GROWTH PERFORMANCE OF INDIAN MAJOR CARPS *VIS-À-VIS* BIOTIC FACTORS IN SELECTED MICRO-WATERSHEDS OF SOUTHERN RAJASTHAN

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1. INTRODUCTION

Water is the most widely distributed substance on our planet. However, it's distribution is unequal inthe different parts of the world. All living organisms on the earth need water for survival and growth. Major part of water on earth is in oceans (97%) and only 3% present as freshwater; slightly over two third of this is frozen in glaciers and polar ice caps. The remaining unfrozen freshwater is found mainly as groundwater, with only a small fraction present on ground or in the air.

India has vast freshwater resources in the form of both lentic and lotic ecosystems. The total water resources of 73.59 lakh hectares include 19521 km of rivers and canals, 29.07 lakh hectares of reservoirs, 24.14 lakh hectares of tanks and ponds, 7.98 lakh hectares of flood plains lakes and derelict waters and 12.40 lakh hectares of brackish water (Srinivasa, *et al.* 2012). The perennial reservoirs play an important role as domestic, agriculture and aquaculture water resource.

Rajasthan is endowed with varied surface freshwater resources like perennial reservoirs, seasonal and two perennial rivers viz., Chambal and Mahi, irrigation canals, small tanks and ponds, all covering around 4.23 lakh hectares of water area. Out of this, large and medium reservoirs constitute about 2.47 lakh hectares of water area, while small reservoirs and ponds contribute 1.76 lakh hectares. Whereas, 0.30 lakh hectare water area is available in the form of rivers and canals (source, DOF Rajasthan 2011).

Southern Rajasthan which constitutes two sub regions viz., as "Mewar" and "Vagad" is especially famous for its water bodies. Udaipur division due to its interconnected and beautiful lake system has an exceptional importance at national and international level. In spite of favorable conditions for high fish growth rate in the state of Rajasthan, fish culture has yet not gained required popularity. Fish production in any aquatic ecosystem is mainly dependent on the abiotic and biotic factors in their environment. Abiotic factors are chemical and physical factors such as temperature climate, along with the amount of sunlight, salinity and pH. Biotic factors are living organisms (i.e., producers, consumers or decomposer) and are important because they directly affect the survivability and growth of an organism in aquatic ecosystem.

Water quality refers to all physical, chemical and biological characteristics of water. Water quality plays an important role in the growth and survival of aquatic organisms. Relationship between water quality and aquatic primaryproductivity is a pre-requisite for obtaining optimum fish production and itsgrowth.

Phytoplankton is the basis of aquatic food pyramid in aquaculture systems. The phytoplanktons are the main primary producers in surface water, so they grossly influence the density of consumers and also the physico-chemical characteristics of water. Phytoplankton quickly responseds to theenvironmental changes. Phytoplankton constitutes a major part of the living aquatic ecosystem, they being primary producers; support the growth of aquatic fauna and produces oxygen by photosynthesis process. Phytoplankton also plays an important role in material circulation and energy flow in aquatic ecosystem.

Primary productivity is the rate, at which the sun's radiant energy is stored by photosynthetic and chemosynthetic activities of basic producers like phytoplankton and plants in the form of organic substances. The primary productivity of different water bodies has been widely investigated to assess the fish production potentiality of water bodies and formulate fishery management policies. Primary productivity is mainly of two types; Gross primary productivity and Net primary productivity. Gross primary productivity is a measure of the total amount of organic matter and organic carbon fixed in photosynthesis. The net primary productivity is the gross primary productivity minus plant respiration. Natural levels of primary productivity are usually inadequate to support high aquaculture yields. The knowledge of phytoplankton, variations in primary production, nutrient concentration and community structure are fundamental to the understanding of ecosystem dynamics.

Zooplankton plays a pivotal role in aquatic food weband forms animportant food for fish and invertebrates. In terms of biomass and group diversity dominant groups of zooplankton in most natural waters are crustacean and rotifer. Zooplankton density is susceptible to the variations in a wide number of environment factors such as water temperature, light, pH, oxygen, salinity, food availability (algae, bacteria, etc.) and predation by fish and invertebrates. The population of zooplankton is a function of the availability of suitable food. In tropics zooplankton communities are typically diverse (more than 20 species) and occur in almost all lakes and ponds. Zooplankton quality

and quantity may be used as indicators of the trophic status of a water body. Biological production in any aquatic body is an indication of the physico-chemical trophic status and fisheries resources potential of any given water body (Jhingran,*et al*.1969).

Indian major carps viz., *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* dominate the fishery wealth of north Indian reservoirs especially of Rajasthan. Carps belongs to the category of second level in food chain as they feed on plankton, detritus and benthic organisms such as worms, insect and molluscus. (Adamek,*et al*. 2004) and hence are particularly suitable for culture in ponds. Indian major carps are the most cultivated fish species in India contributing about 87% of the total freshwater aquaculture (Ayyappan and Jena, 2003). However, besides the supplementary feedings, the basic natural productivity of the ponds is necessary for supporting higher level of fish biomass production.

Growth of fish targeting higher total production in terms of weight is influenced by the quality and quantity of natural food available andany variation in this will affect the role growth of fish. Natural food provides protein, free amino acids oligopeptides, fat and fatty acid and vitamins which are essential for the fish growth.Various “live foods” have been tested in fish nutrition studies and all concluded real benefits for growing performance and meat quality.

Though Indian major carps dominant the reservoir fishery of north India, their population as seen from the total catch is getting drastically reduced in comparison to their production potential (Rajkumar, 2005). This he chiefly attributes to the improper management practices and inadequate seed supply of I.M.C.Keeping in view the importance of biotic factors in primary production and second and tertiary productivity of natural aquatic ecosystems the present research work was carried out with the following objectives:

1. To assess the zooplanktonicbiomass in micro- watersheds,
2. To correlate planktonic biomass with fish growth.

2. REVIEW OF LITERATURES

A detailed consideration of biology of lakes reasonably begins with phytoplankton, its productivity and periodicity (Hutchinson, 1967). Thus, the qualitative as well as the quantitative knowledge of these organisms, growing in an ecosystem is of fundamental importance.

Taylor, *et al*. (1988) have studiedabiotic factors (i.e. physical and chemical parameters) influencing macro invertebrates in aquatic systems. They suggestedthat the biotic factors are more difficult to measure, as they are mainly the interactions between organisms. These interactions include predation, competition (interspecific or interaspecific), and parasitism. Numerous potential effects of vertebrate predators on aquatic macro invertebrates have been described, such as salamander predation on macro invertebrates.

Plankton, primary productivity and some physico-chemical factors of lake were investigated by Barbieri, *et al.* (1989). Such studies were also conducted by Estok and Millkins (1989) and Lampos, *et al*. (1990). Effects of concentration of orthophosphate on growth of phytoplankton was reported by Adachi and Tadasi (1990). Pollinger and Berman (1991) have noticed that primary productivity in tropical lakes is higher than that of temperate lakes. Gupta, *etal.* (1991) studied the primary productivity of a shallow pond of southern Rajasthan and reported higher biological production

Along with the effects of zooplankton on growth, abiotic factors are probably important. Complex interactions between abiotic and biotic factors could influence larval fish growth variability (Miller, *et al.*1990). The influence of zooplankton as food on larval fish has received much attention because they form the principal primary food source during the early life of fishes. The role of abiotic and biotic factors in determining larval fish growth rates: A comparison across species and reservoirs was investigated byRandall and David(2000). The abiotic variables loaded highest in Principal Components Analysis (PCA)and explained the most variation across reservoirs. The relationships between larval fish growth, using otolith daily rings, were then examined with the principal components and by multiple regression. Larval fish growth rates were highly variable across reservoirs. Mean growth was lowest, but the range of growth rates were highest for crappie and bluegill; growth rates of larval gizzard shad were higher but less variable across reservoirs The

relationships between larval fish growth rates and biotic variables, such as zooplankton and larval fish densities, were more species specific. They were also able to generate an understanding of the complex interactions between abiotic and biotic variables that influence larval fish growth rates.

Sultan, *et al*. (2003) investigated a small reservoir Pahunj, located at Jhansi in Uttar Pradesh for its physico-chemical features and productivity status. They concluded that higher primary productivity indicated congenial environment for biological production. Temperature, solar radiation and available nutrients may be important limiting factors for primary production and its seasonal variation in any aquatic ecosystem. They are a major mode of energy source between phytoplankton and other aquatic animals. They occupy an intermediate position in the aquatic food web. Zooplankton diversity is one of the most important ecological parameters in water quality assessment (Altaff, 2004).

Gupta and Gupta (2006) studied the quality of water in terms of physico-chemical and biological characteristics in fish ponds. The most favorable conditions for the existence of fish and other higher trophic level biota in a water body are biotic and abiotic features of the water. They have also suggested that the maintenance of good water quality is essential for both survival and optimum growth of culture organisms.

Ayoade, *et al*. (2006) have studied the dynamics of limnological features of two man-made lakes in relation to fish production. The mean surface water temperature, transparency, dissolved oxygen content and pH were 29.9 ± 2.34° C, 1.5 ± 0.19 m, 7.1 ± 0.96 mg/L and 7.4 ± 0.43, respectively, in Oyan lake and for Asejire lake (south-western Nigeria) the values were 28.5 ± 1.91°C, 1.3 ± 0.35 m, 6.9 ± 1.33 mg/L and 7.4 ± 0.54, respectively. The Oyan and Asejire lakes exhibited features that are typical of tropical environment. The high dissolved oxygen value indicates that the water bodies can successfully supports aquatic life including fish.

Balai (2007) studied the fish and planktonic biodiversity of Jaisamand reservoir of Udaipur (Rajasthan). Bhatnagar, *et al*. (2007) investigated the plankton and icthyo-fauna in Jhamri dam, Udaipur, Rajasthan. Jagetiya, *etal*. (2007)Conducted an experiment on phytoplankton diversity in Raithalias dam, near Chandra bhaga river in Bhilwara, Rajasthan. Zooplankton communities estimated were also correlated with certain physico-chemical parameters. These studies indicate that the distribution and

density of zooplankton species were influenced by prevailing physical and chemical factors of the aquatic environment

Chouhan and Sharma (2007) reported physico-chemical and biological status of a perennial lake Buddha pushkar of Ajmer, Rajasthan. In this investigation pollution status was studied with special emphasis on physico-chemical and biological parameters. The lake had high content of NPK along with the micro nutrients like Fe, Mn, Cu and Zc.

Paulose and Maheshwari (2007) conducted a comparative study of Jalmahal and Ramgarh lake of Jaipur with special reference to plankton diversity. They suggested that high nitrate content of these waters can be correlated with high density of phytoplankton and high rate of organic decomposition.

Sarang and Sharma (2007) havestudied the seasonal variations in benthic fauna and selected limno-chemical parameters of Kishore Sagar Lake, Kota. They reported that the lake is affected by pollution (domestic and industrial effluents) as indicated by its low dissolved oxygen content. The biodiversity of macro benthic invertebrates was appreciably high with the record of 34 species. Most dominant benthic species encountered were *Bellamya bengalensis,*chironomus *larvae,Melanoides tuberculata, Lymnaea acuminata* (Gracilior) and *Indoplonorbis exustus.* Richness of organic matter in this water body might have favored the species composition and abundance of benthic fauna.

A number of studies have been carried out on the of ecology of freshwater bodies in various parts of India (Smitha, *et al*. 2007). Zooplankton diversity is one of the most important ecological parameters in water quality assessment. Environmental factors and innate characteristics of water have great importance upon the growth and abundance of zooplankton (Thirumala, *et al*. 2007).

Koliand Ranga(2008) estimated primary productivity and abiotic water quality parameters in Ana Sagar Lake, Ajmer. They observed the GPP value to range between 1.93 and 6.24 gC/m^2 /day, NPP to range between 0.72 and 4.99 gC/m^2 /day and Community respiration to range from 0.26 to 3.6 gC/m^2 /day. Water temperatures have varied from 16.4 to 31.2°C. pH and transparency ranged between 6.7 to 10.2 and 34 cm and 65 cm respectively. Variation in dissolved oxygen (DO) was from 6.7 to 10.7 mg/l. Biological oxygen demand (BOD) and alkalinity varied from 9.2 to 25.2

mg/l and 176 to 264 mg/l. Concentration of nutrients viz. chloride (18.5 to 32.4 mg/l), nitrate (12.9 to 26.4 mg/l) and phosphate (1.2 to 3.2 mg/l) also varied independently. They conclude that primary productivity and physico-chemical values of the lake were high, and caused mainly by the sewage discharge, industrial effluents and the agricultural runoff. High values of productivity and nutrients also speak of its eutrophic condition.

Korai, *et al*.(2008) studied the decline in productivity, changes in growth of aquatic biota, decline of the physico-chemical properties of Keenjhar lake were within the tolerance limits and no adverse effect of water quality on biota were seen. Primary productivity, altered faunal community structure, changes in aquatic ecosystem process such as nutrient cycling and losses of valuable species. A total of 142 species of phytoplankton, 37 species of zooplankton, 39 species of aquatic plants, 51 species of fishes, and 8 species of prawns were recorded.

Lashari, *et al*. (2009) Studied physico-chemical parameters such as, temperature, pH, alkalinity, chlorides, conductivity, total dissolve solids, turbidity, dissolve oxygen, calcium and magnesium and concluded that the variation in parameters were due to rain and flow of River Indus.

Laskar and Gupta (2009) while investigating a seasonal study on phytoplankton diversity and dynamics of Chalta floodplain lake, Barak Valley, Assam used diatoms extensively in environmental assessment and monitoring because they have ranges and tolerances for environmental variables like pH, nutrient concentrations, suspended sediment, flow regime, elevation and different types of human disturbances.

Sharma, *et al*. (2011) studied limnological characteristic, planktonic diversity in lake Pichhola. The specific status of limnological characteristic and diversity of plankton in lake Pichhola have been studied through seasonal surveys in two annual cycles. On the basis of water quality parameters in general, lake Pichhola was found to be eutrophic. A high rate of primary production (302.085mgc/m^2/hr), diversity of phytoplankton (58 forms), zooplankton (104 forms) and fish (15 species) were also observed during the study period. Therefore, lake Pichholaappcoss to be in species diversity.

Mishra,*et al.* (2012) investigated the aquatic macrophytes, planktonic biodiversity and fisheries potential of lake Goverdhan Sagar, Udaipur. He also suggested fisheries management in Goverdhan Sagar in the light of abundance of aquatic macrophytes. The authors found a dominance of Chlorophyceae followed by Bacillariophyceae amongst the phytoplankton. With a GPP of 0.42g Cm^3 h^{-1} in the lake a fourfold increase in fish production was estimated with an existing fish production of 6500 kg/yr.

Rathore (2012) found a dominance of major carps during her study on limnology and its relationship with fisheries potential and biodiversity in lake Udaisagar (Southern Rajasthan). She claimed that domestic and industrial sewage has increased the eutrophication in the lake through increasing in nitrates and orthophosphates.

Devi and Antal (2013) observed the Phytoplanktonic diversity in relation to water quality in a tropical pond, Datte da Talab in J&K. The physico-chemical parameters here showed well-marked seasonal variations. A total of twenty one genera belonging to three different groups of phytoplankton (Bacillariophyceae, Chlorophyceae and Cyanophyceae) were recorded during the study. Qualitatively and quantitatively, Bacillariophyceae dominated followed by Chlorophyceae and Cyanophyceae.

Tiwari (2013) studied physicochemical factors and zooplankton of Ramgarh Lake, Gorakhpur with an aim of acquiring the necessary knowledge for the management of lakes in semi-arid areas of Gorakhpur region. Out of the physico-chemical parameters studied, only temperature, pH and sulphate concentration showed significant seasonal variation ($P<0.001$). However, all the physico-chemical parameters exhibited highly significant spatial variations ($p<0.001$). Pearson's product moment correlation coefficient between conductivity and other physical properties of the lake indicated a highly positive significant correlation. The zooplankton of Ramgarh Lake was found to be of four groups, Cladocera (41%), Copepods (24%), Rotifers (27%) and Protozoa (18%). There were a total 16 species with Moina and Keratella dominating. The zooplankton showed significant seasonal and spatial variation ($P<0.001$).

Umadevi (2013) studied the abundance, composition and distribution of zooplankton in relation to water quality parameters viz., temperature, pH, dissolved oxygen, alkalinity, total dissolved solids, total hardness and biochemical oxygen demand (BOD). Total 36 species of zooplankters were identified. The effect of several

physico-chemical parameters on the abundance and distribution of zooplankton was discussed and reported that zooplankton better thrives in alkaline water.

Similar studies were done by Balai, *et al*. (2014)in the lake Jaisamand (Udaipur, Raj.) They observed 51 species of zooplankton - 17 species of Rotifer, 18 species of Cledocera, 5 species of Osrocoda and 4 species of Copepods. Amongst zooplankton, Rotifers were dominant and the highest count (group) was recorded in the summer or pre-monsoon period while low incidence was observed in winter season. Zooplankton community is also correlated with certain physico-chemical parameters. This study indicated that the distribution and density of zooplankton species were influenced by prevailing physical and chemical factors of the aquatic environment.

Gadekar (2014) determined the zooplankton diversity in relation to tropic status in tropical pond situated in the centre of the Gondia city. A total 20 zooplanktonic groups were encountered during this study. Out of 20 species of zooplankton, 3 species belonged to Protozoa, 10 to Rotifer, 3 to Cledocera, 3 to Copepods and only 1 species to Osracoda. During this investigation, the class Rotifera dominated in the zooplanktonic groups in all the seasons. The maximum density was observed in winter season (18 species) and summer season (16 species), while low density was observed in monsoon season (14 species). However the diversity of zooplankton varied from season to season with a maximum in winter and minimum monsoon.

Some physico-chemical parameters were assessed in selected freshwater lakes of Andhra Pradesh (India) to investigate their seasonal variations by Reddy, *et al.* (2014). They concluded that the water quality parameters influenced the biomass production of aquatic organisms especially fishes and prawns.

Phyto- plankton diversity in relation to primary productivity of lake Udai Sagar, (Udaipur) was investigated by Kumar (2015). The outcome of this study was thata total 36 species of phytoplankton were noticed with the individual groups contributing13 to Cyanophyceae (blue green algae), 11 to Chlorophyceae (green algae) 9 to Bacillariophyceae (diatoms) and 3 belonged to Desmidiaceae.

Manickam, *et al.* (2015) investigated the biodiversity of freshwater zooplankton and physico-chemical parameters of Barur Lake. The outcomes was that out of total 47 species of zooplankton, 18 species was of rotifer, 11 of cledocera, 11 of copepods and 7 of Osracoda were observed. The population wise rotifer dominated followed by

copepods, cledocera and Ostracoda. As the productivity of zooplankton was good, the lake could be continuously utilized for aquaculture.

A study is also available on the qualitative plankton diversity of Varala Lake, Bhiwandi, (Shaikh, 2015). She reported that a total of four classes of phytoplankton and four of zooplankton were present in Varala lake. This lake contained 17 phytoplankton and 16 zooplankton species. Species diversity and their seasonal changes in fresh water lake ecosystem located in semi-arid region of Karnataka was investigated by Khan, *et al*.(2016) This study identified a total of 22 species belonging to four groups, namely, Rotifer, Cledocera, Copepods and Osracoda. The results reveal variations in the presence and absence of species in different seasons. Among 22 species, 17 species were recorded in summer season, 12 species in rainy season and 14 species in winter season. The occurrence of zooplankton was found high in summer, low in rainy season and moderate in winter season.

3. MATERIAL AND METHODS

The present study was carried out for a short period of six month from January 2016 to June 2016. The aim of this study was to assess the dynamics of selected biotic factors inspecified micro-watersheds of southern Rajasthan. The relationship of the studied biotic factors with fish growth and primary productivity was also investigated. For the purpose, laboratory studies were conducted in *Aquaculture Research and Seed Unit, of theDirectorate of Research and College of Fisheries, MPUAT, Udaipur.*

A. Climate of Study Area

The study area "Southern Rajasthan" experiences a subtropical climate with average rainfall ranging from 67 to 105 cm. and relative humidity of 75-95 % during monsoon period. The summers are hot and winters are cool having an average range of maximum temperature between 38-41ºC and minimum between 1-5ºC.

