DISCUSSION
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The historical Rishi lake of Karanja (Lad) Dist. Washim is a perennial one and is exposed to various human activities. Lake has a more complex and fragile ecosystem as it does not have a self cleaning ability and therefore readily accumulates pollutants. The various physico-chemical and biological parameters play significant role in controlling the water quality. The anthropogenic influences in and around the lake contribute to a large extent to deteriorate the water quality leading to its eutrophication.

In the present investigation, the water samples from Rishi lake were analysed for various physico-chemical and biological parameters during the period of fourteen months i.e. from December 2001 to January 2003 and the results are summarised in Tables 2 to 39.
Temperature is one of the most important factors in an aquatic environment. It affects the growth and distribution of flora and fauna in the lake (Plate 1). The range of temperature is useful in indicating the trends of biochemical and biological activities in the water body. The optimum temperature range enhances the biological activities of the lake. In the present investigation, water temperature followed the parallel trend as that of atmospheric temperature. The water temperature of the lake showed higher values during summer while low during winter. Our results are well in agreement with those of Ahmed and Krishnamurthy (1990) and Hiware and Ugale (2003).

In the present investigation, the water temperature of the lake ranged between 21 °C to 30 °C. Water temperature showed highly significant positive correlation with atmospheric temperature. The same results were shown by Pathak and Shastree (1993) while analysing the water of Rukmini and Visar Sarovar of Gaya. Water temperature showed positive correlation with total solids, magnesium and total phosphates on most of the sampling spots of the lake. While it showed significant inverse correlation with pH, transparency and nitrate during the period of investigation.

The water vapour present in the air is called humidity. This is expressed in terms of percentage of water vapour present in the air at a certain temperature. The atmospheric humidity influences directly the physiological activities of plants. The combination of temperature and humidity plays vital role in determining the broad features of plant distribution.
on the earth surface. In the present investigation, the minimum humidity was recorded in May 2002 however the maximum values were recorded in August 2002 at various sampling spots. Our findings are in agreement with Ahmed and Krishnamurthy (1990) where they observed maximum humidity during monsoon and minimum during summer season in the Wohar reservoir, Aurangabad (M.S). Statistically, it was more or less negatively correlated with all physico-chemical parameters except dissolved oxygen, transparency and nitrate where they are weakly positively correlated (Table 10-15).

pH of water is hydrogen ion concentration present in it. It measures, the relative acidity or alkalinity. It plays a limiting role in the growth of flora and fauna of the aquatic body. Hydrogen ion concentration controls the chemical state of many nutrients including phosphate, ammonia and trace elements (Goldman and Horde, 1983). During the present study the minimum pH values were recorded during monsoon and maximum in winter season. The pH of Rishi lake water was observed to be alkaline throughout the period of observation. Generally, pH of water is influenced by geology of catchment area and buffering capacity of the water. However, pH values were maximum in winter months which appears to be influenced by some of the climatological and vegetation factors (Kant and Kachroo, 1975). Higher values of pH in the winter and lower during the monsoon season have also been reported earlier by Shanoo (1982). Further lower pH observed during monsoon season was perhaps due to mixing of rain water and surface runoff with the lake water.
(Sampathkumar and Kannan 1998). Our results are in well agreement with above authors.

In the present investigation, pH showed significant positive correlation with dissolved oxygen and transparency at all sampling spots. Similar trend was shown earlier by Dutta et al. (1993) while analysing the water of Deepar beel, Guwahati, Assam. pH showed significant positive correlation with Bacillariophyceae at spots 2, 5 and 6 (r = 0.76, 0.76 and 0.82) respectively while moderately significant negative correlation with Chlorophyceae (r = -0.70) and Dinophyceae (r = -0.78) at spot no. 4. Our findings are well in agreement with Baily (1963), Sreenivasan (1963), Moitra and Bhattacharya (1965), Jana (1973) Chari (1980) and Bhatt et al. (1999). In the present study average pH value of lake water showed moderately significant positive correlation with total phytoplankton (Plate-4). Similar findings were observed by Krishnan et al. (1999).

