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A LIMNOLOGICAL STUDY OF PRIMARY PRODUCTIVITY IN SEASONAL VARIATIONS OF A TYPICAL TROPICAL POND OF BUNDELKHAND REGION, INDIA

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ABSTRACT

The primary productivity of the Mahil pond has been estimated from March 2017 to February 2018 at four different stations. Various physicochemical parameters and phytoplankton were studied. The seasonal variation of primary productivity revealed that maximum and minimum values of Gross primary productivity and community respiration were associated with rainy and summer seasons respectively. The minimum values of Net primary productivity were recorded during rainy season and maximum during winterfor different study stations.

Keywords: Gross primary Productivity, Net primary productivity, Community respiration, Physicochemical, Seasonal fluctuations.

INTRODUCTION

The expending of human population and the growing need of the organic matter has necessitated the evaluation of the primary productivity of the different ecosystem, which provide food to the consumers of the higher trophic level.The inland aquatic system covers less than 1% of the earth surface but after are among the most productive areas. Further the fluctuations in the rate of production in freshwater systems are the great ecological importance due to their marked spatial and temporal variability. Despite this, the work on these aspects is still meagre in our country. Some important contribution from the tropical regions is those of Adoni *et al.,* (1985), Saran(1980), Saha *et al.,* (2001), Sharma and Sharma (1992),Ahmed *et al.,* (2005), Verma and Srivastave (2016), Deka (2017), Rajan (2018), Yusuf *et al.,* (2019), Untoo *et al.,* (2016), Shwetan Shumla *et al.,* (2019).

Ponds are historically and ecologically important ecosystem representing around 30 % of the global surface area of standing water (Dowing *et al.,* 2006, 2010). Ponds serve as cheap and convenient source of water for drinking, domestic, irrigation and industries. The services provided by the pond are ground water recharge, food alleviation, high local and regional aquatic biodiversity, culture, aesthetic and recreation (Chia *et al.,* 2009; Takaura, 2012; Cereghino, 2004; Yadav *et al.,* 2017). Ponds also provide an underutilized resource for teaching and training of the next generation of limnologist (Mullins and Doyle, 2019).In view of the paucity of information on the phytoplanktonic productivity during different seasons, the present study was carried out in the Mahil pond.

MATERIAL AND METHODS

The pond selected for investigation is known as "Mahil Ka Talab". It is situated on the south east part of the Orai city, U.P. Orai city is also known as city of the king Mahil who was the ruler of this region during 18th century A.D. Orai is located between 25° 59′ N latitudes and 79° 28′ E longitudes.The pond is somewhat elliptical in outline having granite steps and raised concrete walls on all sides. Maximum depth of the pond at full water level is about 5.8 m.

For the determination of primary productivity monthly water sample was collected from each study sites. The primary productivitywas estimated by measuring the changes in the dissolved oxygen concentration in light and dark bottles after following methodology of Gaarder and Gran (1927) and Vollewinder (1974).

RESULTS

The productivity of Mahil pond calculated in terms of gross primary productivity (GPP), net community respiration (CRR) and Net primary productivity (NPP). The results envisaged that the mean values of gross primary productivity during the study period varied between 0.48±0.6 $g.cm^{-3}$ day^{-1} to 8.45±2.9 $g.cm^{-3}$ day^{-1} (Table 1).The gross primary productivity sharply decreased from the month of December to February with minor variation i.e. 0.48±0.6 to 0.9±1.05 $g.cm^{-3}$ day^{-1} and then again increased from March to May i.e. 1.72±1.1 to 3.24±1.5 $g.cm^{-3}$ day^{-1} . Season wise analysis showed that maximum value of gross primary in rainy season i.e. 3.04 ± 2.12 $g.cm^{-3}day^{-1}$and minimum in summer i.e. 2.44

± 1.25 g.cm^{-3}day^{-1}. It has been found that gross primary productivity showed significant positive correlation with community respiration ($r = 0.811$ $P < 0.01$) (Fig.1 & 2) and significant negative correlation with electrical conductivity ($r = -0.683$ $P < 0.05$) (Fig. 3 & 4).

The value of net primary productivity showed irregular pattern throughout the year. The value of net primary productivity was higher in July i.e. 3.722±3.90 g.cm^{-3} day^{-1} and lowest in the month of June i.e. 0. 43±0.21 g.cm^{-3} day^{-1} (Table 2). It was observed that the value of net primary productivity gradually decreased from August to December (i.e. 3.52±2.5 to 0.46±0.19 g.cm^{-3} day^{-1}) and then increased till the May i.e. 1.87±1.27 g.cm^{-3} day$^{-1.}$). Season wise analysis showed that during the winter season the average value i.e. 1.18± 1.36 g.cm^{-3} day$^{-1)}$ and highest during the rainy i.e. 2.458± 1.85 g.cm^{-3} day^{-1}). Besides net primary productivity recorded the significant positive relationship with chloride ($r = 0.609$ $P < 0.05$) (Fig. 5 & 6) but significant negative correlation with secchi transparency ($r = -0.579$ $P < 0.05$) (Fig 7 & 8).

During the course of present investigation, community respiration values on an average were found to vary from 0.1±0.2 g.cm^{-3} day^{-1} to 7.9±2.62 g.cm^{-3} day^{-1} (Table 3). The value of community respiration show decline in December i.e. 0.61±0.76 g.cm^{-3} day^{-1} to March i.e. 0.6±0.17 g.cm^{-3} day^{-1} and then in the later month with minor variation. Community respiration average value showed marked seasonal variation being minimum during the rainy season and maximum during the winter (1.04± 0.63 to 2.72± 1.7 g.cm^{-3} day^{-1}). Besides community respiration was found to record a positive significant correlation with dissolved oxygen ($r = 0.650$ $P < 0.05$) (Fig. 9 & 10), and gross primary productivity ($r = 0.811$ $P < 0.01$) (Fig. 11 & 12) but negative significant correlation with electrical conductivity ($r = -0.678$ $P < 0.05$) (Fig. 13 & 14).

Table1: Seasonal variation in Gross primary productivity (g.cm-3 day-1) of Mahil Pond (March 2017-Feburary 2018)

S. No.	Season	Range		Mean ± SD
		Minimum	Maximum	
1	Summer	1.72	3.24	2.44±1.25
2	Rainy	0.96	4.51	3.04±2.12
3	Winter	0.48	8.45	2.84±1.86

Table2: Seasonal variation in Net primary productivity (g.cm-3 day-1) of Mahil Pond (March 2017-Feburary 2018)

S. No.	Season	Range		Mean ± SD
		Minimum	Maximum	
1	Summer	0.76	1.87	1.28±0.88
2	Rainy	0.43	3.72	2.45±1.85
3	Winter	0.46	2.2	1.18±1.36

Table3: Seasonal variation in Community respiration (g.cm-3 day-1) of Mahil Pond(March 2017-February 2018)

S. No.	Season	Range		Mean ± SD
		Minimum	Maximum	
1	Summer	0.6	1.9	1.27±0.59
2	Rainy	0.19	2.11	1.04±0.63
3	Winter	0.1	7.9	2.72±1.74

