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# A Study on Planktonic Diversity in Reference to Major Carps Productivity in Govindgarh Lake, Rewa (M.P.)

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**Abstract:** *When discussing diversity in zoology, plankton deserve special attention due to their fundamental roles in aquatic ecosystems and the immense variety of species within this group. By studying and understanding planktonic diversity, we gain valuable knowledge about the intricate web of life in our oceans, lakes, and rivers.*
*Seasonal variation of plankton was recorded highest 485 org./L in summer followed by 332 org./L and 267 org./L in winter and rainy season respectively during the first period of research, same variation season wise 497 in summer followed by 346 org./L and 280 org./L in winter and rainy seasons respectively.*

**Keywords:** aquatic ecosystem, intricate web, variation etc

## I. INTRODUCTION

Diversity in zoology refers to the variety of animal species found within the field of study. When it comes to discussing diversity in zoology, it is important to mention phytoplankton as one aspect of this diversity. Phytoplankton, although not considered animals but rather microorganisms, play a significant role in the study of zoology as they form the foundation of aquatic food chains.

Phytoplankton are microscopic, photosynthetic organisms that drift in oceans, lakes, and other bodies of water. They are primarily made up of various types of algae, such as diatoms, dinoflagellates, and cyanobacteria. These organisms are vital to the health of aquatic ecosystems as they provide essential nutrients and oxygen to other organisms.

The diversity of phytoplankton has numerous implications for zoology. Firstly, it serves as a food source for many zooplankton species, which in turn are consumed by larger aquatic organisms, including fish, crustaceans, and whales. Secondly, phytoplankton play a crucial role in the global carbon cycle, as they absorb carbon dioxide during photosynthesis, helping mitigate climate change. Additionally, the distribution and abundance of different phytoplankton species can be indicators of ecosystem health and water quality, making them valuable in ecological research and monitoring.

Understanding the diversity of phytoplankton and their interactions with other organisms is fundamental in the field of zoology. It allows scientists to comprehend the intricate relationships within aquatic ecosystems, study population dynamics, and investigate the impact of climate change and pollution on these delicate systems. By studying the diversity of phytoplankton, zoologists can gain insights into the broader biodiversity of our planet and develop conservation strategies to protect these vital ecosystems.

Zooplankton are a diverse group of small, drifting organisms that inhabit marine and freshwater ecosystems. They are classified into different taxonomic groups, including various types of crustaceans, such as copepods, krill, and shrimp, as well as other small organisms like jellyfish, rotifers, and larval forms of larger animals. Zooplankton play crucial roles in the food chain as primary consumers, feeding on phytoplankton (microscopic plants) and forming a vital link between primary producers and higher trophic levels.

In conclusion, diversity in zoology encompasses the vast range of animal species, characteristics, and ecological roles observed in the animal kingdom. Zooplankton exemplifies this diversity, showcasing a plethora of species with unique

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adaptations and ecological functions. Understanding the diversity of zooplankton and their ecological significance contributes to our knowledge of ecosystems and the intricate web of life within them.

Chandrasekhar and Kodarkar (1997) studied to the diversity of zooplankton in PowaiReservior, Mumbai. Chapman (1996) published a guide for the analysis of properties of water for the assessment of biological properties of water as well as sediment and the environment monitoring of water.

Abonyiet. al., (2018) studies to functional richness outperforms taxonomic richness in predicting ecosystem functioning in natural phytoplankton communities. Craven et. al., (2018) studied to multiple facets of biodiversity drive the diversity-stability relationship. Garcia-Palacios et. al., (2018) studied to Climate mediates the biodiversity of an ecosystem stability relationship worldwide. Hillebrandet. al., (2018) studied to decomposing multiple dimensions of stability in global change experiments in various water bodies.

Hodappet. al., (2019) examined and give the concept of unifying resource and use efficiency in ecology along with physical, chemical and biological parameters of the water body. Van der Plas (2019) studied the ecosystem functioning and biodiversity with various biological communities of aquatic ecosystem. Jonah and George (2019) studied the properties of water and its impact on zooplankton community and stated that how the zooplankton impact the quality of water in EtimEkpo River, Akwa, Nigeria.Jonah et. al., (2020) observed to agrochemical impact on the quality of water and distribution and abundance of macro invertebrates in a river of Nigeria.

## II. MATERIALS AND METHODS

### (A) Description of site:

The Govindgarh lake is one of the unique water body in M.P. and located in south of Rewa district at a distance of 20 km. with a longitude 81°15'0" and latitude 24°20'25". It comes under the Rewa district and in Huzur tehsil. The lake is connected with Rewa-Shahdol and Satna-Sidhi Road. The lake was formed by impounding of small nalla originating from Kaimore hill. With a view to storing rain water, the Maharaja of Rewa at that time built a bandh across the nalla to form a tank in 1958.

Various species of fishes were bred in this lake and feed of gram and small pills of wheat flour was given to them twice a day from the budget sanctioned by Rewa head office. Fishing in the lake was totally prohibited. This practice continued till it was handed over to the M.P. Government. Now fisheries department looks after it and exports fishes worth several thousand rupees every year.

### (B) Collection and Identification of Plankton)

**Plankton net:**

The plankton net is a field-equipment used to trap plankton. It has a polyethylene filter of a defined mesh size and a graduated measuring jar attached to the other end. A handle holds the net. The mesh size of the net determines the size range of the plankton trapped.

**Sampling procedure:**

Plankton net number 25 of mesh size 60 µm was used for collecting samples. 100 liters of water was measured in a graduated bucket and filtered through the net and concentrated in a 100 ml bottle. Samples were collected as close to the water surface as possible in the morning hours and preserved for further analysis.

**Labelling:**

The samples are labelled with the date, time of sampling, study area, lake name, sampling site, name and the volume measured and pasted on the containers.

**Preservation of the sample:**

Between the time that a sample is collected in the field and until its analysis in the laboratory, physical, chemical and biochemical changes may take place altering the intrinsic quality of the sample. It is therefore necessary to preserve the samples before shipping, to prevent or minimize changes. This is done by various procedures such as keeping the samples in the dark, adding chemical preservatives, lowering the temperature to retard reactions by freezing or by a combination of these methods. For a phytoplankton sample to be analysed for an extended period, commonly two preservatives are used: Lugol's iodine using acetic acid which will stain cells brownish yellow and will maintain cell

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morphology and of 4% formaldehyde. The samples collected for this study were preserved by adding suitable amounts of 1 ml chloroform to act as the narcotizing agent and 2ml of 4% formalin for preservation and analyses.

**Concentration technique:**

The plankton nets were used to collect samples for the qualitative and quantitative estimation of the plankton, by filtering a known volume of water (100 liters) through the net. The sample was allowed to settle for 24-48 hours and was further concentrated to approximately 30 ml by decanting. The concentration factor is used during the calculation.

**Qualitative and quantitative evaluation of plankton:**

Detailed analysis of phytoplankton populations are done by estimating the numbers in each species. The phytoplankton consisting of individual cells, filaments and colonies are counted as individual cells. When colonies of species are counted, the average number of cells per colony is counted, and in filamentous algae, the average length of the filament has to be determined.

**Mounting the slides:**

Preserved samples in bottles are mixed uniformly by gentle inversion and then one drop of the sample is pipetted out from a calibrated pipette on the glass slide for analysis. A cover slip is carefully placed ensuring no air bubbles remain and the cover slip is ringed with a transparent nail enamel to prevent evaporation during the counting process.

**Microscope:**

A binocular compound microscope is used in the counting of plankton with different eyepieces such as 10X and 40X. The microscope is calibrated using an ocular micrometer.

**Drop count method:**

In this method one drop of the sample is pipetted out from a calibrated pipette on a glass slide and the planktonic organisms are counted in strips. The total area under the cover slip represents the number of organisms present per given volume of the sample. This volume expanded to an appropriate factor yields the organisms per liter of water for the pond.

**Phytoplankton counting units:**

Some plankton are unicellular while others are multicellular (colonial), posing a problem for enumeration. For analysis, a colony of plankton is accounted as a single count.