The conductivity of lake water is a measure of the capacity of a substance or a solution to conduct electrical flow. Conductivity is a good and rapid method to measure the total dissolved solids and is directly related to total solids (Mishra and Sakse, 1993). In the present investigation a range of conductivity in Rishi lake water from 110 to 313 µmhos/cm. The conductivity of the inland water should be ranged between 150 to 450 µmhos/cm to flourish good flora and fauna (Ellis, 1937). During the present investigation the minima and maxima of conductivity were recorded in the month of July 2002 and April 2002.
In our observation a low conductivity profile was recorded in monsoon months and high in summer months. The seasonal variation in the conductivity is mostly due to the increased concentration of salts because of evaporation of water; the dilution resulted from precipitation brings down the low values. These results are well in agreement with those of Trivedi, et.al. (1985); Meshram (1996) and Ade (2001).

Statistically, conductivity showed a positive correlation with calcium carbonate hardness, calcium hardness and magnesium hardness at maximum sampling spots. It also exhibited highly positive correlation with Dinophyceae at spot 4 (r = 0.91) and at spot 5 ( r = 0.30) showed weakly positive correlation. However, it showed moderately significant negative correlation with Chlorophyceae at spot 5 and 6 (r = -0.79, r = -0.68) respectively.

The total phytoplankton density showed significant correlation with conductivity while studying seasonal dynamics of phytoplankton population in relation to abiotic factors of a fresh water pond at Barwani M.P. (Gujarathi and Kanhere, 1996).

The total dissolved solids and total suspended solids together make the total solids in water. The presence of solids in water vary greatly at different time and affect the density of water and thereby the quality of aquatic environment, resulting in imbalance of aquatic ecosystem. Increase in value of total solids indicates pollution by extraneous sources (Aboo and Mannuel, 1967).
The total solids in the lake water fluctuated in the range of 135.5 to 215 mg/l and higher values were found at spot 5 and 6, during monsoon. Statistically, at all sampling spots it showed moderately significant negative correlation with transparency. Kataria et al., (1996) stated that suspended solids interfere with the transmission of light thereby decreasing transparency of the Tawa reservoir, M.P. Our views are similar with the views of above authors. Total solids also showed positive correlation with total phosphate, and total alkalinity; however, significant negative correlation with total hardness, magnesium hardness and chloride.

During the period of studies total solids exhibited significant negative correlation with Cyanophyceae and Bacillariophyceae (plate-6). However, Bhatt et al., (1999) showed positive significant correlation of total dissolved solids with Cyanophyceae but negative correlation with Bacillariophyceae and Chlorophyceae thereby stating that scum formation by filamentous blue green algae prevents particulate matter from air to settle at bottom and given high values during sampling, whereas, this is not a case with non-filamentous Chlorophyceae and Bacillariophyceae.

The occurrence of dissolved oxygen in water is mainly due to direct diffusion from air and photosynthetic evolution by aquatic autotrophs. The primary effect of dissolved oxygen in water is on oxidation reduction reactions involving iron, manganese, copper and compounds that contain nitrogen and sulphur.
Dissolved oxygen ranged between 7 to 12 mg/l in the Rishi lake. It’s minimum value was recorded in September 2002 and maximum in November 2002. Bhatt et al., (1999) while studying water quality of Taudaha Lake, Kathmandu, reported lowest average value during summer, which increased during rainy season and attained highest value during winter. Our findings are well in agreement with above authors.

In present investigation, dissolved oxygen showed positive correlation with transparency at various sampling spots. However, the Dutta et al.(1993) reported negative correlation with total hardness and chloride. Our findings are similar to that of above authors, in case of spot no. 6 and 3 respectively. The dissolved oxygen showed moderately significant positive correlation with Bacillariophyceae while negative correlation with Dinophyceae. However, Bhatt et al., (1999) have shown positive correlation with Chlorophyceae and Bacillariophyceae and highly negative with Cyanophyceae.

Secchi devised a method for studying the transparency of aquatic bodies. It is directly proportional to the amount of suspended organic and inorganic matters. The Secchi disc transparency’s, essential a function of the reflection of light from its surface, is, therefore, influenced by the absorption characteristics both of the water and of its dissolved and particular matter, especially in productive waters. It is the expression of optical property in which the light is scattered by the particles present in water. Transparency has a direct bearing on the light penetration of water.
and depends upon suspended matter and dissolved coloured particles (Pathak and Shastree, 1993).

