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Seasonal variation in primary productivity of two freshwater lakes of Aurangabad district, Maharashtra, India.

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Abstract
Primary productivity gives information related to the amount of energy available to support bioactivities of system. The present study is aimed to know the status of primary productivity of two freshwater lakes namely, Mombatta and Kagzipura. It is determined by using standard 'Light and Dark bottle' method of Garden and Gran (1927) at an interval of 15 days in every month a period of two years (October 2008 to September 2010). Results indicate that Primary productivity of Kagzipura Lake is higher than Mombatta Lake. High productivity of Kagzipura Lake favors better growth of zooplanktons.

Keywords: Primary productivity, Mombatta Lake, Kagzipura Lake.

1. Introduction
The flow of energy through any ecosystem starts with the fixation of sunlight by plants and other autotrophic organisms. In this way the plants accumulate which is called primary production. The rate at which this energy accumulates is called primary productivity. The total energy accumulated is gross primary production; however, since plants use some of this energy themselves, it is not available for the food web [10]. Estimation of primary productivity is essential to understand food chain and food web [5], water quality [19] and pollution study [13]. The primary productivity of the aquatic ecosystem is adversely affected by anthropogenic activity. The overall productivity of a water body can easily be deduced from its primary productivity, which forms the backbone of the aquatic food chain Ahmed SH [1] *et al*. It gives information related to support bioactivities of the system. According to Odum and Barrett [11] the primary productivity of an ecosystem is the rate at which radiant energy is converted to organic substances by the photosynthetic and chemosynthetic activity of the producer organisms. The aquatic resources have been till date the potential source of organic production for the entire living organisms. Many ecologists of the world have laid emphasis on the importance of the primary productivity as an important functional attribute of the biosphere because of its controlling effects on the rate of multiplication and growth of the living organisms of the ecosystem [18]. Primary productivity of aquatic ecosystem has been measured by several workers [5, 8, 12, 16]. The present study has been undertaken to analyze the seasonal variations of Primary productivity in two freshwater lakes, namely Mombatta and Kagzipura.

2. Materials and Methods
2.1 Study area: - Kagzipura lake (latitude 19º57'N and longitude 75º15'E) is located near Kagzipura village, Tal. Khultabad 16 km away from Aurangabad city whereas Mombatta lake is situated in Daulatabad valley (Latitude 19º57"N and longitude 75º13'24"E) near Daulatabad village, Tal. Aurangabad. Both lakes are used for irrigation and aquaculture purposes.
The primary productivity is determined by using standard "light and dark bottle" method of [7] at an interval of 15 days in every month for a period of two years from October 2008 to September 2010. The method of Gardner T [7] *et al*. is slightly modified by Vollenweider RA [17] and Wetzel RD [19] *et al*. to make it more suitable. The time of exposure (incubation period) in the present study was for the period of 2 hours. The dissolved oxygen is estimated by initial bottle and light and dark bottle method of Winkler [19]. The observed Gross Primary Productivity (GPP), Net Primary Productivity (NPP) and Community Respiration (CR) in mg/l/hr were converted into gC/m³/hr by multiplying these values with a factor of 0.375 as

suggested by Benton AH [3] *et al*.
The Gross Primary Productivity (GPP), Net Primary Productivity (NPE) and Community Respiration (CR) were estimated by using following formulae of **[18]**. NPE and Respiration (% of GPP) were calculated by using formulae of Chattopadhyay C [4] *et al*. with the help of GPP, NPP and CR.

$$\text{Net production efficiency (NPE):} \quad (\%) = \frac{NPP}{GPP} \times 100$$

$$\text{Respiration (\% of GPP):} \quad \% = \frac{CR}{GPP} \times 100$$

3. Result

In the present study primary productivity of Mombatta and Kagzipura Lake has been calculated. Seasonal record of primary productivity recorded as Gross primary productivity, Net primary productivity, Community respiration, Net production efficiency and respiration (% of GPP) from Mombatta and Kagzipura Lake during October 2008 to September 2010 is depicted in Table 1 and 2.

Table 1: Seasonal record of Primary Productivity of Mombatta Lake during October 2008 to September 2010.

