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Study of oxygen generation as free service and its economic value from *Hydrilla* sp plant in aquatic ecosystem

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ABSTRACT

We are getting various natural ecological services from nature as free. We are getting most life saving component oxygen from plant as free. If we able to estimate the economic value of intangible free services of nature, then we will give much more concern to save our natural resources for restoration, so that the balance of ecosystem of water bodies remains in equilibrium. Through simple process of estimation of photosynthesis for aquatic plant like *Hydrilla* was attempted for 24 hour data for free oxygen generation at standard temperature and pressure for six consecutive days in the month of September, 2023 in Sonarpur block of South 24 parganas, West Bengal and its economic value was compared with the market value of medical oxygen. The data was analysed by Excel software. The amount of free oxygen generated by 60cm^2 *Hydrilla* plant was compared with whole experimental aquatic field. Mean oxygen generated by per cm^2 of *Hydrilla* plant at STP in 24 hour is multiplied with total field area of rectangular 400000 cm^2 submerged field which is the total free oxygen generated. The experiment was conducted with time interval 6 am-9 am, 9 am-12 pm, 12 pm -3 pm, 3 pm-6 pm, 6 pm-9 pm, 9 pm-6am. The economic value of free oxygen is calculated from the data of market value of medical oxygen at STP in Indian context. In all the experiment set morning time, i.e. from 6am-9am the rate of photosynthesis was highest. Gradual reduction of rate of photosynthesis hence rate of oxygen generation from morning to afternoon was observed. 10 mg $NaHCO_3$/1000 ml concentration set shows higher rate of oxygen generation than the control. In 24 hour, rupees 306 and 431 value of free oxygen was generated from experimental submerged field for control and 10 mg $NaHCO_3$/ 1000 ml respectively. The economic value of free oxygen generated by aquatic plants in submerged field will be astonishing feelings to us for conservation of natural resources and to create value based learning towards the nature.

Key words: *Oxygen as free service, Hydrilla, Photosynthesis, $NaHCO_3$, Economic value*

Introduction

We are getting various natural ecological services from nature as free services. We are getting most life saving component oxygen from plant as free. Plant gives free oxygen to the nature through photosynthesis process. Gradual pollution to the wet lands such as ponds, lakes, rivers, sea, etc causes drastic changes to aquatic ecosystem. If we able to estimate the economic value of intangible free services of nature then we will give much more concern to save our natural resources for restoration, so that the bal-

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ance of ecosystem of water bodies remains in equilibrium. More concern on restoration of aquatic ecosystem components of water will provide adequate dissolved oxygen in water body. This will be beneficial for both aquatic plants and animals. In aquatic environment the pool of HCO_3^- is many fold higher than CO_2(Carbon dioxide), which led to preference to HCO_3^- for great source of carbon for underwater photosynthesis of aquatic plants (Sculthorpe, 1967; Colmer *et al*., 2011; Raven and Hurd, 2012). The efficiency of utilization of bicarbonate as the source of inorganic carbon may determine the efficacy of photosynthesis process under water condition (Cavalli *et al*., 2012). The process of photosynthesis may also be affected by atmospheric temperature and pressure (Wang *et al*., 2017). The value of various free ecosystem services may not be easily visible in markets at all (Costanza *et al*., 1997). Creation of value management in terms of free service of wet land may show the way of cost of waste management of water body pollution. Free ecosystem services provide most of its share to the human welfare. Thus, through simple process of estimation of photosynthesis for aquatic plant like *Hydrilla* was attempted for 24 hour data for free oxygen generation at standard temperature and pressure and its economic value was compared with the market value of oxygen. This will promote among ourselves to be more responsible to restore the water bodies near us.

Materials and Methods

The study area

The whole experiment was conducted in the month of September, 2023. The study area is located in the Sonarpur block of South 24 Parganas district of state of West Bengal, India. Its geographical coordinates are 22° 26' 18'' North, 88° 25' 55'' East and its altitude from sea level is average 9 meters. The *Hydrilla* plant was collected from submerged aquatic field of rectangular 400000 cm^2 (square centimeter) in which width is 800 cm and breadth is 500 cm. The field is located in Bidyadharpur of Sonarpur block of South 24 Parganas district of state of West Bengal, India. The field was full of *Hydrilla* plant population.