In the present investigation, the range of transparency in the lake water was between 5 to 28.2 cm. The minima and maxima of transparency were recorded in the month of July 2002 and January 2003.

George (1976) reported high turbidity due to degeneration of blue green algae which reduced the light penetration, while Sreenivasan (1970) found even distribution of blue green algae especially the species of Microcystis, responsible for low transparency of water. The minimum values were observed during monsoon months, which would have been due to flow of surface run off to the pond as well as addition of allochthonous materials through rainfall. However, high transparency was observed during winter period (Das and Chand, 2003). In the present investigation, we got similar trend of transparency at maximum sampling spots.

Transparency showed positive correlation with Bacillariophyceae and Cyanophyceae at all sampling spots. However, it showed positive correlation with Chlorophyceae at spot no. 4 ($r=0.77$) and 5 ($r=0.70$). But Bhatt et al. (1999) showed the value of correlation coefficient of transparency was positive with Chlorophyceae and Bacillariophyceae while negative with Cyanophyceae.

Free CO$_2$ is essential for photosynthesis and its concentration affects the aquatic flora and its productivity. Free CO$_2$ was absent at maximum spots except spot 3 where it was recorded in the month of
April 2002. Jain et al., (1996) estimated nil to 5.6 mg/l of CO₂ in Halali reservoir. However, Mathew (1978) observed an inverse relationship between CO₂ and dissolved oxygen in Gobindsagar lake. Shrivastava et al. (2003) also reported higher dissolved oxygen and nil CO₂ while studying Ramgarh lake, Jaipur. In the present investigation, we have also recorded similar findings.

Alkalinity is a measure of the ability to neutralize acids. Constituents of alkalinity in natural system includes CO₃²⁻, HCO₃⁻, OH⁻, HPO₄²⁻ and H₂PO₄⁻. These originate from detergents in waste water discharges and from fertilizers and insecticides from agricultural land. The most common constituents of alkalinity are bicarbonate, carbonate and hydroxide.

The total alkalinity in the lake water was recorded between 94 to 250 mg/l. The minimum value was recorded in September 2002 and the maximum in May 2002. Das and Chand (2003) recorded low alkalinity during monsoon season, which might be due to dilution effect of rainfall. Katariya et al. (1996) have measured maximum value of alkalinity due to confluence of industrial and domestic wastes. Our results are in well agreement with above authors. In the present study, the higher alkalinity was recorded in the month of may 2002, which may be due to concentration of water body by evaporation and the dumpings of detergents through human activities (Fig.3 and 6) and surface run off from agricultural fields. Sreenivasan (1974) and Kannan and Job (1980) also recorded low alkalinity values in rainy season due to influx of rainwater.
Total hardness in water is the sum of concentration of alkaline earth metal cations such as Ca\(^{++}\), Mg\(^{++}\). In most fresh waters nearly all the hardness is imparted by the calcium and magnesium ions which are in combination with bicarbonates and carbonates.

During the period from December 2001 to January 2003 the water of Rishi lake showed range of total hardness from 56 to 210 mg/l. The maximum hardness was recorded in May 2002 while minimum in November 2002.

Bhatt et al. (1999) reported hardness of water as maximum during summer and its gradual decrease in rainy season while its lowest value during winter. Higher value in summer may be due to higher temperature, which increases concentration of salts by excessive evaporation. The contents released from dead molluscan shell may also increase the concentration of total hardness (Khan and Chowdhury, 1994). Our findings are well in agreement with the above authors.