B. Study Area

The proposed study was conducted in selected micro watersheds of Southern Rajasthan mainly comprising four districts: Udaipur, Dungarpur, Banswara and Pratapgarh.Geographical location and area of the selected micro-watersheds is presented in Table 3.1.

C. Collection of Water Sample

To monitor the status of water quality (physico-chemical and biological) in selected micro-water sheds (Table 3.1). The surface water samples were collected during January 2016 to June 2016 at on interval of 45 days. The surface water samples were collected using wide mouth sterile transparent plastic bucket. The water samples were secured in one litre air tight plastic bottles. A total of 11 physico-chemical parameter viz., Temperature, pH, dissolved oxygen, free carbon-dioxide, total dissolved solid, conductivity, hardness, total alkalinity, salinity, nitrate-nitrogen and orthophosphate and 3 biological factors viz., primary productivity, plankton production and fish growth were studied. The detailed techniques for the analysis of selected water quality parameters are described below.

D. Analytical Techniques for Water Samples

The water quality parameter viz., water temperature, pH, dissolved oxygen and free carbon-dioxide were determined in the field itself by usingwater analysis kit; while for the analysis of hardness, alkalinity (carbonate and bicarbonate), nitrate nitrogen and orthophosphate, the samples were brought to the laboratory in plastics sampling bottles of one liter capacity and analyzed as soon as possible.

1.Water Temperature

The surface water temperature of micro-watersheds was noted on the spot using a portable centigrade thermometer with the sensitivity of 0.1□C.

2. pH

It is the negative logarithm of the concentration of hydrogen ions. pH was recorded using pH meter (HACH). The instrument was calibrated for each measurement with standard buffer solution having pH 7.

3. Electrical conductivity

Electrical conductivity was recorded using electronic meter (HACH) and concentration was reported as mS/cm.

4. Dissolved Oxygen

The concentration of dissolved oxygen in micro-watershed waters was estimated with a standard DO meter (HACH HQ-30).

5. Free Carbon-dioxide

The rate of CO_2 in water is that, when CO_2 enters pure water, a small proportion of it is hydrated to form carbonic acid. Some of the carbonic acid dissociates into bicarbonates and hydrogen ions, bringing about a lowering of the pH. Free CO_2 of experimental water was deminedby following procedure:

- 50 ml of sample water was taken in a conical flask. Two drops of phenolphthalein indicator were added in the flask.
- If the solution was colourless, then it was titrated with 0.05N NaOH solution to slight pink colour end point. The calculation was done as follows:

$$\text{Free } CO_2 \text{ (mgl}^{-1}\text{)} = \frac{\text{ml of titrant} \times 1000}{\text{Volume of sample taken}}$$

6. Total Alkalinity

Alkalinity measures the buffering capacity of water. It was estimated by titrating the sample with a strong acid (HCL) using phenolphthalein and methyl orange indicators.

Procedure

- 50 ml of sample water was taken in a conical flask and two drops of phenolphthalein indicator were added to it.
- The pink colour developed was titrated against 0.2N H_2SO_4 until the colourless end point. The amount of titrant used was noted.
- Now, two drops of methyl orange indicator in the sample were added and further titrated till the colour changed from yellow to orange. The amount of titrant used was again noted.
- The total alkalinity was calculated with following formula:

$$\textbf{Total Alkalinity as } CaCo_3 \textbf{ mgl}^{-1} = \frac{\textbf{No. of ml of titrant used x 1000}}{\textbf{Volume of sample}}$$

7. Total Hardness

Eriochrome black-T forms wine red complex compound with metal ions (Ca^{++} and Mg^{++}). Therefore by addition of EDTA the complex is broken down and a new complex of blue colour is formed. Total hardness of experimental water was determined by following procedure:

- 50 ml of water sample was taken in a conical flask and 1 ml of ammonia buffer was added which followed by 5 drops of Eriochrome black-T indicator.
- The colour of sample turned wine red. This was titrated against EDTA (0.01 N) solution until a blue colour appeared noted end point.

The total hardness in water sample was calculated as follows formula.

$$\textbf{Total hardness (mg/l)} = \frac{\textbf{ml of EDTA used}}{\textbf{Volume of sample}} \textbf{ x 1000}$$

8. Total dissolved solids

TDS was estimated with the help of TDS meter (HACH SI2) and the concentration was expressed as mg/L.

9. Salinity

Salinity was also estimated using HACH SI2 meter and the concentration was expressed as ppt.

10. Nitrate-nitrogen

Nitrate concentration was determined by phenol-di-sulphonic acid method. Following steps were followed:

- A known volume (25ml) of the sample was pipetted into a porcelain dish and evaporated to dryness on a hot water bath.
- 2 ml of phenol di-sulphonic acid was added to dissolve the residue by constant stirring with a glass rod. Concentrated solution of sodium hydroxide or concentrated ammonium hydroxide and distilled water was added with stirring to make it alkaline.
- This was filtered into a Nessler's tube and made up to 50ml with distilled water.
- The absorbance was read at 410nm using a spectrophotometer after the development of colour.
- The standard graph was plotted by taking concentration along X-axisand the spectrophotometric readings (absorbance) along Y-axis. The value of nitrate was found by comparing absorbance of sample with the standard

11. Orthophosphate

The orthophosphates reacts with acidified ammonium molybdates solution and form molybdo-phosphoric acid, which is then, reduces to a blue complex in the presence of stannous chloride. This is read on spectrophotometer at 690nm. The estimation was made using following procedure:

- 25ml of the water sample was taken in a conical flask.
- 4 ml of ammonium molybdate solution was added to it followed by 4-5 drops of stannous chloride and shaking the content. Blue colour appeared.
- Within 12 minutes the absorbance was recorded on spectrophotometer at 690nm. Deduced the value of $O\text{-}PO_4$ mg/l with the help of standard curve.

Biological Parameters

Primary Productivity

Primary productivity was measured on site at all the water bodies following light and dark bottles method. For this purpose, glass stoppered black and colorless BOD bottles of 250 ml were used. The bottles were suspended about 1 m below the waterline. The incubation period was kept three hours. Oxygen (O_2) estimations in the BOD bottles were made using HACH (HQ-30) DO meter. The calculation was done as under

Gross Oxygen Production (GOP) mg l^{-1} = LB-DB

Net Oxygen Production (NOP) mg l^{-1} = LB-IB

Community Respiration (CR) mg l^{-1} = IB-DB

The values of gross and net primary productivity were calculated as follows

Gross Primary Productivity (g C m-3 h^{-1}) = GOP x 0.375/1.2 x h

Net Primary Productivity (g C m-3 h^{-1}) = NOP x 0.375/1.2 x h

Gross primary productivity (GPP), net primary productivity (NPP) and rate of community respiration (RQ) were calculated as follows:

A. GPP gC $m^{-3}h^{-1} = \frac{GOP}{PQ \times h} \times 0.375$

B. NPP gC $m^{-3}h^{-1} = \frac{NOP}{PQ \times h} \times 0.375$

C. RQ gC $m^{-3}h^{-1} = \frac{R}{PQ \times h} \times 0.375$

Where, LB = Dissolved oxygen in light bottle

DB = Dissolved oxygen in dark bottle

IB = Dissolved oxygen in initial bottle

H = Duration of incubation or exposure

PQ – Photosynthetic Quotient (Normally PQ value of 1.2 is considered for field experiments)

0.375 = A factor value (1 g of oxygen is equal to 0.375 g carbon)

Phytoplankton and Zooplankton

Sample for phyto and zooplankton were also collected along with water sample. The samples were collected by filtering 50 l of water through plankton net of bolting silk No. 30 micron mesh size and concentrated up to 50 ml. The concentrated sample was preserved immediately with the help of 4% neutral formalin solution and added two drops of glycerin. The samples were observed under the inverted microscope and qualitative and quantitative analysis was done as per the standard keys procedures (Adoni, 1985). The zooplankton species have been identified with the help of a standard keys of Needham and Needham, (1962). The quantitative estimation of zooplankton was done by using Sedge wick - Rafter Cell and expressed as numbers per liter. For phytoplankton hemocytometer was used for the purpose. The standard procedure for the enumeration of phytoplankton count was followed (Adoni, 1985).

Fish Growth Studies

The water bodies are being maintained by local tribal for fish culture withRajasthan tribal area development corporation federation (RTADCF), Udaipur, providing inputs and technical assistance. The selected water bodies were stocked with IMC fingerling @ 2500 nos/ha in the ratio of 3:4:3 of Catla, Rohu and Mrigala. The initial respective size of catla, rohu and mrigal fingerling was 7.2 $\pm$0.05 cm/ $\pm$0.01g, 8.0$\pm$0.03 cm/$\pm$0.03g and 6.9$\pm$0.09 cm/$\pm$0.02g. The seed was stocked during 4th October to 19th October 2015. Though the final harvesting has yet not started but the random sample with cast and drag nets were collected to monitor the growth performance of stocked seed. On the basis of the initial size of the stocked seed the size of sampling data (length and weight) was estimated using the following formula:

1. Weight gain

   WG (gm) = Final weight – Initial weight

2. Length gain

   LG (cm) = Final length – Initial length

3. Specific Growth Rate (SGR)

   Specific Growth Rate (%/day) = [Ln^1 (Final Weight) – Ln^2(Initial Weight)] / Culture Period (Day) x 100

Statistical Analysis: The data collected during present study were analyzed statistically for the analysis of correlation coefficient among different parameters. Further, the standard error was also calculated for fish growth parameters. For the purpose statistical methods of Stm and tam (1985) were followed.

Table 3.1: List of selected water bodies and their geographical location

S.N.	Dist.	Name of Water Body	Area(ha)	Lon.	Att.	MSL
1	Udaipur	Manas/Sibiya	20	24˚19.727'	73˚31.902'	635
2		Biyata	16	24˚30.036'	73˚12.780'	455
3		Baksho Ka Naka	20	24˚16.234'	73˚16.713'	328
4		Rajol	15	24˚01.063'	73˚46.508'	300
5	Dungarpur	Advert Samand	8	23˚47.179'	73˚40.350'	312
6		Loar Godhi	10	23˚56.487'	73˚39.334'	289
7		Kanhar Vala	10	23˚42.629'	73˚47.079'	272
8		Pani Dara	10	23˚48.038'	73˚50.856'	272
9		Banjariya	12	23˚52.436'	73˚57.048	254
10		Bassi	10	23˚54.176'	73˚43.236'	284
11		Makodi	6	23˚44.919'	73˚55.557'	188
12		Kalu Dara	8	23˚44.215'	73˚36.761'	354
13		Jhalawadi Talai	4	23˚33.251'	73˚31.355'	244
14		Khanmal	10	23˚54.350'	73˚30.812'	345
15	Banswara	Nala Pada	10	23˚29.595'	73˚09.529'	189
16		Jithula	10	23˚36.228'	74˚13.317'	170
17		Kohala	10	23˚37.010'	74˚18.892'	183
18		Bhamri Tandi	26	23˚18.503'	74˚19.600'	228
19		Gopalpura	4	23˚13.355'	74˚31.508'	402
20	Pratapgarh	Vakhtod	24	23˚45.018'	74˚37.055'	313

4. RESULTS

Theresults pertaining to physico-chemical water quality parameters, primary productivity, plankton counts and fish growth are presented in Table 4.1 to 4.5 and Figures 4.1 to 4.21. In the micro-watersheds of the present study, the quality of water, productivity levels and fish growth were markedly different. The result of the study are described below:

1.Physico-chemical parameters

Temperature: The water temperature varied between minimum of 24□C in Manas and maximum of 35.1□C in Kohala (Table 4.1), the averages also being lowest (26.2□C) in Manas and highest (32.7□C) in Kohala (Table4.1).The statistical resultshows that the temperature had negative relationship with zooplankton only and positive relationship with all other parameters (Table 4.4).

pH: In general, the water of all the micro watersheds remained alkaline throughout the study. The pH value of water varied between a minimum of 6.9 in Manas and a maximum of 10.9 in Banjariya (Table 4.1). The Figure 4.2 shows the average values of water pH in different micro-water sheds. The average being lowest (7.3) in Rajol and highest (10.05) in Banjariya (Table 4.1). The statistical relationship of pH with selected water quality parameters has been shown in the Table 4.4. It indicates a positive relationship with temperature, DO, TDS, electrical conductivity, hardness, alkalinity, salinity, Nitrate-nitrogen, GPP, NPP, phytoplankton, zooplankton and a negative relationship with free Co_2, orthophosphate and RQ.

Dissolved oxygen: Dissolved oxygen (DO) is an important environmental parameter for the survival of aquatic life. DO affects the growth, survival, distribution, behavior and physiology of fishes and other aquatic organisms. The dissolved oxygen concentrations in all the micro-water sheds remained above the critical level of 4 mg/l. The maximum of 12.62mg/l dissolved oxygen was observed in Kanhar vala, while the minimum of 5.02mg/l was noticed in Vakhtod (Table 4.1). The average DO was found to be lowest (6.71mg/l) in Manas and highest (10.21mg/l) in Banjariya (Figure 4.3). The statistical relationship of DO with selected water quality parameters has been shown in Table 4.4. A positive relationship with temperature, conductivity, pH, alkalinity, salinity, TDS, NO_3-N Nitrate-nitrogen, GPP, NNP, phytoplankton and

a negative relationship with free Co_2, hardness, HPO_4^{-3}, RQ, and zooplankton was calculated.

Free Carbon-Dioxide: The free carbon-dioxide fluctuated from 0.0mg/l to 0.9mg/l. Figure 4.4 shows the average values of free CO_2 in different micro-watersheds. The average free CO_2 was recorded maximum in Nala pada(0.45mg/l). The statistical results shows that the free Co_2 had positive relationship with temperature, HPO_4^{-3}, GPP, RQ, phytoplankton and negative relationship with pH, DO, TDS, conductivity, alkalinity, salinity, hardness, NPP, NO_3-N and zooplankton (Table 4.4).

Total Dissolved Solid: Figure 4.5 shows the average values of total dissolved solids (TDS) in different micro-watersheds. In general, the total dissolved solid values fluctuated between of 69.5mg/l and 489mg/l. The minimum was in Jhalawadi talai while the maximum was recorded from Khanmal pond. The average lowest TDS (76.55mg/l) was found in Kaludara but highest (473mg/l) was in Khanmal. The statistical results shows that TDS had positive relationship with temperature, pH, DO, conductivity, hardness, alkalinity, salinity, NO_3-N, NPP and negative relationship with free CO_2, HPO_4^{-3} GPP, RQ, phytoplankton and zooplankton (Table 4.4).

Electrical Conductivity: Conductivity is an index of the total ionic content of water, and therefore indirectly indicates nutrient richness or otherwise of the water. The electrical conductivity of micro- watersheds recorded in the present study, ranged between 125.8 and 997mS/cm with a minimum in Kanhar vala and a maximum in Khanmal (Table 4.1). The average electrical conductivity was found to be lowest (160.4mS/cm) in Kaludara and highest (965mS/cm) in Khanmal (Figure 4.6). The statistical relationship of electric conductivity with selected water quality parameters has been shown in the Table 4.4, it indicate a positive relationship with temperature, DO, TDS, hardness, alkalinity, salinity, NO_3-N, NPP and a negative relationship with free CO_2, HPO_4^{-3}, GPP, RQ, phytoplankton and zooplankton.

Total Hardness: - In general, the total hardness values fluctuated between 42 and 200 mg/l with lowest in Kaludara and highest in Khanmal. Similarly, the average total alkalinity was also found to be lowest and highest in Kaludara and highest in Khanmal (Figure 4.7). The statistical relationship of hardness with selected water quality parameters has been shown in the Table 4.4, it indicated a positive relationship with temperature, TDS, electrical conductivity, alkalinity, salinity, nitrate-

nitrogen,and a negative relationship with DO, free CO_2, HPO_4^{-3}, GPP, NPP, RQ, phytoplankton, and zooplankton.

Total Alkalinity: The total alkalinity values in micro-watershedsranged between 42 to 152 mg/l, with lowest in Kaludara and highest in Loar godhi (Table 4.1). The lowest average value of total alkalinity (34mg/l) was found in Kaludara but highest (141mg/l) was in Kohala (Figure 4.8). The statistical results show that alkalinity had positive relationship with temperature, pH, DO, TDS, conductivity, hardness, salinity, NO_3-N, GPP, NPP, zooplankton and negative relationship with free CO_2, HPO_4^{-3}RQ, and phytoplankton (Table 4.4).

Salinity: Salinity is the measure of the ionic composition of water. In general, salinity values in micro-watersheds ranged between 0ppt and 0.5ppt with lowest both in Kaludara &Jhalawadi talai and highest in Khanmal (Table 4.1). Similarly, the average salinity was also found to be lowest in Kaludara but highest in both Kanhar vala &Jhalawadi talai (Figure 4.9). The statistical relationship of salinity with selected water quality parameters has been shown in the Table 4.4. A positive relationship with temperature, conductivity, pH, DO, TDS, hardness, alkalinity, NO_3-N,NNP and a negative relationship with free CO_2, HPO_4^{-3}, GPP, RQ, phytoplankton and zooplankton was calculated.

Nitrate nitrogen (NO_3-N): The range and average values of nitrate-nitrogen in micro-water sheds have been depicted in Table 4.1, while mean values are shown in Figure 4.10. The respective highest (0.988 mg/l) and lowest (0.05mg/l) values of nitrate-nitrogen were observed in Loar godhi and Kaludara. The highest and lowest mean values were also found in Loar godhi and Kaludara respectively (Figure 4.10). The statistical results shows that nitrate-nitrogen had positive relationship with temperature, pH, DO, TDS, conductivity, hardness, salinity, HPO_4^{-3}, GPP, NPP, phytoplankton and negative relationship with free CO_2, RQ, and zooplankton (Table 4.4).

Orthophosphate (HPO_4^{-3}): The orthophosphate concentration in micro-water shed varied between 0.00 to 0.33mg/l (Table 4.1) with lowest in three water bodies (i.e. Advert samand, Panidara, and khanmal) and highest in Makodi. The average being lowest 0.0 mg/l in Jithula but the highest was seen in Biyata (Figure 4.11). The statistical results shows that the orthophosphate had positive relationship

withtemperature, free CO_2, NO_3-N, NPP, phytoplankton zooplankton and negative relationship with pH, DO,TDS, conductivity, hardness, alkalinity, salinity, GPP, and RQ (Table 4.4).

Primary Productivity

The ranges and mean values of primary productivity (GPP, NPP and RQ) in selected micro-water sheds are depicted in Table 4.2. Whereas, the mean values of GPP, NPP & RQ are also presented in Fig 4.12 to 4.14.

The highest ($0.538gC/m^3/h^{-1}$) and lowest ($0.087gC/m^3/h^{-1}$) values of GPP were observed in Bassi and Biyata respectively. The mean value of GPP varied between 0.119 and 0.350 $gC/m^3/h$ with minimum in Baksho ka naka and maximum of in Bassi (Figure 4.12). The statistical relationship of GPP was found to be positive with temperature, pH, DO, free CO_2, total alkalinity, Nitrate-nitrogen, NPP, RQ, zooplankton and negative relationshipTDS, conductivity, hardness, salinity, HPO_4^{-3}, and phytoplankton (Table 4.4).

The maximum ($0.488gC/m^3/h^{-1}$) value of NPP was observed in Bassi, while the minimum of $0.009gC/m^3/h^{-1}$ was noticed in Rajol (Table 4.2). The average NPP value was highest ($0.306gC/m^3/h^{-1}$) in Bassi and lowest ($0.028gC/m^3/h^{-1}$) in Jhalawadi talai (Figure 4.13). The statistical results indicated that NPP had positive relationship with temperature, pH, DO, TDS, EC, alkalinity, salinity, NO_3-N, HPO_4^{-3}, GPP, and negative relationship with free CO_2, salinity, total hardness, RQ, phytoplankton and zooplankton (Table 4.4).

