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BIOMASS AND RELATIVE FREQUENCY OF AQUATIC MACROPHYTES OF GOVERDHAN SAGAR LAKE OF UDAIPUR, RAJASTHAN IN RELATION TO PRIMARY PRODUCTIVITY AND CERTAIN WATER QUALITYPARAMETERS

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ABSTRACT

The present research work was conducted on Goverdhan Sagar, a medium class shallow water lake of Udaipur in southern Rajasthan. Attempt has been made to assess its macro plant flora in relation to selected water quality and status of primary productivity.The shallower and fringed margins combined with rooted and submerged vegetation accounts 41.64% of the lake. Principally two types of aquatic weeds were found in good quantity *i.e.* submerged and emergent weeds with a relative dominance of the former. The macrophytes were represented by *Hydrilla, Potamogeton, Vallisneria, Chara, Ceratophyllum, Trapa, Nymphoides and Typha*. The water quality of GoverdhanSagar was found congenial throughout the study period for ample growth of aquatic macrophytes and productivity. The study also indicated excellent nutrient absorption capacity of macrophytes.

KEY WORDS
Macrophytes
Primary productivity
Water quality

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INTRODUCTION

Aquatic macrophytes are the large, predominantly angiospermic plants, inhabiting various sections of aquatic ecosystems and are of considerable importance from the productivity point of view in shallow water bodies or in the littoral zones of the deep water bodies. They play an important role in providing food to fish and other aquatic animals. They also play a significant role in cycling of nutrients in the given water body. The higher organic load and nutrients make it susceptible for the luxuriant growth of floating and submerged vegetations. Much work has been done on the phyto-sociology of different macrophytic fauna in various fresh water bodies of India (Billore and Vyas, 1981 and Dhore *et al.,* 2013).Macrophytes diversity and physico-chemical characteristics of water and soil being closely related, have been studied widely (Goswami *et al.*, 2010 and Okayi *et al.,* 2011).

The economic importance of macrophytes in aquatic ecosystem is equally important and thus utility value of aquatic macrophytes of ecological importance has been studied and recommend by(Uka and Chukwuka, 2011). Plant growth, root anchorage strength, and stem tensile properties of submerged macrophytes are also under the influence of water level and fluctuation in speed(Guorong *et al.,* 2012).

Many waters of fisheries and ethnic importance in Udaipur district of Rajasthan (India) are still lacking scientific information of ecological profiling particularly in relation of their flora. Moreover information their primary productivity and fishery potential is also use full for their economic utilization.

The study was aimed to assess the diversity of its major primary producer *i.e.* aquatic macrophytes to assess and establish its relation with selected water quality parameters and status of primary productivity for getting the optimum fish production.

MATERIALS AND METHODS

Goverdhan Sagar lies on the Udaipur-Ahmedabad highway, about 2.5 km distance from Udaipur city at a geographical location: 24º32′N latitude and 73º41′E longitude. The lake is totally rain-fed and retains water throughout the year accept during certain drought years. The northerly located Pichhola lake feeds water to the GoverdhanSagar when over-flooded during the normal rainfall years by Kotra river. The outlet of Goverdhan Sagar lies towards the south of the tank and its water join Ahar river through a tributary. The deeper position of the lake lies towards north east bank which has steep slope, while towards south and western side, the slope of its terrain is gradual.

Sampling stations

For the proposed study, three sampling stations were selected for collection of surface water samples and macrophytes. Station A was located on the south eastern shore and station B near the dam on eastern shore. Sampling station C was located at the western end of the lake as shown in Figure 1.

Collection of water samples and analysis

During the study period, surface water samples from all the three selected sampling stations were collected every week. Water quality parameters such as temperature of water and air around lake, depth of visibility, pH, alkalinity (carbonates, bicarbonates and total alkalinity), dissolved oxygen, free carbon di-oxide, electrical conductivity (EC) were determined in the field itself. While for the analysis of nitrate-nitrogen and orthophosphates the samples were brought to the laboratory in plastic bottles of one liter capacity and analyzed as soon as possible. The water quality and primary productivity (Gross primary productivity-GPP, Net primary productivity-NPP and Community respiration-CR) of Goverdhan Sagar were analyzed using standard methods (Trivedy *et al*., 1987 and APHA, 1989).

