979): Chemical modification in reservoir regulated stream. In: The ecology of regulated stream. *Plenum Publication.*

Hora S.L. (1921): Fish and fisheries of Manipur with some observations on those on Naga Hills. *Rec. Indian Mus. (22) 165-214.*

Hora S.L. and Pillay T.V.R. (1962): Hand book of Fish culture in IndiaPacific Region. *FAD Fish Biol. Tech. Paper 14:204.*

Hosmani S. P. (1988): Seasonal changes in phytoplankton communitiesin a fresh water pond at Dharwad, Karnataka state, India. *Phykos27; 82-87.*

Hujare M.S. (2005). Hydrobiology studies on some water reservoirs Of Hatkanangale tahsil Maharashtra.: *Ph.D. Thesis submitted to Shivaji University, Kolhapur India.*

Hujare M. S. (2008): Distribution and seasonality of aquatic macrophytes in thrree perennial tanks of Kolhapur district Maharashtra, India. *Journal of Environmental Sciences. 12 (2): 125-128.*

Hujare M. S. and Mule M.B. (2008): Seasonal variation of physico – chemical parameters in the perennial tank of Talsande, Maharashtra.. *J. Ecotoxicol, Environ monit 18(3) 233-242.*

ICMR (1975): Manual of standards of quality for drinking water supplies. *Indian Council of Medical Research.*

Jackson D.F. (1961): Comparative studies on phytoplankton photosynthesis in relation to total alkalinity. *Verh. int. ver.limnol 14 125-133*

Jadhav S.B., Chavan N.S. and Gokhale M.V. (2009): Effect of ritual activity on the lentic water resources of Jotiba (Wadi Ratnagiri), Kolhapur district, Maharashtra. *Ecol. Env and cons.15 (1):71-75.*

Jadhav S.B. and Chavan N.S. (2009): Study of phytoplankton population from water resources of Jotiba (Wadi Ratnagiri),Maharashtra. *Nature, Environment and Pollution Technlogy:8(1):37-42.*

Jain A., J. Pal, E. Sharma and S.C. Rai (2005): Plankton community dynamics of a sacred lake in the Sikkim Himalaya: *Ecol. Env and cons 11 (3-4) :555-561.*

Jana B. B. (1973): Seasonal periodicity of plankton in fresh water in West Bengal, India. *International Review Ges. Hydrobiologia. 58; 127-143.*

Jayaram K. C. (1999): The fresh water fishes of the Indian region.: *Narendra Publishing HousE,Delhi,India.*

Jensin H. E. (1967): Improving irrigation efficiencies in irrigation of agricultural lands. *Americal Society of Agronomy. Monograph-11.*

Jhingran V G (1982): Fish and Fisheries of India. *Hindustan Publishing corp, (India) Delhi.*

Jhingran V. G. (1991). Recent advances in resevoir fishries management in India.:Resevoirs Fishries of Asia. (Ed. Desilva S. S.): *International development research centre- ottwa, canada. 158-178.*

Jose L. and Patel R. J.(1991): An ecological study of algae in the central waste water treatment plant of India Petrochemical Corporation Ltd., Baroda. *Geobios 18(2-3): 87-91.*

Kar D., A. H. Barbhuya, A. R.Baruah, C. Choudhary, P. Banerjee, R. Paul, A. Battacharjee, R. Saikia, B.Das, R. Barman and B. Saha (2009): Panorama of fish diversity in certain rivers, wetlands and protected areas in Assam. *Geobios 36(1) 57-64.*

Kaur H., K. S. Bath, G. Mander and N. Jerath (2000): Physico-chemical status of Kanjli wetland (Panjab-India). *Journal of Environment and pollution 7(1) 2000 pp. 39-42.*

Kavitha A., G.S.R. Balashing and A.D.S. Raj (2005): Fresh water Phytoplanton assemblages of two temple ponds of south Tamil Nadu. *Indian Hydrobiol., 11(2):261-270.*

Khabade S. A. and M.B. Mule (2005): Studies on the physico-chemical parameters of Pundi water reservoir from Tasgaon tahsil (Maharashtra): *Fundamentals of Limnology edited by Arvindkumar. 207-214.*

Khan A.A. and Siddiqui, A,Q. (1971) : Primary production in a tropical fish pond at Aligarh : *India. Ibid, 37, 447-456.*

Khan R. A. (1980): Primary productivity and trophicstatus of two tropical water bodies of Culcutta,India.*J. Zoo. Surv. India, 2 (2&3):128-138.*