Experiment materials

1000 ml two glass beaker (Borosil), two glass funnel (Borosil), 8 ml two graduated glass test tube (Borosil), $NaHCO_3$(Sodium bicarbonate) salt (Nice), *Hydrilla* twigs, 100 °C (Celsius) thermometer, Barometer (cm of Hg).

Experiment procedure

Two set up was made consists of 1000 ml glass beaker containing full of water from experimental field, one is control which was devoid of $NaHCO_3$ (Sodium bicarbonate) salt and other contains 10 mg $NaHCO_3$ Salt. The experiment was conducted for six consecutive days with time interval 6am-9 am, 9 am-12 pm, 12 pm -3 pm, 3 pm-6 pm, 6 pm-9 pm, and 9 pm-6am. For each time interval two set of experimental beaker was used with fresh field water, *Hydrilla* plants and 10 mg $NaHCO_3$ Salt respectively. The process of underwater photosynthesis experiment was done as per standard protocols of Jain (2004).

Ten equal size of small cutted *Hydrilla* twigs are introduced into the mouth of the funnel and the funnel is inverted into the beaker containing water. The graduated test tube is filled with water and it is inverted over the stem of funnel. In the same way the other setups are made. The set up without sodium bi carbonate is used as control. The area of ten small sizes *Hydrilla* was 60 cm^2 in which width is 10 cm and breadth is 6 cm. The whole experiment sets was kept in open sunlight space. The decreased water level from tip of inverted graduated test tube was measured for each time interval. The amount of decreased water level is the amount of oxygen evolved during photosynthesis. For each time interval atmospheric temperature and pressure was recorded.

Statistical/Calculation tools

The amount of oxygen evolved is calculated at standard temperature and pressure by using combined gas law principle of Boyle's law, Charles law and Gay-Lussac's law, i.e. $P1V1/T1=P2V2/T2$ (P = atmospheric pressure in cm of Hg, V = volume, T = temperature in Kelvin). The data was analysed by Excel software. The amount of oxygen generated by *Hydrilla* plant was compared with whole experimental aquatic field. Mean oxygen generated by per cm^2 of *Hydrilla* plant at STP in 24 hour is multiplied with total field area of submerged field which is the total free oxygen generated. The economic value of free oxygen is calculated from the data of market value of medical oxygen from the link of https://www.indiamart.com/proddetail/b-type-oxygen-cylinder-3969562662.html. The volume of medical

oxygen is calculated at STP at room temperature and normal atmospheric pressure.

Results

As per Table 1, the free oxygen generation from 60cm^2 *Hydrilla* plant was recorded at STP as day 1. The free oxygen generation was recorded at 6 am-9 am, 9 am-12 pm, 12 pm-3 pm and 3 pm-6 pm such as 4.5, 3.7,3.5 2.2 ml and 6.6, 5.7, 5.2, 3.1 ml for control and 10 mg $NaHCO_3$/1000 ml respectively. The range of atmospheric pressure was 75-75.3 cm of Hg. The range of atmospheric temperature was 300.5-309.5 K.

In Table 2, as day 2, the free oxygen generation was observed at STP from the 60cm^2 *Hydrilla* plant at 6 am-9 am, 9 am-12 pm, 12 pm-3 pm and 3 pm-6 pm such as 5.3,4.4,3.2,1.7 ml and 6.6, 5.9, 3.5,3 ml for control and 10 mg $NaHCO_3$/1000 ml respectively. The range of atmospheric pressure was 75-75.3 cm of Hg. The range of atmospheric temperature was 301-309 K.

In Table 3, it has been seen that the range of atmospheric pressure was 75-75.2 cm of Hg. The range of atmospheric temperature was 300-308.5 K. In day 3, the free oxygen generated at STP from the 60 cm^2 *Hydrilla* plant at 6 am-9 am, 9 am-12 pm, 12 pm-3 pm and 3 pm-6 pm was 4.8, 4, 3.6, 2 ml and 6.3, 5.7, 5.1, 3.3 ml for control and 10 mg $NaHCO_3$/1000 ml respectively.

