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RESEARCH ARTICLE

ASSESSMENT OF BIOGAS EMISSIONS FROM SOME MACROPHYTES OF ANTIYA TAAL LAKE, JHANSI, WITH SPECIAL REFERENCE TO THEIR BIOMASS ESTIMATION

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ABSTRACT

Owing to the importance of macrophytes in the generation of biomass and production of biogas, present attempt has been made in Antiya Lake, Jhansi, whereby *Typha latifolia* has been found to gather maximum biomass followed by *Ludwigia sps.* and *Iopomea aquatica*. Moreover the biogas emission of *Iopomea aquatic* is greater followed by *Ludwigia sps.* and *Typha latifolia*. The present communication deliberates in detail on the said matter of interest.

INTRODUCTION

Wetlands comprising small proportion (2-3%) of earth surface contribute significant proportion (18-30%) of the total soil carbon. In addition to this, wetlands contribute approximately 22% of annual global methane emission (Barlett and Harris, 1993). Although fresh water lakes and reservoirs account only for 4% of the earth's surface, they can be important conduits for the transfer of terrestrial fixed carbon to the atmosphere. The role of the lakes as CH_4 producer varies in accordance with quality of bottom sediments. Lake with organic carbon rich sediments has been observed to produce more methane than lake where the corresponding content is low (Mathews and Fung, 1987). As a result of physical, chemical, biological and hydrological transformations, a part of the organic matter settles down to the lake bottom whereas part of it may also be released to the atmosphere as CH_4 and CO_2. In fact besides decomposition, quality of substrates also influences the rate of carbon mineralization. Increase in temperature stimulates microbial activity, resulting in greater CO_2 production from microbial–mediated organic carbon mineralization (Chimner, 2004). Studies have shown that microbial activity and decomposition generally increase with an increase in temperature up to 35-40^{0}C (Craft, 2001) while temperatures <5^{0}C inhibit microbial mediated redox reactions (Megonigal *et al.*, 1996). Mineralization of terrestrially derived organic carbon in lakes is an important regulator of organic export to the sea and may affect the net exchange of CO_2 between the atmosphere and boreal landscape (Franco, 1986). High nutrient concentration potentially stimulates the activity of heterotrophic microorganisms associated with submerged leaf litter and hence, influences decomposition rates and availability of detritus to invertebrates (Hansen, 1959; Wetzel, 1975).

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Substantial evidence has accumulated over the period of time that majority of worlds lakes are net sources of CO_2 to the atmosphere (Kling *et al.,* 1991) and that CO_2 emission rates from lakes are proportional to input and lake mineralization rates of terrestrial organic carbon (Kling *et al.,* 1991, Hope *et al.,* 1997; Sobek *et al.,* 2003). Based on CO_2 super saturation in lakes worldwide, Cole *et al.* (1994) suggested that lakes can be potentially important conduits for carbon from terrestrial sources to the atmosphere. Mineralization in lakes and subsequent CO_2 emission to the atmosphere is the most important carbon loss process. The withdrawal capacity of lakes on the catchment scale was closely correlated to the mean residence time of surface water in the catchment and to some extent to the annual mean temperature represented by latitude (Cole *et al.,* 1994). Acidification of surface waters may increase the loss of dissolved organic carbon through accelerated photo decay process (Dillon and Molot, 1997a; Schindler, 1998 and Anesio and Graneli, 2003) and through chemical alterations caused by increase in metal concentration (Schindler *et al*., 1992). Littoral zones at the interface of the lake and the catchment area are intensive sites for mineralization of organic matter. In the view of above mentioned facts, present investigation on the biomass production and biogas emission from the aquatic macrophytes inhabiting the Antiya Taal has been carried out.