The highest ($0.366gC/m^3/h^{-1}$) and lowest ($0.021gC/m^3/h^{-1}$) values of RQ were observed in Bhamri tandi and Advert samand respectively. The highest and lowest mean values of 0.286 and $0.017gC/m^3/h^{-1}$ were found in Biyata and Nala pada respectively (Figure 4.14). The statistical relationship of RQ with selected water quality parameters has been shown in the (Table 4.4), it indicated a positive relationship with temperature, free CO_2, GPP, phytoplankton, zooplankton and negative relationship with pH, TDS, hardness, salinity, DO, conductivity, alkalinity, NO_3-N, HPO_4-^{3}, and NPP.

Plankton production

The mean values of total plankton (phytoplankton and zooplankton) densities in selected micro-watersheds on presented in Table 4.3. While, mean value of plankton in these water bodies are also given in Figures4.15 to 4.19.The values of percent composition of zooplanktonic groups are presented in Fig. 4.21.

In general, the phytoplankton densities rangedbetween 80Nos/l and 470Nos/l with lowest in both Bassi and Kaludara and highest in Makodi. The highest mean (310Nos/l) and lowest (125Nos/l) were noticed in Kanhar vala and Kaludara respectively. The statistical results show that the phytoplankton had positive relationship with temperature, pH, DO, free CO_2, NO_3-N, orthophosphate, RQ, zooplankton and negative relationship with TDS, conductivity, hardness, alkalinity, salinity, GPP, and NPP (Table 4.4).

The counts of total zooplankton in different water bodies were very less. As such the zooplankton count varied between 3 to 12Nos/l. The minimum (3nos/l) was in both Rajol and Kohala. Whereas the maximum (12nos/l) wasboth in Kanhar vala and PaniDara. Further the mean values of different zooplanktonic group viz., Rotifera, Cladocera, Copepoda and nauplii are presented in Table 4.3.On comparing different zooplankton groups it was observed that Copepoda dominated the zooplanktonic count followed by rotifer, cladocera and nauplii (Fig 4.20). The statistical relationship of zooplankton with selected water quality parameters has been shown in the Table 4.4, it indicated a positive relationship with pH, alkalinity, HPO_4^{-3}, GPP, RQ, phytoplankton, and negative relationship with temperature, DO, free CO_2, TDS, conductivity, hardness, salinity, NO_3-N, and NPP.

Fish Growth

The results of fish growth parameters (Net weight gain, net length gain and specific growth rate) from selected micro-watersheds are presented in Table 4.5. The net weight gain of Catla, Rohu and Mrigala varied between 762.38 to 1103.33gm, 628.31 to 932.16gm and 395.15 to 838.29gm respectively with minimum in both Biyata and Banjariya and maximum of in Jhalawadi talai. The highest of 30.03(Catla), 29.50(Rohu) and 28.23cm (Mrigal) and lowest of 18.59(Catla), 17.35(Rohu) and 9.77cm (Mrigal) length gain for Catla, Rohu and Mrigal were observed in Jhalawadi

talai and both Biyata and Banjariya respectively. The respective highest (2.009, 1.990 and 1.839 %) and lowest (2.162, 2.153 and 2.149%) specific growth rate of catla, rohu and mrigal was noticed in both Biyata & Banjariya and Jhalawadi talai. During the present study, highest productive watershed was Jhalawadi talai and lowest productive water shed were both Biyata and Banjariya recorded.

5. DISCUSSION

The enormous expanse of micro-water sheds in Rajasthan after immense scope to fish culture through application of varied aquacultural techniques. However, the present average production from Rajasthan micro-water sheds in frustratingly low, at an average of <650kg/ha. To achieve sustainable optimum production from these waters, it is expedient to study the prevailing limnological conditions in these waters with major thrust on the productivity assessment. The limnological parameters, productivity and fish growth parameter recorded in the present study are presented in Table 4.1 to 4.5 and Fig.4.1 to 4.21.

The results of present study are depicted in Tables 4.1 to 4.5, fig. 4.1 to 4.21. Physico-chemical parameters of selected micro-watersheds were to be congenial for fish growth except for a very high pH in a few water bodies (Banjariya, Loar godhi and Panidara). However, according to Welch (1952) no single satisfactory index can determined the micro-watersheds productivity. Any appraisal of micro-sheds productivity must come from an examination and measurement of several dominating limnological influences. The physico-chemical conditions of waters as a substance and its chemical and physiological influence as a medium for life have their own importance for the living complex. Reid (1967) pointed out that the well being of the aquatic life is governed by the interaction of a number of physical and chemical conditions of water medium and the body physiology of living biota.

All metabolic and physiological activities and processes such as feeding, reproduction, movement and distribution of aquatic organisms are greatly influenced by water temperature. During the study period the water temperature ranged between 24□C to 32.7□C in selected micro-water sheds. Similar ranges of water temperature were observed in water bodies of arid and semi-arid regions of Rajasthan (Gupta, 1988; Sarang, 2001; Rajkumar, 2005; and Balai, 2007). However, in a typical setting of arid and semi arid regions, the surface water temperature normally shows a wide annual fluctuation (Rawat and Jakhar, 2002, Balai, 2007). The variation in the temperature noted in the present investigation may be due to the difference in sampling time and seasonally as also recorded by Tiwari, *etal*. (2004). Temperature is also important in controlling both the quality and quantity of planktonic fauna and flora.

pH is an important factor for freshwater bodies for fish growth, health as well as the productivity of water. In the present study, average pH ranged between 7.3 and 10.05 in different micro-water sheds. The pH of selected micro-water sheds was found to be alkaline. The moderate to slightly alkaline pH has been considered as most suitable for fish culture while pH above 9 is unsuitable for higher fish growth (Swingle, 1967; Jhingran, 1977). Such alkaline pH has also been reported earlier by Sarang (2001), Rawat and Jakhar (2002), Rajkumar (2005) and Balai (2007). The latter authors also found alkaline water in the Daya reservoir and Jaisamand lake of Udaipur (Rajasthan).The alkaline pH was found to be associated with more number of species. However, with increasing pH, the number of species decreased (Venkateswarju, 1969). Further, in the present study the higher value (> 9.0) of pH was found to be associated with lower fish growth rate. Similar result have also been reported by Swingle (1967).

Dissolved oxygen is the most critical water quality variable in an aquatic ecosystem. According to Hutchinson (1957), dissolved oxygen is the most significant chemical abiotic component essential for smooth running of metabolic activities for all organisms in the aquatic ecosystem and is one of the best indicators to show the nature of the water body. Wetzel (1975) opined that adequate oxygen content is important for direct metabolic requirement of many organisms. The DO also affects the water solubility and bio-availability of many nutrients and consequently the productivity of aquatic ecosystem. During the present study, dissolved oxygen concentration was found to range from 5.02 to 12.62 mg/l with the average value of 6.71 to 10.21. DO concentrations were always above 5 mg/l, hence based on the study of Banejea (1967), the water bodies of the present study are suitable for fish culture. Similar values of dissolved oxygen were also noted by Sharma *et al.* (2000), Nandan and Magar (2007), Tamot, *et al.* (2007) and Rathore (2012) in different water bodies.

As per Diwadi and Pandy (2002), the main source of free CO_2 is the composition of organic matter and respirations of plants and animals. In the present study, free CO_2 was absent in most of the micro-water sheds However, the CO_2 was noticed in only two micro-water sheds (Jhalawadi talai and Nala pada) but its levels were very low (0.7 to 0.9mg/l). This is an indicator of healthy aquatic environment. Similar resultsof the absence of free CO_2 were also reported by Das (2000), Parihar, *et al.* (2007) and

Paulose and Maheshwari (2007), Ujjania *et al.* (2007), Balai (2007) and Rajkumar (2005) in different water bodies of Southern Rajasthan.

The electrical conductance represent total ionic load in water due to dissolved substance and sometimes considered as an index of productivity. The electrical conductance of selected micro-water sheds was found to range between 125.8 to 997mS/cm during the study period. Exceptionally high values of EC designate pollution status of the reservoirs. Sharma (1980) recorded average conductance of 426.6 from Fateh Sagar Lake. Whereas, for Goverdhan sagar, Udai sagar, Bhawani sagar and Govind sagar the recorded EC value ranged from 212.4 to 338.0mS/cm (Mishra et.al 2012, Kumar 2015).

In the present study, the total dissolved solids, hardness and salinity were found to range from 69.5 to 489mg/l, 42 to 200mg/l and 0 to 0.5ppt receptively in all the micro-water sheds studied. These concentrations were suitable for the growth of aquatic fauna and flora. In selected micro-water sheds the waters are soft to slightly hard. Such hard water has also been reported earlier by Sarang (2001), Rawat and Jakhar (2002) from waters of Southern Rajasthan.

Natural bodies of water in the tropics usually show a wide range of fluctuation in total alkalinity depending upon the location, seasons, plankton population and nature of bottom deposit. A range of 4 to over 1000 ppm alkalinity has been encountered in natural waters (Jhingran, 1992). In the present study, total alkalinity ranged from 32 to 152mg/l (Table 4.1). Ujjania (2003) observed total alkalinity of 65 to 199 mg/l in three water bodies of southern Rajasthan. Rajkumar (2005) and Balai (2007) also reported higher alkalinity in the different water bodies of Udaipur region. The values of total alkalinity above 60mg/l are indicative of nutrient rich condition of water body. According to Swingle (1967), such waters are suitable for fish culture. The total alkalinity of water is an important factor for pond productivity.

In natural aquatic systems, the major source of nitrate-nitrogen is allochthounous i.e. through runoff. Beside this, it is also contributed by the decomposition of nitrogenous matter and its further oxidation (Goldman and Horne, 1983) which forms autochthonous source of nutrients. Nitrate generally occurs in the trace quantities and is essential for aquatic life. In the present study, the values of NO_3-N varied from 0.05 to 0.988mg/l with an average value of 0.089 to 0.558mg/l. These values are fairly

comparable to those reported by Das (2000), Dwivedi, *et al* (2003), and Sultan, *et al* (2003) from different lentic waters. A higher content of nitrates in the water bodies is an indication of eutrophication. The values of NO_3-N recorded in different micro-water sheds was always recorded within the safe limit hence all the waters studied were assigned as pollution free, but in a stage of early eutrophication.

Along with nitrates, Phosphorus is also recognized as a key nutrient in the fertility of a water body. It directly limits the growth and multiplication of flora and indirectly influences fish growth. Wani and Subla, (1990) observed that during plankton multiplication phosphate concentration is automatically decreased. Phytoplankton absorbs phosphorus very rapidly and most of the uptake following fertilization probably occurs within a few hours or even minutes (Coffin, *et al*., 1949). In the case of selected micro-watersheds, the orthophosphate concentrations ranged between 0.001 to 0.33mg/l. Rao (1987) recorded orthophosphate variations between 0.06 to 0.52 m/l in the Rangsagar Udaipur. Chouhan and Sharma reported higher concentration of phosphate between 2.58 to 2.66mg/l at lake Budha Puhakar near Ajmer, Rajasthan. Rajkumar (2005) also found the same result in Daya reservoir. It is generally recognised that both the major nutrients Nitrate and phosphorus are limiting factors in phytoplankton proliferation. However, in tropical waters, the Nitrate is said to form a critical or decisive limiting factor an against in temperate waters where phosphorus plays the some role.

Primary production is the process by which the inorganic materials of the environment are converted in to the organic matter. In natural waters, the primary production almost entirely depends on photosynthesis particularly by phytoplankton and periphyton. It is evident that Gross primary productivity (GPP) in micro-water sheds ranged between 0.087 to 0.538 $gC/m^3/hr$ with an average value of 0.119 to 0.350 $gC/m^3/hr$. Sultan, *et al*. (2003) and Rajkumar (2005) found higher primary productivity in tropical waters. Mishra, *et al*. (2012) have also reported higher average GPP (0.64 g $C/m^3/h$) in Goverdhan sagar. Rajkumar (2005) also reported higher average GPP (0.45 $gC/m^3/hr$) in the Daya reservoir. However, Gupta (1991) found only (0.19 $gC/m^3/hr$) GPP in the Daya reservoir. According to Sharma and Durve, (1985) water bodies of Rajasthan are highly productive as compared to those located in other parts of India.

The primary productivity values from certain other water bodies of Southern Rajasthan are presented here below for comparison:

S.No.	Water body	Gross primary productivity	Reference
1.	Daya reservoir	0.45 $gC/m^3/hr$	Rajkumar (2005)
2.	Badi Tank	0.17 $gC/m^3/hr$	Rajkumar(2005)
3.	Udaisagar	0.60 $gC/m^3/hr$	Kumar(2015)
4.	Jaisamand	0.08-0.46 $gC/m^3/hr$	Sarang (2001)
5.	Goverdhan sagar	0.64 g $C/m^3/h$	Mishra *et al.*(2012)

From the above Table, it is clear that primary productivity values obtained during present investigation are similar and comparable to those reported by earlier workers. This indicates the productive nature of the all micro-water sheds.

The values of net primary productivity (NPP) in the present study ranged between 0.009 to 0.488 $gC/m^3/hr$ with average values of 0.028 to 0.306 $gC/m^3/hr$. Rajkumar (2005) has reported an NPP value of 0.31 $gC/m^3/hr$ in the surface water of Daya reservoir. Mishra, *et al*. (2012) have also recorded 0.64 $gC/m^3/hr$ NPP from Goverdhan sagar, Udaipur.

The average RQ computed in the present study (0.021 to 0.366 $gC/m^3/hr$) is also comparable with that of Daya reservoir Udaipur (0.14 $gC/m^3/hr$) (Rajkumar, 2005).

Plankton in inland waters holds a key position in the metabolism of water bodies, trophic levels, food chains and energy flow. The phytoplanktons constitutes bulk of primary producers and are the base of food chains in any water body. The seasonal variation of phytoplankton productivity is related to variation in temperature and the photic conditions. The average phytoplankton density observed in different micro-watersheds range between 80 to 470Nos/l. Average phytoplankton count reported in Goverdhan Sagar was 36.71 Nos/ml by (Mishra, *et al.* 2012). Phytoplankton counts observed during the present personal study were fairly good for super supports primary productivities. The higher values of GPP coincided with phytoplankton counts.

Zooplanktons occupy a central position in the food webs of aquatic ecosystem. They form an integral part of the lentic community and contribute significantly to the biological productivity of the freshwater ecosystem. The distribution and diversity of zooplankton depend upon the prevailing physico-chemical parameters of the environment. In the present study, the counts of total zooplankton in different water bodies were low with the zooplankton varying between 03 to 12 Nos/l. The lowest (03 Nos/l) count of total zooplankton was noticed from both Rajol and Kohala (Table 4.3). The observed scenario of zooplankton community wise was Copepoda> Rotifera>Cladocera> nauplii. Sarang, *et al.* (2002) reported only 18 species of phytoplankton with the dominance of green algae and 21 species of zooplankton. They observed zooplankton ranking as Rotifers >Copepods> Cleadocerans >others in Jaisamand reservoir. A total no. of 28 species of phytoplankton and 23 species of zooplankton were noticed in Daya reservoir by Rajkumar, 2005. The average density of zooplankton as reported by Shekhawat (1991) was 15 Nos/l in Rameshwar anicut (Udaipur). Mishra, *et al*. (2012) observed the 27 species of zooplankton in Goverdhan sagar.

In general, the counts of zooplankton in different micro-water sheds were very low. Since these water resources are used for culture based fisheries, a good number of quality fingerlings were stocked (2500/ ha) in these waters, it may be possible that the lesser number of zooplankton in these waters could be due to the grazing action of fishes. Here, it is worth mentioning that the seed stocked in these waters are not maintained on supplementary feed and no fertilization / manuring is done to boost the production of fish. Hence the lesser count of zooplankton is obviously by due to grazing by fishes.

The physico-chemical quality of water affects fish growth. Generally growth is an integrated physiological response encompassing both external (food quality and quantity, temperature, and water quality) and internal physiological status (stress, health and reproductive). It is measured in unit of length and weight gain and is best expressed as the specific growth rate. The fish data are presented Table 4.5. In the present study, the growth in terms of weight, length & SGR of IMC in selected micro-watersheds varied between Catla762.38-1103.33gm, Rohu 628.31-932.16gm and Mrigal 395.15-838.29gm, Catla 18.59-30.03cm, Rohu 17.35-29.50cm and Mrigal 9.77-28.23cm, Catla 2.009-2.162%, Rohu 1.990-2.153% and Mrigal 1.839-2.149%

respectively. Thus the productivity and fish growth trends reported from different micro-watersheds further supports the finding of other researches (Sugunan,1995). The variation in different physico-chemical water quality parameters affects the production of that system.

The fish growth data of catla was noticed in higher level of 1103.33gm followed by rohu 932.16gm. The SGR of Catla was noticed higher 2.162% (Jhalawadi talai) followed by rohu 2.153% (Jhalawadi talai). The lower SGR Mrigal was noticed in 1.839% (Biyata and Banjariya) followed by Rohu 1.990% (Biyata and Banjariya). The variation in growth rate here could not be assigned to only water quality. The difference in growth rate might be due to the potential effect of physico- chemical parameter and productivity. Significantly higher growth rate of IMC in selected water bodies due to favorable physico-chemical parameters was also reported by Ujjania, 2003.

The level of fish growth in wild water primarily depends on the nutrient levels in the natural food, favourable water quality and also the genetic characteristics of the fish seed. In the present investigation, the least factor could not be considered for obvious reasons. However, it is suggested that laboratory experiments to deterrence the rate of growth in seed and selected species and their different strains on specific natural / artificial feeds be conducted.From the results and discussion of this study it is concluded that the quality of water in the present investigated watersheds is fairly good for fish culture. However, the growth was found moderate. To get the maximum production potential, there is an urgentneed to adopt scientific fish culture techniques. Further studies are recommended forproper fertilization, manuring, feeds and above all the stocking ratio and healthy seed supply.

6. SUMMARY

The present study on: **"Growth performance of Indian major Carps *vis-a-vis* biotic factors in selected micro-watersheds of Southern Rajasthan"** was conducted during January 2016 to June 2016. A total 20 micro-watersheds of four districts (Udaipur, Dungarpur, Banswara and Pratapgarh) of Rajasthan were chosen for this purpose. Under this study the status of physico -chemical water quality parameters, primary productivity, plankton counts and fish growth performance in micro-watersheds were monitored to know the suitability of these waters for fish culture.

The first chapter of the thesis gives details of the introduction and genesis of the research work. The reviews of researches conducted earlier on the aspects of the study in tropical waters and have been presented in chapter second. The third chapter gives the materials and methodology followed in the present investigation. The areas and GPS locations of selected micro-watersheds are also depicted in this chapter.

The outcomes of this investigation is presented in chapter fourth of this thesis. As such, the result obtained on present study regarding water quality, primary productivity, plankton counts and fish growth performance are depicted in Tables 4.1 to 4.5, Fig 3.1 and 4.1 to 4.20.

Physico-chemical parameters of water quality in micro-watersheds were found congenied for fish growth except for very high pH in a few water bodies. The average ranges water quality parameters in different micro-watersheds during study period were: water temperature 26.2-32.7□C, pH 7.3-10.05, dissolved oxygen 6.71-10.21mg/l, free CO_2 0-0.45mg/l, total dissolved solids 76.55-473mg/l, electrical conductivity 160.4-965mS/cm, total hardness 61-200mg/l, total alkalinity 34-141mg/l, salinity 0-0.5ppt, NO_3-N 0.089-0.558, HPO_4^{-3}, GPP 0.119-0.350gC/m^3/h, NPP 0.028-0.306gC/m^3/h and RQ 0.017-0.286gC/m^3/h. These values of water quality parameters indicate that the quality of water is relatively moderately productive.

The average phytoplankton counts in different micro-watersheds were 125-310 Nos/l. The counts of total zooplankton in different water bodies were relatively low. The zooplankton counts varied between 3 and 12Nos/l. On comparing different zooplanktonic groups it was observed that Copepoda dominated the zooplanktonic

counts followed by rotifera, cledocera and nauplii. The relationship between zooplankton, primary productivity and physico-chemical parameter were also calculated statistically.