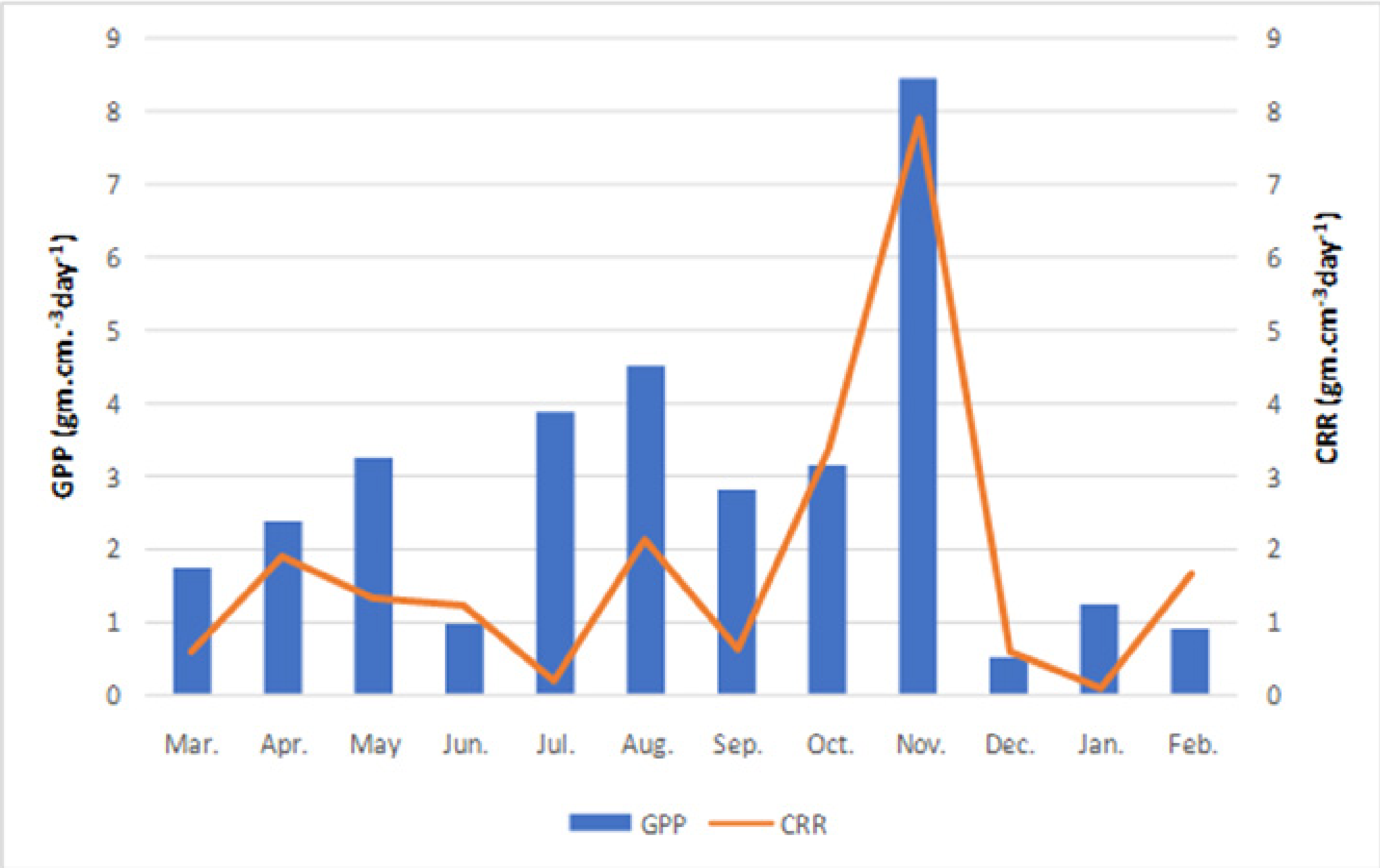

Fig.1: Variability in Gross primary productivity withCommunity respiration

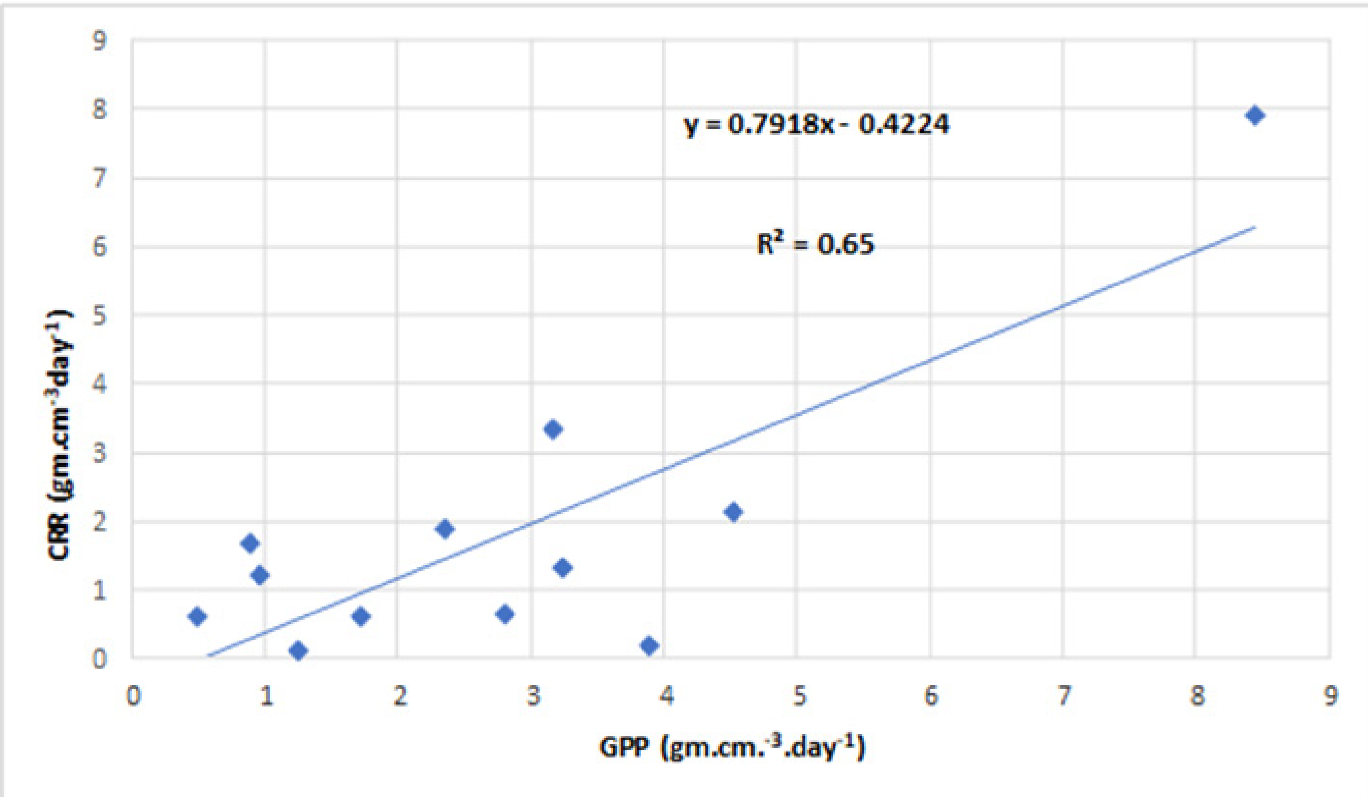

Fig. 2: Scatter diagram with fitted regression line showing relationship between Gross primary productivity and Community respiration