Formula for calculation of organisms per liter:

Total plankton count per litre= A+(l/L_+(n/v)

Where, A= number of organisms per drop

L= volume of original sample (1)

n= total volume of concentrated sample (ml)

v= volume of one drop (ml)

**Zooplankton:**

Zooplanktons were quantitatively estimated by filtering 100 liters of water from the surface through 40 HD silk bolting cloth having 100 mesh/cm. The samples concentrated to 100 ml were preserved in 5 percent buffered formalin. Before counting the samples were thoroughly mixed by rotating the bottle. Subsamples were taken in triplicates on Rafter cells using a volumetric pipette. The complete area of the slide was counted from the three samples to give average number per 100 liters. The systematic identification of zooplankton was done by using standard literature books like Pennak (1953), Edmondson (1959), Tonapi (1980), Sehgal (1983), Michael and Sharma (1988) and APHA (1989). Identification of plankton was done with the help of keys given by Desikachary (1959), Ward and Whipple (1959), Ramanathan (1964), APHA (1980), Biswas (1980), Palmer (1980), Trivedi and Goel (1984), Sarode and Kamat (1984) and Adoni (1985).

## III. OBSERVATION AND RESULT

**Plankton**

Monthly average value of plankton was ranged from 92 to 634 org./L at station A, 88 to 636 org./L at station B, 94 to 636 org./L at station C, 90 to 621 org./L at station D with mean value 91 to 629 org./L at all stations during the first year of research period.In the second year of research period, monthly average value of plankton was ranged from 102

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to 650 org./L at station A, 101 to 649 org./L at station B, 99 to 630 org./L at station C, 100 to 637 org./L at station D with mean value 101 to 642 org./L at all stations.

Station wise annual variation and standard deviation of plankton was recorded 365 org./L and ±183 at station A, 358 org./L and ±180 at station B, 362 org./L and ±182 at station C, 360 org./L and 178 at station D with mean value 361 and 181 at all stations during the first year of research period. While it was record 381 org./L and ±182 at station A, 371 org./L and ±180 at station B, 369 org./L and ±178 at station C, 376 org./L and ±177 at station D with mean value 374 org./L and ±179 at all stations during the second year of study period.

Seasonal variation of plankton was recorded highest 485 org./L in summer followed by 332 org./L and 267 org./L in winter and rainy season respectively during the first period of research, same variation season wise 497 in summer followed by 346 org./L and 280 org./L in winter and rainy seasons respectively.

During the research period in first year august was the month in which average least value was record with 91 org./L and June was the month in which average highest value was 629 org./L. In the second year average least value was in august with 101 org./L and highest in the month of June with 642 org./L organism per liter.

**Phytoplankton**

Monthly variation mean value of phytoplankton was recorded 50 to 342 org./L at station A, 47 to 337 org./L at station B, 52 to 350 org./L at station C, 50 to 342 org./L at station D with mean value 49 to 341 org./L at all stations in the first year of research period.

In the second year of monthly variation mean value of phytoplankton was recorded 56 to 358 org./L at station A, 56 to 357 org./L at station B, 56 to 357 org./L at station C, 53 to 340 org./L at station D with mean value 55 to 353 org./L at all stations.

Average station wise variation of phytoplankton was recorded 197 org./L, 190 org./L, 199 org./L, 198 org./L at stations A, B, C and D with mean value 196 org./L at all stations respectively in the first year of study period, while it was 209 org./L at station A, 204 org./L at station B, 211 org./L at station C, 198 at station D with mean value 206 org./L at all stations in the second year of research period.

Station wise standard deviation of phytoplankton was recorded 99 org./L at station A, 96 org./L at station B, 100 org./L at station C, 98 org./L at station D with mean value 98 at all stations during the first year of research period. In the period of second year it was 100 org./L at station A, 99 org./L at station B, 99 org./L at station C, 95 org./L at station D with mean value 98 org./L at all stations.

Seasonal variation of phytoplankton was recorded 263 org./L in summer, 180 org./L in winter and 145 org./L in rainy seasons during the first year of research period.In the second year of research period, seasonal variation of phytoplankton 273 org./L summer, 191 org./L winter and 154 org./L in rainy seasons.

**Phytoplankton**

During the course of study four groups of phytoplankton vi3, chlorophyceae, cyanophyceae, bacillariophyceae and euglenophyceae were identified. In which chlorophyceae reported four species vi3, Cladophora, chlorella, Protococcus and Teraedron, cyanophyceae reported four species vi3. Asterionella, Fragilaria, Nistzchiaand pinnularia, Bacillariophyceae reported Microcystis, Anabaena, Coelosphaerium and Oscillatoria and euglenophyceae reported euglenas and phacus.

Average annual value of phytoplankton's group ranged from 49 to 341 organisms/liter in which cyanophyceae ranged 20 to 107 organisms per liter was dominant followed by chlorophyceae range from 11 to 102 organisms per liter, Bacillariophyceae from 7 to 90 organisms per liter and euglenophyceae from 11 to 49 organisms per liter. Average seasonal value highest in 263 organisms per liter followed by winter 181 organisms per liter and rainy season with 145 organisms per liter.

In the second year of research period phytoplankton's group annual average ranged from 8 to 109 organisms per liter of Bacillariophyceae, 20 to 108 organisms per liter of cyanophyceae 15 to 100 organisms per liter of chlorophyceae 6 to 40 organisms per liter annual average range of all group from 55 to 357 organisms per liter.

Seasonal average number of phytoplankton's group highest in summer season followed by winter and rainy seasons with 72,47 and 42 organisms per liter respectively of chlorophyceae, cyanophyceae group highest in summer with 79

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organisms per liter followed by winter 59 organisms per liter and rainy season with 47 organisms per liter. Bacillariophyceae seasonal value highest in winter season followed by rainy and summer seasons and 34 organisms per liter in summer seasons followed by winter and rainy seasons with 34, 27 and 23 organisms per liter respectively.

**Zooplankton**

Monthly variation mean value of zooplankton was recorded 42 to 292 org./L at station A, 41 to 299 org./L at station B, 42 to 286 org./L at station C, 41 to 279 org./L at station D with mean value 91 to 629 org./L at all stations in the first year of research period. It was 46 to 293 org./L at station A, 45 to 292 org./L at station B, 43 to 274 org./L at station C, 47 to 299 org./L at station D with mean value 101 to 642 org./L recorded during the tenure of second year research period.

Station wise average fluctuation and standard deviation of zooplankton was recorded 168 org./L and ±84 at station A, 168 org./L and ±85 at station B, 163 org./L and ±82 at station C, 162 org./L and ±80 at station D with mean value 361 org./L and ±181 at all stations during the first year of research period. While station wise average fluctuation and standard deviation of zooplankton was recorded. In the second year of research period 171 org./L and ±82 at station A, 167 org./L and ±81 at station B, 158 org./L and ±79 at station C, 178 org./L and ±82 at station D, with mean value 374 org./L and ±179 with all stations.

Seasonal variation of Zooplankton was highest in summer season with 485 org./L followed by 332 org./L and 267 org./L in winter and rainy seasons respectively during the first year of research period. Seasonal variation of zooplankton was 497 org./L in summer, 346 org./L in winter and 280 org./L in rainy Seasons during the second year of research period.

During the study period five group of zooplankton was examined as protozoa, rotifer, Cladocera, copepod and Ostracoda. In which protozoa group recorded two species as Difflugia and euglypha, rotifer group recorded keratelaatropica K. facta B rubens, monostula, Cladocera recorded daphnia, moina and diaphanosoma, copepod recorded Cyclops, diatoms and Ostracoda recorded cypris and steno cypris.Annual average zooplankton groups were ranged from 42 to 288 organisms per liter.In which protozoa ranged from 11 to 55 organisms per liter, rotifers from 10 to 86 organisms per liter, Cladocera from 12 to 69 organisms per liter, copepod from 4 to 46 organisms per liter and Ostracoda from 5 to 41 organisms per liter during the first year of research period.

Seasonal average value of phytoplankton's group was recorded highest in summer season followed by winter and rainy seasons with 221, 152 and 123 organisms per liter during the first year of research work.Annual average value of Protozoans was 25 organisms per liter, rotifer 46 organisms per liter Cladocera's 42 organisms per liter, copepods 30 organisms per liter and ostracods 26 organisms per liter.Average seasonal value of zooplankton's group highest in summer 224 organisms per liter followed by 156 in winter and 126 organisms per liter in rainy seasons respectively during the second year of research work.