MATERIALS AND METHODS

Antiya Taal is located between latitude 25^{0}12' - 25^{0}16'N and longitude 78^{0}18'- 79^{0}23'E. The lake is shallow with an area of 0.030Km^2 and is surrounded by residential houses all sides. The increased anthropogenic activities in the adjacent catchment area caused increased inflow of untreated sewage, municipal solid wastes, nutrients and pesticides from urban dwelling thereby deteriorating the water quality of the lake. Some aquatic weeds like *Typha latifolia* (cattail), *Ipomea aquatica* (water spinach) and *Ludwigia sps.* Of

Antiya Taal were selected to estimate the biogas (methane) production. A total of 100 gm of each species were collected and placed in oven at 65-70^{o}C to know its total solid weight. The bulk of fresh aquatic weeds (2-3 Kg) were collected and chopped into small pieces having size less than 2mm diameter. As per total solid weight, the chopped materials was mixed with cow dung in five different ratios (T1, T2, T3, T4 and T5) and placed in airtight glass bottles filled with 125 ml of water. For ensuring accuracy, three replicates have been taken for each species. The potential of biogas emission from each of the samples was very high and hence to prevent it from bursting, gas was released and measured twice a day. Furthermore gas samples were collected after every five days.

Biomass Productivity

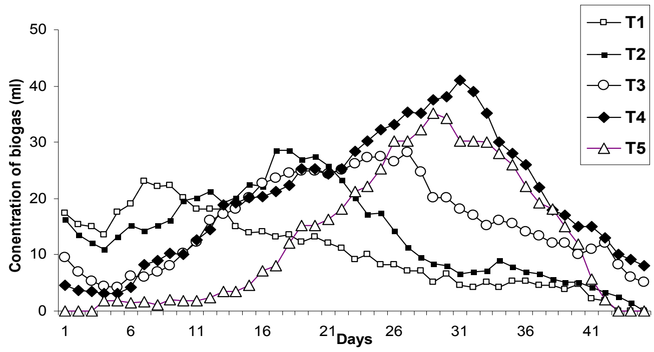
To evaluate biomass productivity, intact emergent vegetation was selected. 10m^2 quadrants were drawn and the vegetation removed and weighed. For each species more than five quadrates have been drawn to take appropriate value of biomass productivity. 100 gm of each species were placed in an oven at a temperature of 75^{0}C till its constant weight appears. The difference between initial and final weight determines the biomass productivity. Furthermore a known weight (3kg) of each species was allowed to grow in the water to estimate growth by checking its weight after every 10 days.

RESULTS AND DISCUSSIONS

Biomass Productivity

Among all the ecological systems, wetlands are considered the most productive ecosystems in the world (Westlake, 1982). The primary productivity of many wetlands is quite high especially when compared to other natural communities. Wetlands with emergent herbaceous vegetation are often more productive than other wetland types. In Antiya Tal, the most dominant species were found *Typha latifolia, Ludwigia sps.* and *Iopomea aquatica*. These species swathe most portion of the Antiya Tal and its catchment area. The hierarchical dominance of the macrophytes in the Antia Taal was found to be *Typha latifolia* followed by *Iopomea aquatica* and *Ludwigia sps*. It has been recorded that *Typha latifolia* generates maximum dry biomass (5.227Kgm^{-2}) followed by *Ludwigia sps.* (0.587Kgm^{-2}) and *Iopomea aquatica* (0.520Kgm^{-2}) respectively (Table 1). The per day growth per plant and per day growth per quadrant was also found to follow the same trend with *Typha latifolia* (22.3gkg^{-1}, 1621.4gkg^{-1}) topping the list followed by *Ludwigia sps.* (19.1gkg^{-1}, 195.7gkg^{-1}) and *Iopomea aquatica* (14.1gkg^{-1}, 112.2gkg^{-1}). The primary productivity of wetlands is of particular interest because it provides a link between terrestrial communities and aquatic ecosystem.

Five different ratios have been made between chopped aquatic weeds and cow dung. It was found that the mixtures containing 25% plant material and 75% cow dung produces maximum biogas and it remains emitting methane for longer duration as compared to other ratios. From each species viz., *Typha latifolia, Ludwigia sps. and Iopomea aquatica* five different mixtures have been made which are as follows: T1 (100% plant material and 0% Cow dung); T2 (75% plant material and 25% Cow dung); T3 (50% plant material and 50% Cow dung); T4 (25% plant material and 75% Cow dung); T5 (0% plant material and 100% Cow dung). Furthermore the mixture T_1 emits the gas very quickly followed by T_2, T_3, T_4 and T_5 as shown in Fig 1.



