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Research Paper

PRIMARY PRODUCTVITY STUDY OF MORAWANE DAM IN RATNAGIRI DISTRICT OF MAHARASHTRA, INDIA

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Abstract

The earthen type Morawane dam is constructed in the Vashishthi River Basin at latitude 17^0 32' 55'' N and longitude 73^0 36' 40'' E by Government of Maharashtra. Its catchment area of 8.03 sq. km. receives an annual rainfall of about 3300 mm. The study of primary productivity in dams or lakes is fundamental aspect to understand water quality and fishery potentials. By keeping a view for studying primary productivity in Morawane dam during January 2012 to January 2014. The water samples were monthly collected and analyzed for physico-chemical parameters and incubation of water samples was done by using 'Light and Dark Bottle' method. The results indicated that productivity greater than respiration shows positive relationship. The aquatic body under study builds biomass with moderate productivity. The positive increase in the dissolved oxygen level indicated that the Morawane dam is moderately productive having adequate density of phytoplankton and adequate penetration of light.

Key words: Morawane dam, Primary productivity, Fishery potential, Phytoplankton.

INTRODUCTION

Primary production refers to the amount of organic matter made from inorganic materials through the process of photosynthesis. Primary producers are organisms able to use inorganic nutrients through the process of photosynthesis to build organic matter. Thus, primary producers, in order to live and grow need essential nutrients such as nitrogen, phosphorus, magnesium, calcium, iron, zinc, etc. in sufficient amounts. The main types of primary producers in lakes and reservoirs are phytoplankton, macrophytes, and periphyton.

Measurement of primary production or photosynthesis is helpful to understand the trophic status and to assess the fish production potential of aquatic ecosystem [1] [2] [3]. To estimate the total bioactivity of a reservoir it is necessary to determine the magnitude of primary production [4]. The study of primary production in lakes is fundamental to understand both water quality and fisheries [5].

Primary production can be distinguished as Net Primary Productivity (NPP) or Gross Primary Production (GPP), where NPP accounts for losses such as respiration and excretion while GPP includes the total amount of fixed carbon.

Primary production estimation is concerned with "evaluation of the capacity of an ecosystem to build up, at the expense of external energy (radiant and chemical), primary organic compounds

for transformation and flow to a higher level trophic system" [6]. Several factors, which include solar radiation, nutrient content, water transparency, high seasonal rate of fluctuation in water level, high flushing rate etc. are known to influence the rate of primary production in fresh waters[7] [8] [9] [10] [11].

A part of the Western Ghats in Konkan region of coastal Maharashtra encircles Morawane dam. As the chief food of the people in this region is rice and fish, it emphasizes the need of fresh water aquaculture in this area. Due to the hilly region, agriculture is not sustainable as much in this area. To accomplish the need of food as cheap source of animal protein from fish, aquaculture practices could be initiated in Morawane dam. But prior to initiate commercial practices hydro biological in-outs of the dam was necessary. No such study was carried out with reference to primary productivity from this dam hence, present investigation was attempted. This study may be helpful in enhancing aquaculture practices, optimum utilization and sustainable management of the dam.

MATERIALS AND METHODS

The present investigation of monthly variation in primary productivity was studied at surface water of the Morawane dam at three sites during January 2012 to January 2014. Physico-chemical parameters of water samples were analyzed [12] and primary productivity was estimated by 'Light and Dark Bottle' method [13].

The primary productivity has been expressed as gross primary productivity (GPP) and net primary productivity (NPP), and community respiration (CR).

