CHAPTER VIII

DISCUSSION
Both the ponds under study are permanent and situated in the midst of the city. They receive rich drainage from the surroundings and abound in algae throughout the year. Since their morphometry and vicinage are different, they are unlike each other in many respects.

The mean depth of pond no. 1 was nearly twice that of pond no. 2. The 'vanishing depth' of Secchi disc was always more in pond no. 1 except in June, on account of more depth and sparse algal growth resulting into a diffuse photo-synthetic zone - the range being 10 - 26 cm. On the other hand, the value was always less in pond no. 2 on account of small mean depth and dense algal growth resulting into a narrow photosynthetic zone - the range being 10 - 17 cm.

The factors pH and alkalinity show a lot of interrelationship and can rightly be discussed together. Some relationship was seen between pH and carbonates, in the samples of pond no. 1. The carbonate value was between 66 and 120 ppm when the pH was 9.5 to 10 and it was between 28 and 66 ppm when the pH was 9 to 8.5. The carbonates were virtually
found absent when the pH of the water was 8.2. This supports the view that waters rich in carbonates are more alkaline (Zafar, 1964; Sahai and Sinha, 1969). The minimum pH of 8.2 (average of the year being 9) in the months of December and January suggests a near absence of free carbon dioxide throughout the year, indicative of good photosynthesis by planktonic algae.

Prescott (1969) suggested the alkalinity range between 90 to 250 ppm for eutrophic waters while in the present case the range varies from 240 to 560 ppm and the average of the year was 365 ppm which is suggestive of high productivity and agrees with the bloom condition of the pond. Das (1978) is of the opinion that high alkalinity may be an indicator of pollution and incidentally the alga *Microcystis viridis* which formed a bloom for four months in this pond is the best indicator of pollution (Singh, 1961). Other conspicuous species viz. *Oscillatoria proteus* and *Arthrosira platensis* var. *non-constricta* seem to have good tolerance for such conditions.

Despite some similarity with pond no. 1 the conditions of pH and alkalinity were not the same in pond no. 2. The pH in this pond reached 9.5 and 9 only in the months of February and March respectively. In all other months it remained between 8 and 8.5 and the
average of the year was only 8.2 as compared to 9 in pond no. 1. The comparatively low pH suggests the presence of free CO₂ coming from the decomposition of organic matter. The range of alkalinity was between 198 to 440 ppm which justifies its eutrophic nature. Indeed, the alkalinity in waters is a potential source of fixed carbon-dioxide, a raw material for photosynthesis—that is why the alkaline waters are more productive and can support a good crop of algae and also fish.

The amount of total dissolved solids remained high and varied between 446 - 800 mg/l in pond no. 1. As suggested by Tiffany (1958) the concentration of dissolved solids (which contains salts up to 75%) is considerably high in the water which is highly alkaline. The high alkalinity and salinity are conducive to productivity and a characteristic of eutrophic condition. According to Bold and Wyne (1978) 100 ppm of solutes may be the limit between oligotrophic and eutrophic bodies. From this viewpoint also, the pond can easily be placed in eutrophic group. The range of dissolved solids was 320 - 930 ppm in pond no. 2 and therefore, this also shows eutrophic condition.

The dissolved organic matter present in water has been associated with the growth of blue-green
algae (Fearsall, 1932; Ganpati, 1940; Rao, 1953; and Singh, 1961). Two measures viz. C.O.D. and P.v were employed to assess the amount of organic matter. They are good indicators of organic pollution (Roy, 1961). At pond no. 1 the values of the Parameters remained low during winter season probably due to slow decomposition of the plankton and higher values of dissolved oxygen. With the rise of temperature, the C.O.D. and P.v values increased in the month of March, April and May. The maximum values for C.O.D. and P.v were seen in June and July which may be due to addition of allochthonously derived organic matter with the onset of rains but the high values during other summer months suggest that the autochthonous material coming from algae in the pond was also not less which undergoes decay due to raised temperature and accounts for high values in these months. Singh (1959) also noted that the values of oxygen absorbed from Potassium permanganate were the highest during May, June and July in Ramgarh Tal. In August and September the values in the pond water were moderate due to dilution but the values slightly increased again in October. This may be due to fall in water level and the resulting increase in concentration.