Khare S. L., S.R. Paul and Anita Dubey (2007): A study on water quality of Khomph- Niwari lake at Chhatarpur, M.P.:*Nature, Environment and pollution Technology.: 6(3) 539-540.*

Khatri T. C. (1987): Seasonal distribution of phytoplankton in Idduki reservoir of Kerala (India).*Environ. Ecol. (5) 71-73.*

Kosygin L. and Haobijam D. (2005): Limnological studies of Potsangbam river, Manipur.:*Fundamentals of Limnology edited by Arvindkumar. 16-24.*

Krishnamurthy K. P. and Abdulppa M. K. (1972):Primary production and its Applications to water pollution. *Proc.Symp.Human Environ.(Dept. of Oceanography and meteorology, AndhraUniv. Waltair, India.*

Kumar A., Gupta H. P. and Sigh D. K. (1996): Impact of sewage pollution on chemistry and primary productivity of two fresh water bodies in Santhal Paragna, Bihar. *Indi. J. Ecol.23 : 86-92.*

Kuppa R. N. (1978): Forcasting and water requirements of crops under various conditions including prevention and management problems in relation to salinity and alkalinity. . *Proc. Of Seminar on Irrigation Water Management in drought prone areas. Osmania University, Hyderabad. Pp V- 35-36.*

Lakshami K., P. N. Unnl, N. Neelkanadan and P. S. Harikumar (2000): Environmental status of mangrove ecosystem in Valapattanam river basin, Kerala.: *Ecol. Env and cons 6 (4):363-371.*

Laxminarayana J.S.S. (1965): Studies on phytoplankton of the river Gangas, Varanasi, India.*Hydrobiologia 25(1-2) 119-137, 138-164.*

Lee G. F., Jones R. A. and Rast W. (1981): Alternative Approach to trophic state classification for water quality management. *Occasional Paper No. 66, Department of Civil and Environmental Engineering Programme, Colorado State University, Fort Collins, Colorado.*

Lind O. T. (1974): Handbook of common methods in limnology. : *The C. V. Mosby Company Scaint Louis.*

Malkanna, R. P. and C. Patil (2007): Wetland avifauna of Raichur in North Karnataka. *Eco. Env and Cons*. 73(4): 687-696.

Mandal O.P., inha A.K.and Sinha K.M.P. (2005) : Studies on Primary productivity of a wetland *Fundamentals of Limnology edited by Arvindkumar. 230 - 237.*

Mathew T., Deviprasad A. G. and Hosmani S.P. (2007): Physico- chemical parameters and plankton communities in the wetlands of Mysore district. *Journal of Ecotoxicol. Environ. Monit. 17 (1) 91-96.*

Mathivanan V., P.Vijayan and Selvi Sabhanayakam:(2005):An assessment of water quality of river Cauvey at Mettur,Salem District,Tamil Nadu in relation to pollution: *Fundamentals of Limnology edited by Arvindkumar. 36-42.*

Michael K.and Frey John, K. (1973): Environment in profile an aquatic perspective. *Harper and Row publishers Inc 10 East 53rd street New York 10022.*

Mishra A. P., Borah B. K. and Sharma M. (1999): Limnological investigation of fresh water tributary. *J. Fresh Water Biol. 11: 1-5.*

Mishra K. S. (1952): An aid to the identification of fishes of India, Burma and Celone.

Mitchell D. S.(1974): “Aquatic vegetation and its use and control”, *Unesco, Paris.*

Moyle J. B. (1949): Some indices of lake productivity. *Trans. Amer. Fish. Soc. 76. 2-334.*

Munawar M. (1970): “Limnological studies on freshwater ponds of Hydrabad India I. The biotope”, *Hydrobiologia 35 (1) 127-162.*

Mustafa S.and Zubair A. (1997): Environmental factors and planktonic communities of Baigul and Nanaksagar reservoirs, Nainital.: *Journal Bombay Nat. Hist. Society V0182 13-21.*

Nagarajan K. and Yuvarani K.E. (2006): Influence of neem oil on history of gills, intestine & retine of Indian major carp Labeo ruhita. *Nature, Environment Pollution Technology 5(3) 437-441*

Naik U. G., Bhosale S. H., Rathod J. L. and Bhat V. G. (2005): Diversity of phytoplanktonic groups in the river Kali, West coast of India. *Proceeding Of Senior Lecture University Grant Commission Haveri. 192-196.*