Calculations for Primary Productivity:

Initial DO = Z mg/L
Light bottle DO after incubation period (3 hrs.) = X mg /L
Dark bottle DO after incubation period = Y mg/L
1. Gross photosynthesis = X – Y mg/L
2. Net photosynthesis = X – Z mg/L
3. Respiration = Z – Y mg/L

$$\text{i) Gross Primary Productivity (mg C/L/hr)} = \frac{(X - Y) \times 0.536}{PQ \times N}$$

Where, PQ = 1.2 (Photosynthetic quotient)

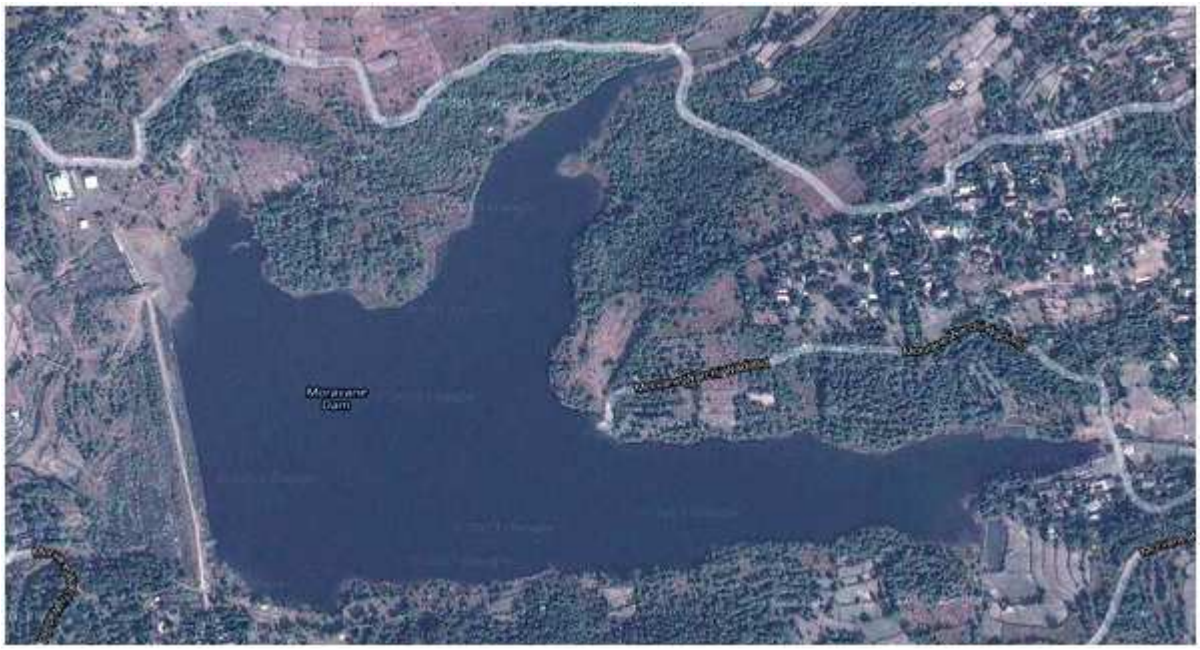
N = Incubation period

0. 536 = Factor to convert mg O_2 to mg of C

$$\text{ii) Net Primary Productivity (mg C/L/hr)} = \frac{(X - Z) \times 0.536}{PQ \times N}$$

STUDY AREA

The Morawane dam is constructed across the Morawane Nalla in Vashishthi River Basin in the year 2004 at the Latitude 17^0 32' 55" N and Longitude 73^0 36' 40" E. Its catchment area of 8.03 km^2 receives an average annual rainfall of about 3300 mm. The dam is of earthen type having length of 420 meters and maximum height of 24.37 meters with spillway of about 75 meters. The spillway of dam is of Ogee type with maximum flood discharge of 281.015 M^3. It has only one outlet in the form of left bank canal (LBC) of 5.50 km length. The 75% dependable yield of the dam is about 19.65 Mm^3 with gross annual utilization of about 3.841 Mm^3. Out of total water, 0.13 Mm^3 is available for drinking purpose and 2.97 Mm^3 for irrigation purpose. The information pertaining to reservoir storage indicates that the maximum water level (MWL) in the dam is 115 meters while full reservoir level (FRL) is 112 meters. Two village *viz*. Morawane and Dalvatne come under the command of dam with gross command area of about 286 hectares.



Google view of Morawane dam

RESULTS AND DISCUSSION

In the present study average water temperature at the euphotic zone of three sites has varied between 26.2 ^{0}C and 34.1 ^{0}C in January and April 2012, respectively (Table 1). For most of the study period, water temperature remained close to 29.0 ^{0}C (Fig. 5). Monthly and seasonal record of primary productivity reported as Gross Primary Productivity (GPP), Net Primary Productivity (NPP) and Community Respiration (CR) are depicted in Table No.1 and 2, respectively.