In Table 4, as in day 4, the range of atmospheric pressure was 75-75.2 cm of Hg. The range of atmospheric temperature was 300-307 K. The free oxygen generated at STP from the 60cm^2 *Hydrilla* plant at 6 am-9 am, 9 am-12 pm, 12 pm-3 pm and 3 pm-6 pm was 4.4, 3.8, 3.3, 1.9 ml and 5.9, 5.4, 4.7, 3.1 ml for control and 10 mg $NaHCO_3$/1000 ml respectively.

In Table 5, as in day 5, the range of atmospheric pressure was 75-75.2 cm of Hg. The range of atmospheric temperature was 300-306 K. The free oxygen generated at STP from the 60cm^2 *Hydrilla* plant at 6am-9am, 9am-12pm, 12pm-3pm and 3pm-6pm was 4.5, 3.9, 3.5, 2 ml and 6.3, 5.6, 4.8, 3.1 ml for control and 10 mg $NaHCO_3$/1000ml respectively.

In Table 6, as in day 6, the range of atmospheric pressure was 75-75.2 cm of Hg. The range of atmospheric temperature was 300-306 K. The free oxygen generated at STP from the 60cm^2 *Hydrilla* plant at 6 am-9 am, 9 am-12 pm, 12 pm-3 pm and 3 pm-6 pm was 4.2, 3.8, 3.4, 2.1 ml and 5.8, 5.4, 4.6, 2.9 ml for control and 10 mg $NaHCO_3$/1000 ml respectively.

No oxygen generation was recorded from 6pm-6am for both experiments in all six days.

In Table 7 and Figure 1, it has been seen that from all six days total free oxygen released by 60cm^2 *Hydrilla* plant in 24 hour was 13.9, 14.6, 14.4,13.4, 13.9, 13.5 ml with mean value 13.9 ml and 20.6, 19, 20.4, 19.1, 19.8, 18.7 ml with mean value 19.6 ml for control and 10 mg $NaHCO_3$/1000 ml respectively. In Table 8 shows that the mean total free oxygen generation by submerged field totally filled with *Hydrilla* plant in 24 hour were 92.7 litre and 130.7 litre for control and 10 mg $NaHCO_3$/1000 ml respectively.

From the India Mart (2023) source the B type medical oxygen cylinder of 1500 litre gas capacity

Table 1. Oxygen generation by *Hydrilla* plant in 24 hr time intervals at STP, Day 1

Time	DAY 1					
	P1 (cm of Hg)	V1 (ml)	T1 (Kelvin)	P2 (cm of Hg)	T2 (Kelvin)	V2 (ml)
			Control			
6 am-9 am	75.1	5	303	76	273	4.5
9 am-12 pm	75.1	4.2	305	76	273	3.7
12 pm-3 pm	75.3	4	309.5	76	273	3.5
3 pm-6 pm	75.1	2.5	303	76	273	2.2
6 pm-9 pm	75.1	0	301.5	76	273	0.0
9 pm-6 am	75	0	300.5	76	273	0.0
			10 mg $NaHCO_3$/1000 ml			
6 am-9 am	75.1	7.4	303	76	273	6.6
9 am-12 pm	75.1	6.5	305	76	273	5.7
12 pm-3 pm	75.3	6	309.5	76	273	5.2
3 pm-6 pm	75.1	3.5	303	76	273	3.1
6 pm-9 pm	75.1	0	301.5	76	273	0.0
9 pm-6 am	75	0	300.5	76	273	0.0

Table 2. Oxygen generation by *Hydrilla* plant in 24 hr time intervals at STP, Day 2