Nazneen S. (1980) : Influence of hydrological factors on seasonal abundance of phytoplankton in Kinjhar lake, Pakistan. Int.Rev.Ges.*Hydrobiol, 65 : 269-282.*

Niranjan Kumar K., S. Srinivas Reddy, K. Srinivas Verma and R. Mallikarjun Reddy (2008): Assessment of ground water quality for agriculture in Gajwel, Andhra Pradesh, India. *Nature, Environment and Pollution Technology. 8(3) 407-416.*

Omana P.K.and Mahesh Mohan (2008): The new mercury pollution threat to aquatic ecosystem of India:An example from Kerala: *Ecol. Env and cons14 (4) :789-794.*

Pahwa D. V. and Mehrotra S. N.(1966): Observation on fluctuation in the abundance of plankton in relation to hydrological condition of river Ganga. *Proc. Nat. Acad, Sci.,India(B) 36(2) 157-189.*

Paka S. and Rao N. (1997): Interrelationships of physico-chemical factors of a pond. *J. Environ. Biol 18 (1) 67-72.*

Palmar C. M, (1969): Composite rating of algae tolerating organic Pollution. *British Phycology Bulletin 5: 78-92.*

Pandey S. N. and A. K. Tripathi (1988): “Studies on algae of polluted ponds of Kanpur (India) VIII role of blue green algae”, *Phykos 27:38-43.*

Philipose M. T. (1960): Freshwater phytoplankton of inland fisheries. *Proceding of the symposium on Algology – 279-291.*

Philipose M. T., Ramchandran V., Singh S. B. and Ramaprabhu T. (1970): Some observations on the weeds of cultivable freshwaters in Orissa, J. Inland Fish. Soc, India 2 : 61-83.

Prajapati J.R. and B.V. Raol (2007): Studies on the ground water quality of Kalol city,Gujrat, India.:*Nature,Environment and Pollution Technlogy:6(2):197-201.*

Prajapati J.R. and B.V. Raol (2008): Studies on the ground water quality of Patan city,North Gujrat, India. *Nature,Environment and Pollution Technlogy:7(1):27-32.*

Prasad R.R. and Nair P.V.R. (1963): *Studies on aquatic production I Gulf of Mannar.* J. Mar. biol Assoc. India 5: 1-26.

Prescott G.W. (1982): Algae of the great western lakes area. *Otto Koeltz Science Publishers. Koenigstien, Germany.*

Pundhir P. and K. S. Rana (2002): Pollution dynamics of phytoplankton in the wetland area of Keoladeo National Park, Bharapur (Rajsthan). *Eco. Env. and Cons.8(3):253-235.*

Raghuwanshi A. K. (2005). The impact of physico-chemical parameters of lower lake of Bhopal on the productivity of *Eichhornia crassipes: Eco.Env.and Cons.11(3-4):333-336.*

Rajput S.I., G.P. Waghulade and S.P. Zambare (2004): A study on physico-chemical characristics of water from right canal of Hatnur reservoir of Jalgaon,Maharashtra State. *Eco.Env.and Cons.10 (2):171-173.*

Rana K. S. (1991): Impact of solar radiation on the aquatic ecosystem. A case study of Soor Sarowar, Agra. *Nature Environment and pollution Technology: 8(2) 43-49.*

Rana K. S.(1996): Assessment of pollution in river Jamuna. Part II Phytoplankton *Nature Environment and pollution Technology: 13(2) 41-48.*

Rao D. S. and Govind B. V. (1964): “Hydrology of Tungabhadra Reservoir”, *Indian Journal of Fisheries 11 (1) 321-344.*

Rao T. Ramakrishna (1991): “Limnology of India Quo vadis ?”, *Gopal B and Asthana (Editors) Aquatic sciences in India 1-6.*

Raveen R., C.Chennakrishnan and A. Stephen (2008): Impact of pollution on the quality of water in three fresh water lakes of Suburban,Chennai. *Nature Environment and pollution Technology: 7(1) 61-64.*

Richards L. A. and Richards S. A. (1957): Soil moisture in soil. *The 1957 Year book of Agriculture. USDA, Washigton, pp 49-60.*

Sadhu D.N (1993): Toxicity of an organophosphorus insecticide monocil to the air breathing fish *Channa punctatus* I. *Ecotoxicology Environment 3(2) 133-136.*

Saksena D.N. (1987): On the use of gonadosomatic index volume of the gonads as indicators of gonadal state in Indian fresh water body Glossogobius giuris(Ham.) with note on the role of temperature in fish reproduction. *Int. J. Acad. Ichthyol. 8(1).*