3.1 Gross Primary Productivity (GPP):

The station-wise analysis indicated minimum productivity (0.049) in December 2012 and January 2013 at all the stations, therefore, in the same period, average GPP of dam was low. At station – I, GPP was maximum (0.225 mg C/l/hr) during May 2012, at station - II it was 0.199 mg C/l/hr during June and November 2013, while at station – III it was 0.175 mg C/l/hr during January 2014. Average GPP value of dam was 0.190 mg C/l/hr during June 2013 (Table No.1); but seasonal record indicated as low as 0.055 mg C/l/hr during post-monsoon of 2012 and highest of 0.159 mg C/l/hr during post-monsoon of 2013 (Table No.2, Fig. 1).

The study also reported gradual increase in GPP from January to May 2012, and decline from June to December 2012. It further showed gradual increase from February to June 2013 (Fig. 5).

Seasonal study of GPP indicated gradual decline from the pre-monsoon to monsoon to post-monsoon of 2012-13, whereas exactly opposite trend was noticed during 2013-14 (Fig. 1 and 2). Primary productivity in aquatic ecosystem mostly depends upon nutrient input, algae, macrophytes, green bacteria and temperature. Low temperature (28.6 ^{0}C) during post-monsoon of 2012-13 (Fig. 4) might have grossly affected primary productivity of the dam.

Maximum average temperature of 29.0 ^{0}C was reported during post-monsoon season of 2013-14 (Fig. 4). Comparatively higher values of GPP (0.159) and NPP (0.048) were recorded during post-monsoon period 2013-14 (Table No.2, Fig. 1 and 2). The highest rate of primary productivity in pre-monsoon of 2012 may be due to intensive sunlight with high temperature (29.9 ^{0}C) and phytoplankton diversity whereas, low productivity during post-monsoon could be attributed to the reduced photo period coupled with low light intensity, temperature and reduced phytoplankton. Higher primary productivity due to high light penetration during pre-monsoon period was reported by many researchers [14] [15] [16].

Table No.1: Monthly variation in **GPP, NPP, CR** (mgC/l/hr) and **Temperature** (^{0}C) of water samples from Morawane dam during January 2012 to January 2014.