Time	DAY 2					
	P1 (cm of Hg)	V1 (ml)	T1 (Kelvin)	P2(cm of Hg)	T2(Kelvin)	V2(ml)
			Control			
6 am-9 am	75.2	6	305	76	273	5.3
9am-12 pm	75.2	5	307.5	76	273	4.4
12 pm-3 pm	75.3	3.6	309	76	273	3.2
3 pm-6 pm	75.2	1.9	302	76	273	1.7
6 pm-9 pm	75.2	0	302	76	273	0.0
9 pm-6 am	75	0	301	76	273	0.0
10 mg $NaHCO_3$/1000 ml						
6 am-9 am	75.2	7.4	305	76	273	6.6
9 am-12 pm	75.2	6.7	307.5	76	273	5.9
12 pm-3 pm	75.3	4	309	76	273	3.5
3 pm-6 pm	75.2	3.3	302	76	273	3.0
6 pm-9 pm	75.2	0	302	76	273	0.0
9 pm-6 am	75	0	301	76	273	0.0

Table 3. Oxygen generation by *Hydrilla* plant in 24 hr time intervals at STP, Day 3

Time	DAY 3					
	P1 (cm of Hg)	V1 (ml)	T1 (Kelvin)	P2(cm of Hg)	T2(Kelvin)	V2(ml)
			Control			
6 am-9 am	75.1	5.4	303	76	273	4.8
9 am-12 pm	75.1	4.5	304	76	273	4.0
12 pm-3 pm	75.2	4.1	308.5	76	273	3.6
3 pm-6 pm	75.1	2.2	303	76	273	2.0
6 pm-9 pm	75.1	0	301	76	273	0.0
9 pm-6 am	75	0	300	76	273	0.0
			10 mg $NaHCO_3$/1000 ml			
6 am-9 am	75.1	7.1	303	76	273	6.3
9 am-12 pm	75.1	6.4	304	76	273	5.7
12 pm-3 pm	75.2	5.8	308.5	76	273	5.1
3 pm-6 pm	75.1	3.7	303	76	273	3.3
6 pm-9 pm	75.1	0	301	76	273	0.0
9 pm-6 am	75	0	300	76	273	0.0

Table 4. Oxygen generation by *Hydrilla* plant in 24 hr time intervals at STP, Day 4

Time	DAY 4					
	P1 (cm of Hg)	V1 (ml)	T1 (Kelvin)	P2(cm of Hg)	T2(Kelvin)	V2(ml)
			Control			
6 am-9 am	75.1	4.9	301	76	273	4.4
9 am-12pm	75.1	4.2	302	76	273	3.8
12 pm-3 pm	75.2	3.8	307	76	273	3.3
3 pm-6 pm	75.1	2.1	302	76	273	1.9
6 pm-9 pm	75.1	0	301	76	273	0.0
9 pm-6 am	75	0	300	76	273	0.0
10 mg $NaHCO_3$/1000 ml						
6 am-9 am	75.1	6.6	301	76	273	5.9
9 am-12 pm	75.1	6.1	302	76	273	5.4
12 pm-3 pm	75.2	5.3	307	76	273	4.7
3 pm-6 pm	75.1	3.5	302	76	273	3.1
6 pm-9 pm	75.1	0	301	76	273	0.0
9 pm-6 am	75	0	300	76	273	0.0

has volume of 1374.2 litre at STP in room temperature and normal atmospheric pressure and its price is rupees 4500. Per litre medical oxygen market price at STP is rupees 3.30. Hence as per Table 8 in 24 hour rupees 306 and 431 value of free oxygen was generated from experimental submerged field for control and 10 mg $NaHCO_3$/1000ml respectively.

Discussion

The present studies show that it is possible to measure the free oxygen generation by plants. There are various environmental factors are responsible for underwater photosynthesis. In the experiment it has been observed that gradual reduction of rate of photosynthesis hence rate of oxygen generation from morning to afternoon. Atmospheric pressure was more or less similar throughout the experiment. Variation of atmospheric temperature was observed which may lead to variation of rate of photosynthesis. In all the experiment set morning time i.e. from

Table 7. Total Oxygen released by 60 sqcm *Hydrilla* in 24hr (ml at STP)

Day	Control	10 mg $NaHCO_3$/1000 ml
1	13.9	20.6
2	14.6	19
3	14.4	20.4
4	13.4	19.1
5	13.9	19.8
6	13.5	18.7
Mean	13.9	19.6