Seasons parameters	Winter	Summer	Monsoon
GPP (gC/m3/hr**)**	1.53 ± 0.19	1.65 ± 0.15	0.66 ± 0.17
NPP (gC/m3/hr**)**	1.46 ± 0.19	1.44 ± 0.13	0.60 ± 0.15
CR (Gc/m3/hr**)**	0.07± 0.01	0.20 ± 0.07	0.06 ± 0.02
NPE (%)	95.39 ± 0.60	87.74 ± 3.37	91.19 ± 2.32
RESP. (% of GPP)	1.04 ± 0.79	1.86 ± 2.18	2.97 ± 2.27

± Standard Error of mean

Abbreviations: GPP= Gross Primary Productivity, NPP= Net Primary Productivity, CR= Community Respiration, NPE= Net Production Efficiency, RESP = Respiration.

Table 2: Seasonal record of Primary Productivity of Kagzipura Lake during October 2008 to September 2010.

Seasons parameters	Winter	Summer	Monsoon
GPP (gC/m3/hr**)**	2.50 ± 0.90	2.13 ± 0.72	1.19 ± 0.78
NPP (gC/m3/hr**)**	2.38 ± 0.88	1.89 ± 0.69	1.12 ± 0.73
CR (gC/m3/hr**)**	0.12± 0.03	0.23 ± 0.09	0.07 ± 0.09
NPE (%)	95.64 ± 0.44	89.16 ± 5.12	94.80 ± 2.33
RESP. (% of GPP)	2.05 ± 1.98	2.29 ± 2.37	0.75 ± 0.67

± Standard Error of mean

Abbreviations: GPP= Gross Primary Productivity, NPP= Net Primary Productivity, CR= Community Respiration, NPE= Net Production Efficiency, RESP = Respiration.

3.1 Gross Primary Productivity (gC/m^3/hr): Seasonal record of GPP in Mombatta Lake showed lower in monsoon (0.66±0.17) and higher in summer season (1.65±0.15), whereas in Kagzipura Lake also it was minimum in monsoon (1.19±0.78) and maximum in summer season (2.50±0.90).

3.2 Net Primary Productivity (gC/m^3/hr): Seasonal record at Mombatta Lake showed minimum in monsoon (0.60±0.17) and higher in summer season (1.45±0.23), whereas in Kagzipura Lake also it was lower in monsoon (1.12±0.73) but maximum in winter season (2.38±0.88).

3.3 Community Respiration (gC/m^3/hr): Seasonal record at Mombatta Lake showed minimum in monsoon (0.06±0.01) and higher in winter season (0.20±0.07), whereas in Kagzipura Lake also it was lower in monsoon (0.07±0.09) but maximum in summer season (0.23±0.09).

3.4 Net Production Efficiency (%): Seasonal record at Mombatta Lake showed minimum in monsoon (87.74±3.37) and higher in winter season (95.39±0.60) whereas in Kagzipura Lake also it was lower in monsoon (1.12±0.73) but higher in winter season (2.38±0.88).

3.5 Respiration (% of GPP): Seasonal record in Mombatta Lake showed minimum in summer (1.04±0.79) and maximum in monsoon season (2.97±2.27), whereas in Kagzipura Lake it was lower in monsoon (0.75±0.67) but higher in summer season (2.29±2.37).

4. Discussion

4.1 Gross and Net primary productivity

Gross primary productivity is the total rate of photosynthesis including the organic matter utilizes in respiration during the period of measurement. This is also known as total photosynthesis or total assimilation. Net primary productivity is the rate of storage of organic matter in plant tissues in the excess of the respiratory use by the plants during the measurement period. This is also called as apparent photosynthesis or net assimilation.
Seasonal record of gross and net primary productivity is minimized in monsoon at both lakes. Whereas it was maximum in summer at Mombatta and in winter at Kagzipura lake. Mitsch WJ [10] *et al*. stated that the trend of fluctuations shows that the values of gross and net primary productivity increased gradually during winter and summer and decreased during monsoon. The highest rate of productivity during the summer may be due to bright sunshine with high temperature, high phytoplankton density and algal blooms. The low in monsoon could be attributed to the reduced photoperiod coupled with low light intensity, temperature and reduced phytoplankton Mitsch WJ [10] *et al*. reported high primary productivity during summer season due to high light penetration while low productivity during monsoon season because of the influx of the turbid water to the reservoir.
Prabhakar VM [13] *et al*. reported that the primary productivity higher in winter and lower in monsoon season from Khadakwasla reservoir of Pune. Clear water surface, which permitted more light to penetrate and water flow perhaps accounted for the higher values of primary productivity during winter. Addition of nutrients with runoff water during monsoon rain and later clarity of water during this season are responsible for high primary productivity during winter. Lower values are observed during monsoon might be due to increased turbidity and suspended slit content of water resulting from soil erosion from surrounding hills.
Radwan AM [14] from Nainital and Bhimtal lakes of Kumaon Himalaya of Uttarakhand state reported that a lake having a dense population of plankton indicating higher productivity and less plankton concentration showed low productivity. Less plankton density, nutrient status and deep water body are responsible for low primary productivity of Mombatta Lake while Kagzipura Lake has during winter and summer season rich population of planktons, high nutrient load dues to inflow of sewage, human activities, brick factories, excessive algal