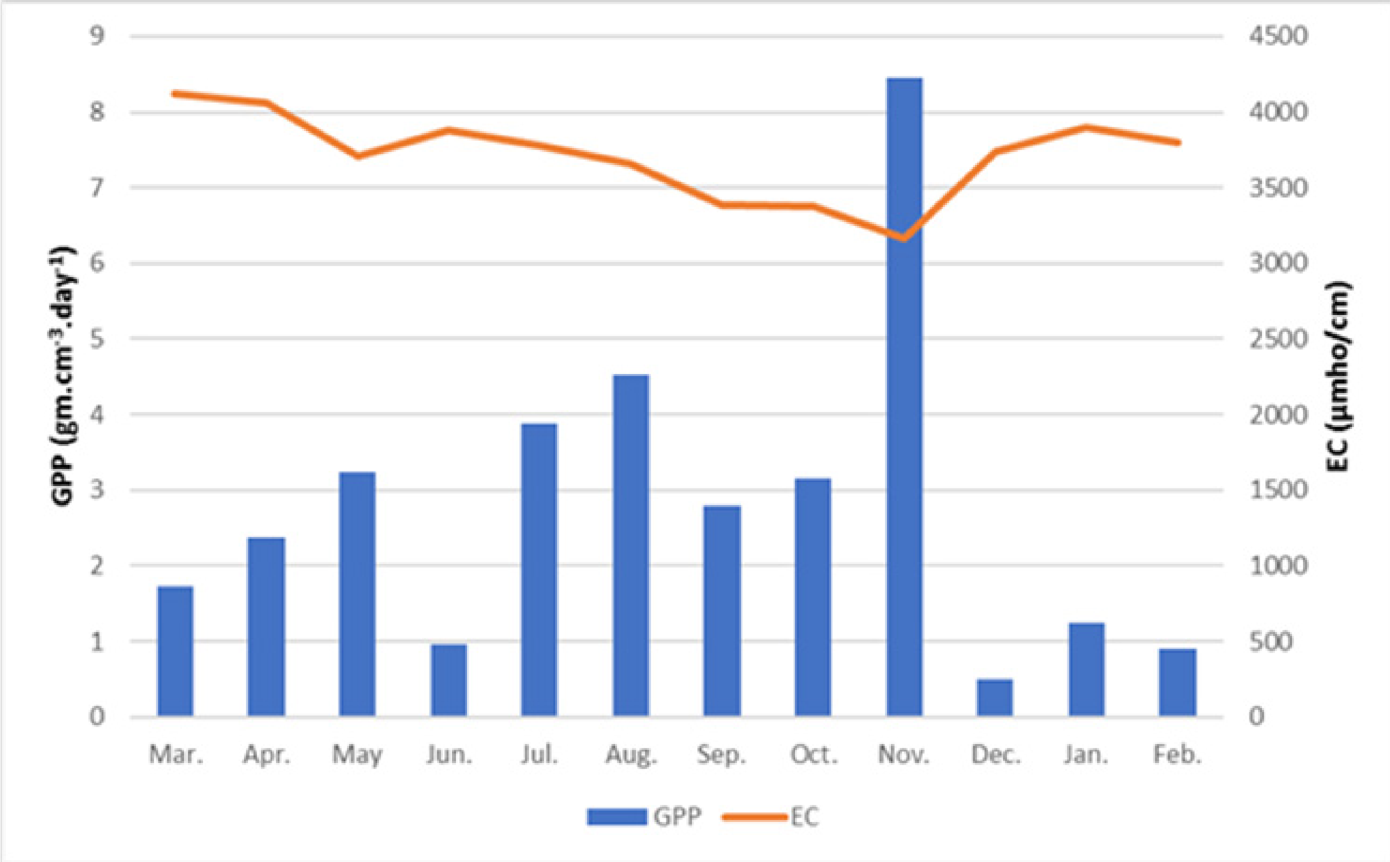

Fig. 2: Scatter diagram with fitted regression line showing relationship between Gross primary productivity and Community respiration

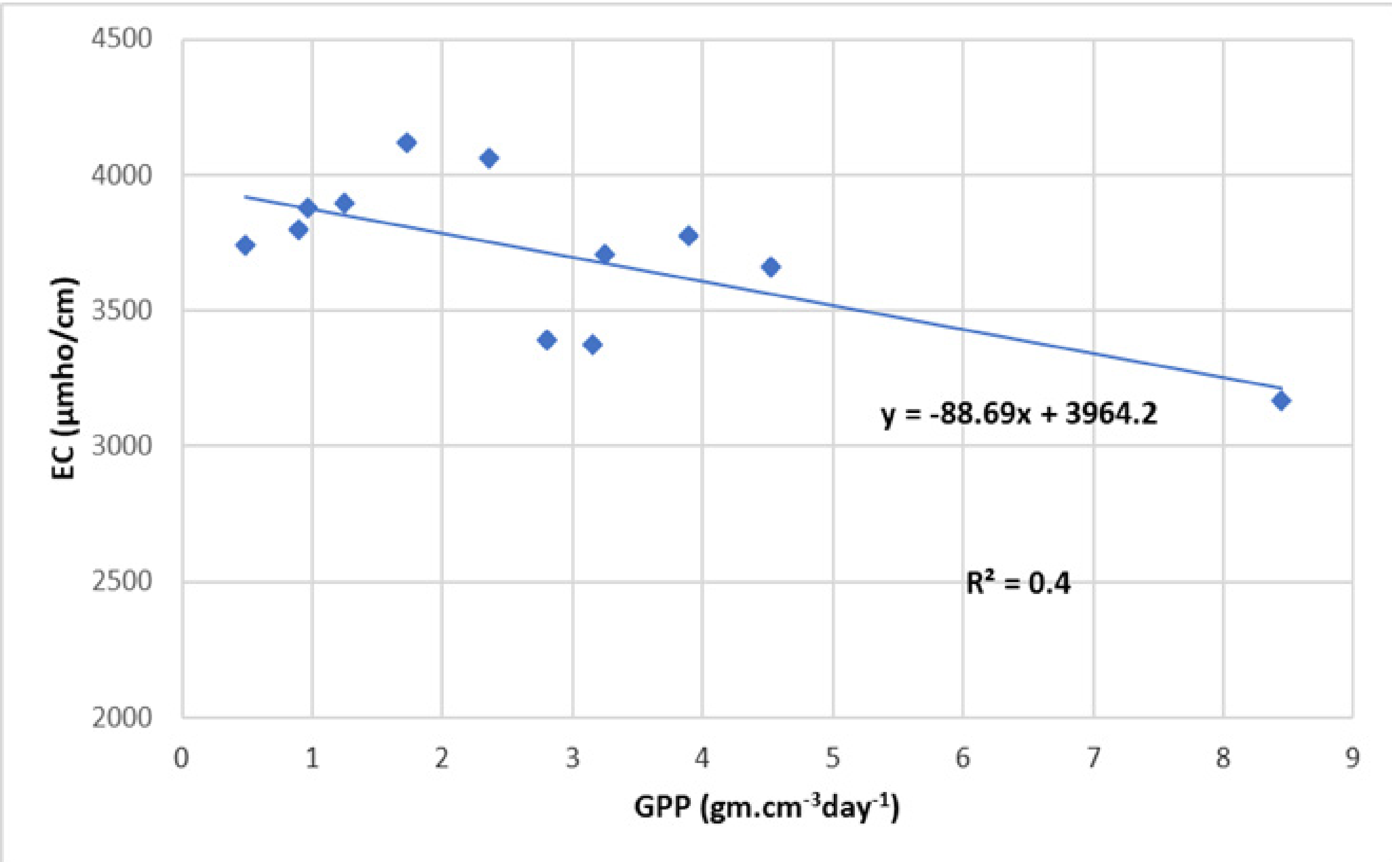

Fig.4: Scatter diagram with fitted regression line showingrelationship between Gross primary productivity andElectrical conductivity