Statistically, total hardness showed positive correlation with calcium carbonate hardness, magnesium hardness, calcium hardness and chlorides at all sampling spots. Kumaresen and Bagavathiraj (1996) showed positive correlation of hardness with above factors while studying physico-chemcial and microbiological aspects of Courtallam water. Our investigation shows similar trend of correlation of hardness with calcium carbonate hardness, calcium hardness, magnesium hardness and chlorides respectively.
Calcium is essential for metabolic processes in all living organisms. In the present investigation, calcium hardness fluctuated in the range of 12.61 to 33.64 mg/l. The increase in calcium hardness during summer may be again attributed to evaporation of surface water. The excessive dilution of heavy rains can be responsible for lowering down the hardness of water in monsoon (Bagde and Verma, 1985). Our findings are more or less similar to the above results. According to Zafar (1964) calcium is one of the most important elements influencing the distribution of Bacillariophyceae in water bodies. Munawar (1974) observed that Cyanophyceae respond favourably in water having very high calcium contents. Significant positive correlation between calcium and Bacillariophyceae, Chlorophyceae and Cyanophyceae were observed by him. However, our results showed weakly positive correlation with Chlorophyceae and Bacillariophyceae at spot 4 and 5.

Magnesium is the important source of hardness to water. In the present study, the range of magnesium hardness was between 4.37 to 34.48 mg/l. It showed positive correlation with total hardness. Singhai (1986) also reported a positive correlation between magnesium and the total hardness.

Chloride content indicates the pollution degree of water. It is found in the form of Na, K and Ca salts. During the period of study the chloride in the lake water fluctuated in the range of 14.01 to 39.08 mg/l. It was more during summer and pre monsoon and low in
post monsoon and winter. Similar trend has showed by Ahmed and Krishnamurthy (1990), while studying hydrobiological studies of Wohar reservoir, Aurangabad.

According to Trivedy and Goel (1986) the most important source of chloride in the natural fresh water is the discharge of domestic sewage and so the concentration of chloride serves as an indication of sewage pollution. Statistically, chloride exhibited positive correlation with Cyanophyceae, Euglenophyceae and Dinophyceae at various sampling spots. Verma and Mohanty (1995) reported a similar relationship between chloride and various groups of phytoplankton. In present investigation, chloride showed negative correlation with dissolved oxygen at all sampling spots. These results are well in agreement with those of Dutta et al. (1993).

The sulphate ion is one of the important anion present in natural waters and produces laxative cathartic effect on human health when present in excess amount. It is an important constituent of hardness with Ca and Mg. During the period of study, the sulphate of lake water varied in the range of 0.12 to 1.35 mg/l. The minimum values were recorded in the monsoon while maximum in summer.

Sulphate enters into the water body from the catchment through surface run off. Since the study area is bordered by agricultural land where sulphate based fertilizers are used in plenty, relatively higher concentration of sulphate observed could be attributed to the surface run off from these agricultural land, during monsoon period (Krishnan et al. 1999).
In the present investigation, the minimum value of sulphate was recorded in monsoon while maximum in summer which may be attributed to the higher concentration due to evaporation of water body in the summer.

Phosphorus in lake water occurs in both organic and inorganic forms. Major part of the inorganic phosphate is present in the form of orthophosphates. Welch *et al.* (1978) stated that phosphate is considered as one of the important nutrients limiting growth of the phytoplankton. In the present study the phosphate recorded was in the range of 0.31 to 1.78 mg/l.

Statistically, at spot No. 1 and 2 it showed positive correlation with Chlorophyceae and Dinophyceae. The significant relationship shows higher phosphate concentration favoured in their growth (Krishnan *et al.* 1999). Heron (1961) has indicated that the increase in phosphate may be due to decayed phytoplanktons and concentration of zooplankton excreta. Addition of phosphorus in different forms causes explosive growth of algae and aquatic weeds, which leads to the eutrophication of lake.

Nitrate is the important nutrient, which affects the growth of phytoplankton. It is an important factor for controlling the occurrence and abundance of phytoplankton. Rainfall was supposed to be responsible for increasing the nitrate in water (Nandan and Patel, 1992). Higher concentration of nitrate is an indication of organic pollution and eutrophication, in the present investigation nitrate contents,
were in the range of 0.18 to 0.90 mg/l. Krishnan et al. (1999) reported highly significant positive correlation between nitrate and Bacillariophyceae. Our findings are well in agreement with the above authors.

Comparatively higher concentration of nitrate was found during winter than in summer. Hutchinson (1967) and Munawar (1970) also observed a similar trend and suggested that, in summer, denitrifying bacteria break up nitrates into nitrites and ammonia. In winter, however, the activity of these bacteria slows down. It was suggested that in winter nitrifying bacteria convert free ammonia into nitrites and the matter is further oxidized to nitrates (Zafar, 1964 and Munawar 1970). We have also observed the similar trend.