Collection of aquatic macrophytes

For collection of aquatic macrophytes five random quadrates each of 2500 sq. cm marked by a metallic wire frame of 50 x 50 cm, were sampled at each sampling station. From each quadrate all the rooted, submerged and floating vegetation were collected, washed, identified and counted. Their biomass in total and for different categories was assessed. Samples for later identification and photography were carried in labeled plastic bags to the laboratory. The data were processed for vegetation mapping, and estimation of frequency, biomass and productivity following, Trivedy *et al*.(1987). The aquatic macrophytes were identified using, Fassett (1998) and Gupta (2001). The relative frequency (RF)of occurrence of aquatic macrophytes showing the dispersion of a species relative to that of the other species was calculated from the frequency data in the quadrate as:

$$\text{R.F.} = \frac{\text{Number of occurrence of a species}}{\text{Number of occurrence of all species}} \times 100$$

The collected plants were washed thoroughly by water to remove extraneous material like soil, animals and algae attached to these plants. The sorting of macrophytes was done on site in a shade for different species and their respective weight. A subsample of 250 g of each species was taken to the laboratory and their dry weight was determined by keeping the plants for 24 hours in hot air oven at 105ºC. The average of five quadrates' wet weight and dry weight values of each plant species at each sampling station were used for calculating the biomass/m^2.

The daily productivity of aquatic macrophytes was calculated using the weekly observations of the biomass per unit area as per the following formulae:

The productivity of dry weight or organic dry weight/m^2/day

$$= \frac{b_2 - b_1}{d}$$

Where,

b_1 = Biomass (g/m^2) at time t_1

b_2 = Biomass (g/m^2) at time t_2

d = Days interval between t_1 and t_2

RESULTS AND DISCUSSION

The shallower and fringed margins in the littoral zone of the lake (41.64 per cent area), whereas the deeper water area representing limnetic zone of the lake is about 58.36% of the total area of lake *i.e.* 30.81 ha. The littoral zone of the lake combined with rooted and submerged vegetation indicated high productivity of the lake (Table 1 and Fig. 1). However, any appraisal of lake productivity should come from an examination and measurement of several dominating and interacting limnological influences. In the present study a higher production of macrophytes was noted at higher temperature and lower solubility of gases.

The study indicate that submerged category of plants the relative frequency was gradually reduced from 93.68% on first observation to 91.39% on the last observation after eight weeks(Table 2). However, the number of submerged weeds wasfound gradually increasing from 356 to 478 plants/m^2

Table 1: Morphometric features of Goverdhan Sagar, Udaipur (Raj.)

1	Location:	
	Latitude	24°32'N
	Longitude	73°41'E
	Altitude	582 m (MSL)
2	Average rainfall	670 mm
3	Deeper water area	Over 17.97 ha.
4	Weed choked marginal area	Over 12.83 ha.
5	Total water spread area	30.81 ha. (41.64%)
6	Catchment area	2.56 sq.km.
5	Maximum depth (Zm)	7.50 m.
6	Maximum length (L)	1.97 km
7	Maximum width (bx)	0.72 km
8	Length of shoreline (L)	3888.8 m
9	Capacity of F.T.L.	9 million cubic meter
10	Type of dam	Masonry
11	District	Udaipur
12	Accesses	2.5 km away from Udaipur on the Udaipur Ahmadabad highway.

Table 2: Total number of plants and per cent relative frequency (RF) of aquatic macrophytes/m^2 (average weekly values of all three stations) of GoverdhanSagar, Udaipur (Raj.)

S.	Weeks/category	I	R.F	II	R.F	III	R.F	IV	R.F	V	R.F	VI	R.F	VII	R.F	VIII	R.F	Avg. R. F.
1	Submerged weeds	356	93.68	375	93.28	392	93.11	405	92.46	418	91.9	435	91.96	448	91.42	478	91.39	92.4
2	Emergent weeds	24	6.31	27	6.71	29	6.88	33	7.53	37	8.13	38	8.03	42	8.57	45	8.77	7.61
	Total	380		402		421		438		455		473		490		513		99.98

Table 3: Biomass (g dry weight) and productivity (g/m^2/d) of aquatic weeds in GoverdhanSagarlake considering average weight of plants at three stations