## IV. DISCUSSION

Seasonal average number of phytoplankton's group highest in summer season followed by winter and rainy seasons with 72,47 and 42 organisms per liter respectively of chlorophyceae, cyanophyceae group highest in summer with 79 organisms per liter followed by winter 59 organisms per liter and rainy season with 47 organisms per liter. Bacillariophyceae seasonal value highest in winter season followed by rainy and summer seasons and 34 organisms per liter in summer seasons followed by winter and rainy seasons with 34, 27 and 23 organisms per liter respectively.

Moitra and Mukherjee (1992) reported that distribution and composition of planktonic communities vary considerably from one water body to another.

Phytoplankton is primary producer and plays an important role in the material circulation and energy flow in the aquatic ecosystem. Ariyadej et al. (2004) reported that phytoplankton controls the growth, reproduction capacity, and population characteristics of other aquaticorganisms. Phytoplankton is affected by different environmental factors such as pH, light, and temperature (Celekli et al., 2007). Pillai et al. (2011) reported the Bacillariophyceae as the most dominant group in Pachiparai dam, Kanyakumari district, Tamil Nadu, India. The productivity of an aquatic environment is directly correlated, with the density of phytoplankton (Narasimha and Banarjee, 2013) as they play an important role as primary producers and thus can affect higher trophic levels by providing nutritional bases for

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zooplankton and subsequently to other invertebrates and fish. High density of phytoplankton in summer was also observed by Nandan and Aher (2005) and Chellappa et al. (2008). Baba and Pandit (2014) reported that phytoplankton population show two peaks, one in summer and other in autumn, with Bacillariophyceae dominating in autumn and winter, Chlorophyceae dominating in spring and both Cyanophyceae and Euglenophyceae dominating in summer. Singh (2015) reported the 5 groups of phytoplankton namely Cyanophyceae, Bacillariophyceae, Chlorophyceae, Dinophyceae and Euglenophyceae in open pond of Town Deeg (Bharatpur) Rajasthan.

During the study period five group of zooplankton was examined as protozoa, rotifer, Cladocera, copepod and Ostracoda. In which protozoa group recorded two species as Difflugia and euglypha, rotifer group recorded keratelaatropica K. facta B rubens, monostula, Cladocera recorded daphnia, moina and diaphanosoma, copepod recorded Cyclops, diatoms and Ostracoda recorded cypris and steno cypris. Annual average zooplankton groups were ranged from 42 to 288 organisms per liter.

**Graph 15: Mean annual and seasonal variation of Plankton in Org/L from November 2019 to October 2021 in Govindgarh Lake, Rewa (M.P.)**

| S. No. | Month's Name | RS1 | RS2 | RS3 | RS4 | Average | RS1 | RS2 | RS3 | RS4 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Nov | 312 | 300 | 307 | 296 | 304 | 335 | 313 | 305 | 319 | 318 |
| 2 | Dec | 267 | 251 | 253 | 265 | 259 | 291 | 264 | 274 | 289 | 280 |
| 3 | Jan | 286 | 275 | 286 | 287 | 284 | 305 | 288 | 296 | 306 | 299 |
| 4 | Feb | 356 | 352 | 348 | 354 | 353 | 376 | 365 | 363 | 374 | 370 |
| 5 | Mar | 428 | 419 | 418 | 410 | 419 | 445 | 432 | 419 | 427 | 431 |
| 6 | Apr | 551 | 531 | 543 | 545 | 543 | 560 | 544 | 554 | 554 | 553 |
| 7 | May | 628 | 618 | 636 | 621 | 626 | 642 | 631 | 630 | 635 | 635 |
| 8 | Jun | 634 | 636 | 624 | 621 | 629 | 650 | 649 | 630 | 637 | 642 |
| 9 | Jul | 211 | 218 | 223 | 219 | 218 | 235 | 231 | 228 | 243 | 234 |
| 10 | Aug | 92 | 88 | 94 | 90 | 91 | 102 | 101 | 99 | 100 | 101 |
| 11 | Sep | 126 | 134 | 127 | 136 | 131 | 133 | 147 | 145 | 143 | 142 |
| 12 | Oct | 483 | 478 | 487 | 475 | 481 | 495 | 491 | 484 | 487 | 489 |
| Average | | 365 | 358 | 362 | 360 | 361 | 381 | 371 | 369 | 376 | 374 |
| Min. | | 92 | 88 | 94 | 90 | 91 | 102 | 101 | 99 | 100 | 101 |
| Max. | | 634 | 636 | 636 | 621 | 629 | 650 | 649 | 630 | 637 | 642 |
| SD± | | 183 | 180 | 182 | 178 | 181 | 182 | 180 | 178 | 177 | 179 |
| Season's Name | | RS1 | RS2 | RS3 | RS4 | Average | RS1 | RS2 | RS3 | RS4 | Average |
| Rainy | | 266 | 269 | 267 | 267 | 267 | 280 | 282 | 276 | 281 | 280 |
| Winter | | 337 | 326 | 333 | 331 | 332 | 357 | 339 | 340 | 350 | 346 |
| Summer | | 491 | 480 | 486 | 483 | 485 | 506 | 493 | 492 | 498 | 497 |

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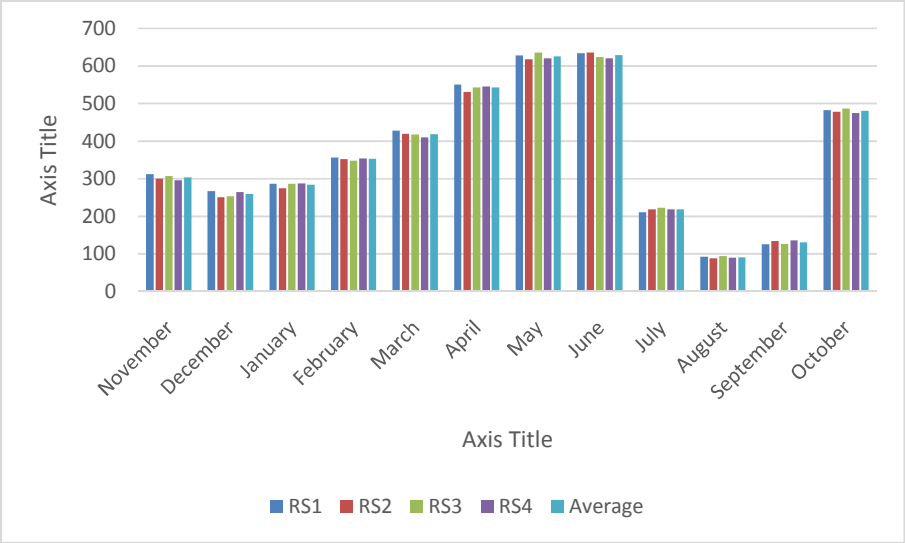
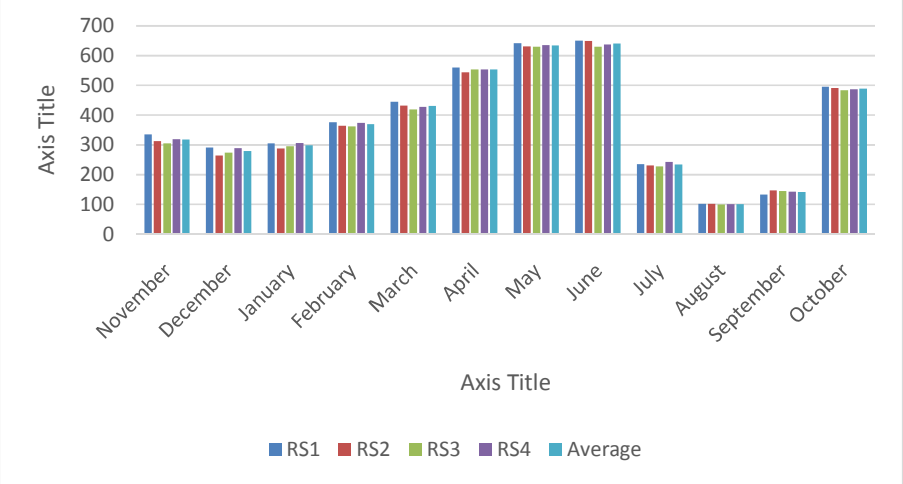
**Graph 15a: Mean annual and seasonal variation of Plankton in Org/L from November 2019 to October 2020 in Govindgarh Lake, Rewa (M.P.)**