T_1(100%PM+0%CD), T_2(75%PM+25%CD), T_3 (50%PM+50% CD), T_4(25%PM+75% CD), T_5(0%PM+100% CD)

Fig. 1. Average Biogas Production from different ratios of *Typha latifolia*

The ratio T_5 starts emitting gas very slowly and also emits for short duration as compared to other mixtures. In case of *Typha latifolia*, the average production of biogas from T_1, T_2, T_3, T_4 and T_5 was recorded to be 10.46ml, 13.72ml 15.76ml, 20.12ml & 13.09ml (Table 2). However, total production of gas followed the sequence of $T_4>T_3>T_2>T_5>T_1$. But in case of *Iopomea aquatica* and *Ludwigia sps.* the ascending trend follows as $T_3>T_2>T_4>T_1>T_5$ and $T_4>T_3>T_2>T_1>T_5$. The average production of biogas from different ratios (T_1, T_2, T_3, T_4 and T_5) of *Iopomea aquatica* was found to be 15.86ml, 20.89ml, 24.32ml, 20.11ml, 11.33ml and that of *Ludwigia sps.* was found to be 15.04ml, 17.31ml, 21.35ml, 22.32ml, 9.18ml (Table 2, Fig. 1,3,5) respectively. To decompose the species anaerobically, *Typha latifolia* takes the maximum duration followed by *Ludwigia sps.* and *Iopomea aquatic*. The maximum amount of gas emitted by *Typha latifolia* was found to be 905.57ml in T_4 (Fig. 2) and that of *Ludwigia sps.* emits 1026.84ml gas in T_4 (Fig. 6) during anaerobic decomposition. While in case of *Iopomea aquatica* the maximum amount of gas was released from T3 mixture as 1118.5ml (Fig. 4). During anaerobic decomposition of aquatic weeds, the emission of gas starts in all different ratios but at a slower rate. With

Table 1. Biomass Productivity in Antiya Taal

Species	Initial Biomass (kg)	Final Biomass (kg)	Per Day Growth (gkg^{-1})	Growth/day/m^2 (gkg^{-1})	Dry Biomass (kgd^{-1}m^{-2})
Typha latifolia	3.0	3.670	22.3	1621.4	5.227
Iopomea aquatica	3.0	3.042	14.1	112.2	0.520
Ludwigia sps.	3.0	3.057	19.1	195.7	0.587

Table 2. Biogas Production (ml) from Aquatic weeds

	Species								
Treatment	*Typha latifolia*			*Iopomea aquatica*			*Ludwigia sps.*		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
T_1 (100%PM+0% CD)	1.09	22.99	10.46	2.05	41.35	15.86	3.15	38.16	15.04
T_2 (75%PM+25% CD)	1.05	28.61	13.72	3.15	38.22	20.89	2.01	30.10	17.31
T_3 (50%PM+50% CD)	4.02	15.76	15.76	4.21	41.21	24.32	3.25	36.52	21.35
T_4 (25%PM+75% CD)	3.04	41.1	20.12	6.00	38.01	20.11	3.21	43.21	22.32
T_5 (0%PM+100% CD)	1.05	35.21	13.09	1.00	32.15	11.33	2.15	30.12	9.18

Biogas

Animal waste (cow dung) and fresh plant material of Antiya Taal could be subjected to anaerobic digestion to produce biogas (Methane) that can be used for different purposes like cooking, lightening etc. the passage of time (after 5-8 days) the emission of gas goes on increasing till it reaches its maxima and then slows down to zero level till the complete decomposition occurs as shown in Fig. 1, 2, 3. In the past Antiya Taal has played a vital role in sustaining the human