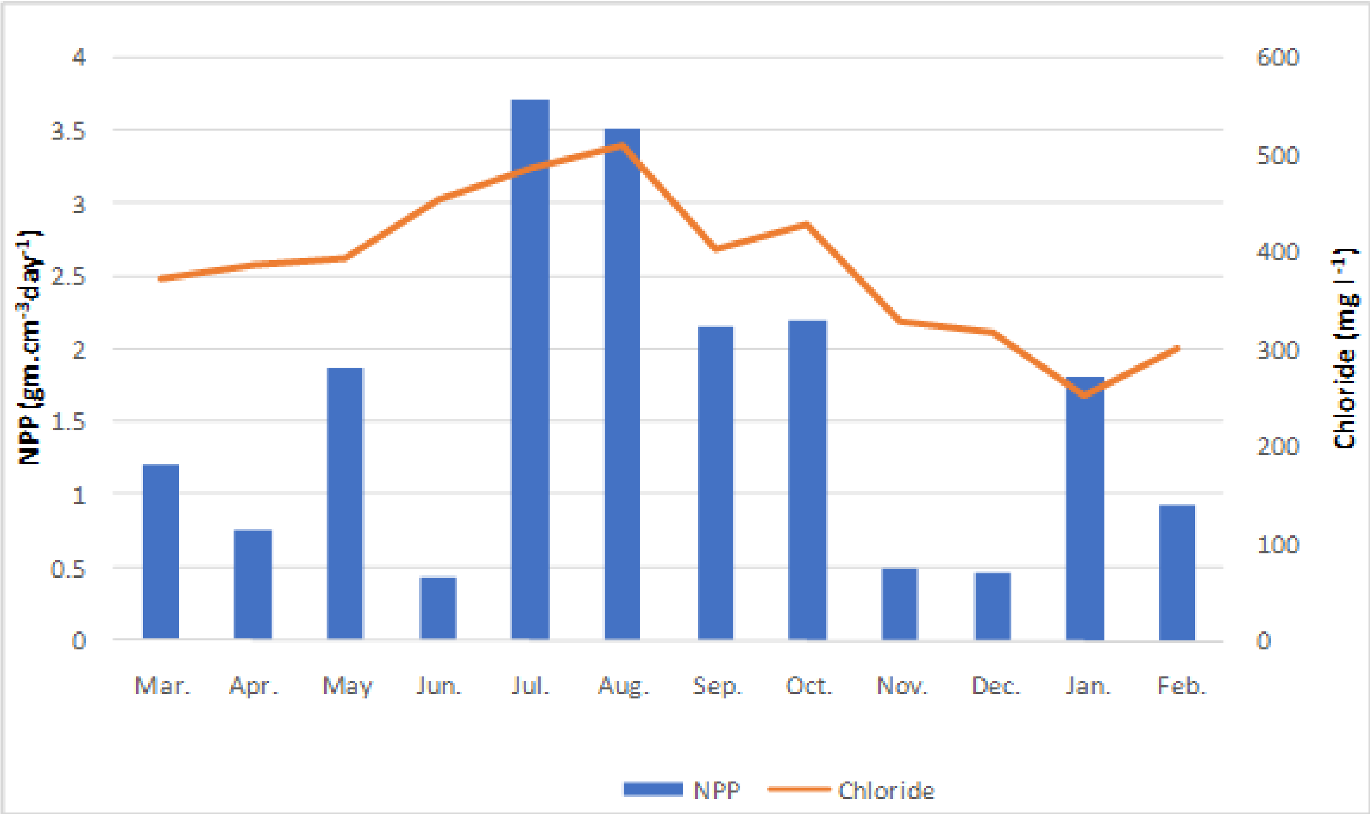

Fig. 5: Variability in Net primary productivity with Chloride

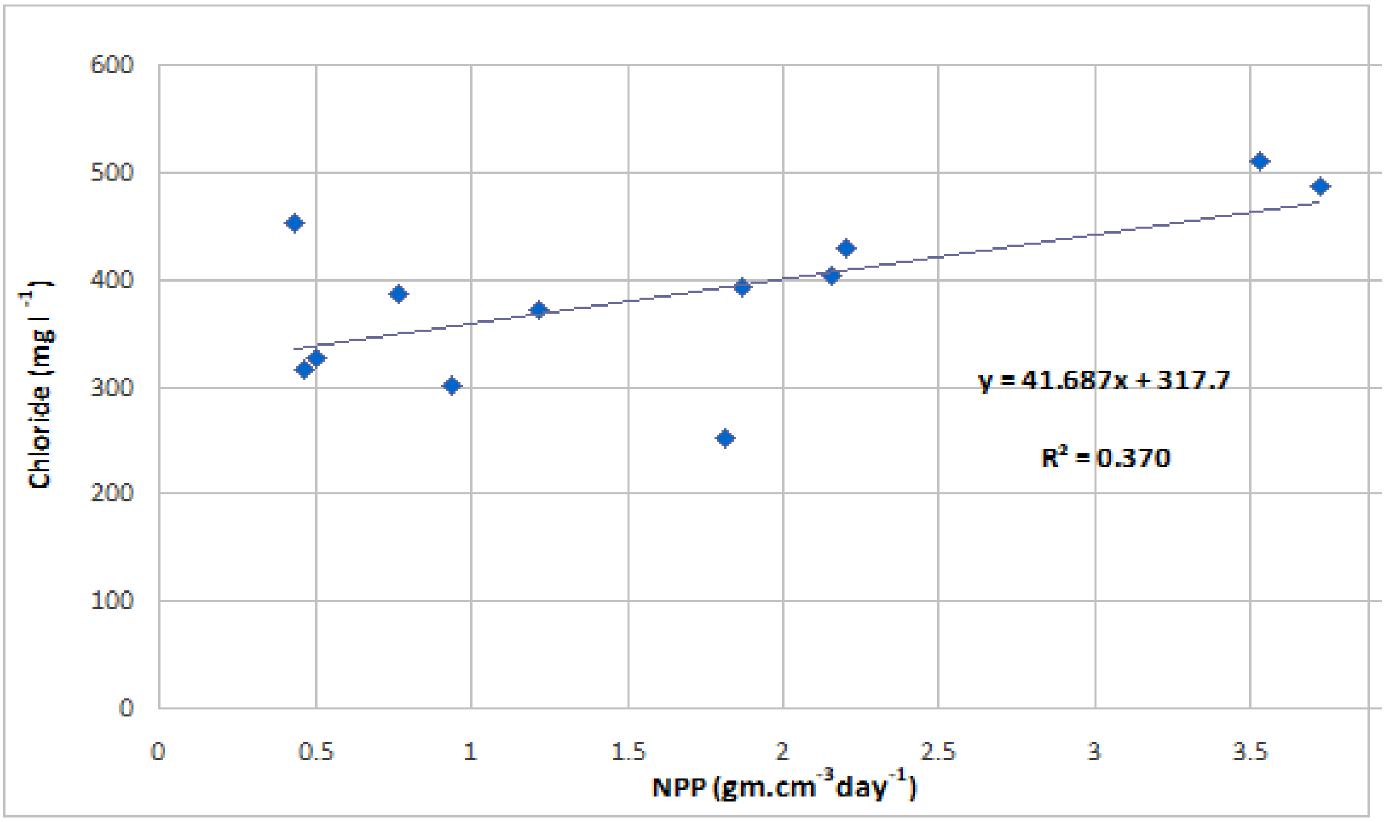

Fig.6: Scatter diagram with fitted regression line showingrelationshipbetween Net primary productivity and Chloride