**Graph 15b: Mean annual and seasonal variation of Plankton in Org/L from November 2020 to October 2021 in Govindgarh Lake, Rewa (M.P.)**



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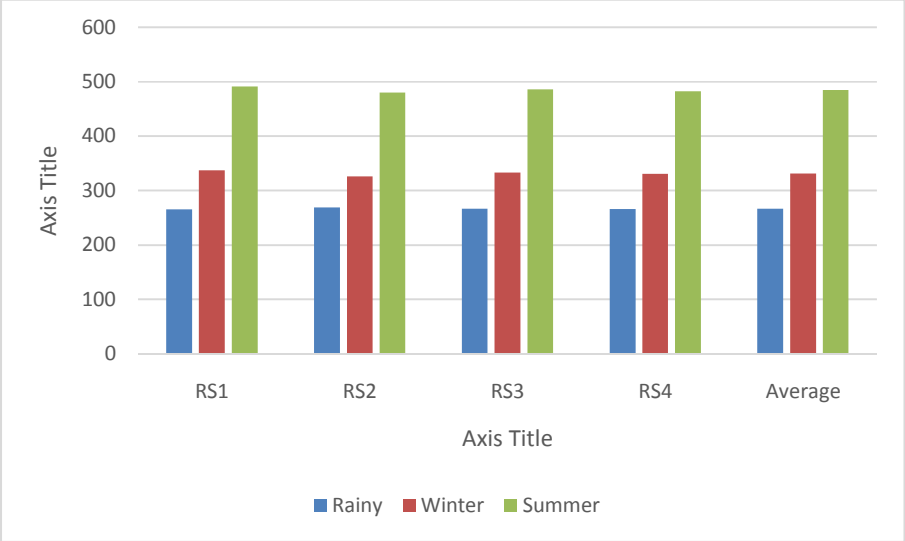
**Graph 15c: Mean annual and seasonal variation of Plankton in Org/L from November 2019 to October 2020 in Govindgarh Lake, Rewa (M.P.)**




**Graph 15d: Mean annual and seasonal variation of Plankton in Org/L from November 2020 to October 2021 in Govindgarh Lake, Rewa (M.P.)**

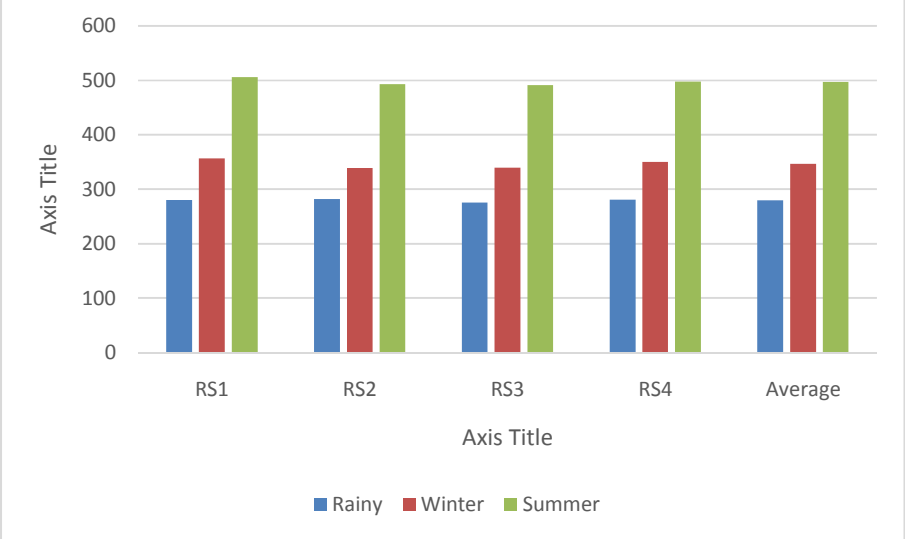


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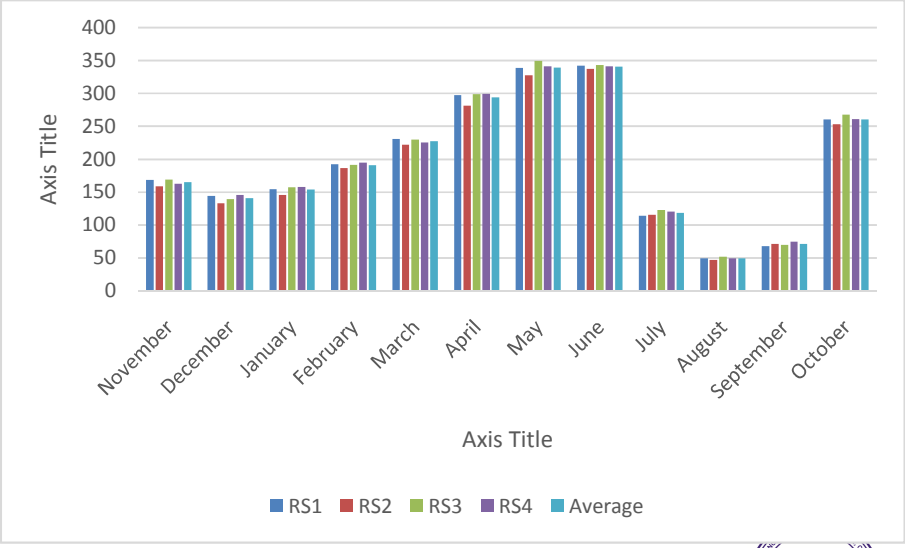
**Table 16: Mean annual and seasonal variation of Phytoplankton in Org/L from November 2019 to October 2021 in Govindgarh Lake, Rewa (M.P.)**

| S. No. | Month's Name | RS1 | RS2 | RS3 | RS4 | Average | RS1 | RS2 | RS3 | RS4 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Nov | 168 | 159 | 169 | 163 | 165 | 184 | 172 | 179 | 169 | 176 |
| 2 | Dec | 144 | 133 | 139 | 146 | 141 | 160 | 145 | 162 | 148 | 154 |
| 3 | Jan | 154 | 146 | 157 | 158 | 154 | 168 | 158 | 171 | 158 | 164 |
| 4 | Feb | 192 | 187 | 191 | 195 | 191 | 207 | 201 | 209 | 196 | 203 |
| 5 | Mar | 231 | 222 | 230 | 226 | 227 | 245 | 238 | 239 | 228 | 237 |
| 6 | Apr | 298 | 281 | 299 | 300 | 294 | 308 | 299 | 310 | 293 | 303 |
| 7 | May | 339 | 328 | 350 | 342 | 340 | 353 | 347 | 356 | 336 | 348 |
| 8 | Jun | 342 | 337 | 343 | 342 | 341 | 358 | 357 | 357 | 340 | 353 |
| 9 | Jul | 114 | 116 | 123 | 120 | 118 | 129 | 127 | 136 | 124 | 129 |
| 10 | Aug | 50 | 47 | 52 | 50 | 49 | 56 | 56 | 56 | 53 | 55 |
| 11 | Sep | 68 | 71 | 70 | 75 | 71 | 73 | 81 | 80 | 75 | 77 |
| 12 | Oct | 261 | 253 | 268 | 261 | 261 | 272 | 270 | 273 | 259 | 269 |
| Average | | 197 | 190 | 199 | 198 | 196 | 209 | 204 | 211 | 198 | 206 |
| Min. | | 50 | 47 | 52 | 50 | 49 | 56 | 56 | 56 | 53 | 55 |
| Max. | | 342 | 337 | 350 | 342 | 341 | 358 | 357 | 357 | 340 | 353 |
| SD± | | 99 | 96 | 100 | 98 | 98 | 100 | 99 | 99 | 95 | 98 |
| Season's Name | | RS1 | RS2 | RS3 | RS4 | Average | RS1 | RS2 | RS3 | RS4 | Average |
| Rainy | | 144 | 143 | 147 | 147 | 145 | 154 | 155 | 157 | 148 | 154 |
| Winter | | 182 | 173 | 183 | 182 | 180 | 196 | 186 | 196 | 184 | 191 |
| Summer | | 265 | 254 | 267 | 265 | 263 | 278 | 271 | 279 | 263 | 273 |