Month / Station	GPP				NPP				CR				Temp
	S – I	S – II	S – III	Avg.	S – I	S – II	S – III	Avg.	S – I	S – II	S – III	Avg.	Avg.
Jan. 12	0.099	0.075	0.075	**0.083**	0.049	0.049	0.024	**0.040**	0.049	0.249	0.049	**0.115**	**26.2**
Feb	0.124	0.124	0.099	**0.115**	0.075	0.075	0.049	**0.066**	0.049	0.049	0.049	**0.049**	**27.6**
Mar	0.174	0.174	0.150	**0.166**	0.099	0.174	0.099	**0.124**	0.075	0.075	0.049	**0.066**	**28.0**
Apr	0.097	0.097	0.097	**0.097**	0.123	0.150	0.198	**0.157**	0.024	0.024	0.024	**0.024**	**34.1**
May	0.225	0.150	0.099	**0.158**	0.172	0.123	0.075	**0.123**	0.048	0.024	0.024	**0.032**	**30.2**
Jun	0.097	0.097	0.075	**0.089**	0.049	0.049	0.049	**0.049**	0.048	0.048	0.024	**0.040**	**29.6**
Jul	0.097	0.075	0.075	**0.082**	0.075	0.024	0.024	**0.041**	0.024	0.048	0.048	**0.040**	**29.7**
Aug	0.097	0.097	0.123	**0.105**	0.075	0.075	0.097	**0.082**	0.024	0.024	0.024	**0.024**	**30.2**
Sep	0.075	0.075	0.075	**0.075**	0.048	0.024	0.024	**0.032**	0.024	0.048	0.048	**0.040**	**29.1**
Oct	0.075	0.049	0.049	**0.057**	0.024	0.024	0.024	**0.024**	0.049	0.024	0.024	**0.032**	**30.9**
Nov	0.049	0.075	0.075	**0.066**	0.024	0.049	0.049	**0.040**	0.024	0.024	0.024	**0.024**	**28.4**
Dec	0.049	0.049	0.049	**0.049**	0.024	0.066	0.066	**0.052**	0.024	0.024	0.024	**0.024**	**29.0**
Jan. 13	0.049	0.049	0.049	**0.049**	0.024	0.024	0.024	**0.024**	0.024	0.024	0.024	**0.024**	**26.3**
Feb	0.075	0.075	0.075	**0.075**	0.049	0.049	0.049	**0.049**	0.024	0.024	0.024	**0.024**	**26.9**
Mar	0.099	0.099	0.099	**0.099**	0.075	0.049	0.049	**0.057**	0.024	0.049	0.049	**0.040**	**26.6**
Apr	0.124	0.150	0.174	**0.149**	0.099	0.099	0.124	**0.107**	0.024	0.049	0.049	**0.040**	**29.2**
May	0.150	0.174	0.174	**0.166**	0.124	0.124	0.124	**0.124**	0.024	0.049	0.049	**0.040**	**29.6**
Jun	0.199	0.199	0.174	**0.190**	0.150	0.150	0.150	**0.150**	0.049	0.049	0.024	**0.040**	**29.3**
Jul	0.150	0.099	0.049	**0.099**	0.099	0.049	0.024	**0.057**	0.049	0.049	0.024	**0.040**	**28.0**
Aug	0.174	0.150	0.174	**0.166**	0.124	0.124	0.124	**0.124**	0.049	0.024	0.049	**0.040**	**28.2**
Sep	0.099	0.099	0.075	**0.091**	0.075	0.075	0.024	**0.058**	0.024	0.024	0.049	**0.032**	**29.8**
Oct	0.150	0.174	0.174	**0.166**	0.099	0.150	0.124	**0.124**	0.049	0.024	0.049	**0.040**	**30.8**
Nov	0.174	0.199	0.125	**0.166**	0.124	0.124	0.150	**0.132**	0.049	0.075	0.075	**0.066**	**28.7**
Dec	0.150	0.174	0.150	**0.158**	0.099	0.124	0.124	**0.115**	0.049	0.049	0.049	**0.049**	**29.2**
Jan.14	0.124	0.150	0.175	**0.149**	0.099	0.124	0.150	**0.124**	0.049	0.024	0.049	**0.040**	**27.3**
Avg.	**0.074**	**0.117**	**0.108**	-	**0.083**	**0.085**	**0.080**	-	**0.037**	**0.045**	**0.038**	-	

S: Station, **Avg.:** Average, **GPP:** Gross Primary Productivity, **NPP:** Net Primary Productivity, **CR:** Community Respiration, Temperature ^{0}C.

Table No.2: Seasonal variations in **GPP, NPP, CR** (mgC/l/hr) and **Temperature** (^{0}C) of Morawane dam during study period.

Year	Seasons	GPP	NPP	CR	Temp. ^{0} C
2012-13	Pre-monsoon	0.134	0.042	0.042	29.9
	Monsoon	0.087	0.036	0.036	29.6
	Post-monsoon	0.055	0.026	0.026	28.6
2013-14	Pre-monsoon	0.122	0.036	0.036	28.0
	Monsoon	0.136	0.038	0.038	28.8
	Post-monsoon	0.159	0.048	0.048	29.0

Fig. 1: Year wise comparison of seasonal variation in GPP of Morawane dam.