growth and macrophytes resulting in high productivity. Hence high productivity indicating the pollution and eutrophication of water bodies. Similar results are also observed by Anjinappa H *et al* [2] and [6] Das AK.

4.2 Community Respiration

Community respiration means deducting the net primary productivity from gross primary productivity and converted into CO_2 release. Seasonal values of community respiration were minimum in monsoon at both lakes, but maximum in winter in Mombatta Lake and in summer in Kagzipura Lake.

Shallow lake water leads to a rapid change in the productivity with the change in Physico-chemical conditions of water. The high respiration of all living organisms and non-living organic matter reduce the dissolved oxygen content [13]. This observation supports the present study as values of dissolved oxygen content were found lower during the summer season in Mombatta and Kagzipura Lake.

According to Prabhakar VM [13] *et al*. rate of respiration attain highest values in summer due to the effect of drainage water discharged from the different drains around the station. These effluents enhance the biological activities of bacteria, especially in summer due to the decomposition of organic matter. Similar findings are observed in present study for Kagzipura Lake because this lake receives domestic sewage from surrounding village and other human activities responsible for higher community respiration. And also low count of phytoplanktons and high density of zooplanktons might be responsible for high values of community respiration. Similar finding is reported by [15] from Burulus Lake of Egypt. Radwan AM [14] reported maximum primary productivity for Lake Burulus of Egypt in summer season and lower in winter and monsoon season. Values of community respiration of Kagzipura Lake are higher than the Mombatta Lake. Patil A [12] and Sheriff ZM [15] *et al*. reported that community respiration is increases during summer and decreased in monsoon season.

4.3 Net production efficiency

It is the ratios measure the efficiency with which an organism converts assimilated energy into primary or secondary production.

Seasonal record of Net production efficiency minimum in monsoon in Mombatta and in Kagzipura Lake lowers in summer. It was higher in winter season at both lakes. Chattopadhyay C [4] *et al.* reported seasonal records of Net Production Efficiency to be maximum in monsoon and minimum in winter season for Krishnasayar Lake at Burdwan. Chinnaiah B [5] *et al*. reported that seasonal record of Net Production Efficiency was higher in monsoon and summer and lower in winter season for Darmasagar Lake in Adilabad. Such findings inverse relationship to present study of Mombatta and Kagzipura Lake.

4.4 Respiration (% of GPP)

Seasonal records of respiration were minimum in monsoon at both lakes, whereas and maximum was found in winter in Mombatta and Kagzipura Lakes in summer. Chinnaiah B [5] *et al*. reported that seasonal records of respiration were higher in winter and summer and lower in monsoon seasons for Darmasagar Lake in Adilabad. Such findings support the present study on Mombatta and Kagzipura Lakes.

High productivity has close relationships with the degree of cultural eutrophication which is mainly caused by high amounts of nutrients from sewage, fertilizer, animal wastes, detergents and run-off nitrates from catchment areas which enter the lakes and result in excessive growth or bloom of microorganism and aquatic vegetation. Thus, the nutrients stimulate algal growth and lead to plankton blooms. The productivity of water which body greatly depends on the amount of available dissolved nutrients in water is directly controlled by nutrient cycling in the area. High nutrient content causes eutrophication.

5. Conclusion

It is observed from above results that most of the seasonal values of primary productivity of Kagzipura Lake were higher than the Mombatta Lake. Hence it is concluded that the productivity of Kagzipura Lake is more productive than Mombatta Lake. High productivity of Kagzipura Lake showed their food chain and food web is in good condition and it favors better growth of zooplanktons and fishes. It also indicates water body is polluted and leads towards eutrophication. Rich productivity of Kagzipura Lake may be due to shallowness of area which is more productive than deep lakes in part due to nutrients regulating from sediments and extent of attached macrophyte growth.

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