Salim Ali (2002): The book of Indian Birds: *13th Edition : Bombay Natural History Sociaty, Oxford University Press.*

Sankala S. K., Jain S. L. Dhakar M. L. and Vyas L. N. (1981): Phytoplankton Periodicity in three lakes around Udaipur. *Acta. Limnology, India. 1: 11-16.*

Sankara Reddy G. K. (1976): Management of irrigation water. *Tech. Bull. No.3.APAU, Hyderabad.*

Saradamani N., R. Saraswati and B. Dhanalakshmi (2007):Effects of the detergent commondo on Cholesterol content of the fresh water fish *Labeo rohita : Natural Environment Pollution Technology 6(3) 433-436.*

Sathe S. S., Khabade S. and Hujare M. (2001):Hydrobiological studies on two man made reservoirs from Tasgaon Tahsil (Maharashtra): India. *Ecol. Env and cons. 7 (2):2001 PP (211-217).*

Sathe S. S., Patil A. A. and Bodhale S. B. (2006): Significance of man made reservoirs in agricultural productivity: A case study of Tasgaon (Maharashtra): *Ecol. Env and cons. 12 (2):253-256.*

Sawant R. S. and A. B. Telave (2009): Seasonal variation in physico-chemical characteristics of four aquatic ecosystems in Gadhinglaj tahsil of Maharashtra. *Nature, Environment and pollution Technology: 8(3)509-514.*

Sharma A., Mudgal L. K, Sharma A. and Sharma S. (2004): Fish diversity of Yashwant Sagar reservoir, Indore (M.P.) *Him. J. Env. Zool. 18(2): 117-119.*

Sharma D. and R. Jain (2000): Physico-chemical analysis of Gopalpura tank of Guna District (M.P.): *Eco.Env.and Cons: 6 (4):441-445.*

Shinde Vinod A. and More S.M.,(2013): Study of Physicochemical Characterization of Lonar Lake, Maharashtra, India, *Int. Res. J. Environment Sci*. 2(12),25-28.

Shrivastava N. (2005): Seasonal variation in water quality of Kali Sindh river in Chambal command area: *Ecol. Env and cons 11 (3-4) :461-465.*

Shrivastava B.and Alam Mansood (2007): Studies on physico-chemical characteristics and heavy metals in Kelo river along city Stretch in Raigarh, Chattisgarh: : *Nature, Environment and pollution Technology.: 6(4) 609 -613.*

Singh J. and Dhillon S. S. (1984): Agricultural Geography. Ed. 2, *TMH Publication Company Ltd., New Delhi, 443.*

Singh H. P. (1998): Studies on primary production in Gobindsagar reservoir Himachal Pradesh. *J. Environ. Biol. 19 (2) 167- 170.*

Singh A., K. Arvind, N. Shukla, P. Saxena and K. Mendhe (1996): Some observations on primary productivity in river Narmada (Western zone) M. P. India. *Journal of environment and pollution 3 (384) 1996, PP 203-206.*

Singh R. (1990): Correlation between certain physico-chemical parameters and primary production of phytoplankton at Jamalpur, Munger. *Geobios 17: 229-234.*

Singh M. and K.C. Gupta (2004) :Physico-chemical studies of Water of river Yamuna at Mathura.: *Eco.Env.and Cons.10(2):193-196.*

Singh S. (2007): Impact of an insecticide Rogor on ovary of Channa punctatus (Bloch): *Nature Environment Pollution Technology 6(3) 471-475.*

Sobha V. and Harilal C. (2005): Influence of changing water quality on *Eicchornia crassipes* (Mart) Solms. In the uptake pattern of various minerals and nutrients: *Ecol. Env and cons12 (1):1-6.*

Solanki V.R., S. S. Murthy, Amarjit Kour and S. Sabita Raja (2007):Variation in dissolved oxygen and biochemical oxygen demand in two fresh water lakes of Bodhan,Andhra Pradesh, India. *Nature, Environment and pollution Technology: 6(4) 623-628.*

Sreekantha and T. V. Ramchandra (2005): Fish Diversity in Linganamakki Reservoir Sharavathi River. *Eco. Env. and Cons. 11 (3-4) 337-348.*

Sreenivasan A. (1964): Limnological feature and primary production in a polluted moat at Vellore, Madras state. *Environmental, Health. 6: 237-245.*