Fish growth performance in different water bodies were recorded as below:

Net weight gain: Catla 762.38-1103.33gm, Rohu 628.31-932.16gm and Mrigal 395.15-838.29gm.

Net length gain: Catla 18.59-30.03cm, Rohu 17.35-29.50cm and Mrigal 9.77-28.23cm

Specific growth rate: Catla2.009-2.162%, Rohu1.990-2.153% and Mrigal1.839-2.149%. Studies on fish growth parameters indicate the moderate productivity of the selected micro-watersheds except a few water bodies in which pH was very high.

Based on the results of present study it can be concluded that the quality of water investigated in the selected micro-watersheds is fairly good for fish culture. However, the growth performance was found moderate. To get the maximum production, there is an urgentneed to adopt scientific fish culture techniques. Further studies are recommended for proper fertilization, manuring, feeds and above all the stocking ratio and healthy fish seed supply.

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Table 4.1: Ranges and mean values of water quality parameters of selected micro-water sheds (Figure in parenthesis gives mean value)

Watershed name	Temperature (□c)	pH	D.O. (mg/l)	Free CO_2 (mg/l)	T.D.S. (mg/l)	Conductivity (µs/cm)	Hardness (mg/l)	Total alkalinity (mg/l)	Salinity (mg/l)	Nitrate – nitrogen (mg/l)	Ortho-phosphate (mg/l)
Manas	24 – 28.4 (26.2)	6.9 – 10.5 (8.7)	6.33-7.09 (6.71)	0-0 (0)	180.5-183.2 (181.85)	375-380 (377.5)	106-120 (113)	50-86 (68)	0.1-0.1 (0.1)	0.164-0.176 (0.170)	0.01-0.03 (0.02)
Biyata	29.5 – 32.5 (31)	7.4 – 10.6 (9.0)	7.43-8.07 (7.75)	0-0 (0)	217-275 (246)	450-568 (509)	148-180 (164)	108-120 (114)	0.2-0.2 (0.2)	0.132-0.141 (0.137)	0.03-0.26 (0.145)
Baksho Ka Naka	29.9 – 34.5 (32.2)	7.9 – 10.8 (9.4)	7.11-8.79 (7.95)	0-0 (0)	162.7-228 (195.35)	388-471 (429.5)	120-160 (140)	96-110 (103)	0.1-0.2 (0.15)	0.162-0.169 (0.166)	0.02-0.26 (0.14)
Rajol	27.4 – 27.5 (27.45)	7.3 – 7.3 (7.3)	7.79-8.25 (8.02)	0-0 (0)	242-272 (257)	500-561 (530.5)	144-166 (155)	82-112 (97)	0.1-0.2 (0.15)	0.096-0.146 (0.121)	0.03-0.04 (0.035)
Advert Samand	31.2 – 33.1 (32.15)	6.9 – 8.3 (7.6)	7.31-7.33 (7.32)	0-0 (0)	244-263 (253.5)	244-542 (393)	156-168 (162)	58-84 (71)	0.2-0.2 (0.2)	0.147-0.156 (0.152)	0.001-0.04 (0.0205)
Loar Godhi	30.4 – 30.7 (30.55)	9.8 – 9.9 (9.85)	6.93-9.34 (8.14)	0-0 (0)	315-340 (327.5)	315-698 (506.5)	168-182 (175)	112-152 (132)	0.3-0.3 (0.3)	0.127-0.988 (0.558)	0.03-0.06 (0.045)
Kanhar Vala	26.3 – 32.1 (29.2)	9.5 – 10 (9.75)	6.31-12.62 (9.46)	0-0 (0)	117.1-125.8 (121.45)	125.8-244 (184.9)	86-90 (88)	78-90 (84)	0-0.1 (0.5)	0.119-0.173 (0.146)	0.01-0.02 (0.015)
Pani Dara	29 – 31.2 (31.7)	8 – 10.5 (9.25)	7.41-7.95 (7.68)	0-0 (0)	246-257 (251.5)	509-571 (540)	134-152 (143)	98-118 (108)	0.2-0.2 (0.2)	0.10-0.272 (0.186)	0.001-0.05 (0.0255)
Banjariya	28.7 – 31.6 (30.15)	9.2 – 10.9 (10.05)	9.71-10.71 (10.21)	0-0 (0)	236-249 (242.5)	488-514 (501)	100-130 (115)	110-152 (131)	0.2-0.2 (0.2)	0.273-0.307 (0.290)	0.03-0.04 (0.035)
Bassi	29.6 – 31.3 (30.45)	7.8 – 10 (8.9)	7.92-9.24 (8.58)	0-0 (0)	205-248 (226.5)	425-512 (468.5)	86-100 (93)	120-134 (127)	0.1-0.2 (0.15)	0.110-0.650 (0.380)	0.03-0.11 (0.07)
Makodi	29.6 – 33.8 (31.7)	8.3 – 8.5 (8.4)	7.52-9.09 (8.31)	0-0 (0)	264-282 (273)	545-582 (563.5)	114-144 (129)	96-112 (104)	0.2-0.2 (0.2)	0.140-0.539 (0.340)	0.05-0.33 (0.19)
Kalu Dara	27.7 – 28.5 (28.1)	7.3 – 8 (7.65)	5.75-8.64 (7.195)	0-0 (0)	72.6-80.5 (76.55)	152.3-168.5 (160.4)	42-80 (61)	32-36 (34)	0-0 (0)	0.057-0.120 (0.089)	0.07-0.1 (0.085)

Watershed name	Temperature (□c)	pH	D.O. (mg/l)	Free CO_2 (mg/l)	T.D.S. (mg/l)	Conductivity (µs/cm)	Hardness (mg/l)	Total alkalinity (mg/l)	Salinity (mg/l)	Nitrate – nitrogen (mg/l)	Ortho-phosphate (mg/l)
Jhalawadi Talai	28.3 – 29.5 (28.9)	7.3 – 8.1 (7.7)	5.26-9.97 (7.615)	0-0.7 (0.35)	69.5-93.7 (81.6)	145.7-196 (170.85)	62-66 (64)	34-50 (42)	0-0.1 (0.5)	0.14-0.218 (0.179)	0.06-0.14 (0.1)
Khanmal	27.7 – 29.4 (28.55)	8.2 – 9.6 (8.9)	7.81-8.33 (8.07)	0-0 (0)	457-489 (473)	933-997 (965)	200-200 (200)	96-130 (113)	0.4-0.5 (0.45)	0.102-0.128 (0.115)	0.001-0.04 (0.0205)
Nala Pada	30.3 – 34.9 (32.6)	7 – 9.5 (8.25)	6.58-8.87 (7.725)	0-0.9 (0.45)	165.3-190.3 (177.8)	343-394 (368.5)	170-180 (175)	82-136 (109)	0.1-0.1 (0.1)	0.139-0.192 (0.166)	0.02-0.06 (0.04)
Jithula	30.7 – 33.6 (32.15)	8.7 – 9.9 (9.3)	9.25-9.78 (9.515)	0-0 (0)	204-215 (209.5)	423-445 (434)	118-136 (127)	90-106 (98)	0.1-0.1 (0.1)	0.234-0.260 (0.247)	0.04-0.06 (0.0)
Kohala	30.3 – 35.1 (32.7)	7.5 – 9.3 (8.4)	9.51-10.7 (10.10)	0-0 (0)	211-213 (212)	437-441 (439)	112-130 (121)	132-150 (141)	0.2-0.1 (0.15)	0.116-0.153 (0.135)	0.02-0.02 (0.02)
Bhamri Tandi	30.9 – 31.4 (31.15)	8.3 – 8.8 (8.55)	6.87-7.23 (7.05)	0-0 (0)	177.7-192.5 (185.1)	369-399 (384)	108-124 (116)	106-120 (113)	0.1-0.1 (0.1)	0.101-0.198 (0.150)	0.09-0.14 (0.115)
Gopalpura	30.3 – 30.5 (30.4)	8.5 – 8.6 (8.55)	7.53-8.62 (8.075)	0-0 (0)	135.2-156.2 (145.7)	281-325 (303)	100-128 (114)	114-114 (114)	0.1-0.1 (0.1)	0.173-0.171 (0.122)	0.05-0.06 (0.055)
Vakhtod	29.8 – 30.8 (30.3)	9.7 – 10.3 (10)	5.02-10.97 (7.995)	0-0 (0)	138.8-139.3 (139.05)	289-290 (289.5)	122-128 (125)	122-136 (129)	0.1-0.1 (0.1)	0.265-0.438 (0.352)	0.06-0.1 (0.08)

Table 4.2: Ranges and mean values for primary production of selected micro-water sheds in Southern Rajasthan (Figure in parenthesis gives mean value)

SN.	Water-shed name	GPP ($gC\ m^{-3}h^{-1}$)	NPP ($gC\ m^{-3}h^{-1}$)	RQ ($gC\ m^{-3}h^{-1}$)
1.	Manas	0.197-0.306 (0.252)	0.028-0.113 (0.070)	0.084-0.278 (0.181)
2.	Biyata	0.087-0.228 (0.158)	0.066-0.216 (0.141)	0.013-0.022 (0.017)
3.	Baksho Ka Naka	0.097-0.141 (0.119)	0.069-0.122 (0.095)	0.019-0.028 (0.023)
4.	Rajol	0.122-0.128 (0.125)	0.009-0.056 (0.033)	0.066-0.119 (0.092)
5.	Advert Samand	0.103-0.138 (0.120)	0.044-0.103 (0.073)	0.021-0.094 (0.047)
6.	Loar Godhi	0.159-0.269 (0.214)	0.125-0.203 (0.164)	0.034-0.066 (0.050)
7.	Kanhar Vala	0.144-0.275 (0.209)	0.053-0.078 (0.066)	0.091-0.197 (0.144)
8.	Pani Dara	0.256-0.416 (0.336)	0.050-0.125 (0.088)	0.206-0.291 (0.248)
9.	Banjariya	0.169-0.194 (0.181)	0.081-0.172 (0.127)	0.022-0.088 (0.055)
10.	Bassi	0.163-0.538 (0.350)	0.125-0.488 (0.306)	0.038-0.050 (0.044)
11.	Makodi	0.106-0.300 (0.203)	0.022-0.188 (0.105)	0.084-0.113 (0.098)
12.	Kalu Dara	0.131-0.356 (0.244)	0.059-0.156 (0.108)	0.072-0.200 (0.136)
13.	Jhalawadi Talai	0.063-0.216 (0.139)	0.013-0.044 (0.028)	0.050-0.172 (0.111)
14.	Khanmal	0.128-0.159 (0.144)	0.028-0.056 (0.042)	0.072-0.131 (0.102)
15.	Nala Pada	0.334-0.388 (0.361)	0.047-0.103 (0.075)	0.231-0.341 (0.286)
16.	Jithula	0.138-0.528 (0.333)	0.094-0.166 (0.130)	0.044-0.363 (0.203)
17.	Kohala	0.197-0.306 (0.252)	0.050-0.063 (0.056)	0.147-0.244 (0.195)
18.	Bhamri Tandi	0.197-0.459 (0.328)	0.094-0.144 (0.119)	0.053-0.366 (0.209)
19.	Gopalpura	0.250-0.269 (0.259)	0.034-0.072 (0.053)	0.178-0.234 (0.206)
20.	Vakhtod	0.156-0.181 (0.169)	0.053-0.09 (0.056)	0.097-0.128 (0.113)

Table 4.3: Ranges and mean value of phytoplankton and zooplankton densities in selected micro-water sheds in Southern Rajasthan

S.NO.	Watersheds name	Phytoplankton (Nos/l)	Zooplankton (Nos/l)				
			Rotifers	Cladocerans	Copepods	Nauplii	Mean total
1.	Manas	130-220 (175)	2-1 (2)	1-1 (1)	2-3 (2)	1-2 (1)	6
2.	Biyata	150-230 (190)	3-3 (3)	1-3 (2)	2-5 (3)	1-4 (2)	9
3.	Baksho Ka Naka	120-270 (195)	2-1 (1)	1-3 (2)	2-4 (3)	1-4 (3)	9
4.	Rajol	110-190 (150)	1-1 (1)	0-1 (0)	0-2 (1)	0-1 (0)	3
5.	Advert Samand	180-220 (200)	2-1 (1)	0-1 (1)	1-1 (1)	1-1 (1)	4
6.	Loar Godhi	210-220 (215)	2-1 (1)	1-1 (1)	1-2 (1)	0-1 (1)	4
7.	Kanhar Vala	210-410 (310)	3-3 (3)	2-4 (3)	4-4 (4)	2-2 (2)	12
8.	Pani Dara	130-350 (240)	4-4 (4)	2-4 (3)	2-5 (4)	1-2 (1)	12
9.	Banjariya	170-220 (195)	0-1 (1)	0-3 (2)	0-2 (1)	1-1 (1)	5
10.	Bassi	80-210 (145)	1-1 (1)	1-1 (1)	2-3 (2)	1-1 (1)	5
11.	Makodi	120-470 (295)	1-2 (1)	2-2 (2)	1-1 (1)	1-1 (1)	4
12.	Kalu Dara	80-170 (125)	1-1 (1)	1-1 (1)	3-4 (3)	1-1 (1)	6
13.	Jhalawadi Talai	150-380 (265)	0-0 (0)	1-2 (1)	2-3 (2)	1-2 (1)	5
14.	Khanmal	140-180 (160)	1-1 (1)	0-0 (0)	2-4 (3)	1-1 (1)	5
15.	Nala Pada	210-240 (225)	1-2 (2)	1-1 (1)	1-3 (2)	0-1 (0)	5
16.	Jithula	130-220 (175)	1-3 (2)	1-1 (1)	2-3 (2)	1-1 (1)	6
17.	Kohala	130-190 (160)	1-1 (1)	1-1 (1)	0-1 (1)	0-1 (0)	3
18.	Bhamri Tandi	110-180 (145)	1-2 (1)	1-0 (0)	2-3 (2)	1-2 (1)	4
19.	Gopalpura	130-190 (160)	1-2 (2)	1-0 (0)	2-3 (2)	2-3 (2)	6
20.	Vakhtod	160-230 (195)	3-4 (3)	1-2 (2)	2-4 (3)	3-3 (3)	11

Table 4.4 correlation coefficient between selected water quality parameters

	Temp.	pH	DO	Free Co_2	TDS	EC	Hard.	Alkali.	Salinity	NO_3^--N	HPO_4^{-3}	GPP	NPP	RQ	PP	ZP
Temperature	1.0000															
pH	0.1578	1.0000														
DO	0.3348	0.4427	1.0000													
Free Co_2	0.1291	-0.3154	-0.1746	1.0000												
TDS	0.0594	0.1674	0.1025	-0.2990	1.0000											
EC	0.0365	0.2294	0.1103	-0.2767	0.9627	1.0000										
Hardness	0.2699	0.1168	-0.0856	-0.0238	0.7964	0.7443	1.0000									
Alkalinity	0.4693	0.5679	0.4920	-0.2565	0.4767	0.4932	0.4782	1.0000								
Salinity	0.0668	0.2383	0.0864	-0.2574	0.9699	0.9205	0.7738	0.4780	1.0000							
NO_3^--N	0.1830	0.5296	0.2083	-0.1106	0.2277	0.1140	0.0970	0.4436	0.2591	1.0000						
HPO_4^{-3}	0.2698	-0.0600	-0.2378	0.0063	-0.1515	-0.0713	-0.1503	-0.0481	-0.1273	0.1286	1.0000					
GPP	0.2179	0.0957	0.0439	0.1613	-0.1799	-0.1236	-0.1660	0.1975	-0.2783	0.1083	-0.1582	1.0000				
NPP	0.2195	0.2958	0.1363	-0.2314	0.1177	0.0928	-0.1068	0.3124	0.0727	0.5609	0.2101	0.4335	1.0000			
RQ	0.0550	-0.1328	-0.0613	0.3510	-0.2809	-0.2023	-0.0895	-0.0394	-0.3483	-0.3284	-0.3310	0.7045	-0.3340	1.0000		
Phytoplankton	0.1390	0.2266	0.1491	0.3141	-0.1002	-0.1650	-0.0467	-0.1239	-0.0380	0.2154	0.1582	-0.1471	-0.2101	0.0116	1.0000	
Zooplankton	-0.0462	0.5676	-0.0104	-0.1456	-0.2688	-0.1726	-0.1230	0.0044	-0.1830	-0.0604	0.0325	0.0198	-0.0589	0.0670	0.3575	1.0000

Table 4.5: Growth parameters of IMC in selected micro-water sheds in Southern Rajasthan

S.No.	Water sheds	Catla			Rohu			Mrigala		
		NWG(gm)	NLG(cm)	SGR (%)	NWG(gm)	NLG(cm)	SGR (%)	NWG(gm)	NLG(cm)	SGR (%)
1.	Manas	806.19	20.06	2.0321	717.74	20.92	2.0451	636.33	19.82	2.0351
2.	Biyata	762.38	18.59	2.0090	639.31	17.35	1.9901	395.15	9.77	1.8385
3.	Baksho Ka Naka	830.95	20.89	2.0446	728.31	21.35	2.0512	451.03	12.10	1.8930
4.	Rajol	935.71	24.41	2.0937	824.47	25.19	2.1025	652.99	20.51	2.0458
5.	Advert Samand	950.95	24.92	2.1004	920.62	29.04	2.1482	739.27	24.10	2.0972
6.	Loar Godhi	872.86	22.30	2.0650	665.81	18.85	2.0141	449.07	12.01	1.8912
7.	Kanhar Vala	848.10	21.47	2.0531	671.58	19.08	2.0176	505.93	14.38	1.9404
8.	Pani Dara	914.76	23.70	2.0844	675.43	19.23	2.0200	537.31	15.69	1.9652
9.	Banjariya	763.38	18.59	2.0095	628.31	16.35	1.9901	415.15	9.77	1.8589
10	Bassi	811.91	20.25	2.0350	633.12	17.54	1.9933	494.17	13.89	1.9307
11.	Makodi	935.71	24.41	2.0937	718.70	20.96	2.0457	644.17	20.14	2.0402
12.	Kalu Dara	976.67	25.78	2.1115	908.12	28.54	2.1425	640.25	19.98	2.0377
13.	Jhalawadi Talai	1103.33	30.03	2.1620	932.16	29.50	2.1533	838.29	28.23	2.1492
14.	Khanmal	855.71	21.72	2.0568	669.66	18.00	2.0165	463.82	12.10	1.9045
15.	Nala Pada	950.95	24.92	2.1004	830.24	25.42	2.1054	752.01	24.64	2.1043
16.	Jithula	856.67	21.75	2.0572	770.62	23.04	2.0745	555.93	16.47	1.9793
17.	Kohala	857.71	20.82	2.0577	669.66	17.00	2.0165	461.82	12.54	1.9028
18.	Bhamri Tandi	935.71	24.41	2.0937	718.70	20.96	2.0457	644.17	20.14	2.0402
19.	Gopalpura	919.52	23.86	2.0865	729.28	21.38	2.0517	544.17	15.98	1.9705
20.	Vakhtod	862.38	21.95	2.0600	672.54	19.12	2.0182	497.11	14.02	1.9331