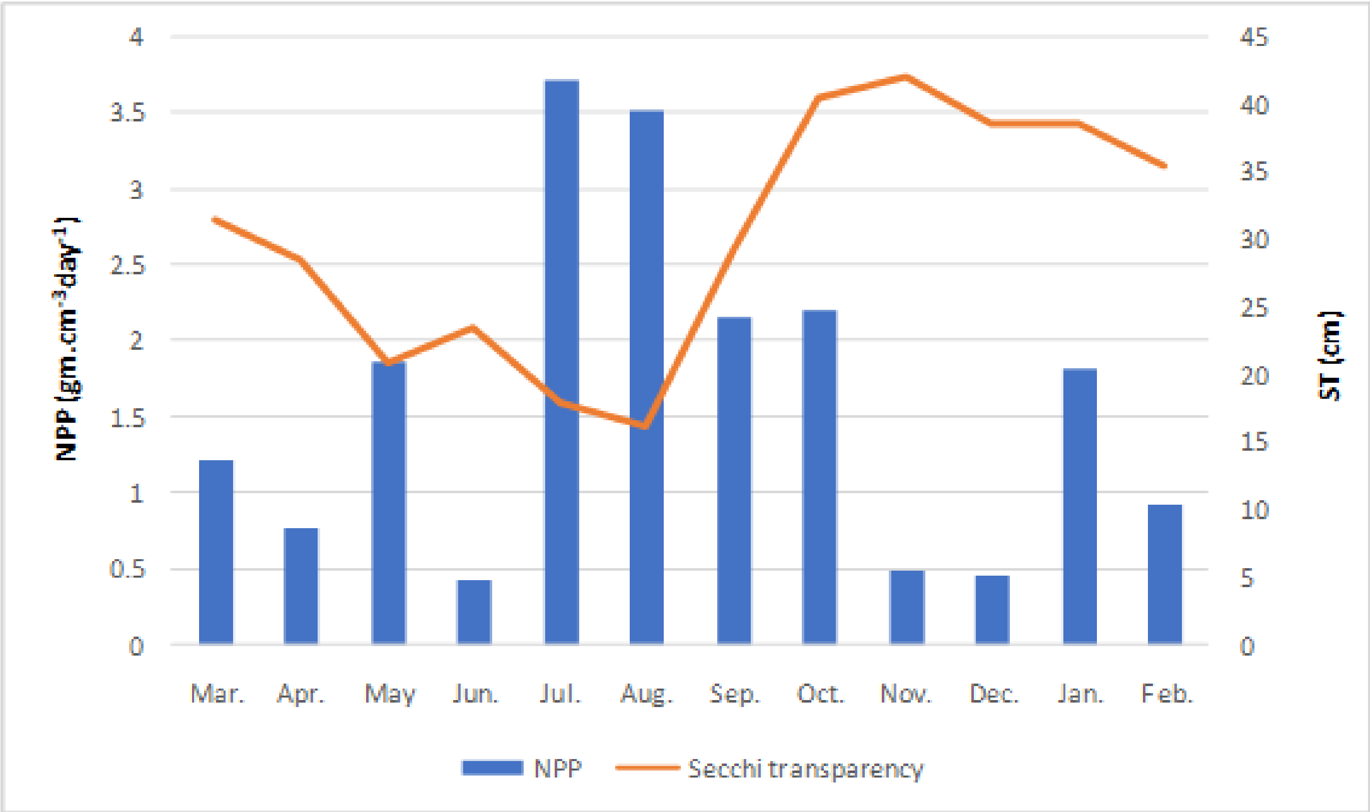

Fig. 7: Variability in Net primary productivity with Secchi Transparency

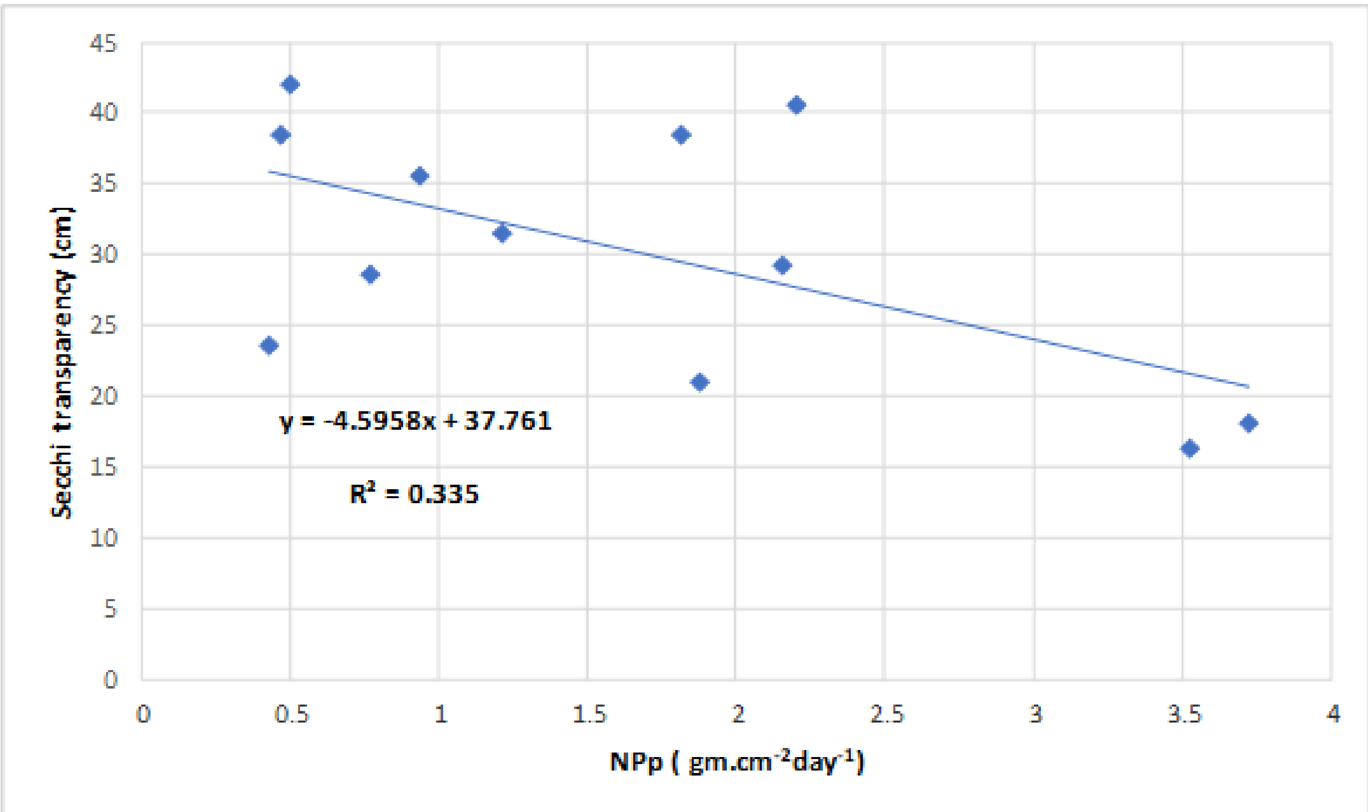

Fig. 8: Scatter diagram with fitted regression line showingrelationship between Net primary productivity and Secchi transparency