Sreenivasan, S. R. and Franklin T. (1974): Diurnal and seasonal changes in a productive shallow tropical pond. *Phycos 86-103.*

Subhashini S. and N. Saradhamani (2005): Hydrobiology of Aliyer reservoir, Coimbatore district, India.. *Fundamentals of Limnology edited by Arvindkumar. 56-60.*

Sudeep B.M., Srikantaswamy S. and S. P. Hosmani (2008): The study of phytoplankton dynamics in two lakes of Mysor,Karnataka state, India.: *Nature, Environment and Pollution Technlogy:7(4):697- 702.*

Sukhija L. (2007): Seasonal variation in zooplanktonpopulation in relation to physico-chemical characteristics of water in Kayad lake near Ajmer,Rajsthan: *Nature, Environment and pollution Technology. 6(2)299-302.*

Synudeen Sahib S. (2002): Primary productivity studies in some aquatic bodies of Kollam district, Kerala. Uttar Pradesh *J. Zool. 22(3):247-250.*

Thirugnanamoorthy K. and M. Selvaraju (2009): Phytoplankton diversity in relation to physico-chemical parameters of Gnanaprekasam temple pond of Chidambaram in Tamilnadu, India. *Recent Research in Science and Technology, 1 (5): 253-258.*

Thornwaite C. W. and Mather J. R. (1955): The water balance. *Laboratory, Climatology Publication 8, Centerton N. J. USA.*

Tiwari D. (2004) Algal Dynamics of a polluted river. *Nature, Environment and pollution Technology.: 3(1) 95-98.*

Tripathy A. K. and Pandey S. N. (1990): Water pollution. *Pub. Ashish Publishing house. PP 1-326.*

Trivedy R. K., P. K. Goel and C. L. Trishal. (1998): Practical methods in Ecology and Environmental Science. *Envir media publications Karad.*

U. S. EPA (1976): Quality Criteria for Water, Environmental Protection Agency. 4409-76-023, Washington DC.

Veerendra D. N., S. Manjappa and E. T. Puttaiah (2006): Diversity of phytoplankton in Mani reservoir, Hosanagar, Karnataka. *J. Environ. and Ecoplan. 12 (2) 335-338.*

Venkteshwaralu V. (1969): An ecological study of Algae of the river Moosi, Hyderabad, India with special reference to water pollution III.Algal periodicity. *Hydrobiologia : (34) 533-560*

Verma J. and Mohanthy R. C. (1995): Phytoplankton and its correlation with certain physico-chemical parameters of Dammukundpur pond. *Poll. Res. (14) 233-242.*

Verma M. C., S. Singh and P. Thakur (2001): Ecology of a perennial wetland: An overview of limnobiotic status. *Journal of Environment and pollution. 8 (1) 2001 PP. 53-59.*

Vijaya Bhaskar C., S. A. G. Mansour and G. Nagendrappa (2009): Phytoplankton Studies in relation to physico-chemical environment of some lakes around Tumkur City,Karnataka, India. *Nature, Environment and pollution Technology: 8(3) 533-538.*

Vijaykumar K., Shashikantha M., Mural J. and B. Vasanth Kumar (2005): Pollution status of Bhima river at Gulbarga.: *Ecol. Env and cons11 (3-4) :467-469.*

Vijaykumar K. (1994): Seasonal variation in the primary productivity of a tropical pond. *J. Ecobiol. 6(3) 207-211.*

W.H.O. (1993): Guidelines for drinking water quality (vol.2): Recommendations. *World Health Organization, Geneva*.

Wavde P.N. and P. R. Shaikh (2008) : Potability status of ground water in Malegaon village of Nanded district, Maharashtra: *Nature, Environment and pollution Technology: 7(1) 55-60.*

Welch P. S. (1952): Limnology. *2nd Ed, Mc Graw Hill Book co. N. Y. 1952*

Wilcox L.V. (1955): Classification and use of irrigation waters. U.S. Dept. of Agricultural Sciences, Grc. *966-969*.

Yadava J. S. P. (1972): Coordinated research on water management and salinity in India. *Ind. Fing.22 (2) 43-45.*

Yadav S. R. and Sardesai M.M. (2002): Flora of Kolhapur District *Published by Shivaji University Kolhapur (India).*

Zafar A. R. (1966): "Limnology of Hussain Sagar lake Hydrabad India", *Phykos, 5 (1-2) 115-226.*

Zimmerman J. D. (1966): Irrigation. *John Wiley and Sons Inc. New York.*

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