Plankton community on which whole aquatic population depends is largely influenced by interaction of a number of physico-chemical factors. Davis (1954) showed that a number of physical, chemical and biological factors acting simultaneously must be taken into consideration in understanding the fluctuation of plankton population.

Phytoplankton population in Rishi lake was composed of Chlorophyceae, Bacillariophyceae, Cyanophyceae, Dinophyceae and Euglenophyceae and represented by 26, 14, 9, 1 and 2 species respectively.

In the total phytoplankton, Chlorophyceae showed dominance in November, January, February and March and again showed decline from
May onwards, while Bacillariophyceae showed maximum dominance in
the month of December, January and February and the minimum in the
month of May, June and July, Cyanophyceae was dominant in January,
February and March while minimum from May onwards. However
Dinophyceae and Euglenophyceae showed its dominance in two different
seasons.

During the study period, the maximum dominance of phytoplankton was observed in winter and post summer while minimum in monsoon. Mandal (1976) reported abundant phytoplankton
during winter. Hazarika and Dutta (1998) observed high plankton
density during winter while studying interrelationship of physico-chemical
parameters and plankton community of Tasek lake (Meghalaya).
However, Nair and Mishra (1988), Mir and Kachroo (1990) and
Bhatt et al. (1999) reported maximum phytoplankton density during summer and low during winter. While Kumar (1990) observed maximum
showed maximum density of phytoplankton in May and minimum in July in their investigation. Verma and Mohanty (1995) recorded three
peaks in phytoplankton i.e. abundance at Danmukundpur pond.
Choudhary and Singh (2001) showed the abundance of phytoplankton
during warmer months and lesser during winter, while studying phytoplankton population of Boosra lake, Muzaffarpur, Bihar.

During present investigation the maxima of phytoplankton
density in winter attributed to increased range of dissolved oxygen,
transparency and pH which reflected in the increased density of phytoplankton.

Me Combic (1953) stated that temperature affects the seasonal cycle of phytoplankton in temperate zones. Similarly Hutchinson (1957) Jana (1973) and Chari (1980) observed that temperature was a critical factor for the seasonal variations of phytoplankton. In the present study temperature showed significant negative correlation with Bacillariophyceae. Similar findings were observed by Bhatt et al. (1999).

The average mean values of pH showed positive correlation with total phytoplankton. Jana (1979) and Gordon et al. (1981) have reported a positive correlation between pH and phytoplankton. Earlier workers Baily (1963), Sreenivasan (1963), Moitra and Bhattacharya (1965) and Chari (1980) observed that high pH values were related to heavy bloom of phytoplankton. Reid (1961), Saha and Choudhary (1985) showed positive correlation with dissolved oxygen and transparency. Our findings are well in agreements with above authors.

During the period of investigation, the maximum Chlorophyceae individuals were recorded in the winter and minimum during post summer. Similar observations were made by Kohli et al., (1982) and Khatri (1987) where they stated that Chlorophyceae species were found to be dominant over the other phytoplanktonic groups. Hazarika et al. (1998) also reported
maximum density of Chlorophyceae in winter and minimum in summer and rainy season. Choubey (1991) reported peak period of Chlorophyceae in winter while studying Gandhisagar reservoir. The minimum density of Chlorophyceae was estimated in summer season and maximum in winter by Gujrathi and Kanhere (1998). However, Choudhary and Singh (2001) found highest peak of Chlorophyceae in May in the water of Boosra lake, Muzaffarpur.

The dominant species of Chlorophyceae were observed as Spirogyra, Hydrodictyon, Volvox, Ankistrodesmus and Stigeoclonium. Similar findings were made by Jha and Barart (2003). The dominant nature of above species was attributed to organic nutritive rich nature of the lake in the present study. According to Saify et al. (1986) Chlorophyceae dominance was attributed to eutrophic condition of water bodies and we are in well agreement with above statement.