NWG – Net weight gain: NLG – Net length gain; SGR – Specific growth rate

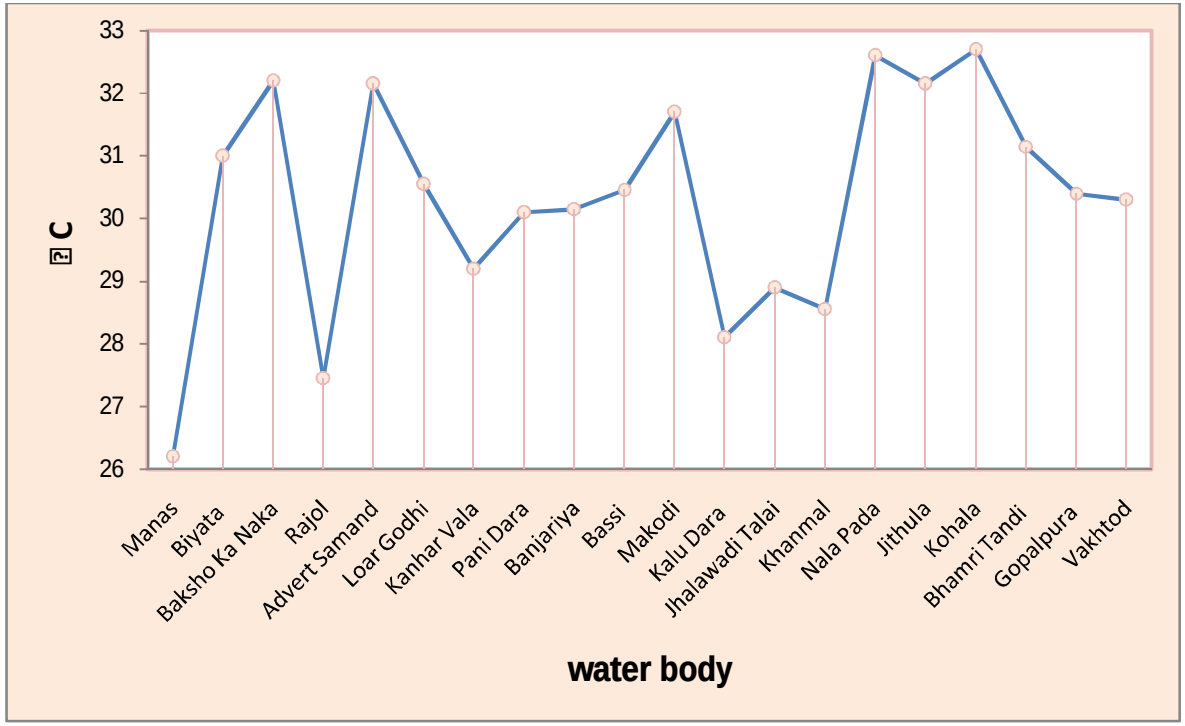


Fig: 4.1. Mean values of temperature in different micro-water sheds

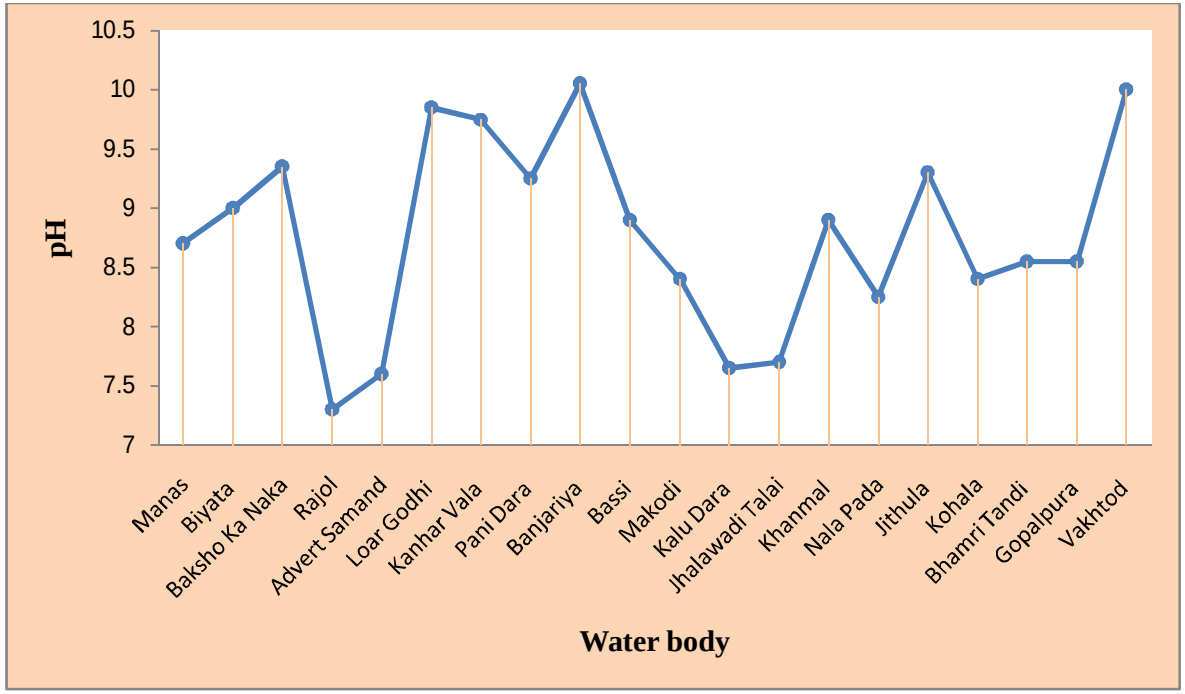


Fig: 4.2 Mean values of pH in different micro-water sheds

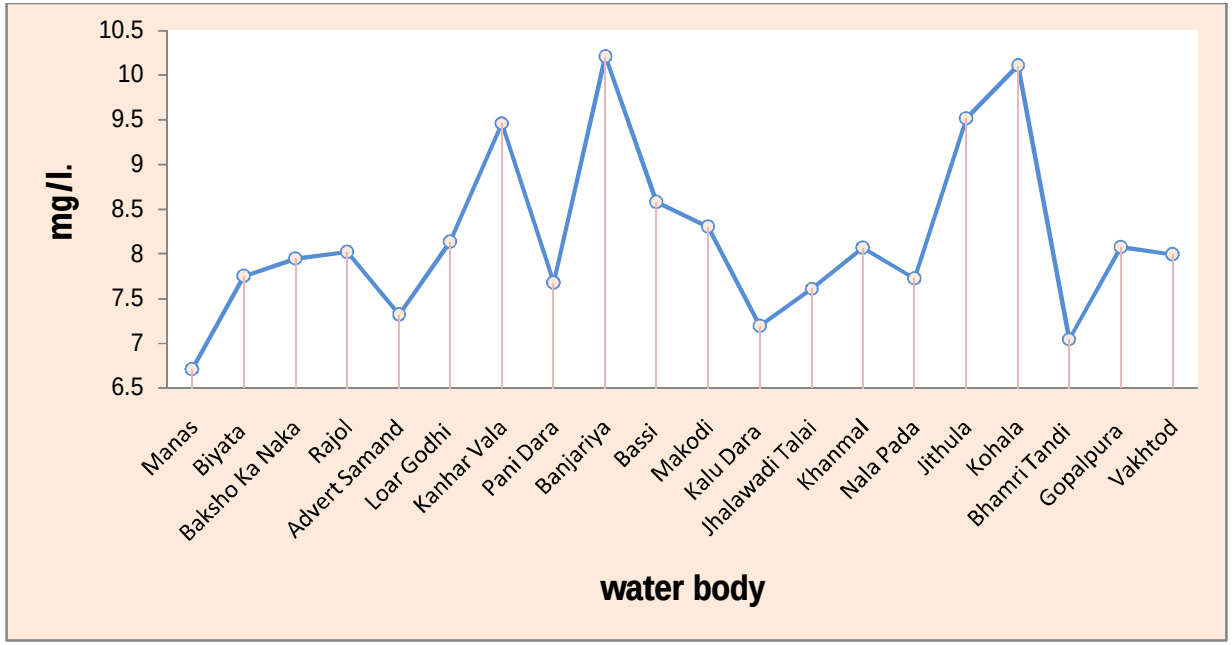


Fig: 4.3 Mean values of dissolved oxygen in different micro-water sheds

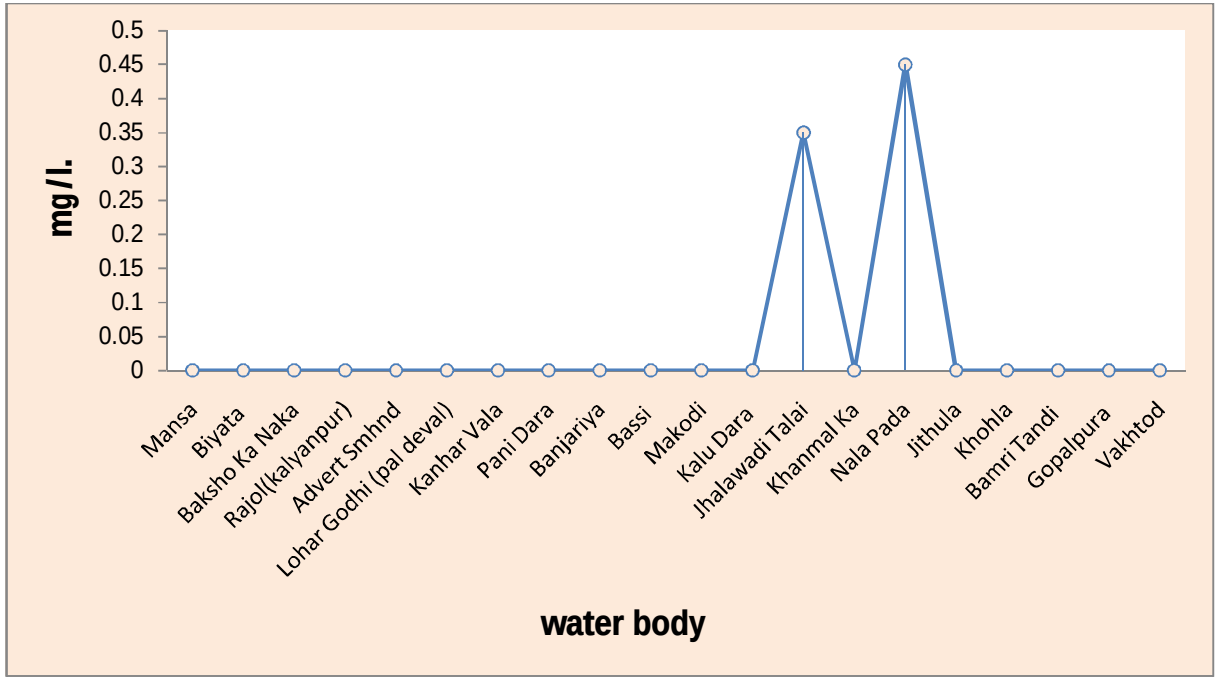


Fig: 4.4 Mean values of free CO_2 in different micro-water sheds

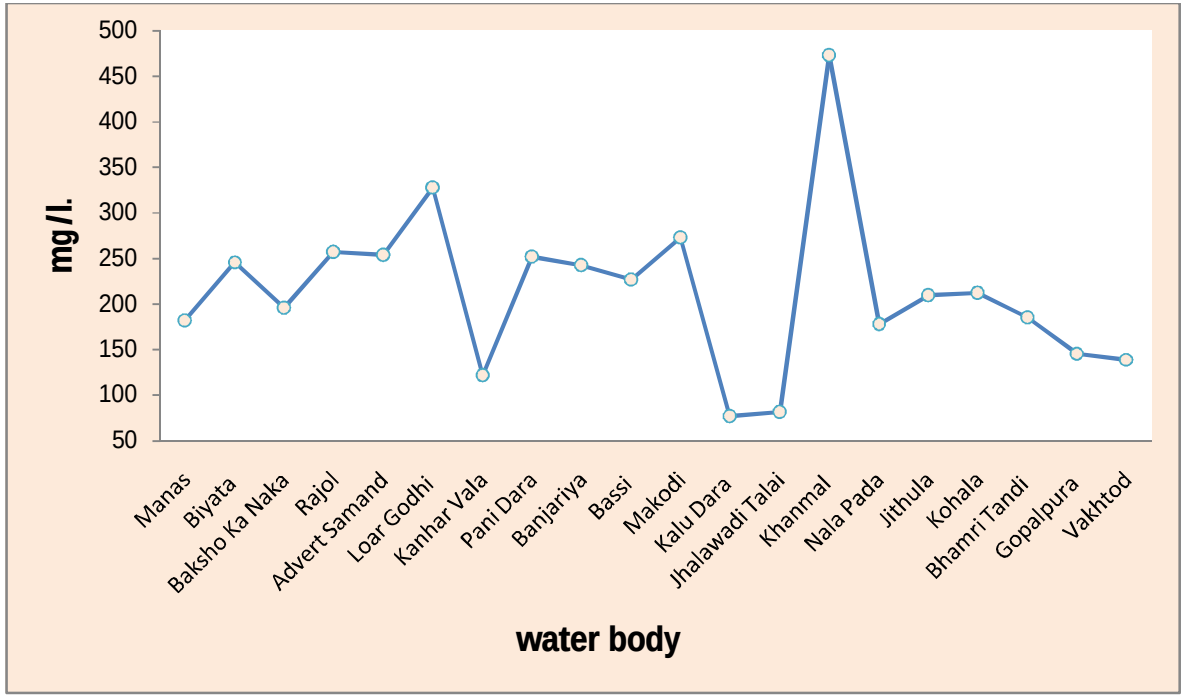


Fig: 4.5 Mean values of total dissolved solids in different micro-water sheds

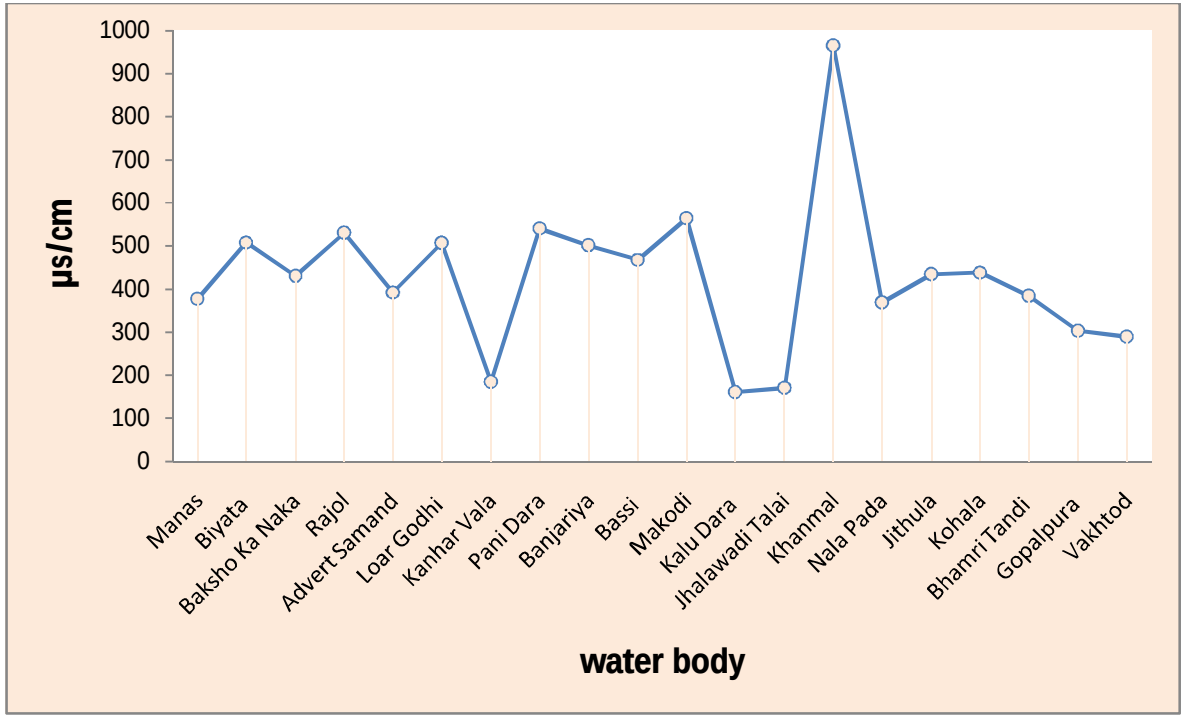


Fig: 4.6 Mean values of conductivity in different micro-water sheds

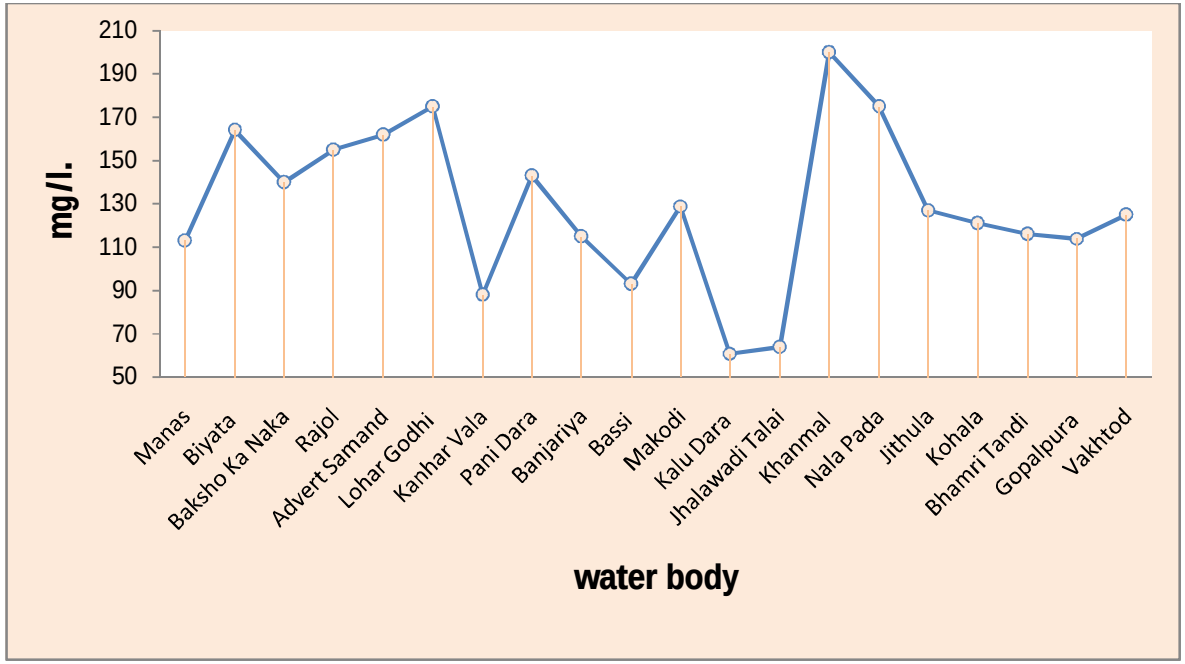


Fig: 4.7 Mean values of hardness in different micro-water sheds

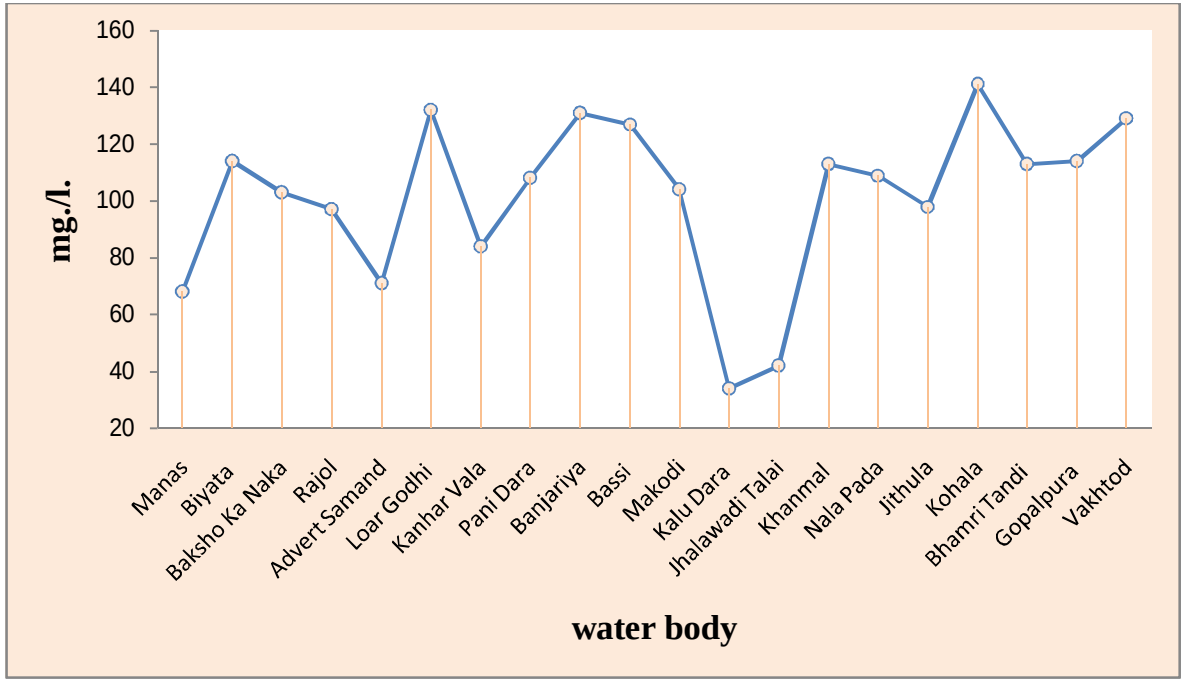