Weed Type	Weekly observations I	II		III		IV		V		VI		VII		VIII		Average	
	Biomass	Biomass	Productivity	Biomass	Productivity	Biomass	Productivity	Biomass	Productivity	Biomass	Productivity	Biomass	Productivity	Biomass	Productivity	Biomass	Productivity
Submerged weeds	575.2	606.17	4.42	632.32	3.73	653.38	3.009	674.16	2.96	702.53	4.05	724.96	3.20	758.53	4.79	761.04	3.737
Emergent weeds	60.77	66.00	0.80	81.97	2.22	81.97	0.00	91.86	1.41	94.96	0.40	94.69	0.00	113.06	2.62	97.85	1.064
Total	635.97	672.17	5.22	714.29	5.95	735.35	3.009	766.02	4.37	797.49	4.45	819.65	3.20	871.59	7.41	858.89	4.801

from the first to the last observation. However, the average relative frequency of submerged weeds was 92.40%. The results also indicate that in case of emergent weeds the number of plants as well as their average relative frequency gradually increased with a minimum of 24 plants/m^2 and relative frequency 6.31% on the first observation to a maximum of 45 plants/m^2 and a relative frequency of 8.77% on the last observation.The macrophytes are principally represented by *Hydrilla,Potamogeton,Vallisneria,Chara,Ceratophyllum, Trapa, Nymphoides and Typha*.

The average biomass and productivity of the major weeds category *i.e.* submerged and emergent weeds of Goverdhan Sagar are shown in Table 3. The results indicate that in the submerged category the biomass was gradually increased from 575.2 g on the first observation to 758.53 g on the last observation. The productivity of submerged weeds was also increased from 4.42 g/m^2/d on II observation to 4.79 g/m^2/d on last observation. The average biomass and productivity of submerged weed in Goverdhan Sagar was 761.04 g and 3.737 g/m^2/d.

The results also indicate that in case of emergent weeds the number of weeds as well as their average biomass increased with 60.77 g on the first observation to 113.06 g on the last observation.The productivity of emergent weeds also increased from 0.80 g/m^2/d on II observation to 2.62 g/m^2/d on last observation. The average biomass and productivity of emergent weed in Goverdhan Sagar was 97.85 g and 1.064 g/m^2/d. The net average productivity of submerged aquatic macrophytes accounted 3.737 g/m^2/d *i.e.*1364.01 g/m^2/year and that of emergent plants 1.064 g/m^2/d *i.e.* 388.36 g/m^2/year and hence the annual productivity of aquatic macrophytes in Goverdhan Sagar during the present study was found 1752.31 g/m^2/year.

Physico-chemical parameters of Goverdhan Sagar were found to be congenial throughout the study period (Table 4). The secchi disc is still one of the valuable tools in the study of limnology. In the present investigation the water clarity ranged within this range (86.0 to 105.0 cm.) throughout the study period. Sharma and Durve (1990) classified lakes on the basis of water clarity and found moderately eutrophic nature of lake Jaisamand with average water clarity values between 88.75 to 101.33 cm. It seems that water clarity has not altered much despite increasing human interferences during the last about thirty years. The pH of Goverdhan Sagar was found to be moderately alkaline which is suitable for supporting fairly good aquatic productivity. However, other water quality parameters *e.g.* free carbon di-oxide, total alkalinity, dissolved oxygen, nitrate nitrogen and orthophosphate of the lake Goverdhan Sagar were in accordance to earlier findings (Sarang *et al.*, 2002; Nandan and Magar, 2007). In the present study, total alkalinity ranged from 149 to 212 mg l^{-1} indicating higher productivity.

The higher primary productivity found in the present study may be assigned to high concentration of nutrients, higher temperature and higher photosynthesis during the pre summer and summer months.Sultan *et al.* (2003) found higher primary productivity in tropical waters, congenial for biological production. The Net primary productivity (NPP) in the present study is found between 0.12 to 0.55g C m^3 h^{-1} with average

Table 4: Water quality and primary productivity of GoverdhanSagar, Udaipur (Raj.)

S. No.	Parameters	Min. – Max.	Avg.	S.D.
1	Air temperature R″C	28.86 - 32.80	30.75	1.25
2	Water temperature R″C	27.50 - 30.70	28.57	1.26
3	Transparency (cm)	90.00 - 100.33	96.23	3.21
4	pH	7.00 - 7.30	7.18	0.09
5	EC(μS cm^{-1})	366.67 - 396.67	381.87	11.80
6	Dissolved oxygen (mg l^{-1})	4.90 - 6.10	5.56	0.49
7	Free CO2 (mg l^{-1})	0.0 - 24.00	19.68	11.13
8	Carbonate (mg l^{-1})	26.66 - 45.50	35.41	6.37
9	Bicarbonates (mg l^{-1})	92.00 - 153.00	137.44	19.45
10	Total alkalinity (mg l^{-1})	177.00 - 202.00	185.73	9.18
11	Orthophosphates (mg l^{-1})	0.05 - 0.27	0.13	0.07
12	Nitrate-nitrogen (mg l^{-1})	0.41 - 0.58	0.46	0.06
Primary productivity (g C m $^{-3}$ h $^{-1}$)				
13	Gross primary productivity	0.38 - 0.45	0.42	0.03
14	Net primary productivity	0.22 - 0.30	0.26	0.03
15	Community respiration	0.15 - 0.20	0.17	0.02