Contrary to pond no. 1, the value of C.O.D. and P.v was high during December, January and February
in pond no. 2. This may be assigned to ephemeral blooms of unicellular forms in November and February resulting into accumulation of degradable matter. Moreover, daily addition of human and animal excreta is also high in the pond. In March, April and May, water was added to this pond from the canal causing the increase in water level and there was a consequent drop in the values of C.O.D. and P.V. The 2nd highest value was recorded in June following the addition of putrescible matter on account of first showers of rains. The increased water level during July, August and September brought a decrease in the value. An increase in the value in October was consequent to a decrease in water level and in November and value showed a decrease as a result of rather quick decomposition.

The oxygen content is one of the most important qualities of water. Fritsch (1906) said, "Air-content is probably as important in the water as water content is on land". Hickling (1962) remarked, "The oxygen content of the water is of strong interest in fish culture, since oxygen minima restrain the whole chain of metabolism and can therefore diminish the expected crop of fish in a given time". The estimation of dissolved oxygen along with C.O.D. and P.V tests is used to assess the quality of water (Roy, 1961).
At pond no. 1, dissolved oxygen content was the highest in the months of March and May when the water temperature was 26 and 30°C respectively. This is not in agreement to the previous observation that periods of high temperature nearly agree with low oxygen content, a feature noted by Gonzalves and Joshi (1949) and Rao (1952). Fritsch as early as 1907 stated that oxygen content of the tropical lakes should be low due to their higher temperature but the data show that the percentage saturation of oxygen recorded at 9 A.M. in March, April and May was 219, 115 and 236 respectively. The value was the highest in May which is incidentally the hottest month. This is only due to very high photosynthetic rate shown by algal community dominated by *Microcystis viridis* in the early morning hours under intense illumination characteristic of tropical regions. The value is higher than that recorded by Seki et al. (1980) -190% at 12 hour during an algal bloom in Lake Kasumigaura at Japan.

It is generally accepted that high oxygen content in waters is accompanied by an increased pH (Singh, 1959); this feature is noticeable in pond no. 1 from February up to May but not in September. Notwithstanding the great demand of oxygen by decaying
organic matter evident from PV and C.O.D. values, it is satisfying to note that the pond water showed an early recovery from night's oxygen deficit in all the seasons. This can be attributed to the following reasons:

(i) Good photosynthetic rate.

(ii) Regular air movement over the water mass because there is much open area around the pond.

(iii) Retention of oxygen bubbles by flocks of algal colonies. This oxygen dissolves at night and becomes a bonus in the absence of photosynthesis.

Since the possibility of a marked stratification in this water body can always be ruled out, (temporary diurnal stratification may be there) it can be concluded that anoxic conditions did not develop in this pond because it is found that fish can generally live in water containing 4 ppm oxygen although a few can withstand lower limits (Ehlers and Steel, 1950).

At pond no. 2, the picture for dissolved oxygen tells a different story. In only two months viz. December and May, the water was saturated with
oxygen but the percentage was only 107 and 125 respectively. The high oxygen content was not accompanied by increased pH in this case. Therefore, the generalisation quoted by Singh (1959) that high oxygen content would be accompanied by increased pH referred earlier seems questionable. In all other months the percentage saturation of oxygen was below 100%. This can be attributed to the higher value of Pv throughout the year suggestive of organic pollution. The value of oxygen was much lower than in pond no. 1 from June up to October. This suggests that the water was able to recover rather late from night's deficit which may be due to the following reasons:

(i) Slow rate of photosynthesis at least in the early morning hours because the pond is largely shaded by houses on the eastern side.

(ii) Lack of breeze.

(iii) More demand for bacterial activity on decaying matter.

(iv) More demand for respiration by the plankton and other organisms.