**Graph 16a: Mean annual and seasonal variation of Phytoplankton in Org/L from November 2019 to October 2020 in Govindgarh Lake, Rewa (M.P.)**



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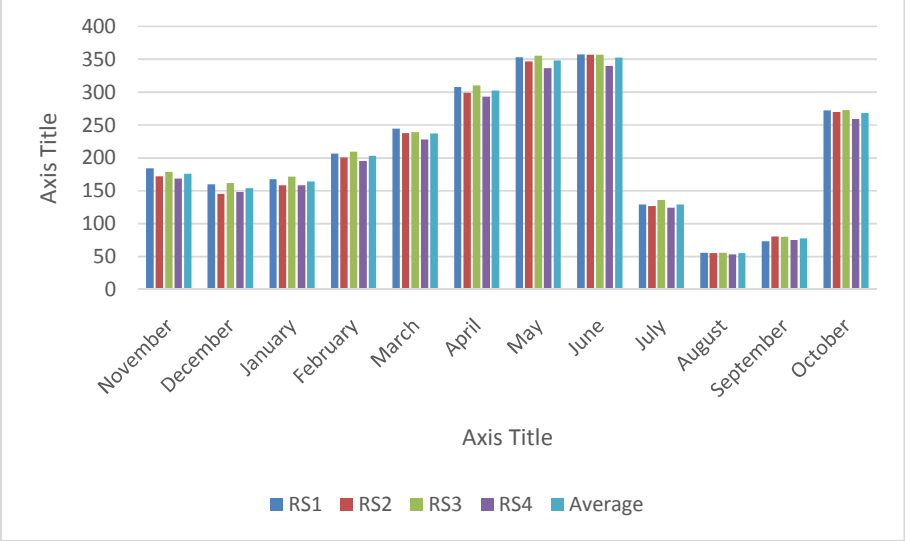
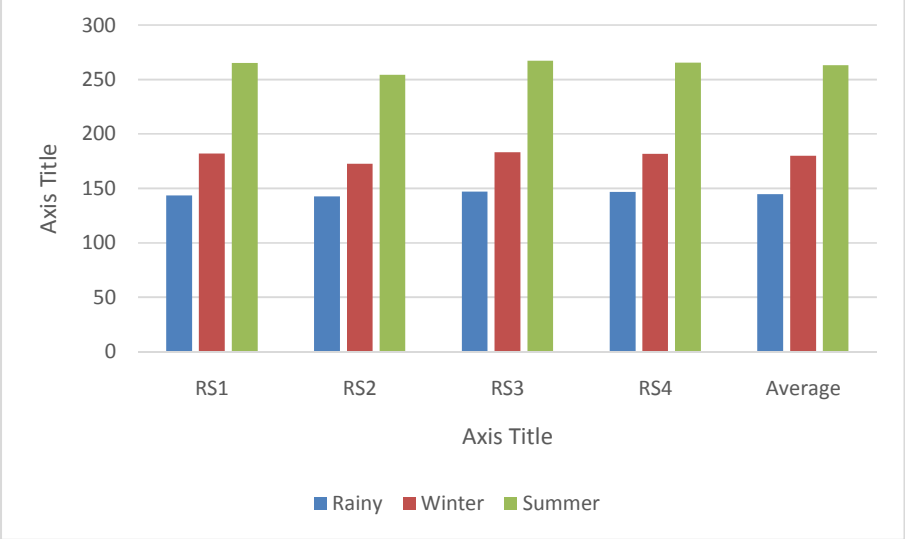
**Graph 16b: Mean annual and seasonal variation of Phytoplankton in Org/L from November 2020 to October 2021 in Govindgarh Lake, Rewa (M.P.)**




**Graph 16c: Mean annual and seasonal variation of Phytoplankton in Org/L from November 2019 to October 2020 in Govindgarh Lake, Rewa (M.P.)**



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**Graph 16d: Mean annual and seasonal variation of Phytoplankton in Org/L from November 2020 to October 2021 in Govindgarh Lake, Rewa (M.P.)**

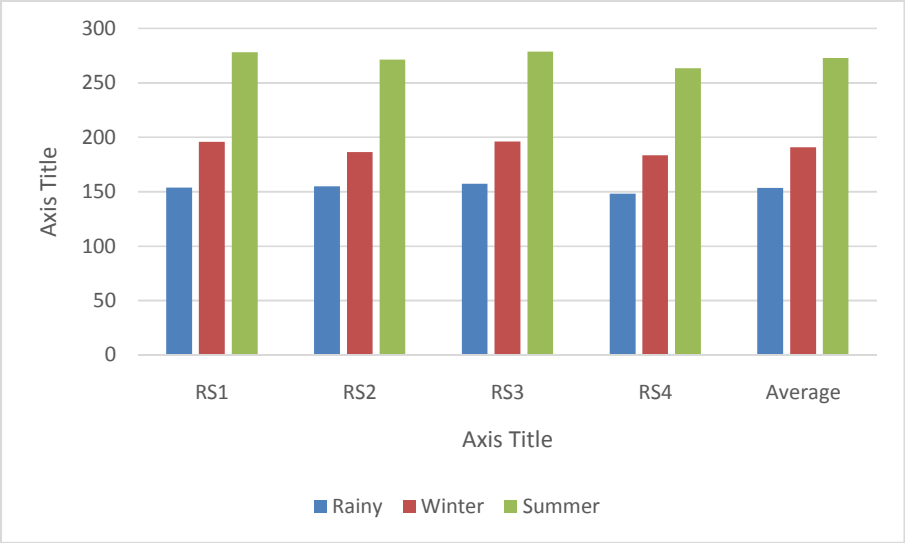


**Table 16a: Mean annual and seasonal variation of Phytoplankton's group and species wise in Org/L from November 2019 to October 2021 in Govindgarh Lake, Rewa (M.P.)**

| | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Min. | Max. | Avg. | Winter | Summer | Rainy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chlorophyceae** | **62** | **52** | **55** | **72** | **73** | **97** | **102** | **99** | **39** | **11** | **14** | **76** | **11** | **102** | **63** | **61** | **86** | **41** |
| *Chladophora sp.,* | 12 | 10 | 11 | 13 | 19 | 23 | 27 | 28 | 7 | 3 | 4 | 19 | **3** | **28** | **15** | **13** | **21** | **11** |
| *Chlorella sp.,* | 17 | 15 | 14 | 21 | 20 | 28 | 30 | 25 | 8 | 4 | 5 | 21 | 4 | 30 | 17 | 17 | 25 | 11 |
| *Protococcus sp.,* | 19 | 15 | 16 | 21 | 19 | 23 | 24 | 24 | 10 | 2 | 3 | 18 | 2 | 24 | 16 | 17 | 22 | 10 |
| *Teraedron sp.* | 14 | 12 | 14 | 17 | 15 | 23 | 21 | 22 | 14 | 2 | 2 | 18 | **2** | **23** | **15** | **15** | **19** | **10** |
| **Cyanophyceae** | **40** | **35** | **39** | **50** | **65** | **80** | **106** | **107** | **37** | **20** | **27** | **83** | **20** | **107** | **57** | **49** | **75** | **48** |
| *Asterionella sp.,* | 10 | 9 | 10 | 15 | 18 | 24 | 32 | 28 | 11 | 6 | 6 | 20 | 6 | 32 | 16 | 12 | 22 | 13 |
| *Fragilaria sp.,* | 12 | 9 | 8 | 11 | 16 | 19 | 24 | 27 | 9 | 4 | 8 | 21 | 4 | 27 | 14 | 13 | 18 | 12 |
| *Nistzchia sp.,* | 10 | 10 | 12 | 14 | 17 | 20 | 26 | 25 | 9 | 5 | 8 | 23 | 5 | 26 | 15 | 14 | 19 | 12 |
| *Pinnularia sp.* | 8 | 7 | 9 | 10 | 14 | 17 | 24 | 27 | 8 | 5 | 5 | 19 | 5 | 27 | 13 | 11 | 16 | 11 |
| **Bacillariophyceae** | **36** | **28** | **38** | **46** | **61** | **70** | **83** | **90** | **27** | **7** | **19** | **64** | 7 | 90 | 48 | 42 | 65 | 36 |
| *Microcystis sp.,* | 8 | 6 | 9 | 12 | 12 | 16 | 18 | 23 | 8 | 4 | 8 | 16 | **4** | **23** | **12** | **10** | **15** | **11** |
| *Anabaena sp.,* | 10 | 7 | 10 | 11 | 15 | 19 | 18 | 21 | 7 | 0 | 4 | 18 | 0 | 21 | 12 | 11 | 16 | 8 |
| *Coelosphaerium sp.,* | 7 | 5 | 8 | 11 | 13 | 15 | 24 | 25 | 4 | 0 | 2 | 19 | 0 | 25 | 11 | 10 | 16 | 8 |
| *Oscillatoria sp.* | 11 | 10 | 11 | 12 | 21 | 20 | 23 | 21 | 8 | 3 | 5 | 11 | 3 | 23 | 13 | 11 | 19 | 9 |
| **Euglenophyceae** | **27** | **26** | **22** | **23** | **28** | **45** | **49** | **45** | **15** | **11** | **11** | **39** | **11** | **49** | **28** | **29** | **36** | **21** |
| *Euglenaacus,* | 13 | 12 | 10 | 13 | 12 | 21 | 26 | 24 | 8 | 7 | 6 | 19 | **6** | **26** | **14** | **14** | **18** | **11** |
| *Phacus sp.* | 14 | 14 | 12 | 10 | 16 | 24 | 23 | 21 | 7 | 4 | 5 | 20 | 4 | 24 | 14 | 15 | 18 | 9 |
| | **165** | **141** | **154** | **191** | **227** | **292** | **340** | **341** | **118** | **49** | **71** | **262** | **49** | **341** | **196** | **181** | **263** | **145** |


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**Table 16a: Mean annual and seasonal variation of Phytoplankton's group and species wise in Org/L from November 2021 to October 2022 in Govindgarh Lake, Rewa (M.P.)**

| | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Min. | Max. | Avg. | Winter | Summer | Rainy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chlorophyceae** | **62** | **52** | **55** | **72** | **73** | **97** | **102** | **99** | **39** | **11** | **14** | **76** | **11** | **102** | **63** | **61** | **86** | **41** |
| *Chladophora sp.,* | 12 | 10 | 11 | 13 | 19 | 23 | 27 | 28 | 7 | 3 | 4 | 19 | **3** | **28** | **15** | **13** | **21** | **11** |
| *Chlorella sp.,* | 17 | 15 | **14** | 21 | 20 | 28 | 30 | 25 | 8 | 4 | 5 | 21 | 4 | 30 | 17 | 17 | 25 | 11 |
| *Protococcus sp.,* | 19 | 15 | 16 | 21 | 19 | 23 | 24 | 24 | 10 | 2 | 3 | 18 | 2 | 24 | 16 | 17 | 22 | 10 |
| *Teraedron sp.* | 14 | 12 | 14 | 17 | 15 | 23 | 21 | 22 | 14 | 2 | 2 | 18 | **2** | **23** | **15** | **15** | **19** | **10** |
| **Cyanophyceae** | **40** | **35** | **39** | **50** | **65** | **80** | **106** | **107** | **37** | **20** | **27** | **83** | **20** | **107** | **57** | **49** | **75** | **48** |
| *Asterionella sp.,* | 10 | 9 | 10 | 15 | 18 | 24 | 32 | 28 | 11 | 6 | 6 | 20 | 6 | 32 | 16 | 12 | 22 | 13 |
| *Fragilaria sp.,* | 12 | 9 | 8 | 11 | 16 | 19 | 24 | 27 | 9 | 4 | 8 | 21 | 4 | 27 | 14 | 13 | 18 | 12 |
| *Nistzchia sp.,* | 10 | 10 | 12 | 14 | 17 | 20 | 26 | 25 | 9 | 5 | 8 | 23 | 5 | 26 | 15 | 14 | 19 | 12 |
| *Pinnularia sp.* | 8 | 7 | 9 | 10 | 14 | 17 | 24 | 27 | 8 | 5 | 5 | 19 | 5 | 27 | 13 | 11 | 16 | 11 |
| **Bacillariophyceae** | **36** | **28** | **38** | **46** | **61** | **70** | **83** | **90** | **27** | **7** | **19** | **64** | 7 | 90 | 48 | 42 | 65 | 36 |
| *Microcystis sp.,* | 8 | 6 | 9 | 12 | 12 | 16 | 18 | 23 | 8 | 4 | 8 | 16 | **4** | **23** | **12** | **10** | **15** | **11** |
| *Anabaena sp.,* | 10 | 7 | 10 | 11 | 15 | 19 | 18 | 21 | 7 | 0 | 4 | 18 | 0 | 21 | 12 | 11 | 16 | 8 |
| *Coelosphaerium sp.,* | 7 | 5 | 8 | 11 | 13 | 15 | 24 | 25 | 4 | 0 | 2 | 19 | 0 | 25 | 11 | 10 | 16 | 8 |
| *Oscillatoria sp.* | 11 | 10 | 11 | 12 | 21 | 20 | 23 | 21 | 8 | 3 | 5 | 11 | 3 | 23 | 13 | 11 | 19 | 9 |
| **Euglenophyceae** | **27** | **26** | **22** | **23** | **28** | **45** | **49** | **45** | **15** | **11** | **11** | **39** | **11** | **49** | **28** | **29** | **36** | **21** |
| *Euglenaacus,* | 13 | 12 | 10 | 13 | 12 | 21 | 26 | 24 | 8 | 7 | 6 | 19 | **6** | **26** | **14** | **14** | **18** | **11** |
| *Phacus sp.* | 14 | 14 | 12 | 10 | 16 | 24 | 23 | 21 | 7 | 4 | 5 | 20 | 4 | 24 | 14 | 15 | 18 | 9 |
| | **165** | **141** | **154** | **191** | **227** | **292** | **340** | **341** | **118** | **49** | **71** | **262** | **49** | **341** | **196** | **181** | **263** | **145** |

**Table 17: Mean annual and seasonal variation of Zooplankton in Org/L from November 2019 to October 2021 in Govindgarh Lake, Rewa (M.P.)**

| S. No. | Month's Name | RS1 | RS2 | RS3 | RS4 | Average | RS1 | RS2 | RS3 | RS4 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | November | 144 | 141 | 138 | 133 | 139 | 151 | 141 | 126 | 150 | 142 |
| 2 | December | 123 | 118 | 114 | 119 | 118 | 131 | 119 | 112 | 141 | 126 |
| 3 | January | 132 | 129 | 129 | 129 | 130 | 137 | 130 | 125 | 148 | 135 |
| 4 | February | 164 | 165 | 157 | 159 | 161 | 169 | 164 | 154 | 178 | 166 |
| 5 | March | 197 | 197 | 188 | 185 | 192 | 200 | 194 | 180 | 199 | 193 |
| 6 | April | 253 | 250 | 244 | 245 | 248 | 252 | 245 | 244 | 261 | 250 |
| 7 | May | 289 | 290 | 286 | 279 | 286 | 289 | 284 | 274 | 299 | 286 |
| 8 | June | 292 | 299 | 281 | 279 | 288 | 293 | 292 | 273 | 297 | 289 |
| 9 | July | 97 | 102 | 100 | 99 | 100 | 106 | 104 | 92 | 119 | 105 |
| 10 | August | 42 | 41 | 42 | 41 | 42 | 46 | 45 | 43 | 47 | 45 |
| 11 | September | 58 | 63 | 57 | 61 | 60 | 60 | 66 | 65 | 68 | 65 |
| 12 | October | 222 | 225 | 219 | 214 | 220 | 223 | 221 | 211 | 228 | 221 |
| Average | | 168 | 168 | 163 | 162 | 165 | 171 | 167 | 158 | 178 | 169 |
| Min. | | 42 | 41 | 42 | 41 | 42 | 46 | 45 | 43 | 47 | 45 |
| Max. | | 292 | 299 | 286 | 279 | 288 | 293 | 292 | 274 | 299 | 289 |
| SD± | | 84 | 85 | 82 | 80 | 83 | 82 | 81 | 79 | 82 | 81 |
| | Season's Name | RS1 | RS2 | RS3 | RS4 | Average | RS1 | RS2 | RS3 | RS4 | Average |
| | Rainy | 122 | 126 | 120 | 120 | 122 | 126 | 127 | 118 | 133 | 126 |
| | Winter | 155 | 153 | 150 | 149 | 152 | 160 | 153 | 144 | 167 | 156 |
| | Summer | 226 | 226 | 219 | 217 | 222 | 228 | 222 | 213 | 234 | 224 |