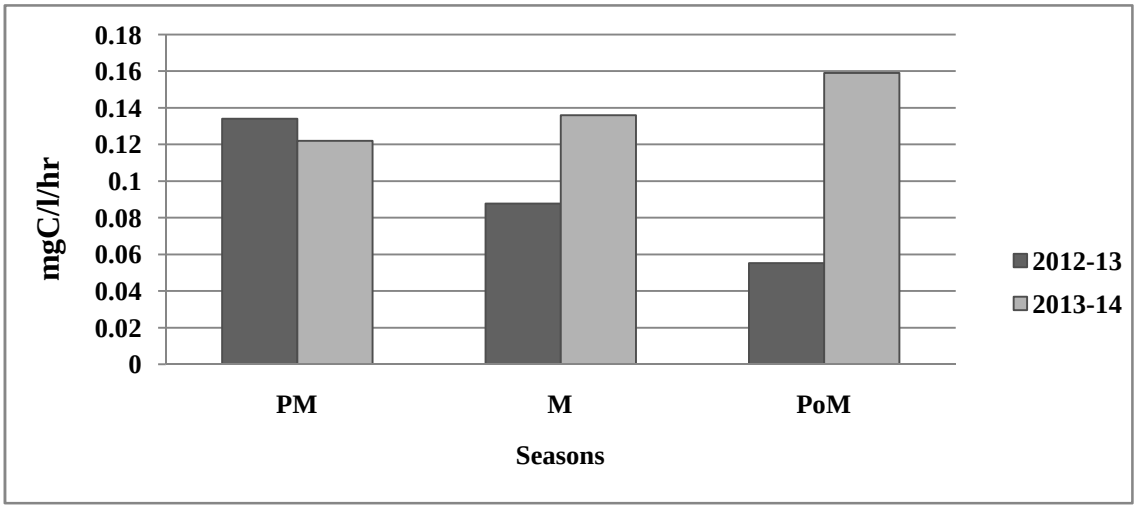


Fig. 2: Year wise comparison of seasonal variation in NPP of Morawane dam.

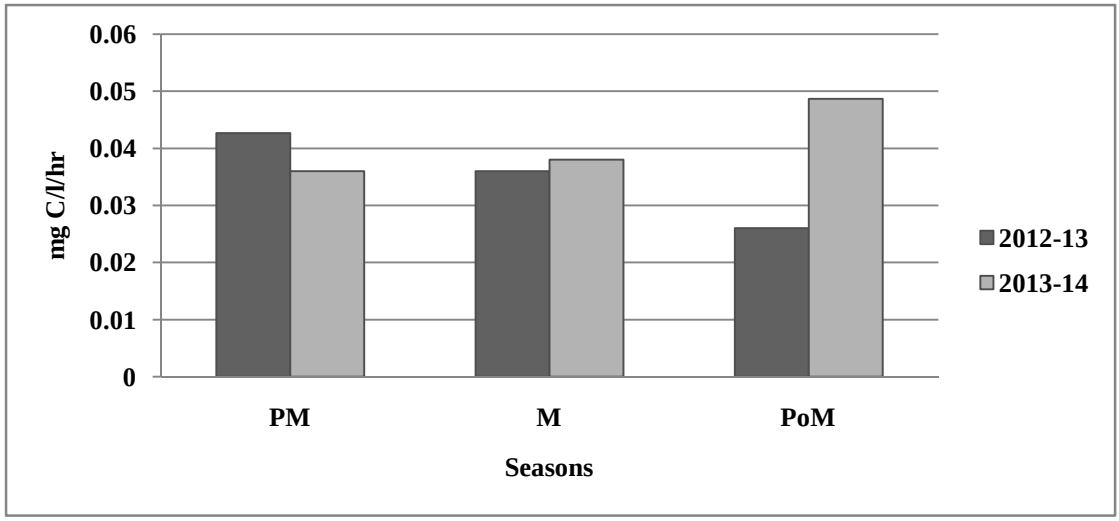


Fig. 3: Year wise comparison of seasonal variation in CR of Morawane dam.