In conclusion, it can be said that the possibility of this pond being deficient in oxygen from June to October can not be wholly ruled out.
As raw materials for protein synthesis, nitrates and phosphates are always reckoned as indispensable nutrients for proper growth of plants. The range of requirement for these nutrients can vary for different species but in case of planktonic algae studied, Chu (1943) found that the lower limit of the optimum range of nitrogen can be from 0.3 to 0.9 ppm when nitrate is the source of nitrogen. In his opinion the nitrogen concentration less than 0.1 ppm and phosphorous concentration less than 0.009 ppm can create a limiting effect on the proper growth of algae. In pond no. 1 the range for nitrate was 0.7 ppm to 1.8 ppm while for phosphate it was 0.1 ppm to 0.25 ppm which shows that the nutrients were readily available for a profuse growth. The easy availability of nitrate and phosphate encouraged proliferation of planktonic algae and were important factors for the formation of continuous bloom of such species which do not 'fix' nitrogen.

In pond no. 2 the range of nitrates varied between 0.3 ppm to 2.0 ppm which is not much apart from the range (0.7 ppm to 1.8 ppm) found in pond no. 1, but the pattern of seasonal variation was somewhat different in pond no. 2. The main difference was seen during winter from November to February when the amount
of nitrates was much less in pond no. 2 as compared to pond no. 1. In other months the difference was not so pronounced. It is clear from the data that the nitrates during winter (0.3 ppm to 0.8 ppm) were just in the range (0.3 ppm to 0.9 ppm) of the lower limit for proper growth suggested by Chu (1943). This minima was brought about due to rather rapid algal growth accompanied by quick changes in the composition of the planktonic algae. The monthly break-up during the period shows that in November it was mainly a bloom of * Euglena viridis* and *E. acus* comprising 85% of the population in a number of 122.5 thousand individuals per ml. In December and January there was no trace of this flagellate and many of its associates and a bloom of filamentous forms comprising species of *Oscillatoria* and *Arthospira* was observed. Thereafter, in February the alga in bloom was a unicellular form a species of *Chlamydomonas* taking the total number up to 156 thousand per ml which is the highest in the year. Such a profuse growth accounts for lowest values of the nutrients (nitrate and phosphate 0.3 ppm and 0.1 ppm respectively) recorded at this pond. An increase in the amount of nitrate and phosphate was noted from April which continued up to October. This was possibly the result of increased decomposition of algae and other forms during these
months. The nutrient phosphate also exhibits a similar pattern of distribution but the amount was always above the lower limit for proper growth.

As regards productivity the amount of biomass in pond no. 1 was higher than in pond no. 2 in all the months except March and April. This can be assigned to the availability of greater depth for the growth of algae and more net production (average of the year being 2.55 gC/m²/day as compared to 2.43 gC/m²/day at pond no. 2). Wide fluctuations were noted nearly every three or four months in the standing crop of algae; peaks and ebbs were noted at regular interval which may be on account of its utilization by herbivorous forms and/or decomposition by microflora.

In case of pond no. 2, the values of biomass were low as compared to pond no. 1 except the slightly higher values in March and April. The range (4.2 gC/m² - 10 gC/m²) at this pond is much less than the range (5.76 gC/m² - 16.75 gC/m²) seen in pond no. 1. However, fluctuations were noticed more frequently in this pond and the data show that the value changed almost every month or in two months. This suggests a higher activity of consumers and decomposers which counteract the effect of photosynthesis. This seems more logical in view of
the fact that the average rate of net primary production (2.43 gC/m²/day) was only slightly less than that (2.55 gC/m²/day) noticed for pond no. 1.

The gross primary productivity at pond no. 1 remained fairly high throughout the year, the average of the year being 3.3 gC/m²/day, bringing the annual production to 1.204 kgC/m²/year which is slightly less than 1.374 kgC/m² annual production (including Macrophytes) for Manasbal Lake reported by Zutshi, 1982. Breenivasan (1963) reported a rate of 3.113 gC/m²/day for Yercaud an eutrophic Lake, at Madras where Microcystis and Oscillatoria were the dominant forms. The highest production rate was noted in April when the algal community was dominated by Arthrosira platensis var. non-constricta. The pH in this month was 9, the Pₖ value was low and the nitrates and phosphates were also comparatively less, but above the minimum limit, probably due to more consumption. Nearly similar conditions are seen in August and September, when the productivity was 2nd only to April. The lowest productivity rate was seen in June and July when the C.O.D. and Pₖ values were the highest and the biomass value was also high. In fact, productivity is a result of multiple physico-chemical and biological features and does not depend on biomass alone.
At pond no. 2 the gross production rate was a little less than in pond no. 1, the average being 2.95 gC/m²/day, bringing the annual production to 1.076 kgC/m²/day which is more than 0.959 kgC/m² annual production reported for Naranbarg Lake (Zutshi, 1982). The peak value of primary production (4.3 gC/m²/day) noted in September was also less than the highest (5.16 gC/m²/day) recorded in April for pond no. 1. The lower photosynthetic rates can be explained on grounds: that direct light availability was checked due to houses on two sides of the pond; the Secchi visibility was less due to which the depth through which photosynthesis can take place was reduced curtailing the unit volume of water effective for photosynthesis. Further, due to lack of wind action, the algae - except the flagellated ones - tend to aggregate at the surface and bring in competition for nutrients as well as light. However, the possibility of nutrient deficiency becoming a limiting factor for primary production at this water sheet seems remote.