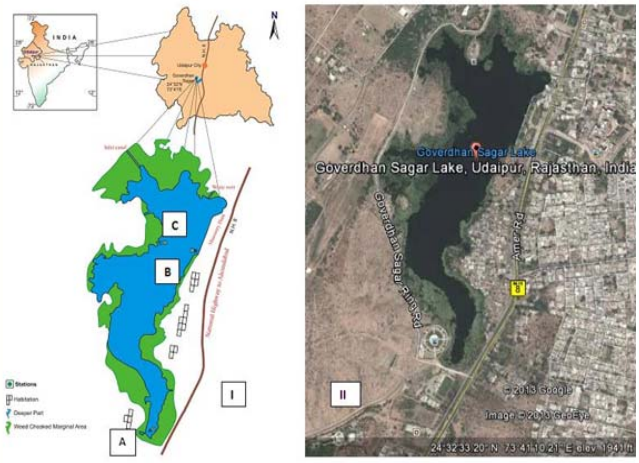

Figure 1: Location map (I) with stations - A, B, C and satellite imagery (II) of GoverdhanSagar Lake, Udaipur (Rajasthan)

values of 0.24, 0.27 and 0.26 g C m^3 h^{-1} at stations A, B and C, respectively.

The significantly positive relationship of GPP and NPP with temperature and nitrate-nitrogen is also supported by Paulose and Maheshwari (2007) while conducting a comparative study of JalMahal and Ramgarh lake of Jaipur. This relationship shows effective use of phosphorus in primary production and its depletion. The statistical relationship of GPP was found positive with temperature, depth of visibility, pH, dissolved oxygen, carbonates, bicarbonates, total alkalinity, nitrate-nitrogen, NPP, CR, phytoplankton, frequency and weight of submerged weeds.

Roy (2010) studied the processes of the mode of release of heavy metals into aquatic environment, their sources, categories, utilization by plants and animals, food chain relationships, bio magnification, toxicity and recovery from the eco system. The ambient macrophytes of the environment act as bioabsorbants and bio accumulators of heavy metals. They also act as bio indicators of the heavy metal pollution. Thus, bioremediation of the heavy metals from the aquatic environment can be done by the use of the algae and macrophytes inhabiting therein.

Usha *et al*. (2010) recorded the 30 macrophytic species and they have been classified under submerged (3 species), rooted with floating leaf (5 species), free floating (6 species) and emergent (16 species) groups respectively from Poiroupat lake, Manipur, India.

The statistical correlation between frequency and weight of submerged weeds and water quality indicated a positive relationship with air and water temperature, depth of visibility, pH, electrical conductivity, dissolved oxygen, carbonates, bicarbonates, total alkalinity, nitrate-nitrogen, GPP and NPP. However, there was a negative relationship with free CO_2, orthophosphates, CR, phytoplankton, frequency of emergent weeds and weight of emergent weeds.

The statistical correlation between frequency and weight of emergent weeds and water quality indicated a positive relationship with electrical conductivity, free CO_2, orthophosphates, CR and phytoplankton. However, there was a negative relationship with air and water temperature, depth of visibility, pH, dissolved oxygen, carbonates, bicarbonates, total alkalinity, nitrate-nitrogen, GPP, NPP, frequency of submerged weeds and weight of submerged weeds.

From the above study it can be concluded that in small reservoir having perennial water of moderately eutrophic nature as found in Goverdhan Sagar lake having marginal area with high growth of aquatic macrophytes can be effectively utilized for fish culture. The correlation between water quality and other parameters indicated greater production of macrophytes at higher temperature and lower level of soluble gases. The study also indicated excellent nutrient absorption capacity of macrophytes.

In view of availability of nutrients and primary producers (mainly macrophytes) the lake is a good example of effective channelization of nutrients into vegetative biomass. On the lines of scientific management of lake it is appropriate to convert the energy at this trophic level of primary producers to the production of suitable fish species, as such the lake can be stocked with appropriate number of phytophagous fishes.

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