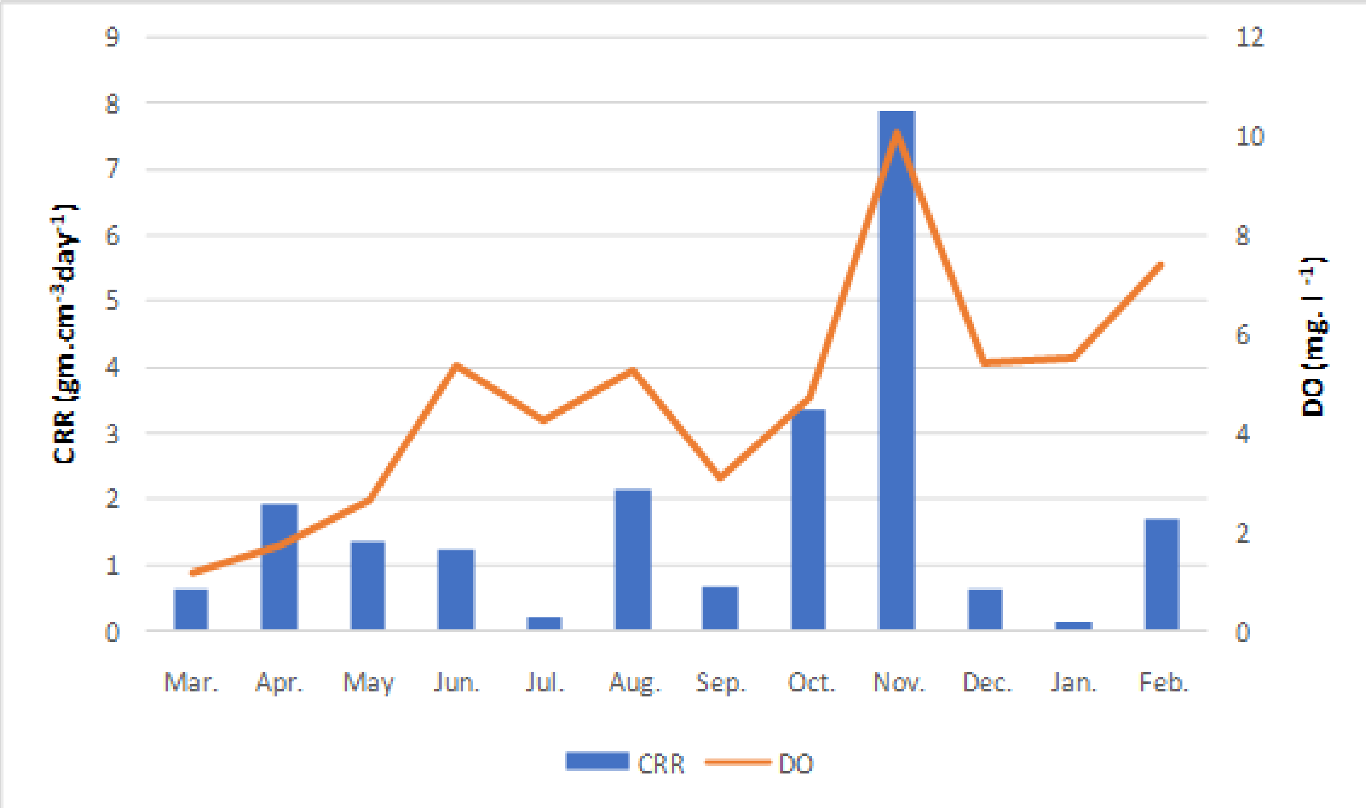

Fig. 9: Variability in Community respirationwith Dissolved oxygen

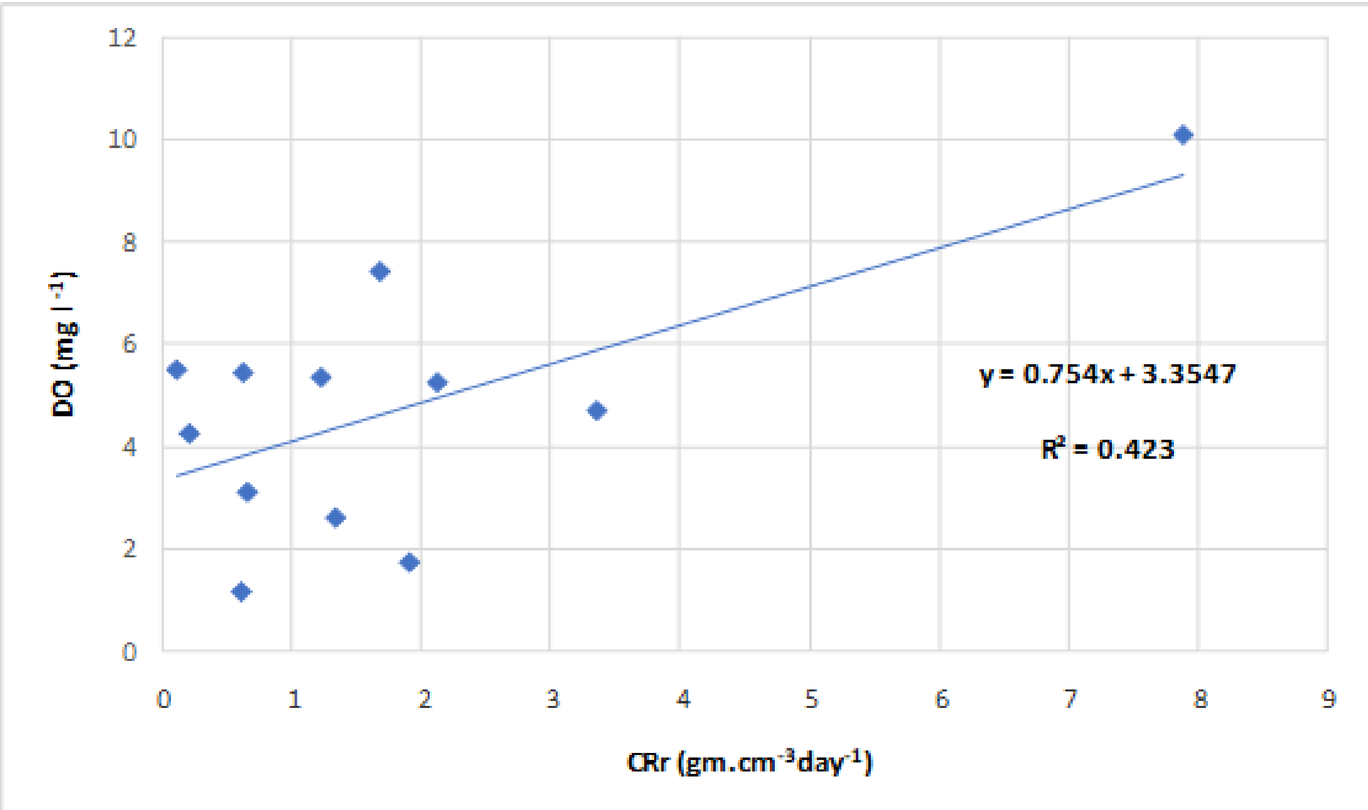

Fig. 10: Scatter diagram with fitted regression line showing relationship between Community respiration and Dissolved oxygen