Net primary productivity has its own place in the study of ecosystems because it is this part of material which accumulates over time to form the biomass; which is available for consumption either before or after the death of the plant, by animals,
bacteria and fungi, which can not create new organic matter themselves (Westlake, 1963). The monthly average of N.P.P. at pond no. 1 was 2.55 gC/m²/day, or in terms of dry matter it comes to 0.38 g/m²/day which brings the annual production to 232.7 g/m²/year.

In pond no. 2, the annual net primary production was 0.836 KgC/m²/year which was calculated from the daily net production of 2.43 gC/m²/day i.e. 6.075 g/m²/day (in terms of dry matter) bringing the annual production to 2217.37 g/m²/year.

The average amount of carbon used in respiration was 0.75 gC/m²/day in pond no. 1 as compared to 0.5 gC/m²/day for pond no. 2. This can be explained on the basis of large biomass and higher rate of gross production in pond no. 1.

Respiration as percentage of G.P.P. varied between 11.76 to 27.05% in case of pond no. 2, but in case of pond no. 1 the range was 10.5 to 43.27%. It is generally accepted that approximately 30% of the carbon fixed by green plants is lost through respiration (Nogge and Fritz, 1976). The data obtained are within this limit except the highest value i.e. 43.27% recorded in May at pond no. 1. This may be due to
high temperature of the month.

The average of the ratio of net and gross primary production was higher (0.82) in pond no. 2 as compared to (0.77) of pond no. 1. This again can be explained on account of large biomass of algae requiring more respiratory substrate leading to a low N.P.P./G.P.P. ratio.

The turnover time at pond no. 1 varied from 0.76 to 3.64 days except in July when it was 8.68 days. A notable point was that the turnover time was more when the biomass value was high. It suggests that an accumulation of biomass is not always accompanied by an increase in gross production. In January, May, June and July gross production was reduced with an increase of biomass value, while a small biomass in the months of April, August and September showed a high production and therefore a quick turnover.

In case of pond no. 2 the turnover time varied from 0.6 day to 2.34 days which suggests a still higher rate of turnover. From the data, it is clear that planktonic algae generally maintain a high metabolic rate and have a rapid rate of turnover and as suggested by Remmert (1930) at times the production of new algae per day may be higher - weight increase being
more than 100% - than the amount of algae present in
the water body at that time. This point comes true in
the present study on days when the turnover time was
less than a day.

The highest activity co-efficient at pond
no. 1 was noted in April during a bloom of *Arthospira
platensis var. non-constricta*. In case of pond no. 2
the activity coefficient was the highest in October when
the plankton was dominated by *Oscillatoria raciborskii
and O. obscura*. The value was always more than in pond
no. 1 except in March & April which indicates that the
production per unit biomass per unit time was higher
in this pond but a lower rate of net production was due
to reasons mentioned earlier.

In conclusion, it can be added that both the
ponds have already reached the eutrophic level and as
suggested by Sawyer (1947) the amount of inorganic
nitrogen and phosphorous has exceeded the upper limit
0.01 mg/l (for phosphorous) and 0.3 mg/l (for nitrogen)
for these nutrients in water bodies endangered with
eutrophication, showing the effect of dense population
and industry of this metropolis on its water sheets.

The prodigious algal growth, however, is not
objectionable since most of the algae are regularly
utilized in the food-web.