Fig: 4.8 Mean values of total alkalinity in different micro-water sheds

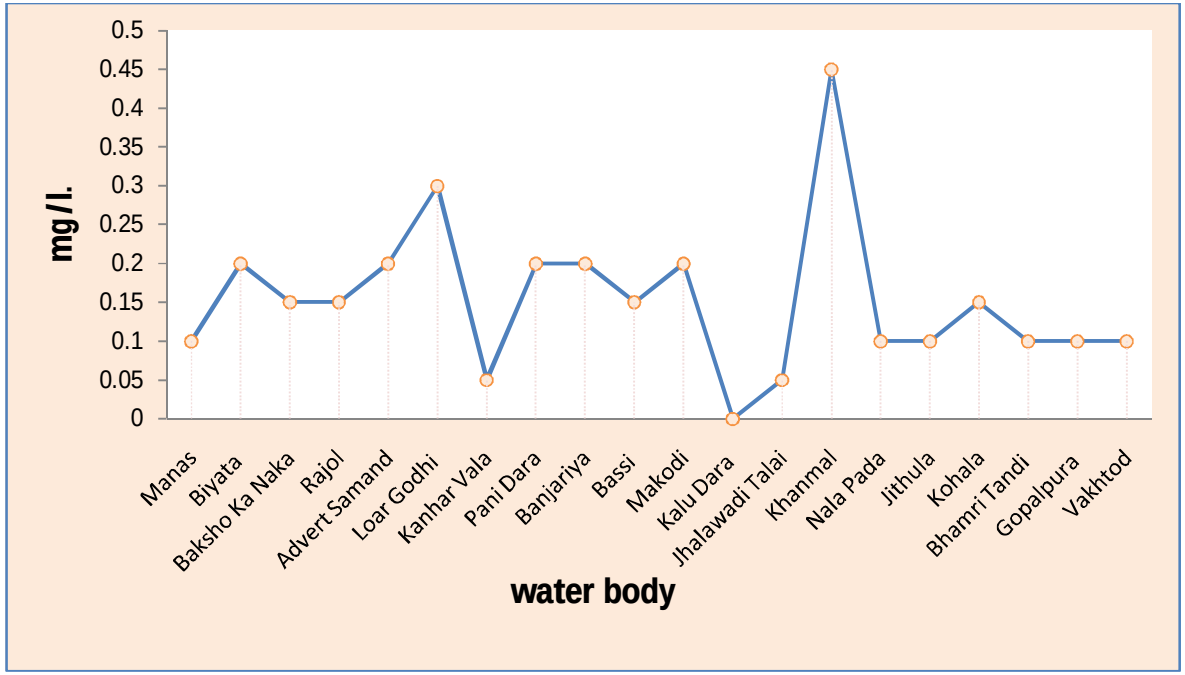


Fig: 4.9 Mean values of salinity in different micro-water sheds

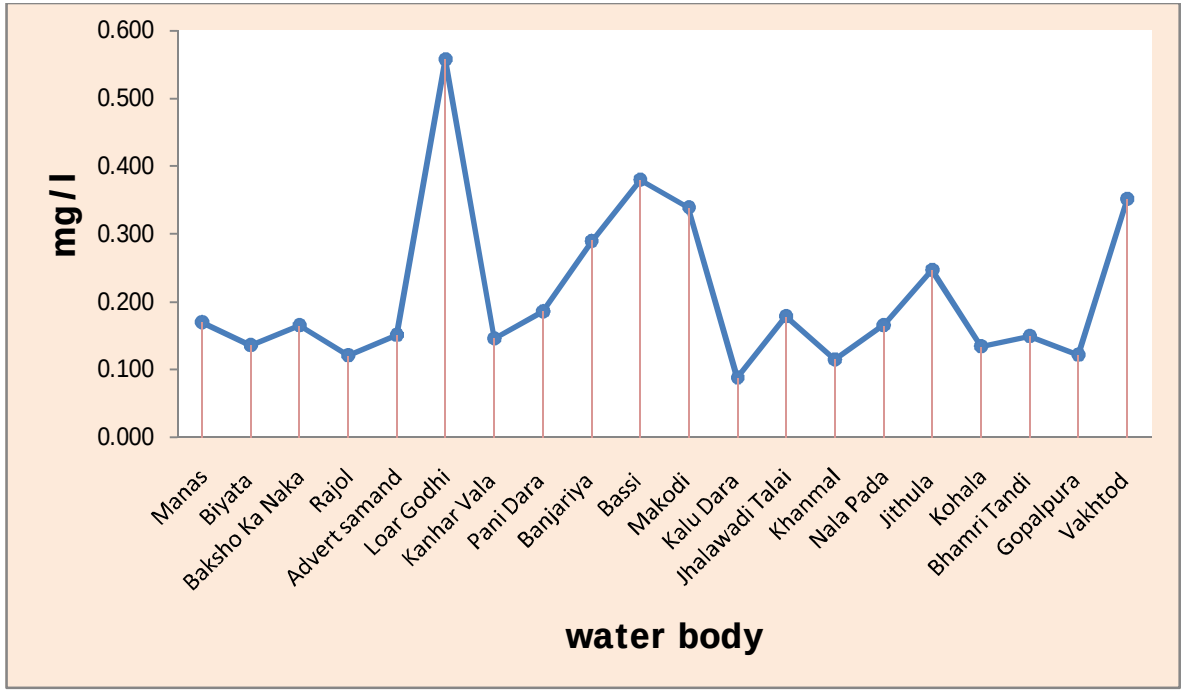


Fig: 4.10 Mean values of Nitrate-nitrogen in different micro-water sheds

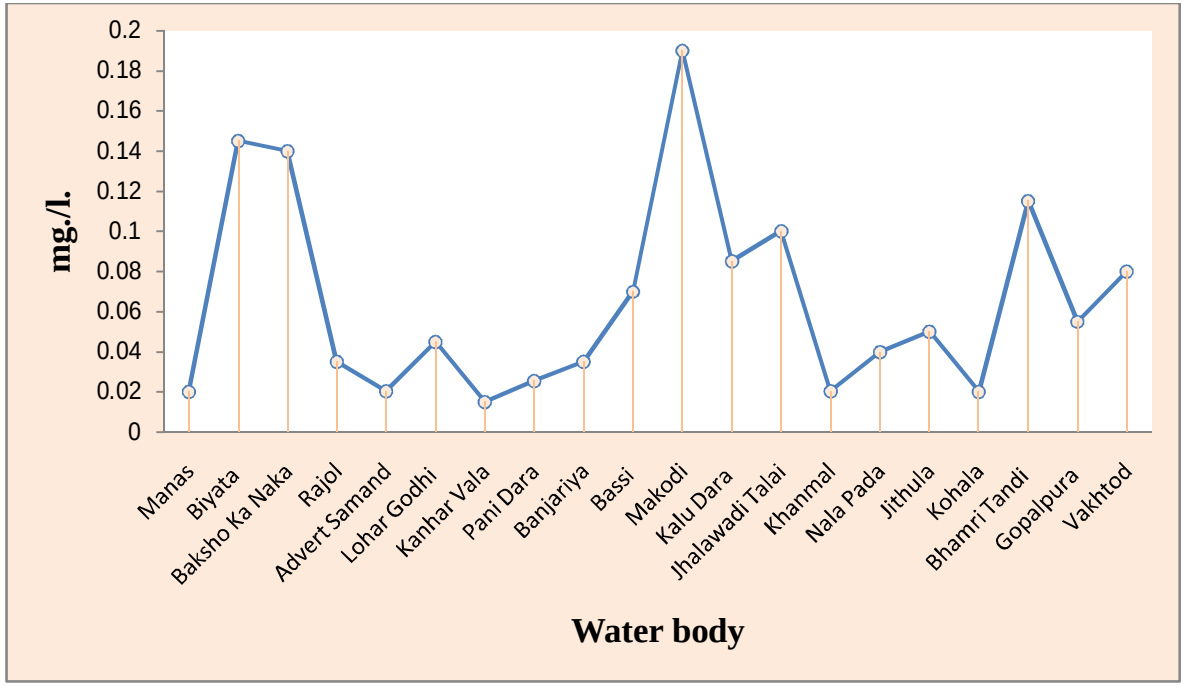


Fig: 4.11 Mean values of Ortho-phosphate in different micro-water sheds

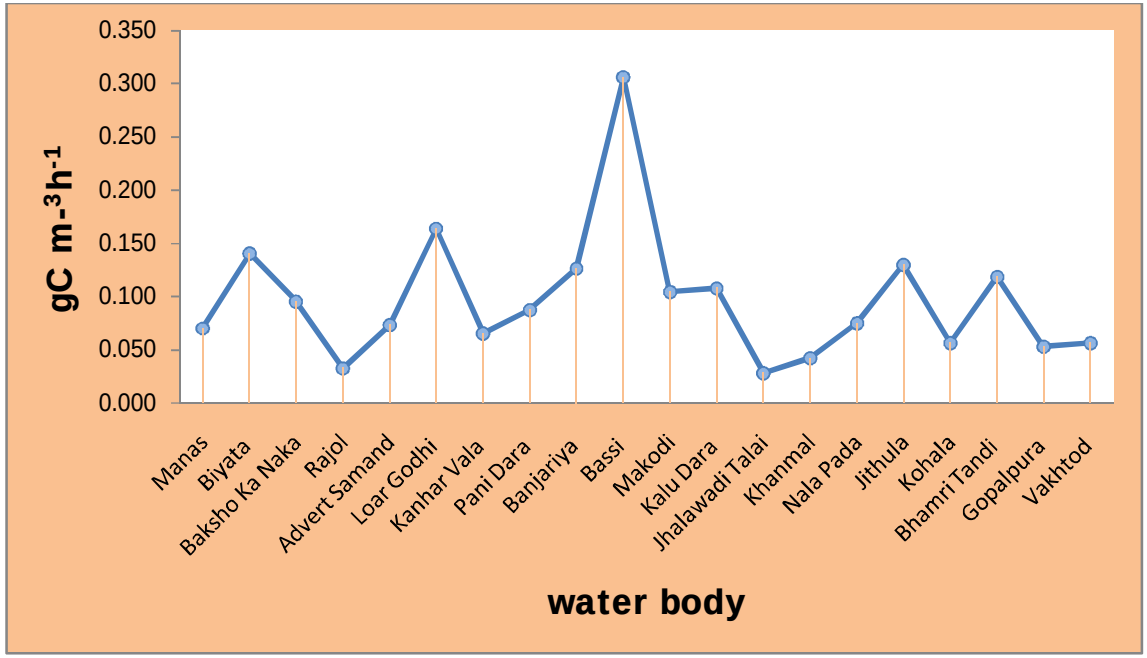


Fig: 4.12 Mean values of gross primary productivity in different micro-water sheds

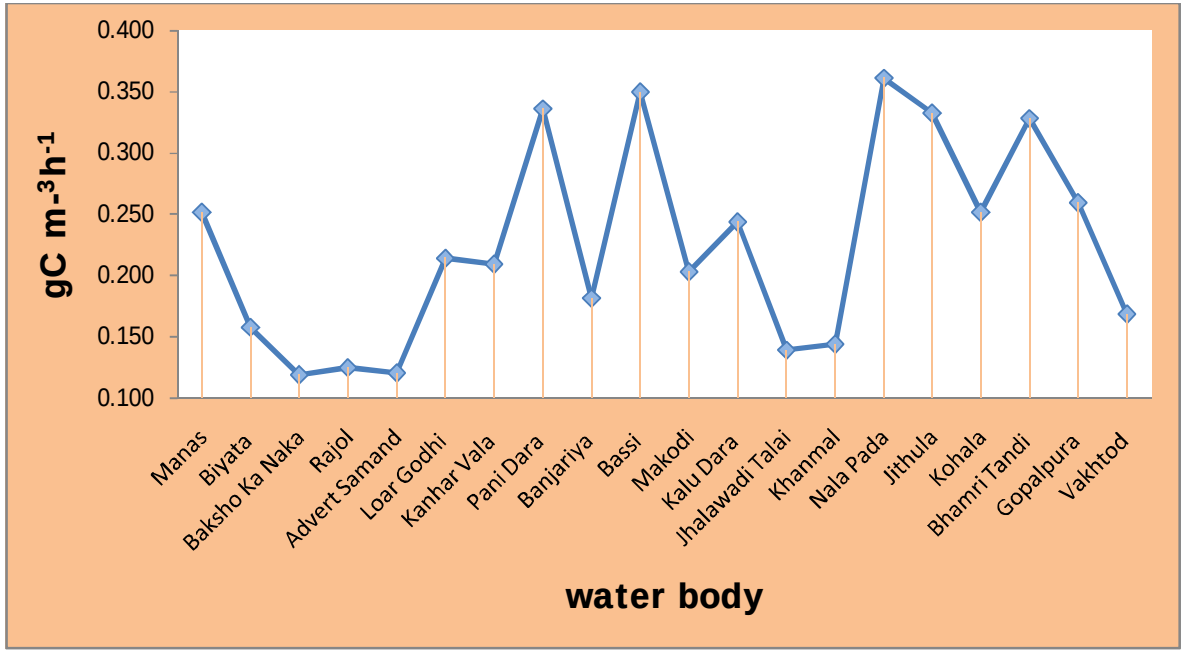


Fig: 4.13 Mean values of net primary productivity in different micro-water sheds

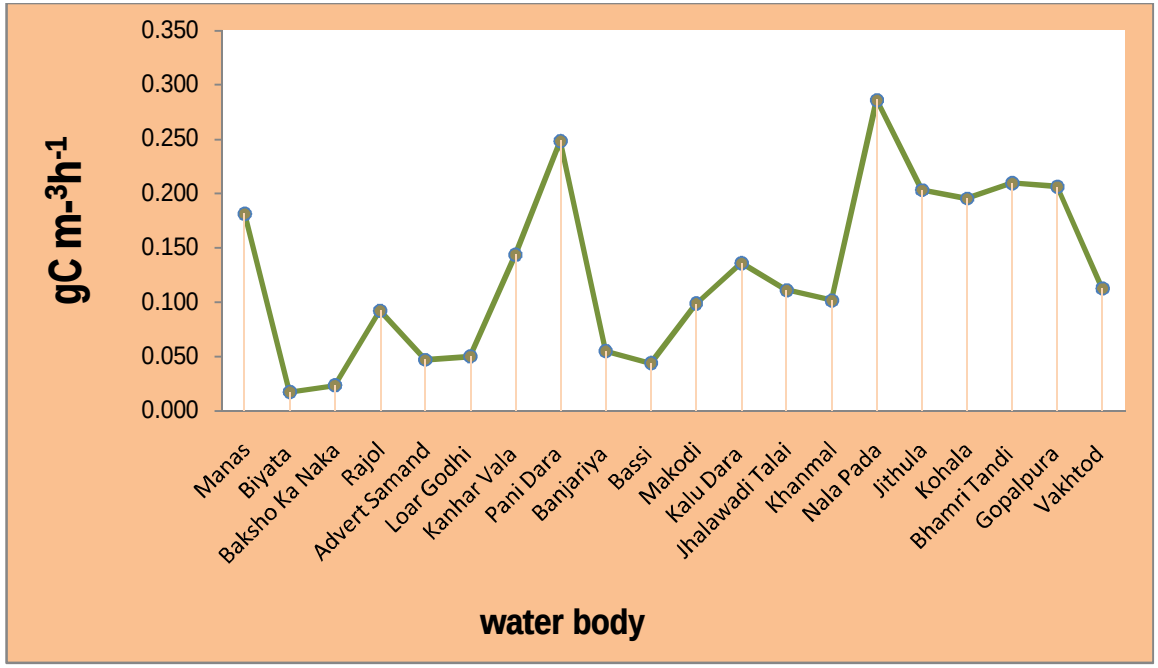


Fig: 4.14 Mean values of rate of community respiration in different micro-water sheds

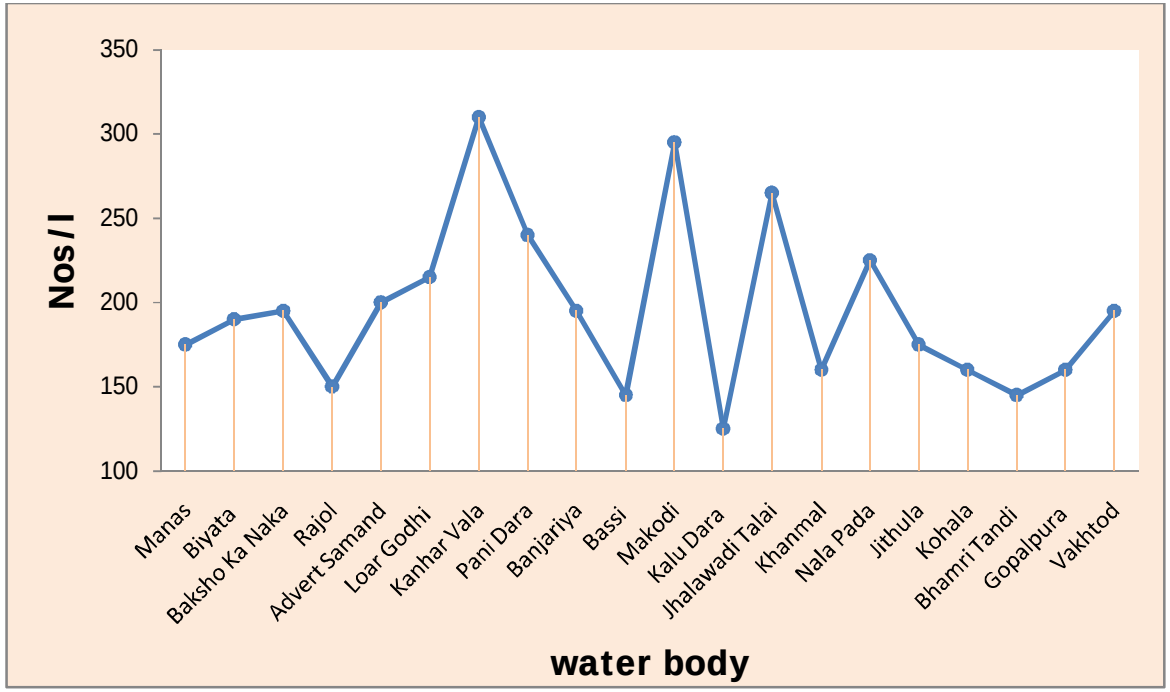


Fig: 4.15 Mean values of the phytoplankton densities in different micro-water shed