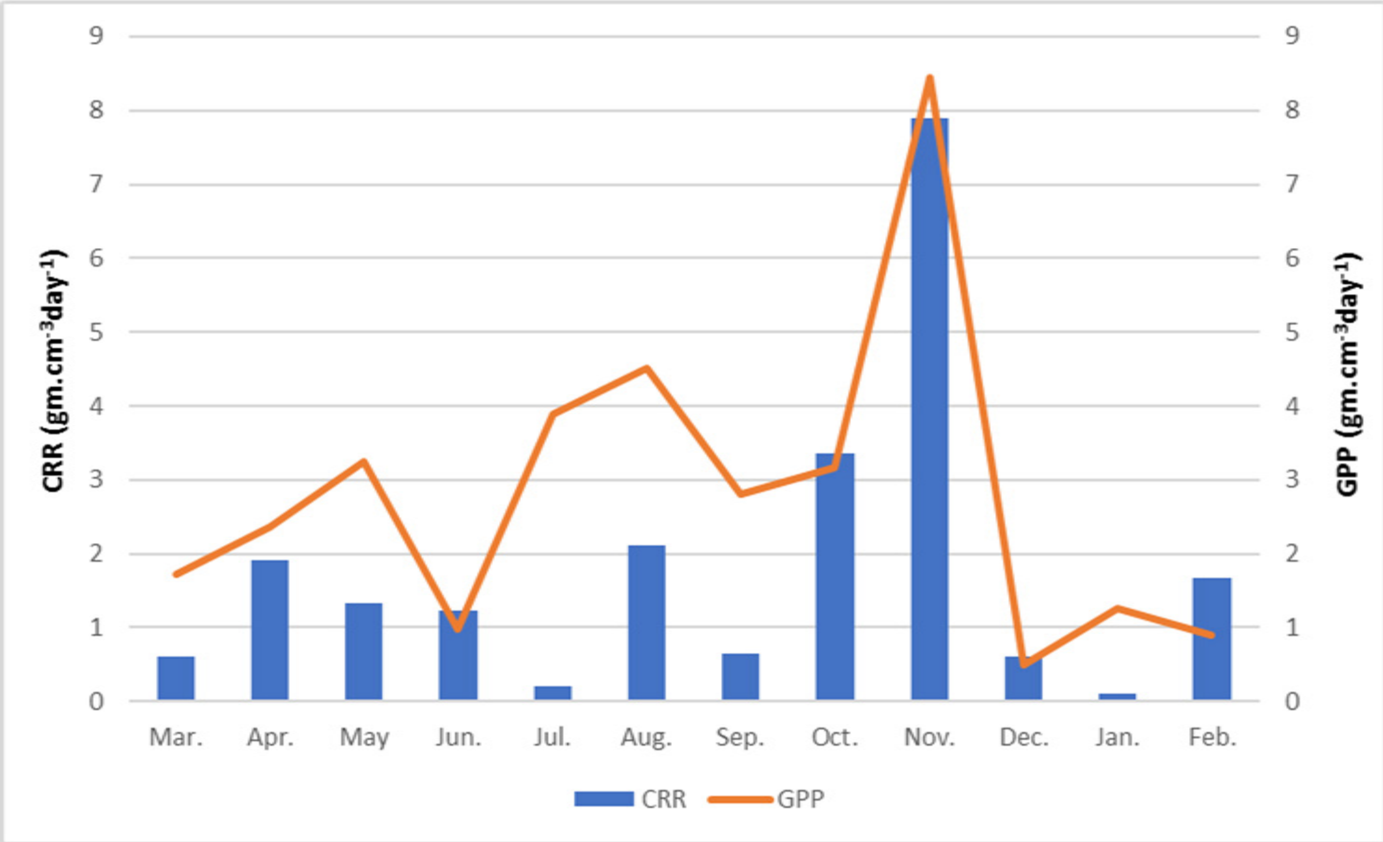

Fig. 11: Variability in Community respirationwith Gross primary productivity

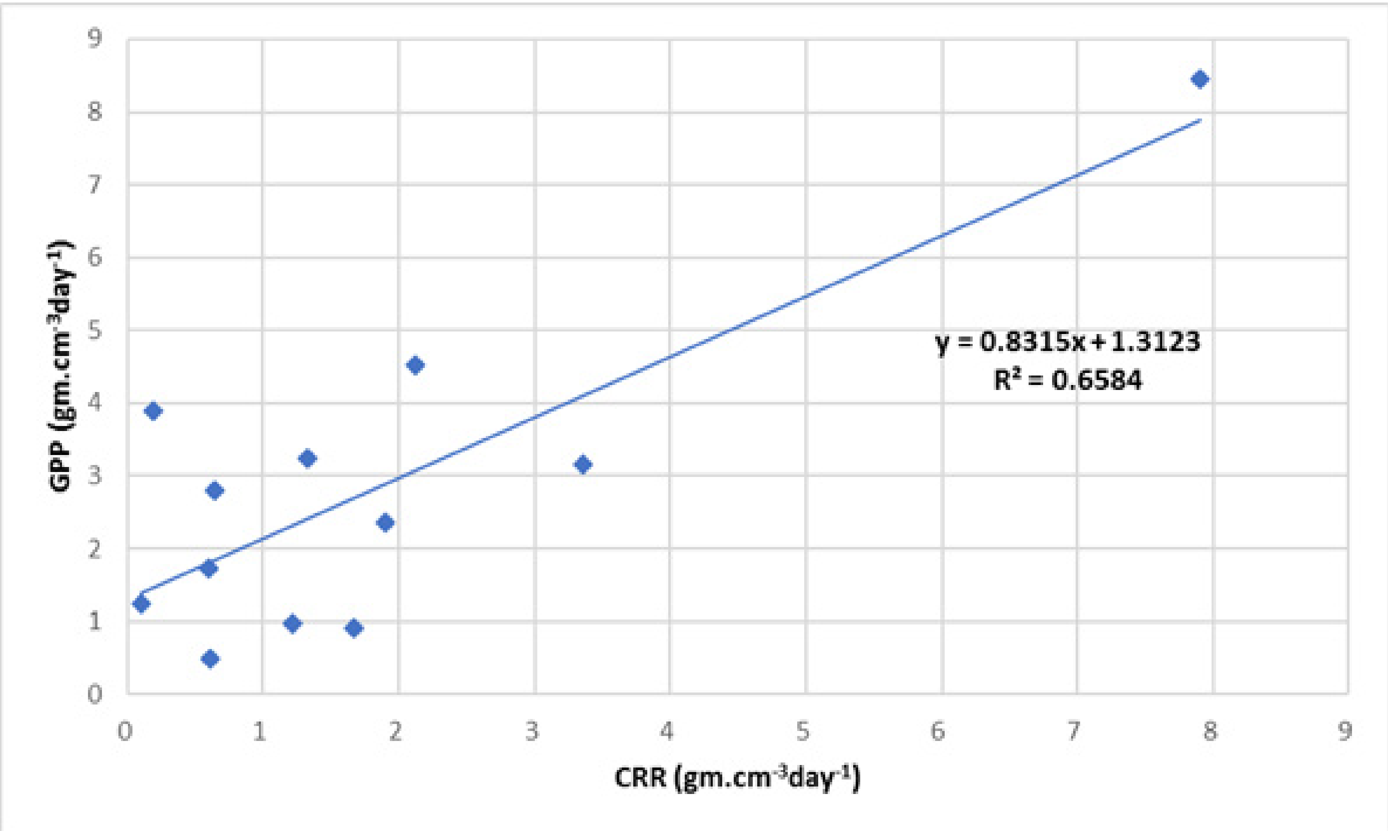

Fig. 12: Scatter diagram with fitted regression line showing relationship between Community respiration and Gross primary productivity