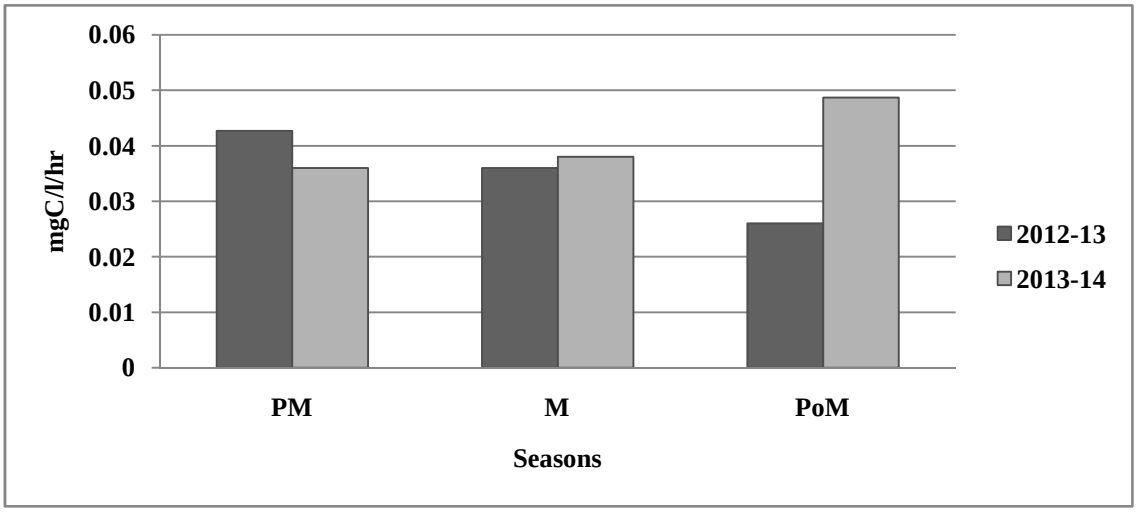


Fig. 4: Year wise comparison of seasonal variation in temperature of Morawane dam.

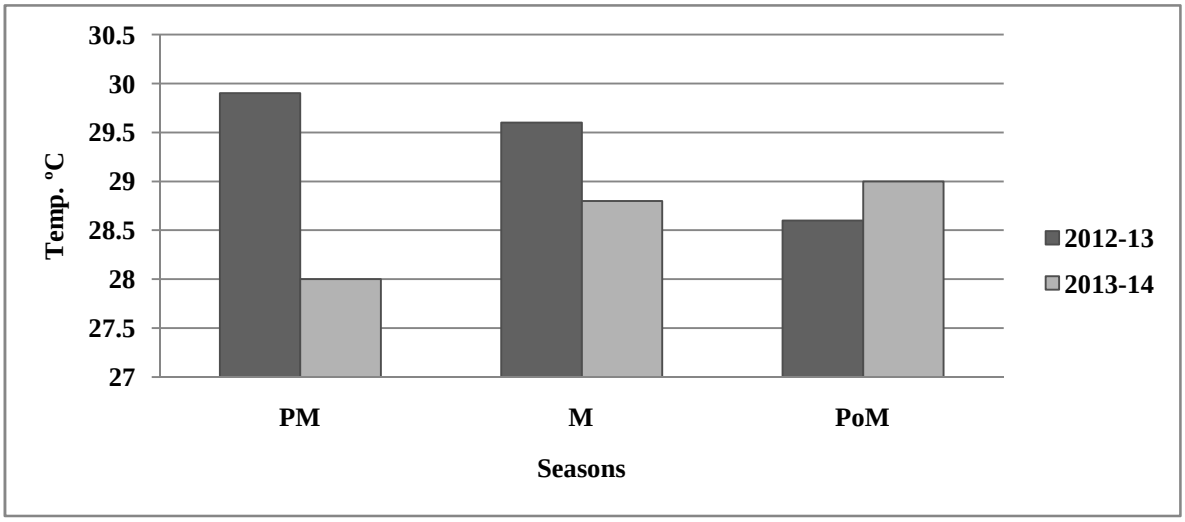


Fig. 5: Monthly variation in GPP, NPP and CR in Morawane dam during study period.