The Chlorophyceae showed positive correlation with average mean value of the pH, transparency and dissolved oxygen of the lake water. While other parameters were negatively correlated. Bhatt et al. (1999) also observed positive correlation of transparency with Chlorophyceae (non-filaments) and negative correlation of dissolved oxygen and pH.

The group Bacillariophyceae constitutes the diatoms and is characteristics of lentic water bodies specially the lakes. Bacillariophyceae was the second dominant group in the present
investigation. This group was represented by 14 species with increasing trend from summer to winter. Sarwar et al. (1996) also reported maximum standing crop of Bacillariophyceae in the floating garden waters of Srinagar in winter and minimum in summer. Hazarika and Dulta (1998) observed the more or less similar trend, stating that Bacillariophyceae showed dominance in early winter and recession in post summer. However, Choudhary and Singh (2001) exhibited highest peak of Bacillariophyceae in the month of June.

During the period of study, the dominant species of Bacillariophyceae were noted as Pinnularia, Synedra, Fragelaria and Gomphonema while Surrirella was moderately recorded. Bhatt et al. (1999) also found similar trend of dominance of Bacillariophyceae.

Bacillariophyceae showed positive correlation with an average mean values of pH, dissolved oxygen, transparency, and nitrate while it is negatively correlated with other physico-chemical parameters. Bhatt et al. (1999) also reported similar pattern of correlation between Bacillariophyceae and various physico-chemical parameters.

Diatoms like Fragelaria and Synedra have been regarded as potential indicators of pollution and eutrophy (Stockener and Benson, 1967; Williams, 1969 and Sarwar et al. 1996). We are of the similar opinion like that of the above authors where the present lake is shifting towards eutrophicication.

In the present study Cyanophyceae group was represented
by 9 species. The maximum Cyanophyceae were recorded in the month of January and February while minimum in May, Jun and July respectively. Govind (1969) reported dominance of Cyanophyceae during February in Tungabhadra reservoir. Verma and Mohanty (1995) observed maximum Cyanophyceae during summer at Danumukundpur pond and in winter at Malayanta pond. However, Gujarathi and Kanhere (1998) estimated minimum density in January and maximum in May. However, Janus and Duthie (1979) recorded maximum Cyanophyceae in late summer.

Out of the 9 species, of Cyanophyceae Microcystes Anabaena and Gloeotrichia are recorded, as dominant ones, while Phormidium, Cylindrospermum and Lyngbya showed minimum population. Among Cyanophyceae, species like Microcystis, Oscillatoria, Lyngbya and Anabaena were recorded throughout the period of investigation by Bhatt et al. (1999). He observed Microcystis as a dominant sp. in all the seasons. Vasishth and Sra (1979) have recorded that dominant and regular presence of Microcystis sp. as an indication of pollution and eutrophication of water body.

Cyanophyceae exhibited positive correlation with average mean value of pH \( r = 0.71 \) and transparency \( r = 0.74 \) while weakly positive with dissolved oxygen and nitrate. Bhatt and Negi (1985) also reported a positive correlation between Cyanophyceae and transparency. However, Bhatt et al. (1999) showed negative correlation of Cyanophyceae with transparency and nitrate. In the present study weakly positive correlation
between nitrate and Cyanophyceae were observed. During the period of study Cyanophyceae exhibited weakly positive correlation with conductivity at spot no. 1. Similar trend were reported by Gujarathi and Kanhere (1998) while studying seasonal dynamics of phytoplankton population in relation to abiotic factors of a freshwater pond at Barwani (M.P.). Krishnan et al. (1999) recorded a positive correlation of pH and Cyanophyceae. We are well in agreement with above authors.

In the present study the group Dinophyceae was represented by a single species *Peridinium palatinum*. This group shows the two different growth periods from September 2002 to November 2002 and from February 2002 to April 2002. Singh and Swarup (1979) recorded maximum Dinophyceae in the winter season during limnological study of Suraha lake, Ballia. Similar observations were made by Sreenivasan (1964), Munawar (1974) Datta et al. (1983a) and Choubey (1991). Sarwar et al. (1996) reported sporadic occurrence of Dinophyceae in Dal lake.

The species *Peridinium* was found at all sampling spots with the maximum population density at spot no. 2 and 3 during the period of investigation.