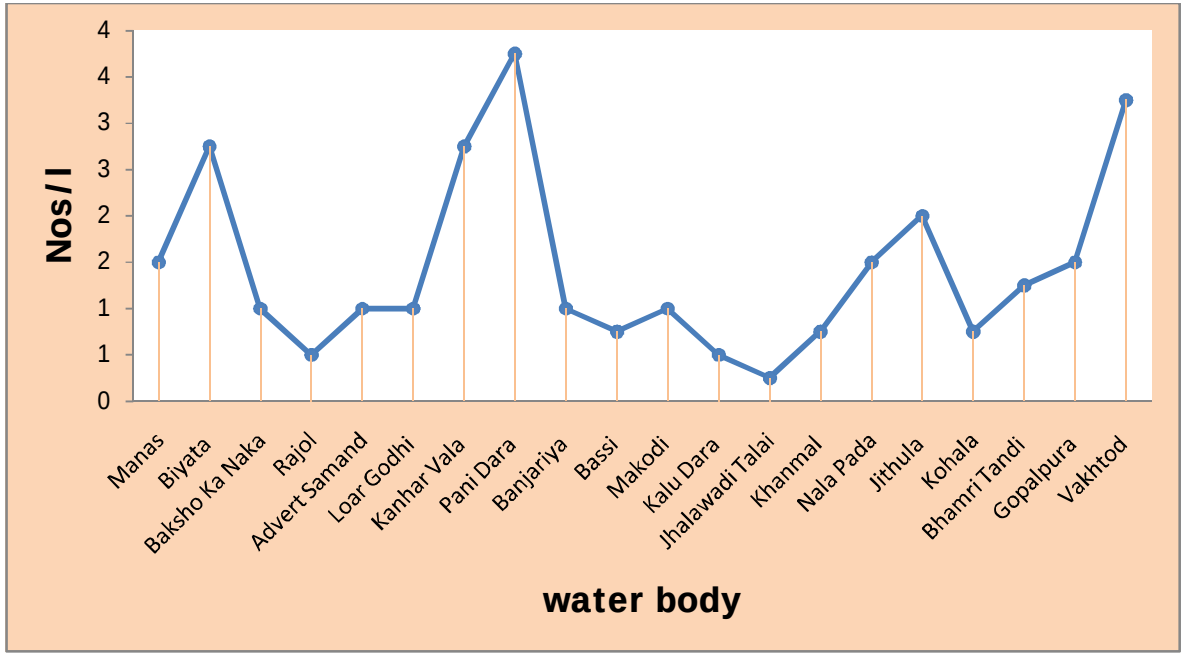


Fig: 4.16 Mean densities of rotifer in different micro-water sheds

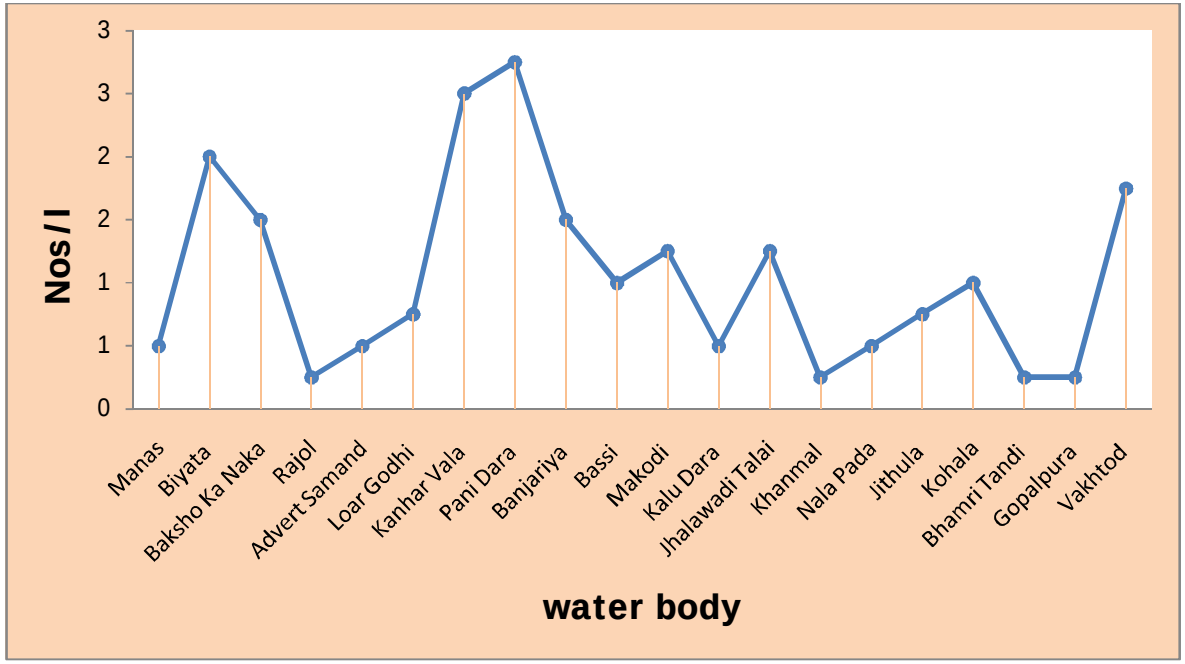


Fig: 4.17 Mean densities of cledocera in different micro-water sheds

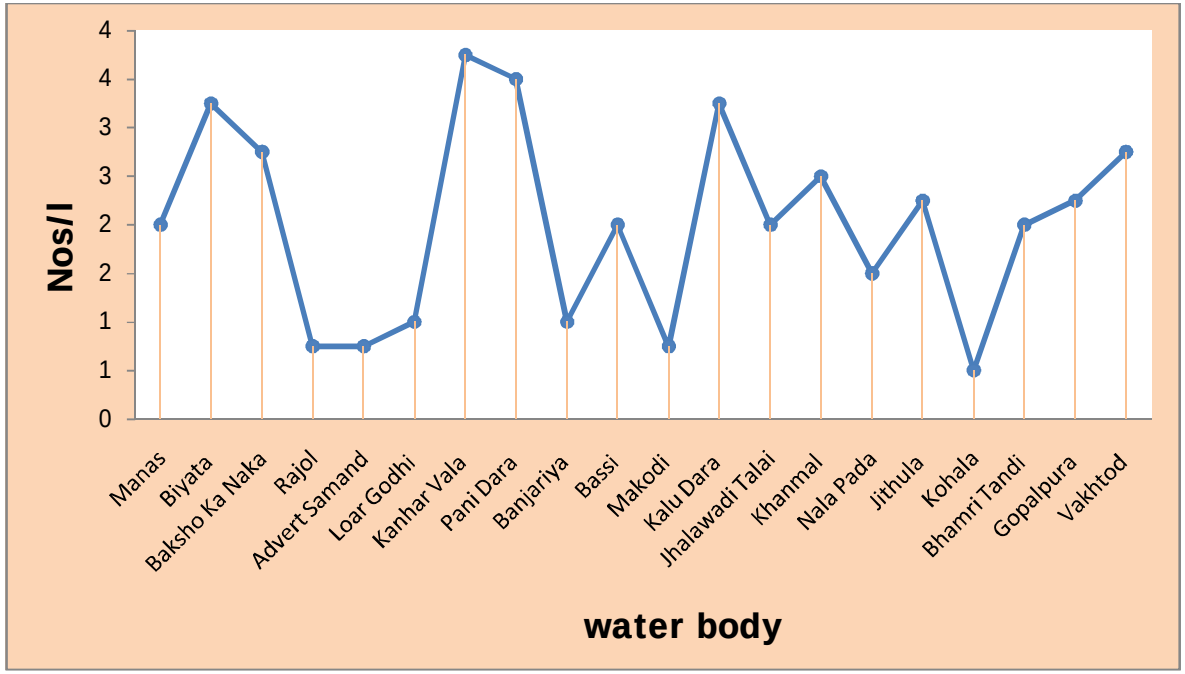


Fig: 4.18 Mean densities of copepods in different micro-water sheds

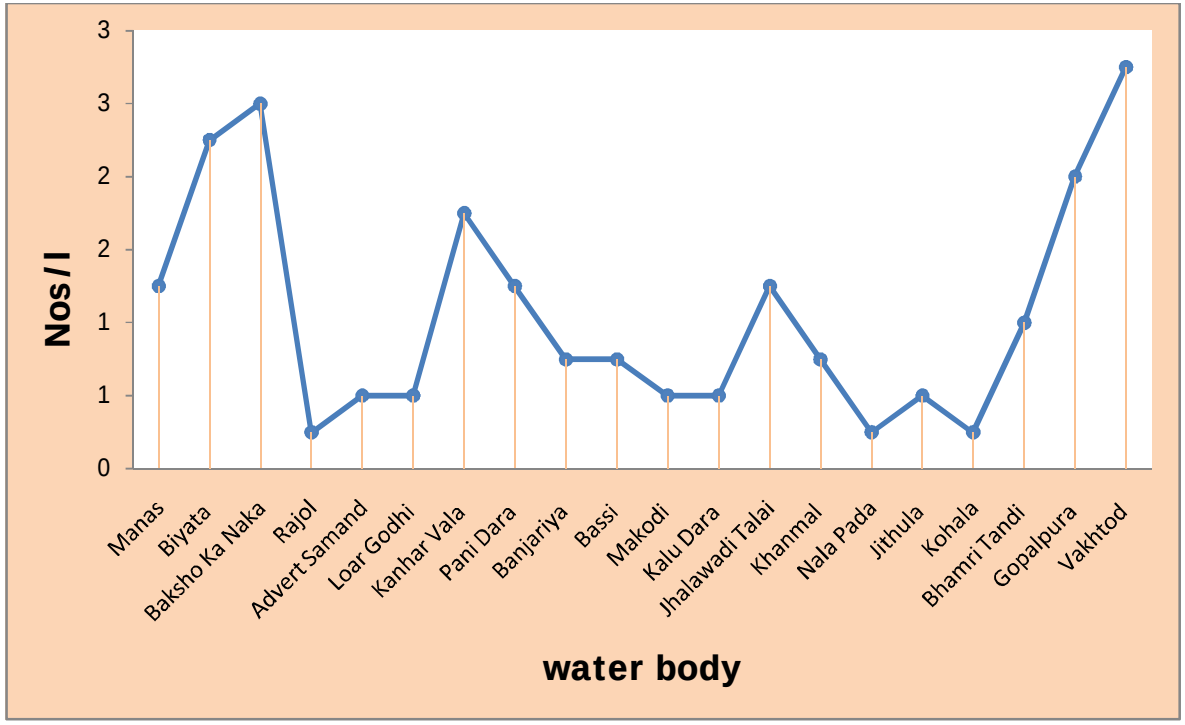
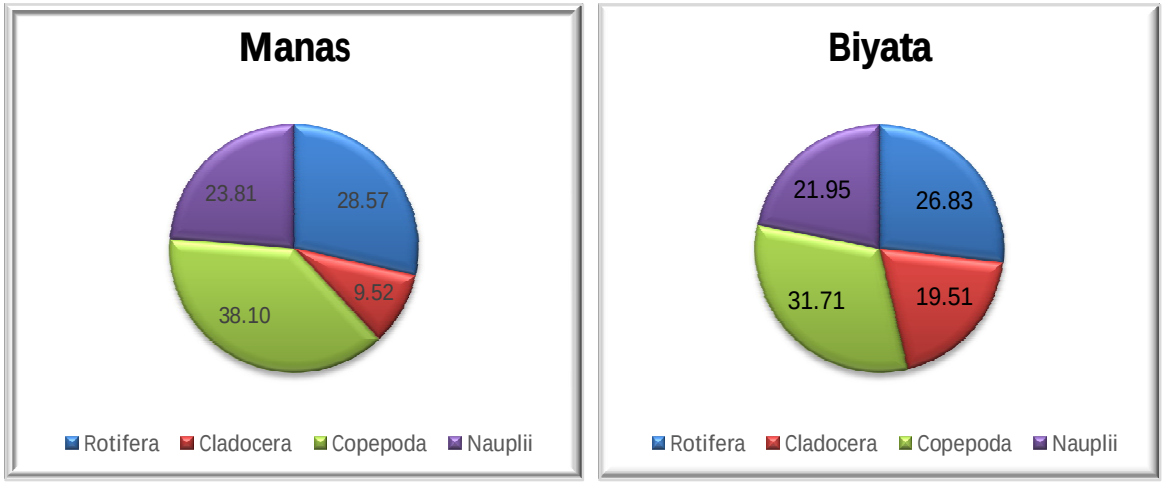
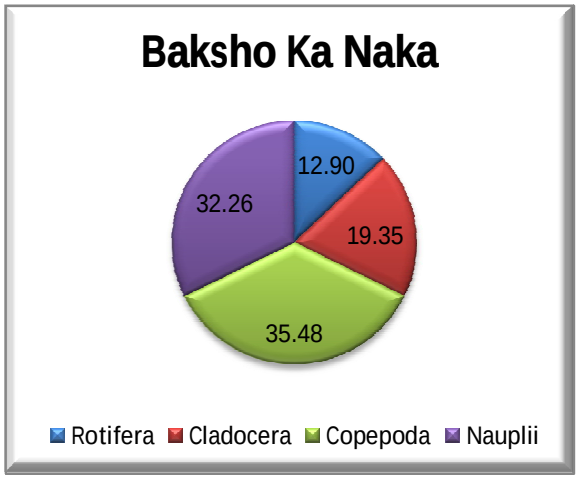
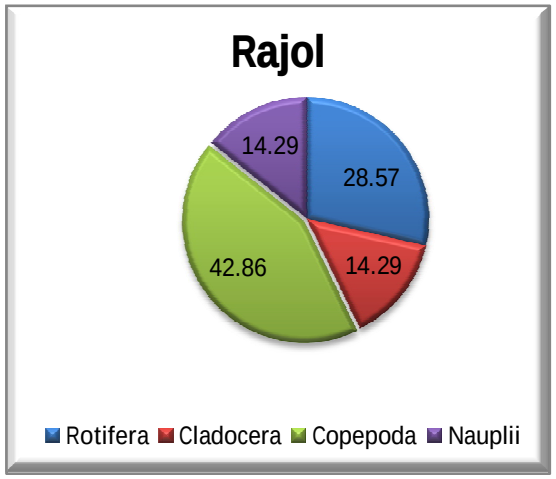


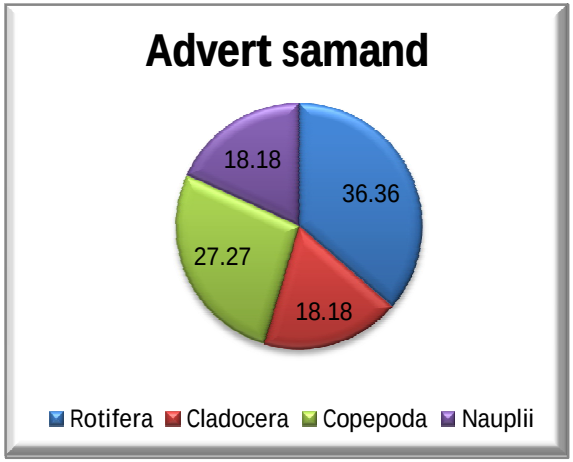
Fig: 4.19 Mean densities of nauplii in different micro-water sheds

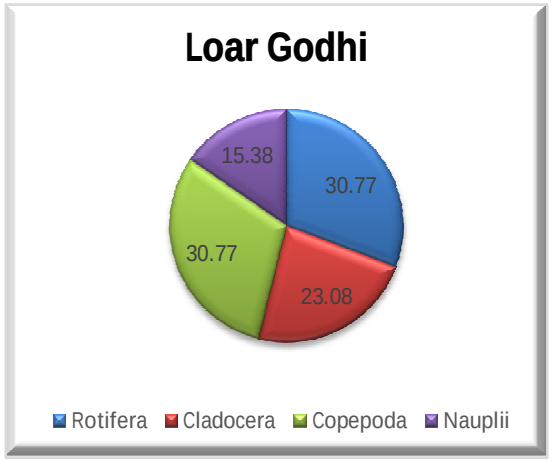
Fig: 4.20 Per cent count of zooplankton in selected micro-water sheds in southern Rajasthan




Baksho Ka Naka
12.90
19.35
35.48
32.26
Rotifera
Cladocera
Copepoda
Nauplii


Rajol
28.57
14.29
42.86
14.29
Rotifera
Cladocera
Copepoda
Nauplii


Advert samand
36.36
18.18
27.27
18.18
Rotifera
Cladocera
Copepoda
Nauplii


Loar Godhi
30.77
23.08
30.77
15.38
Rotifera
Cladocera
Copepoda
Nauplii

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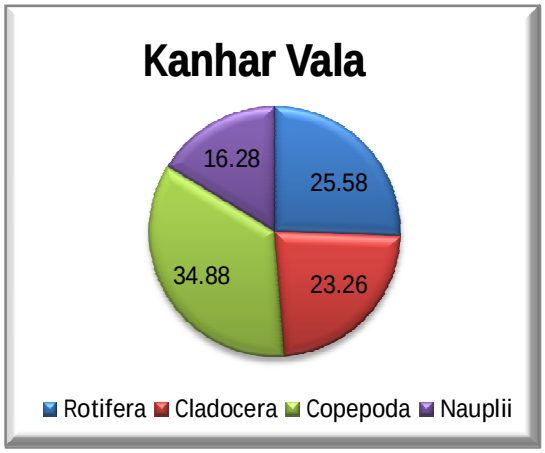
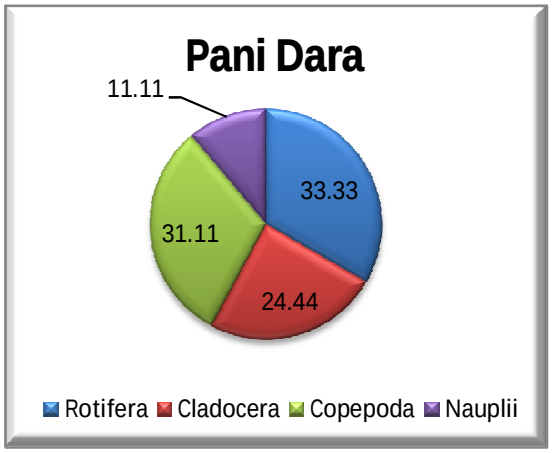
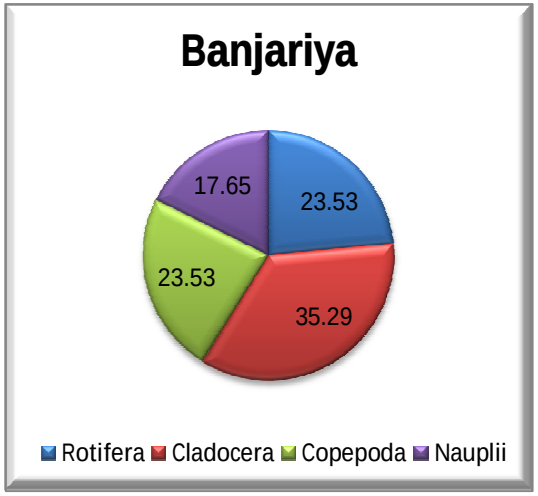
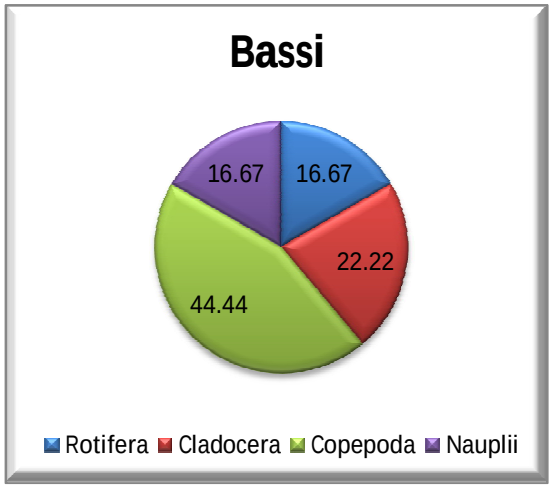
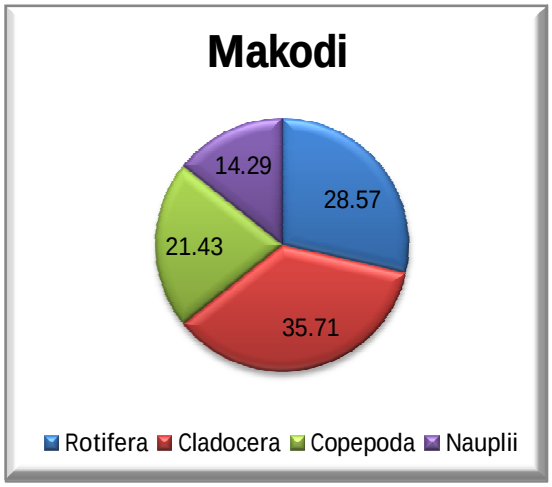
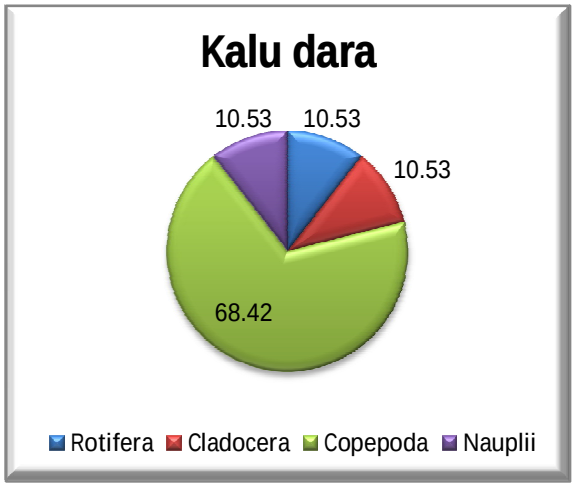