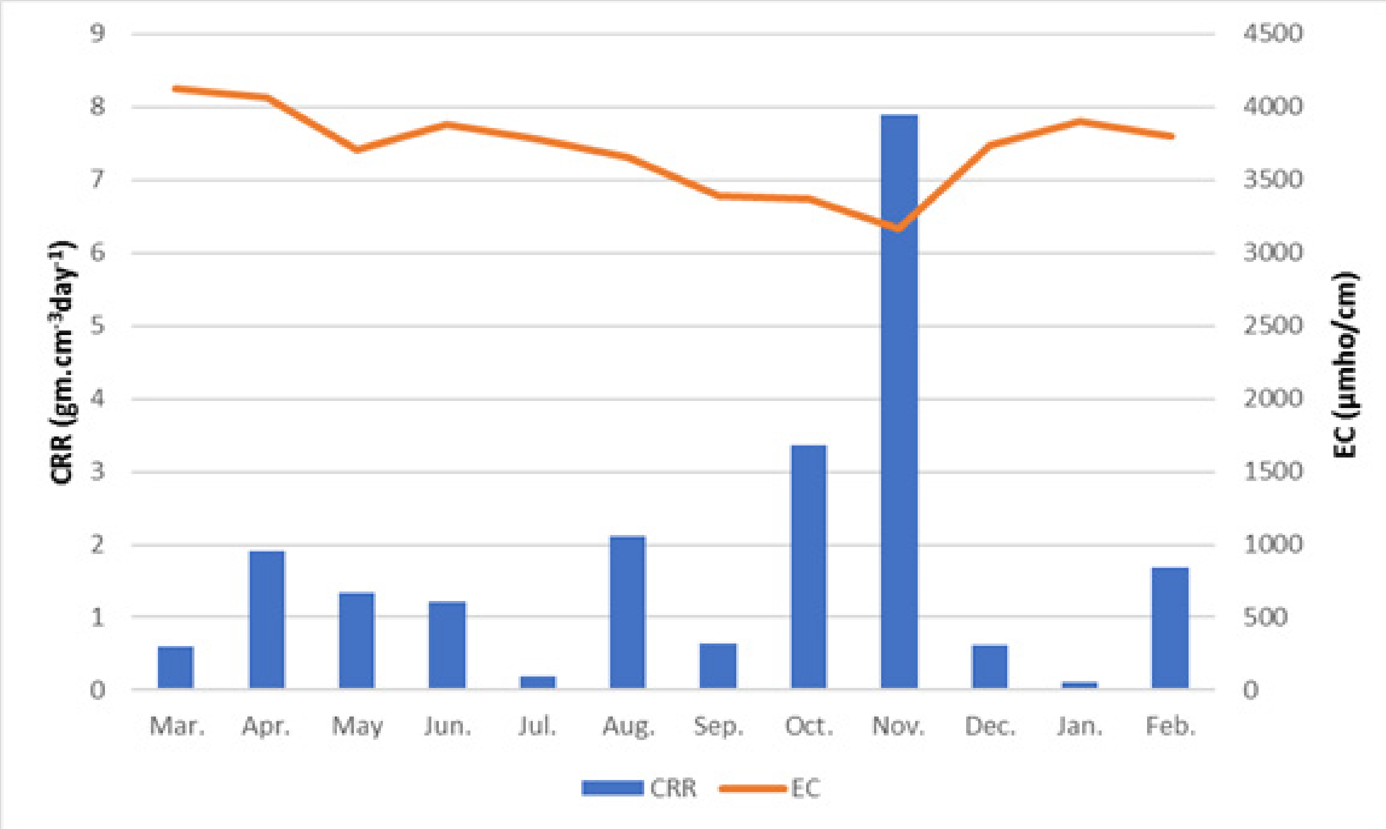

Fig. 13: Variability in Community respiration with Electrical conductivity

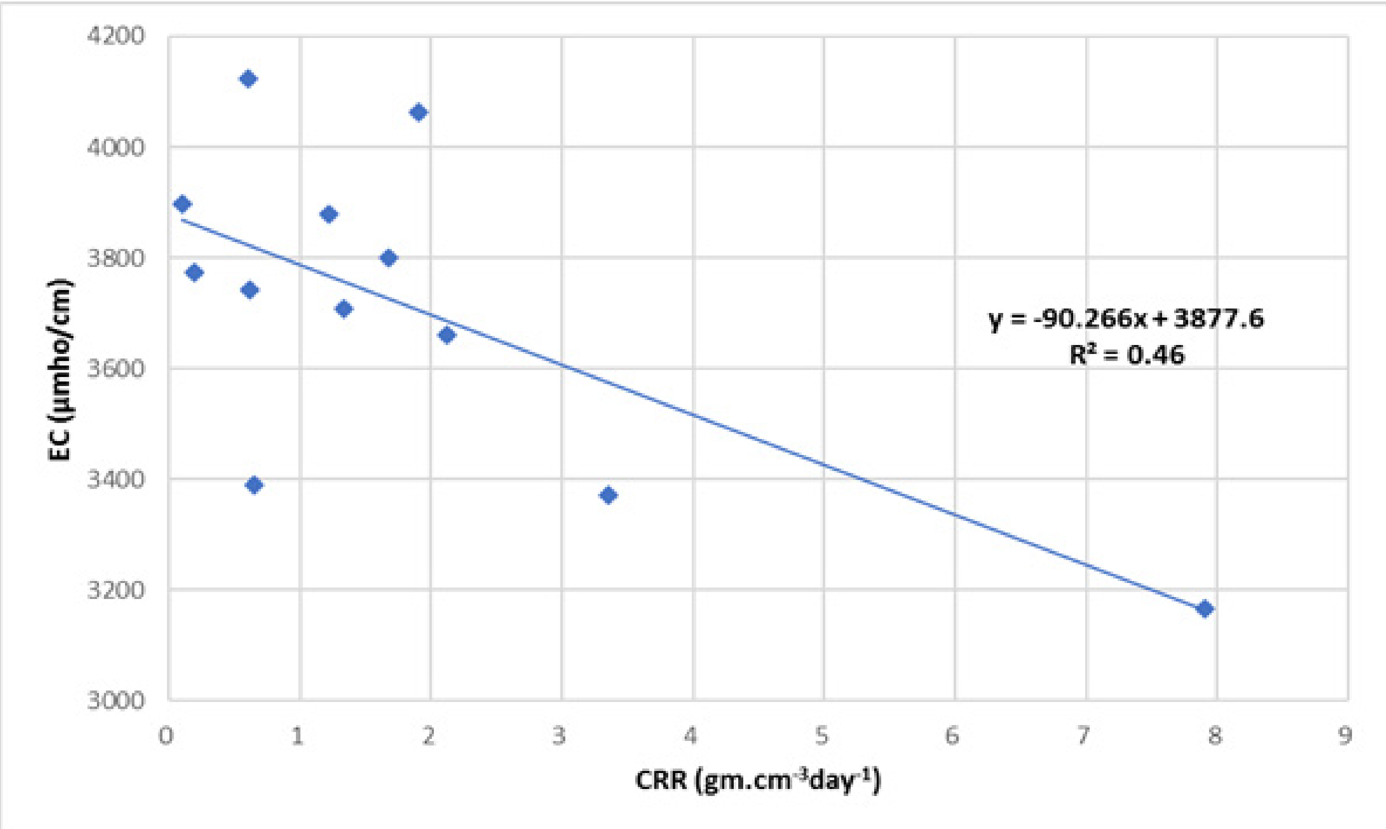

Fig. 14: Scatter diagram with fitted regression line showingrelationship between Community respiration and Electrical conductivity

DISCUSSION

The primary productivity of an ecological system, community or any part thereof, is defined as the rate at which radiant energy is stored by photosynthetic and chemosynthetic activities of the producer organisms (chiefly green plants) in the form of organic substances which can be used as food materials (Verma and Srivastava, 2016). Primary productivity refers to the rate of production or rate of energy flow and thus an indicator of richness of aquatic ecosystems. It is defined as the rate at which radiant energy is stored by producer organisms which can be used as food materials (Odum 1971). Sharma and Sharma (1992) state that phytoplankton encountered in the water body as well as they may be used as indicators of the water quality. The measurement of primary productivity provides a photosynthetic integration of physical, chemical and biological conditions, and if conducted overtime, is an excellent measure of change in the trophic state of an aquatic system (Goldman, 1988). Primary production is an important biological phenomenon in the aquatic environment in which phytoplankton act as a primary producer, their physiological activities greatly controlled by physico-chemical characters of the water body (Sahu *et al.,* 1995; Kumar and Siddiqui 1997).

There are three types of productivity determinations, gross primary productivity (GPP), net primary productivity (NPP) and Community respiration rate (CR). The higher value of gross primary productivity in early rainy and winter was the indication of presence of diverse phytoplankton and higher photosynthesis rate. Similar trend of gross primary productivity (GPP) has also been reported (Bhouyian and Das 1985; Mandal *et al.,* 1999; Naz *et al.,* 2006).While working in different fresh water wetland. The lowest GPP were recorded during monsoon season may be due to water dynamics and turbidity affecting light absorption by plankton population. Saran and Adoni (1985) in Sagar lake and Sharma and Yadav (2006) in Kayad lake also reported the similar trend during monsoon. The ponds recorded average GPP monthly productivity within the range of 0.48±0.6 $g.cm^{-3}\ day^{-1}$ to 3.89±3.8 $g.cm^{-3}\ day^{-1.}$

During the time of observation, the value of Net primary productivity was affected by transparency of the study site. In the present investigation net primary productivity and rain fall are positively correlated. The high values of primary productivity occur with the lower values of secchi transparency which the agreements of the findings (Yadav 2011). The net primary productivity values lower than the gross primary productivity in the present study. This is due to the fact that phytoplankton cell loose anappreciable amount of assimilated carbon during different metabolic activity. In the present study CRR and GPP are positively correlated with each other and negative correlation with the value of electrical conductivity similar observations made (Sreenivasan,1976). Verma and Srivastava (2016) studied that the high values of primary productivity throughout the study period indicating the eutrophic nature of pond.

The average value of pond productivity presence throughout the year, this might be due to desirable pH, temperature and phytoplankton. Primary productivity of the ponds mainly depends on the intensity and quality of light, carbon supply, availability of nutrients and biomass (Khan and Siddiqui, 1971; Sharma and Sahai, 1988). The estimation of primary productivity of aquatic ecosystem is of great importance for aquaculture management and helps to understand the food chain and food web relationship that prevails in the ecosystem. Lot of work has been done on primary productivity of different aquatic ecosystems by different workers (Naz *et al.,* 2006; Sharma and Yadav 2006; Desai 1995; Basheer, 1996; Kumar *et al.,* 2006; Saha *et al.,* 2001; Modi and Saxsena 2001; Sobha *et al.,* 2003; Umavati, 2007; Dekha *et al.,* 2009). The highest rate of productivity during rainy may be due to high temperature and high phytoplankton density algal blooms. The winter lows could be attributed to the reduced photoperiod coupled with low light intensity, temperature and scarce phytoplankton.

CONCLUSION

The high value of primary productivity indicates that the pond primary rich in nutrients with enough lighted zone and energy content. From the present study, it can be concluded that the productivity of Mahil pond is higher which is clearly indicating that the pond headed toward eutrophication. In Mahil pond inflow and outflow of water, nutrient loading and entry of harmful materials of different ways, have a direct and immediate effect on the metabolic rates, so it can be concluded that primary productivity can be taken as an important factor for pollution studies.

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