Dinophyceae showed positive correlation with average mean values of total solids and phosphate while negative with transparency, pH, and sulphate. However Krishnan et al. (1999) showed highly significant positive correlation with sulphate and Dinophyceae. Nandan and Patel (1992) observed similar trend in river Viswamitri in Gujarat.

Euglenophyceae represented with least percentage. The
group Euglenophyceae is represented by two species *Euglena* and *Phacus*. They showed maximum density during winter and pre summer while minimum during rainy season. In the month of July 2002 both these genera were found to be absent. Rao (1987) reported occurrence of Euglenophyceae during summer and monsoon months. Gujarathi and Kanhere (1988) have recorded the range of Euglenophyceae from May to October.

Euglenophyceae showed positive correlation with average mean values of pH, dissolved oxygen and transparency. Gujarathi and Kanhere (1998) also observed positive correlation between Euglenophyceae and pH and dissolved oxygen while negative correlation with transparency. Kulshrestha et al. (1989) showed positive correlation with chloride. Similar findings are observed at sampling spot no. 5 and 6 during the present study.

Nandan and Patel (1992) reported that *Euglena* indicates high degree of organic pollution in the ponds.

Biological activity that involves the utilization of solar energy which is transformed into chemical energy by the green plants through the process of photosynthesis is called productivity. Gross primary productivity (GPP) is the total rate of photosynthesis including the organic matter used up in respiration while the net primary productivity (NPP) is the rate of storage of organic matter in plant tissue in excess of respiratory utilization of plant. Thus gross
primary productivity is the sum of net primary productivity and respiration (Adoni, 1985).

In the present investigation GPP, NPP and CR fluctuated in the range of 0.94 to 2.95 gC/m$^3$d$^{-1}$; from −1.50 to 1.35 gC/m$^3$d$^{-1}$ and from 0.30 to 3.45 gC/m$^3$d$^{-1}$ respectively. The maximum values of GPP 2.95 gC/m$^3$d$^{-1}$ was recorded in the month of January 2002 and the minimum value was recorded as 0.94 and 0.95 gC/m$^3$d$^{-1}$ in the months December 2001 and July 2002 respectively. Sreenivasan (1964) in Ayyagulum tank recorded the maximum production in June and least in December, whereas Prasad (1983) in Hussain Sagar Reservoir and Sharma (1993) in Yeshwant Sagar Reservoir have obtained the maximum GPP in the months of January and May and minimum during July, August and September respectively. Our results are well in agreement with above authors. It was also observed that there are two peaks for primary production. i.e. one in post winter and other in post summer and these findings are similar to those of Sinha et al. (1993).

Statistically, the phytoplankton population was positively correlated with GPP. The effect of phytoplankton population on the productivity has been emphasized by Edmondson and Edmondson (1946) and Kalf (1967). Prasad (1983) observed that the phytoplankton abundance and primary productivity correlated significantly and we have also recorded the similar findings.

In the present investigation the NPP recorded were −1.5 to
1.35 gC/m$^3$d$^{-1}$. The maximum value of NPP 1.35 gC/m$^3$d$^{-1}$ was recorded in the month of November 2002 and the minimum - 1.5 gC/m$^3$d$^{-1}$ was recorded in December 2002. NPP showed two peaks, one in pre summer and the other in post monsoon period. However Singh and Singh (1999) observed maximum NPP during summer and minimum during winter. Our peak values in the winter season are attributed to high photosynthetic efficiency whereas the most minimum value of NPP recorded in the December was an exceptional finding otherwise other minima was recorded in the months of April to August.

During the period of study of Rishi lake, the community respiration (CR) was ranged between 0.3 to 3.45 gC/m$^3$d$^{-1}$. Tongaria and Pande (1987) have recorded the high values of CR from December to March while the minimum form October to November at four aquatic bodies around Ujjain (M.P). Our findings are well in agreement with above authors. However, Mahajan and Kanhere (1996) reported high CR value during February to March while least in Monsoon months.