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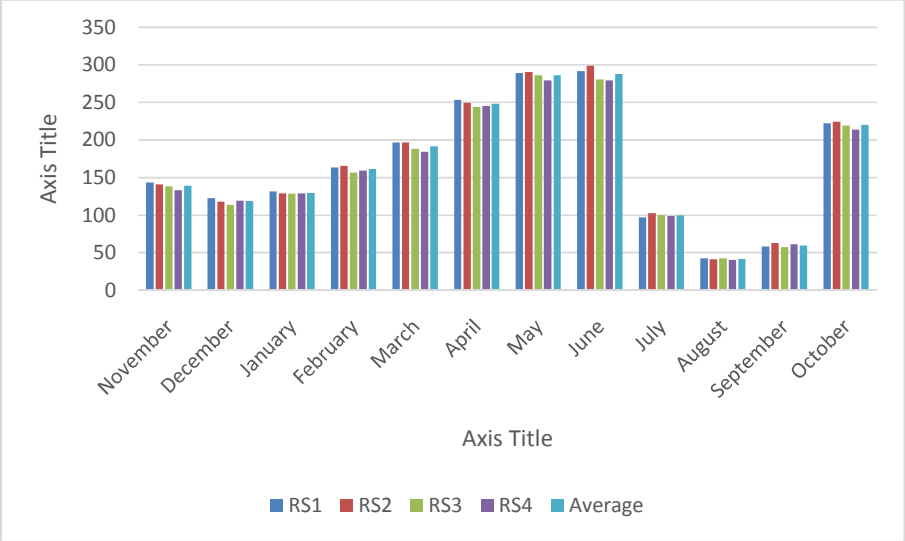
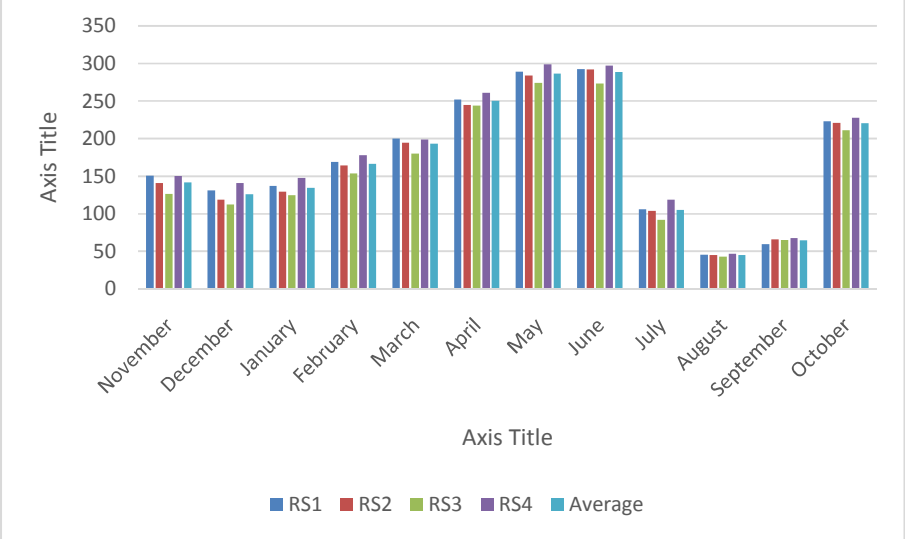
**Graph 17a: Mean annual and seasonal variation of Zooplankton in Org/L from November 2019 to October 2020 in Govindgarh Lake, Rewa (M.P.)**




**Graph 17b: Mean annual and seasonal variation of Zooplankton from November 2020 to October 2021 in Govindgarh Lake, Rewa (M.P.)**




**Graph 17c: Mean annual and seasonal variation of Zooplankton from November 2019 to October 2020 in Govindgarh Lake, Rewa (M.P.)**

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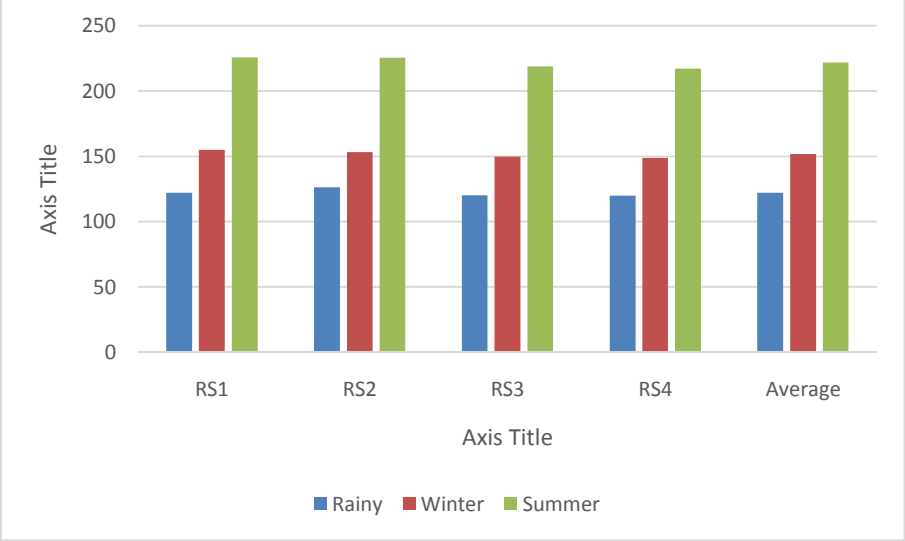
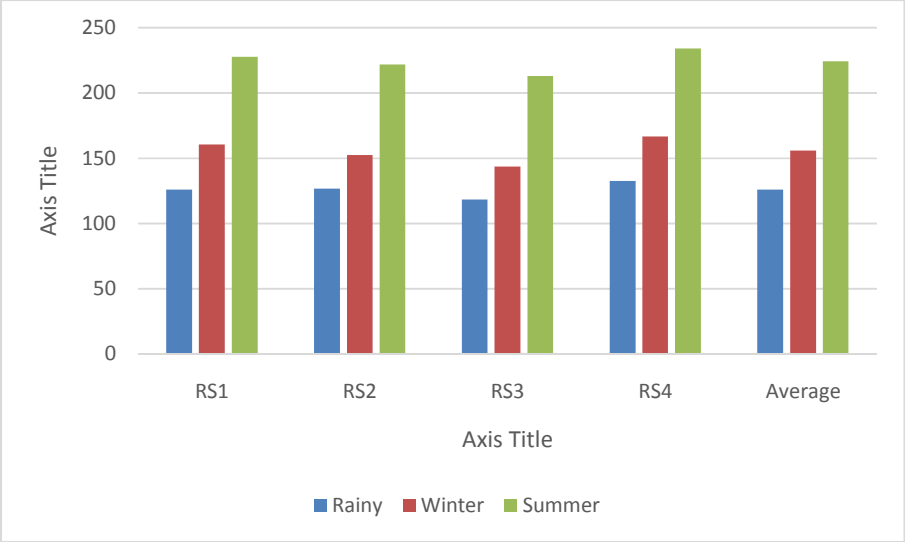



**Graph 17d: Mean annual and seasonal variation of Zooplankton from November 2020 to October 2021 in Govindgarh Lake, Rewa (M.P.)**