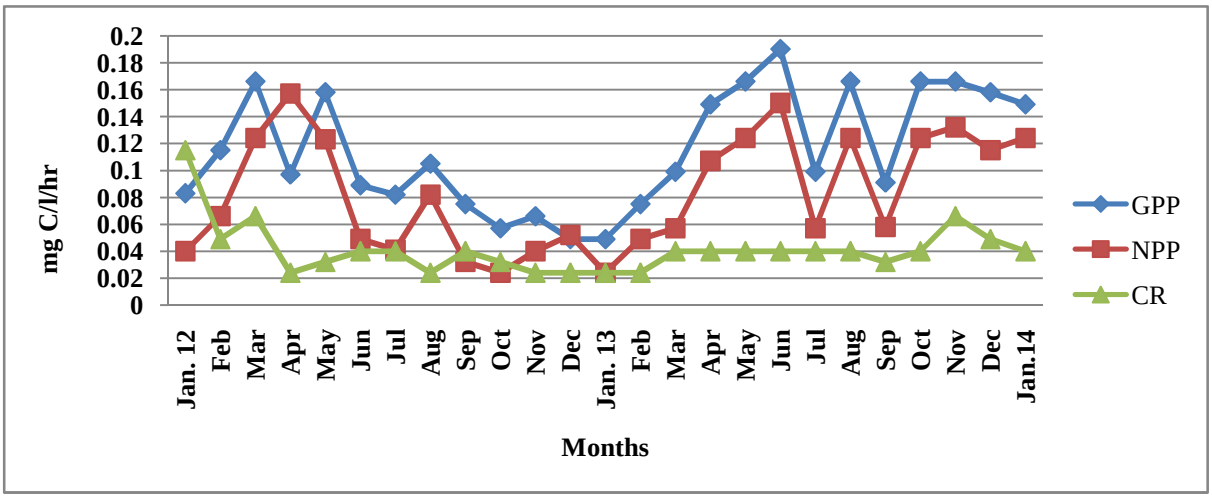
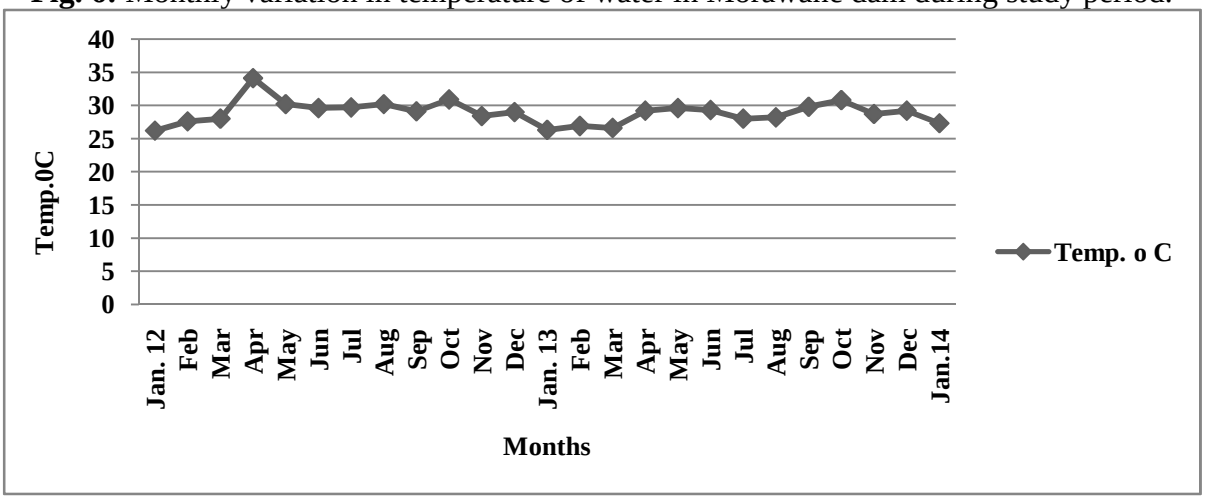


Fig. 6: Monthly variation in temperature of water in Morawane dam during study period.



The high values of GPP and NPP during 2013-14 are well synchronized with the published reports [17]. Heavy rainfall in the Konkan region carries load of suspended particles in all the aquatic bodies of the region. But during post-monsoon most of the particles settle down and the surface water becomes rather clear. This situation permits more light to penetrate leading to high values of primary productivity during winter. Influx of nutrients during monsoon and latter clarity of water during post-monsoon might have enhanced GPP and NPP during post monsoon season of 2013-14.