The productivity has been related with the various physico-chemical parameters like temperature, transparency, pH, alkalinity, dissolved oxygen, phosphate, nitrate etc. Sreenivasan (1964), Siddiqui et al., (1980) and Ahmed and Singh (1987) have observed low production to decline in temperature. While Williams and Murdoch (1966) reported that when temperature was high primary productivity was also high. Saha and Pandit (1990) found an inverse
relationship between gross production and temperature in different water bodies at Bhagalpur. Similar correlation was also seen during the period of investigation.

The transparency was positively correlated with GPP and CR. The similar observations were reported by Siddiqui et al. (1980) and Singh (1986) while carrying studies in a fresh water pond Barauni and tropical lakes respectively. Statistically, pH exhibited positive correlation with GPP and CR while it showed weakly negative correlation with NPP. Direct correlations of productivity to pH have been reported by Goldman and Wetzel (1963). Such correlations can be explained by the photosynthetic activities of the phytoplankton (Singh, 1986).

During the period of investigation productivity showed positive correlation with nitrate and negative correlation with total phosphates. Goldman and Wetzel (1963) stated that the rise in the productivity occurs along with rise in nitrate contents. However, Datta et al. (1984) established a positive correlation between nitrate-nitrogen, phosphate-phosphorus and gross production. Saha and Pandit (1980) found a significant positive correlation between CR and nitrate-nitrogen in a pond at Bhagalpur (Bihar). The present study clearly indicates that the lake is very efficient manufacturer of the organic matter, which may be due to dense phytoplanktonic population. However the greater production is not only governed by a single factor. There are several environmental factor acting simultaneously which should be taken into consideration while evaluating the productivity of the lake.
Macrophytes are an important ecological component of aquatic system (Wetzel, 1983). They contribute to productivity and provide substratum for periphyton and insects to attach, contribute again to water bodies by recycling the nutrients and accumulating the sediment (Carpenter and Lodge, 1986). During the present investigation 38 species of macrophytes were recorded. They belong to 18 families. The maximum macrophytes were recorded in winter and pre summer while the minimum in rainy season. Manna et al. (2000) reported plankton as an index of water quality with reference to sewage pollution. Our findings are well in agreement with above authors.

During monsoon the lake is filled up with water and possesses peculiar vegetation, which consists of short lived annuals. A succession of herbaceous species is observed in these habitats. Purely aquatic herbs are seen during monsoon and these are replaced by wet mud associates which in turn are replaced by dry mud associates ultimately making space for xerophyte (Naik, 1998).

In the present investigations the common species reported during monsoon, were Ammannia baccifera, Eclipta alga, Heliotropium supinum, Merremia aegyptia, Stemodia viscosa, Hygrophila spinosa, Phyla nodiflora, Cynodon dactylon and species of Cyperus, Scirpus and Ipomoea. There were few floating aquatics like Nelumbo nucifera, Nymphoides indica, Marsilea quadrifolia and
few submerged aquatics like *Vallisneria spiralis*, *Chara vulgaris*, *Nitella* sp., *Hydrilla verticillata*, *Najas minor*, *Potamogeton nodosus*, *Potamogeton pectinatus* and *Ottelia alismodes*.

Once the post monsoon period is over lake starts drying because of rise in temperature. Species like *Commelina benghalensis* made their first appearance on the wet mud. Afterwards the species like *Gnaphalium pulvinatum*, *Centaurium centaurioides*, *Bacopa monnieri*, *Ipomoea fistulosa*, *Eleocharis capitata*, and species *Cyperus* and *Scirpus* were noted. However, *Ageratum conyzoides*, *Grangea maderaspatana*, *Merremia aegyptica*, *Stemodia viscosa*, *Sutera dissecta* and *Verbascum chinense* were observed on dry mud.

*Acacia nilotica* was found through out the period of investigation and it occupied a dense population at South West side of lake causing succession. The sequence of successional changes followed similar trend to that of observation made by Naik (1998).

During the period of investigation two species of *Potamogeton* were observed which are generally found in hard water. Hutchinson, 1975 had reported various species of *Potamogeton* in hard water lakes. He had also reported harder water contain more inorganic nutrients. Our findings are well in agreement with above observations.

The flourishing of the macroflora observed during the period of investigation may be attributed to the presence of highly enriched nutrients in the lake.