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**Graph 17a: Mean annual and seasonal variation of Zooplankton's group and species wise in Org/L from November 2019 to October 2020 in Govindgarh Lake, Rewa (M.P.)**

| | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Min. | Max. | Avg. | Winter | Summer | Rainy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Protozoa | 25 | 23 | 26 | 26 | 30 | 35 | 41 | 36 | 15 | 5 | 6 | 37 | 5 | 41 | 25 | 28 | 33 | 16 |
| *Difflugia sp.,* | 14 | 13 | 14 | 13 | 15 | 17 | 21 | 17 | 7 | 3 | 4 | 19 | 3 | 21 | 13 | 15 | 17 | 8 |
| *Euglypha sp..* | 11 | 10 | 12 | 13 | 15 | 18 | 20 | 19 | 8 | 2 | 2 | 18 | 2 | 20 | 12 | 13 | 17 | 8 |
| Rotifera | 34 | 30 | 32 | 38 | 45 | 69 | 89 | 90 | 33 | 13 | 18 | 66 | 13 | 90 | 46 | 41 | 60 | 39 |
| *KeratelaaTropica,* | 8 | 7 | 7 | 9 | 12 | 18 | 23 | 24 | 8 | 4 | 5 | 17 | 4 | 24 | 12 | 10 | 16 | 10 |
| *K. Tacta,* | 10 | 9 | 9 | 10 | 12 | 19 | 24 | 25 | 7 | 4 | 5 | 18 | 4 | 25 | 13 | 12 | 16 | 10 |
| *B. Rubens,* | 8 | 7 | 6 | 10 | 11 | 17 | 21 | 20 | 10 | 3 | 5 | 17 | 3 | 21 | 11 | 10 | 15 | 10 |
| *Monostula sp.* | 8 | 7 | 10 | 9 | 10 | 15 | 21 | 21 | 8 | 2 | 3 | 14 | 2 | 21 | 11 | 10 | 14 | 9 |
| Cladocera | 32 | 28 | 32 | 46 | 54 | 60 | 70 | 72 | 26 | 9 | 14 | 55 | 9 | 72 | 42 | 37 | 58 | 30 |
| *Daphnia sp.,* | 13 | 11 | 14 | 14 | 17 | 18 | 21 | 22 | 9 | 4 | 5 | 21 | 4 | 22 | 14 | 15 | 18 | 10 |
| *Moina sp.,* | 4 | 3 | 6 | 13 | 16 | 19 | 23 | 25 | 9 | 3 | 5 | 19 | 3 | 25 | 12 | 8 | 18 | 11 |
| *Diaphanosoma sp.,* | 15 | 14 | 12 | 19 | 21 | 23 | 26 | 25 | 8 | 2 | 4 | 15 | 2 | 26 | 15 | 14 | 22 | 10 |
| Copepoda | 24 | 21 | 21 | 29 | 36 | 49 | 49 | 48 | 16 | 11 | 17 | 33 | 11 | 49 | 30 | 25 | 41 | 23 |
| *Cyclops sp.,* | 14 | 12 | 11 | 14 | 17 | 24 | 25 | 27 | 7 | 6 | 8 | 18 | 6 | 27 | 15 | 14 | 20 | 12 |
| *Daiptomus sp.,* | 10 | 9 | 10 | 15 | 19 | 25 | 24 | 21 | 9 | 5 | 9 | 15 | 5 | 25 | 14 | 11 | 21 | 11 |
| Ostracoda | 27 | 24 | 24 | 27 | 28 | 37 | 37 | 43 | 15 | 7 | 10 | 30 | 7 | 43 | 26 | 26 | 32 | 19 |
| *Cypris sp.* | 14 | 11 | 12 | 13 | 12 | 18 | 20 | 23 | 8 | 3 | 4 | 13 | 3 | 23 | 13 | 13 | 16 | 10 |
| *Stenocyprissp* | 13 | 13 | 12 | 14 | 16 | 19 | 17 | 20 | 7 | 4 | 6 | 17 | 4 | 20 | 13 | 14 | 17 | 9 |

**Graph 17a: Mean annual and seasonal variation of Zooplankton's group and species wise in Org/L from November 2020 to October 2021 in Govindgarh Lake, Rewa (M.P.)**

| | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Min. | Max. | Avg. | Winter | Summer | Rainy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Protozoa | 25 | 23 | 26 | 26 | 30 | 35 | 41 | 36 | 15 | 5 | 6 | 37 | 5 | 41 | 25 | 28 | 33 | 16 |
| *Difflugia sp.,* | 14 | 13 | 14 | 13 | 15 | 17 | 21 | 17 | 7 | 3 | 4 | 19 | 3 | 21 | 13 | 15 | 17 | 8 |
| *Euglypha sp..* | 11 | 10 | 12 | 13 | 15 | 18 | 20 | 19 | 8 | 2 | 2 | 18 | 2 | 20 | 12 | 13 | 17 | 8 |
| Rotifera | 34 | 30 | 32 | 38 | 45 | 69 | 89 | 90 | 33 | 13 | 18 | 66 | 13 | 90 | 46 | 41 | 60 | 39 |
| *KeratelaaTropica,* | 8 | 7 | 7 | 9 | 12 | 18 | 23 | 24 | 8 | 4 | 5 | 17 | 4 | 24 | 12 | 10 | 16 | 10 |
| *K. Tacta,* | 10 | 9 | 9 | 10 | 12 | 19 | 24 | 25 | 7 | 4 | 5 | 18 | 4 | 25 | 13 | 12 | 16 | 10 |
| *B. Rubens,* | 8 | 7 | 6 | 10 | 11 | 17 | 21 | 20 | 10 | 3 | 5 | 17 | 3 | 21 | 11 | 10 | 15 | 10 |
| *Monostula sp.* | 8 | 7 | 10 | 9 | 10 | 15 | 21 | 21 | 8 | 2 | 3 | 14 | 2 | 21 | 11 | 10 | 14 | 9 |
| Cladocera | 32 | 28 | 32 | 46 | 54 | 60 | 70 | 72 | 26 | 9 | 14 | 55 | 9 | 72 | 42 | 37 | 58 | 30 |
| *Daphnia sp.,* | 13 | 11 | 14 | 14 | 17 | 18 | 21 | 22 | 9 | 4 | 5 | 21 | 4 | 22 | 14 | 15 | 18 | 10 |
| *Moina sp.,* | 4 | 3 | 6 | 13 | 16 | 19 | 23 | 25 | 9 | 3 | 5 | 19 | 3 | 25 | 12 | 8 | 18 | 11 |
| *Diaphanosoma sp.,* | 15 | 14 | 12 | 19 | 21 | 23 | 26 | 25 | 8 | 2 | 4 | 15 | 2 | 26 | 15 | 14 | 22 | 10 |
| Copepoda | 24 | 21 | 21 | 29 | 36 | 49 | 49 | 48 | 16 | 11 | 17 | 33 | 11 | 49 | 30 | 25 | 41 | 23 |
| *Cyclops sp.,* | 14 | 12 | 11 | 14 | 17 | 24 | 25 | 27 | 7 | 6 | 8 | 18 | 6 | 27 | 15 | 14 | 20 | 12 |
| *Daiptomus sp.,* | 10 | 9 | 10 | 15 | 19 | 25 | 24 | 21 | 9 | 5 | 9 | 15 | 5 | 25 | 14 | 11 | 21 | 11 |
| Ostracoda | 27 | 24 | 24 | 27 | 28 | 37 | 37 | 43 | 15 | 7 | 10 | 30 | 7 | 43 | 26 | 26 | 32 | 19 |
| *Cypris sp.* | 14 | 11 | 12 | 13 | 12 | 18 | 20 | 23 | 8 | 3 | 4 | 13 | 3 | 23 | 13 | 13 | 16 | 10 |
| *Stenocyprissp* | 13 | 13 | 12 | 14 | 16 | 19 | 17 | 20 | 7 | 4 | 6 | 17 | 4 | 20 | 13 | 14 | 17 | 9 |
| | 142 | 126 | 135 | 166 | 193 | 250 | 286 | 289 | 105 | 45 | 65 | 221 | 45 | 289 | 169 | 156 | 224 | 126 |

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