3.2 Net Primary Productivity (NPP):

The station wise analysis of NPP indicated that minimum (0.024) productivity in the month of October 2012 and January 2013 at all the stations, therefore, minimum average NPP of the dam was also reported in the month of October 2012 and January 2013. Maximum NPP values at station - I, II and III were 0.172 during May, 0.174 during March and 0.198 during April, 2012, respectively.

Average value of NPP of dam was 0.157 during April 2012 (Table 1), but seasonal record indicated it lower (0.026 mg C/l/hr) during post-monsoon and rather higher (0.042 mg C/l/hr) in the pre-monsoon season of 2012-13. Exactly opposite trend was reported during 2013-14 (Table No. 2; Fig. 2). NPP value of 0.23 ± 0.04 gm c/m^3 /hr during summer season of 2009-10 reported in the Nagaram tank of Warangal district of Andhra Pradesh well synchronizes with the present work [18]. An elevated value of NPP in pre-monsoon season of 2013-14 might be due to proliferation of phytoplankton as fresh rain helped in accumulation of organic matter from decomposed macrophytic vegetation.

Community Respiration (CR):

Difference between GPP and NPP converted into CO_2 release gives community respiration. The station-wise analysis of CR indicated minimum value 0.024 mg C/l/hr from November 2012 to February 2013 at all the stations. Maximum value of CR (0.075 mg C/l/hr) was reported at station - I and II during March 2012; and at station - III during November 2013. Minimum average value of CR was (0.024 mg C/l/hr) during November 2012 to February 2013 and maximum (0.115 mg C/l/hr) was during January 2012 (Table 1).

The seasonal record indicated CR value as low as 0.026 mg C/l/hr during post-monsoon of 2012-13 with average temperature of 28.6 ^{0}C; and highest of 0.042 mg C/l/hr during pre-monsoon with average temperature of 29.9 ^{0}C. In the year 2013-14 the trend was reversed and indicated lower value (0.036 mg C/l/hr) during pre-monsoon and higher value (0.048 mg C/l/hr) during post-monsoon with temperature of 29.0 ^{0}C (Table 2, Fig. 3).

Season-wise analysis of CR showed declining trend from pre-monsoon to monsoon to post-monsoon during 2012-13 but during 2013-14 it was reversed (Fig.3). The CR values were less than GPP and NPP values during entire study period except January and March 2012 (fig. 5).

Present study reported high value of CR during pre-monsoon and low during post-monsoon of the year 2012, which might be due to bright sunlight, high temperature and nutrient input into study dam due to pre-monsoon showers. Similar observations have been noted in Parapper reservoir and Sasthamcotta Lake [19], in two perennial tanks in Kolhapur district [20] and in Nagaram tank of Warangal district in Andhra Pradesh, India [18]. During 2013-14 average temperature of post-monsoon was high due to cloudy climatic conditions and October heat, which might have assisted temperature increase. The raised temperature would have released nutrients from sediments through bacterial decomposition. Elevated nutrient level and high temperature values might have favored growth of aquatic flora, that ultimately favored the primary productivity; specifying that temperature, solar radiation and nutrients act as limiting factor for primary production [21] [22]. In the present study the clean surface water and high rate of light penetration might have favored ecological conditions to increase GPP, NPP and CR.

Location wise average GPP, NPP and CR values are depicted in Table 1. Minimum values of GPP (0.074 mg C/l/hr) and CR (0.037 mg C/l/hr) were at station – I, whereas their maximum value of 0.117 mg C/l/hr and 0.045 mg C/l/hr, respectively were reported at station – II.

Lowest average values of GPP and CR at station –I might be due to more depth of water column in the dam, whereas calm and shallow water at station –II along with cattle washing and mixing of cattle dung daily might have enhanced GPP and CR values. The physiography, catchment, land use, water basin morphology, bathymetry and changing water levels or flushing rates also affect the productivity of reservoirs [23]. The reason for increase in GPP at site – II could be frequent dumping of grave ash and washing of clothes and utensils leading to nutrient rich water. Increase in chloride content of Dal Lake due to organic pollution of animal originwas also reported [24].

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