Kanhar Vala
16.28
25.58
34.88
23.26
Rotifera
Cladocera
Copepoda
Nauplii


Pani Dara
11.11
33.33
31.11
24.44
Rotifera
Cladocera
Copepoda
Nauplii

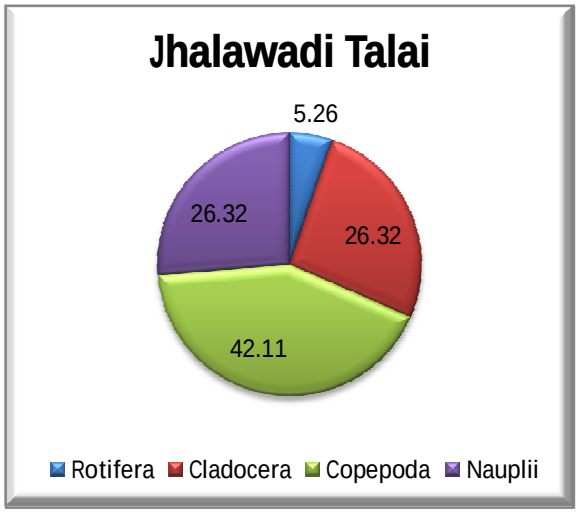

Banjariya
17.65
23.53
23.53
35.29
Rotifera
Cladocera
Copepoda
Nauplii

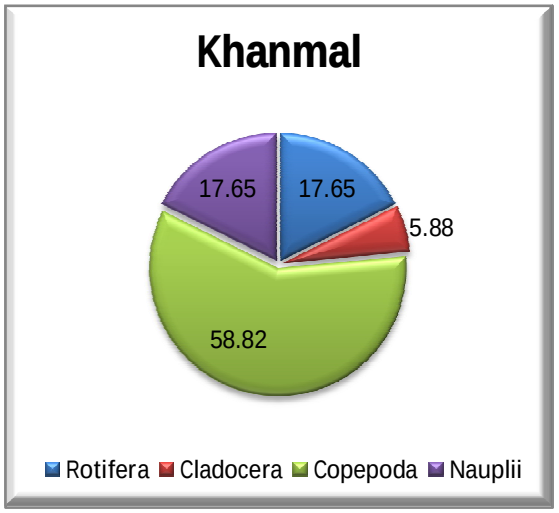

Bassi
16.67
16.67
22.22
44.44
Rotifera
Cladocera
Copepoda
Nauplii

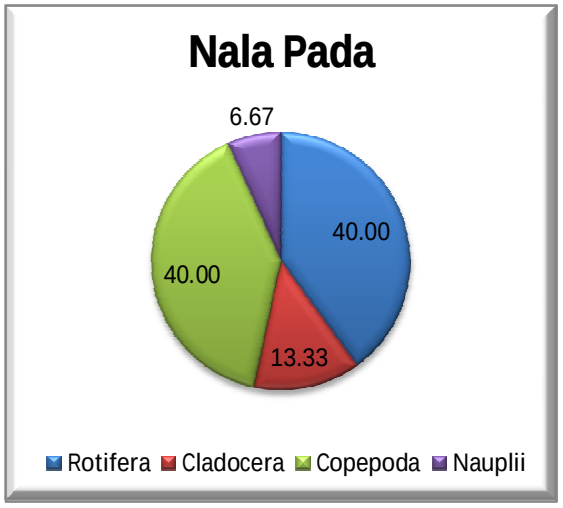

Makodi
14.29
28.57
21.43
35.71
Rotifera
Cladocera
Copepoda
Nauplii


Kalu dara
10.53
10.53
10.53
68.42
Rotifera
Cladocera
Copepoda
Nauplii

Cont…


Jhalawadi Talai
5.26
26.32
26.32
42.11
Rotifera
Cladocera
Copepoda
Nauplii


Khanmal
17.65
17.65
5.88
58.82
Rotifera
Cladocera
Copepoda
Nauplii


Nala Pada
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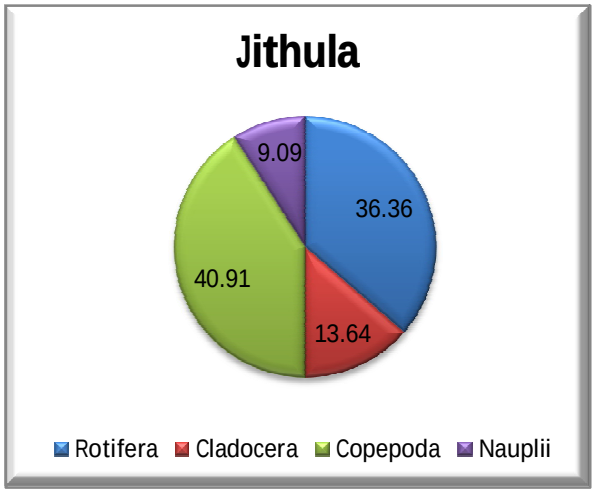
40.00
40.00
13.33
Rotifera
Cladocera
Copepoda
Nauplii


Jithula
9.09
36.36
40.91
13.64
Rotifera
Cladocera
Copepoda
Nauplii

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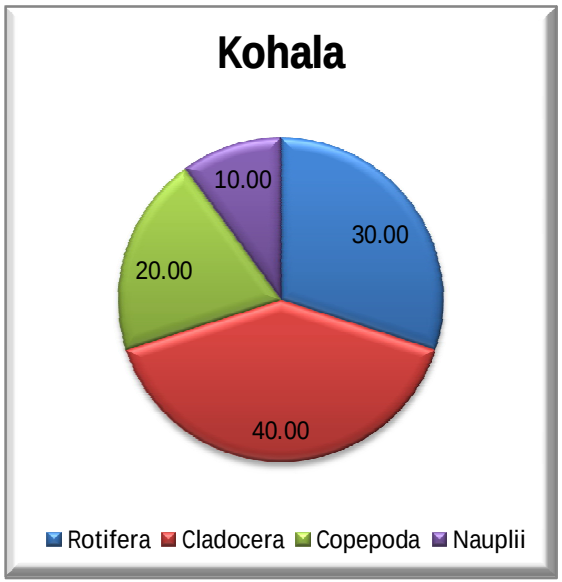
Kohala
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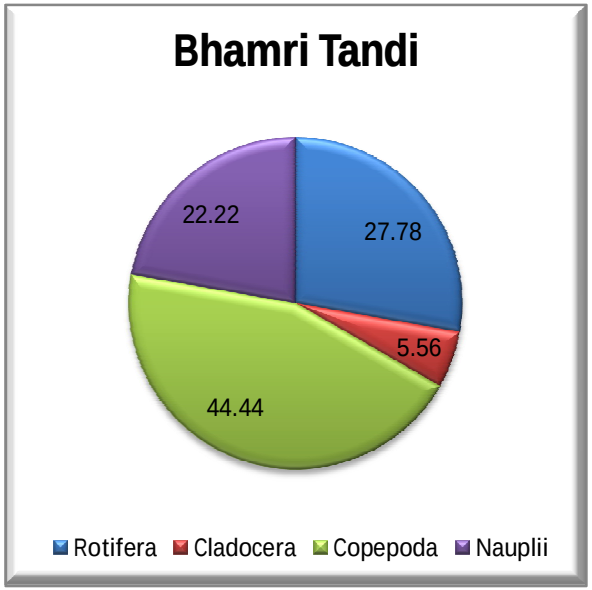
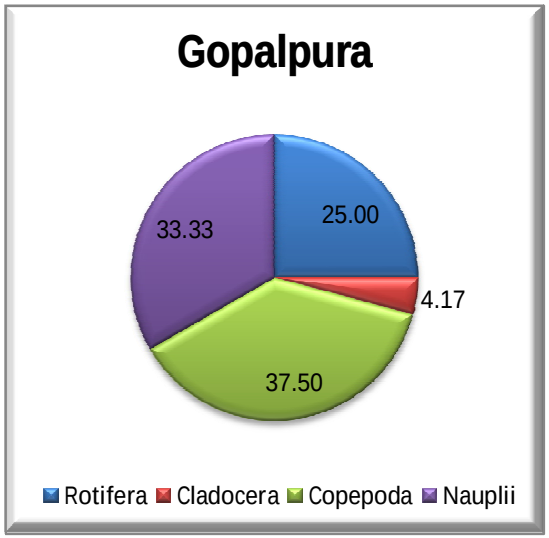
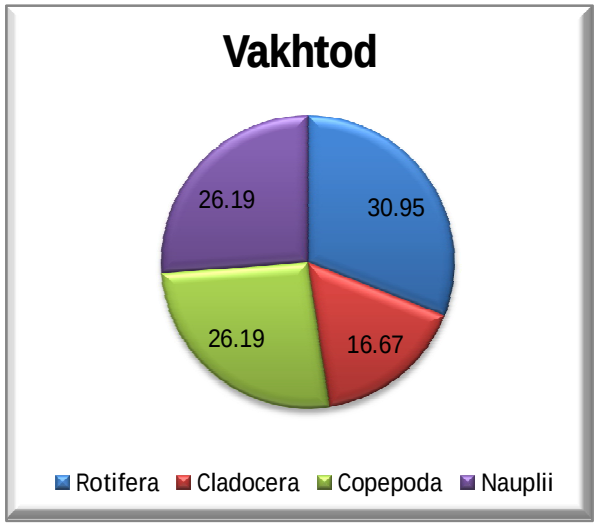
40.00
20.00
10.00
Rotifera
Cladocera
Copepoda
Nauplii


Bhamri Tandi
27.78
5.56
44.44
22.22
Rotifera
Cladocera
Copepoda
Nauplii


Gopalpura
25.00
4.17
37.50
33.33
Rotifera
Cladocera
Copepoda
Nauplii


Vakhtod
30.95
16.67
26.19
26.19
Rotifera
Cladocera
Copepoda
Nauplii

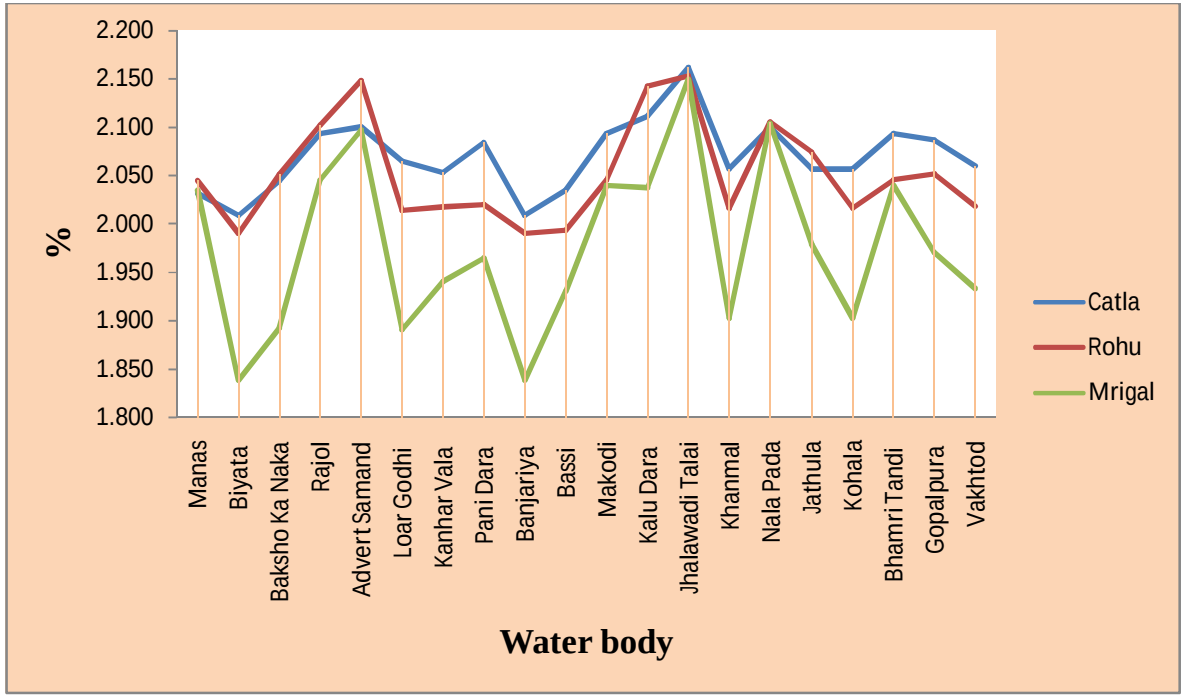


Fig 4.21 Specific growth rate of IMC in selected micro-water sheds

Growth performance of Indian major Carps *vis-a-vis* biotic factors in selected micro-watersheds of Southern Rajasthan

Rajpriyanka Rathor*Dr. M.L. Ojha**

Research Scholar **Major Advisor**

ABSTRACT

The present study deals with the**"Growth performance of Indian major Carps *vis-a-vis* biotic factors in selected micro-watersheds of Southern Rajasthan".** A total 20 micro-watersheds of four districts (Udaipur, Dungarpur, Banswara and Pratapgarh) of Rajasthan were chooses for this purpose.water quality parameters viz.,water temperature (26.2-32.7□C), pH (7.3-10.05), dissolved oxygen (6.71-10.21mg/l), free CO_2(0-0.45mg/l), total dissolved solids (76.55-473mg/l), electrical conductivity (160.4-965mS/cm), total hardness (61-200mg/l), total alkalinity (34-141mg/l), salinity (0-0.5ppt), NO_3-N (0.089-0.558mg/l), HPO_4^{-3}(0.001-0.33mg/l), GPP (0.119-0.350gC/m^3/h), NPP (0.028-0.306gC/m^3/h) and RQ (0.017-0.286gC/m^3/h) were observed throughout the study period and indicate that the water of the selected micro-watersheds remained congenical for fish growth except very high pH in a few water bodies. The phytoplankton counts in different micro-watersheds were ranged between 125 to 310 nos/l. Whereas; the counts of total zooplankton in different water bodies were very less, as such the zooplankton counts varied between 3 to 12Nos/l. On comparing different groups it was observed that Copepoda dominated the zooplanktonic counts followed by rotifera, cledocera and nauplii. The relationship between zooplankton, primary productivity and physico-chemical parameter were also calculated statistically. The present investigation also finds out the fish growth parameters net weight gainCatla(762.38-1103.33gm), Rohu (628.31-932.16gm) and Mrigal395.15-838.29gm), net length gain Catla (18.59-30.03cm), Rohu (17.35-29.50cm) and Mrigal(9.77-28.23cm) and specific growth rate Catla(2.009-2.162%), Rohu(1.990-2.153%) and Mrigal(1.839-2.149%) and indicates the moderate productivity of the selected micro-watersheds. Further study is recommended to have better supplementary feeding and scientifically culture base fisheries for good results for fish production in micro-watersheds.

nf{k.kh jktLFkku d p;fur y?k ty {k=k e tfod dkjdk d lnHk e Hkkjrh; 'kQj ehuk dk of) in'ku

jktfi;dk jkBkM* Mk- eukgj yky vk>k**

Lukrdkùkj 'kk/k Nk=k e[; lykgdkj

vu{kip.k

oreku 'kk/k e nf{k.kh jktLFkku d p;fur y?k ty {k=k e tfod dkjdk d lnHk e Hkkjrh; 'kQj ehuk dh of) in'ku ij v/;;u fd;k x;k gA bl mí'; d fy, jktLFkku d pkj ftyk ¼mn;ij] Mxjij] ckloMk vkj irkix<½ l chl y?k ty {k=k dk puko fd;k x;k gA bl ij v/;;u dh vof/k d nkjku ty dh x.koùkk d ekud tl] tyh; rkieku ¼26-2 l 32-7 fMxh lUVhxM½] ih- ,p- ¼7-3 l 10-05½] ?kyu 'khy vkDlhtu ¼6-71 l-10-21 feyhxke ifr yhVj½] eDr dkcu&MkbvkDlkbM ¼0 l 0-45 feyh xke½ ifr yhVj] dy ?kyu'khy Bkl ¼76-55 l 473 feyh xke ifr yhVj½] tyh; pkydrk ¼160-4 l 965 feyh lkbeku ifr lUVhehVj½] dy dBkjrk ¼61 l 200 feyhxke ifr yhVj½] dy {kkjh;rk ¼34 l 141 feyhxke ifr yhVj½] yo.kh;rk ¼0 l 0-5 ikV ij gtkj½] ukbVV ukbVktu ¼0-089 l 0-558 feyhxke ifr yhVj½ vkFkkQkLQV ¼0-001 l 0-33 feyhxke ifr yhVj½] dy ikFkfed mRikndrk ¼0-119 l 0-350 xke dkcu ifr ?ku ehVj ifr ?kVk½] 'k) ikFkfed mRikndrk ¼0-028 l 0-306 xke dkcu ifr ?ku ehVj ifr ?kVk½ n[kh x;h vkj tyh; ekud ;g n'kkr g fd p;fur y?k&ty {k= ehu dh of) d fy, vudy g] flok; dN tyh; fudk;k dk NkMdj ftudk ih- ,p- eku vR;f/kd gA fofHkUu y?k ty {k=k e iknilyodk dh l[;k 125 l 310 uEcj ifr yhVj d e/; ik;h x;h gA

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* Lukrdkùkj 'kk/k Nk=k] tydf"k foHkkx] ekRL;dh egkfo|ky;] egkjk.kk irki df"k ,o ik|kfxdh fo'ofo|ky;] mn;ij ¼jkt-½

** lgk;d vkpk;] tydf"k foHkkx] ekRL;dh egkfo|ky;] egkjk.kk irki df"k ,o ik|kfxdh fo'ofo|ky;] mn;ij ¼jkt-½

ogh fofHkUu tyfudk;k e tUr lyodk dh l[;k cgr de Fkh x;h gA tUrlyodk dh ryuk mud leg d vulkj dju ij lcl T;knk dkihikMk dk n[kk x;k bld ckn jkVhQjk] DyMklhjk vkj U;iyhvkb bldk vulj.k djr gA tUr lyod] ikFkfed mRikndrk vkj Hkkfrd o jlk;fud ekudk d e/; lkf[;dh; #i l Hkh lc/k dh x.kuk dh x;h gA oreku v/;;u d vUrxr ehu of) d ekudk 'k) otu vftr dryk ¼762-38 l 1103-33 xke½ jkg ¼628-31 l 932-61 xke½ vkj exyk ¼395-15 l 838-29 xke½ 'k) yEckb vftr dryk ¼18-59&30-03 lUVhehVj½ jkg ¼17-35 l 29-50 lUVhehVj½ vkj exyk ¼9-77 l 28-23 lUVhehVj½ vkj fof'k"V of) nj dryk ½2-009 l 2-162 ifr'kr½ jkg ¼1-990 l 2-153 ifr'kr vkj exyk ¼1-839 l 2-149 ifr'kr½ dh Hkh x.kuk dh x;h vkj ; ekud n'kkr g fd p;fur y?k ty {k= e/;e mRiknd gA vkx d v/;;u d fy, flQkfj'k dh g fd vPNk df=e Hkk tu vkj oKkfud rjhd l ikyu ij ehu dk vPNk mRiknu gk ldrk g p;fur y?k ty{k=k eA