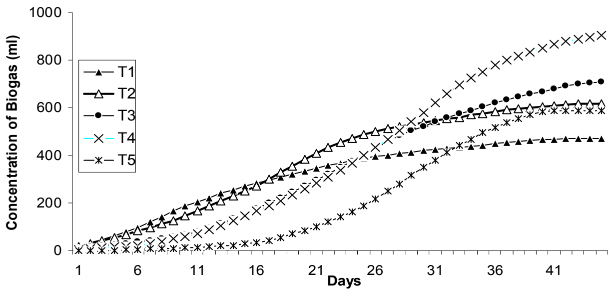
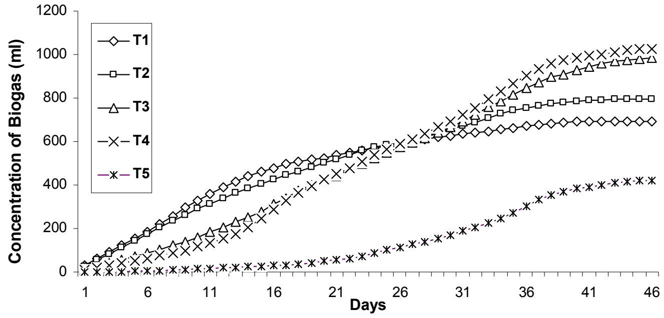
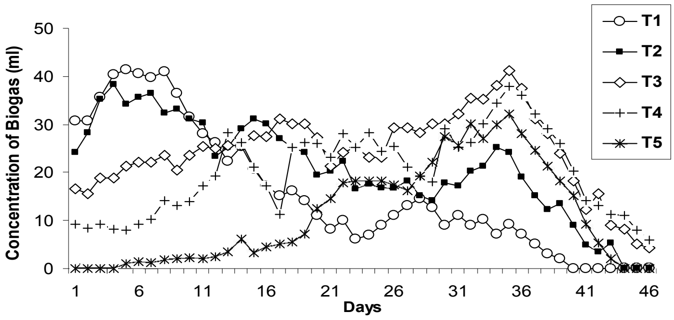


Fig. 2. Cumulative biogas production from different ratios of *Typha latifolia*



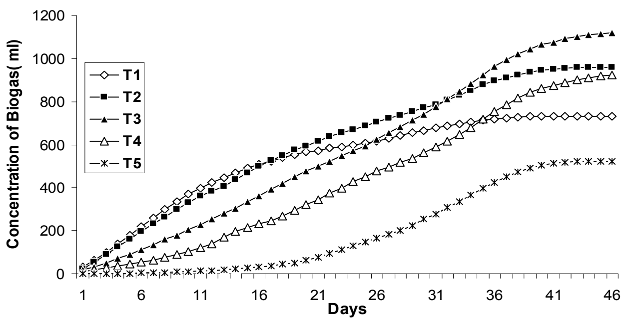
T_1(100%PM+0%CD), T_2(75%PM+25%CD), T_3 (50%PM+50% CD), T_4(25%PM+75% CD), T_5(0%PM+100% CD)

Fig. 3. Average Biogas Production from different ratios of *Iopomea aquatic*



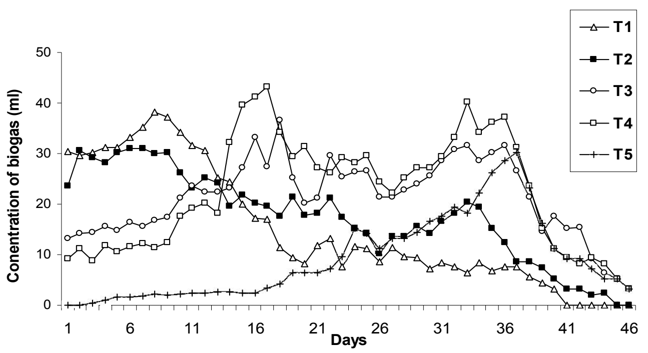
T_1(100%PM+0%CD), T_2(75%PM+25%CD), T_3 (50%PM+50% CD), T_4(25%PM+75% CD), T_5(0%PM+100% CD)

Fig. 4. Cumulative biogas production from Different ratios of *Iopomea aquatica*



T_1(100%PM+0%CD), T_2(75%PM+25%CD), T_3 (50%PM+50% CD), T_4(25%PM+75% CD), T_5(0%PM+100% CD)
T_1(100%PM+0%CD), T_2(75%PM+25%CD), T_3 (50%PM+50% CD), T_4(25%PM+75% CD), T_5(0%PM+100% CD)

Fig. 5. Average Biogas Production from different ratios of *Ludwigia sps.*



T_1(100%PM+0%CD), T_2(75%PM+25%CD), T_3 (50%PM+50% CD), T_4(25%PM+75% CD), T_5(0%PM+100% CD)

Fig. 6. Cumulative biogas production from Different ratios of *Ludiwigia sps.*

population by providing water for drinking, irrigation and for construction purposes. However due to encroachment on the part of catchment area during last few decades the lake has been subjected to various environmental problems and consequently the lake water has deteriorated to such an extent that it is no more suitable for drinking purposes rather it is good for agricultural or irrigation purposes.

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