Table 5. Oxygen generation by *Hydrilla* plant in 24 hr time intervals at STP, Day 5

Time	DAY 5					
	P1 (cm of Hg)	V1 (ml)	T1 (Kelvin)	P2 (cm of Hg)	T2 (Kelvin)	V2 (ml)
			Control			
6 am-9 am	75.1	5	301	76	273	4.5
9 am-12 pm	75.2	4.4	303	76	273	3.9
12 pm-3 pm	75.2	4	306	76	273	3.5
3 pm-6 pm	75.1	2.3	303	76	273	2.0
6 pm-9 pm	75.1	0	301	76	273	0.0
9 pm-6 am	75	0	300	76	273	0.0
10 mg $NaHCO_3$/1000 ml						
6 am-9 am	75.1	7	301	76	273	6.3
9 am-12 pm	75.2	6.3	303	76	273	5.6
12 pm-3 pm	75.2	5.4	306	76	273	4.8
3 pm-6 pm	75.1	3.5	303	76	273	3.1
6 pm-9 pm	75.1	0	301	76	273	0.0
9 pm-6 am	75	0	300	76	273	0.0

Table 6. Oxygen generation by *Hydrilla* plant in 24 hr time intervals at STP, Day 6

Time	DAY 6					
	P1 (cm of Hg)	V1 (ml)	T1 (Kelvin)	P2(cm of Hg)	T2(Kelvin)	V2(ml)
			Control			
6 am-9 am	75.1	4.7	301	76	273	4.2
9 am-12 pm	75.1	4.2	302	76	273	3.8
12 pm-3 pm	75.2	3.9	306	76	273	3.4
3 pm-6 pm	75.1	2.4	302	76	273	2.1
6 pm-9 pm	75.1	0	301	76	273	0.0
9 pm-6 am	75	0	300	76	273	0.0
			10 mg $NaHCO_3$/1000 ml			
6 am-9 am	75.1	6.5	301	76	273	5.8
9 am-12 pm	75.1	6.1	302	76	273	5.4
12 pm-3 pm	75.2	5.2	306	76	273	4.6
3 pm-6 pm	75.1	3.3	302	76	273	2.9
6 pm-9 pm	75.1	0	301	76	273	0.0
9 pm-6 am	75	0	300	76	273	0.0

6am-9am the rate of photosynthesis was highest. Similar findings are observed in Masojidek *et al*., (2001). As in the experiment 10 mg $NaHCO_3$/1000 ml concentration set shows higher rate of oxygen generation than the control. Adequate amount of bicarbonate source promotes aquatic plants to use other factors efficiently for better rate of photosynthesis. This finding is supported by previous work done by Cavalli *et al*., (2012). For under water photosynthesis aquatic plants need optimum level of bicarbonate as the source of carbon. There was no photosynthesis from 6 pm to 6am time period because of no sunlight. This finding is supported by previous work of Pedersen *et al*., (2013). Price tagging of free oxygen generated by aquatic plant was attempted with compare to least Indian market value of medical oxygen. The economic value of free oxygen generated by aquatic plants in submerged field will be astonishing feelings to us for conservation of natural resources and to create value based learning towards the nature. This finding is supported by previous work of Costanza *et al*.,(1997).

Conclusion

The study found that through simple plant physiology based photosynthesis experiment; quantification of free oxygen generation of aquatic plant is possible. It is also possible to measure the free oxygen generation of aquatic field containing hydrophytes through mathematical calculation. Though the accurate findings of oxygen generation from aquatic field may be restricted due to natural obstacles, but through proper mathematical measurement this obstacles may be eliminated. Price tagging of free oxygen may seems difficult due to various uncontrollable factors, but logical planning could give the solution of value of free oxygen released by hydrophytes. Its seems amazing to give economic value of free services of nature but it may promote the gross national income of country if the value based feeling is added to ecosystem services.

Table 8. Mean Total Oxygen released in aquatic field /24 hr (litre at STP)

Control	92.7
10 mg $NaHCO_3$/1000 ml	130.7

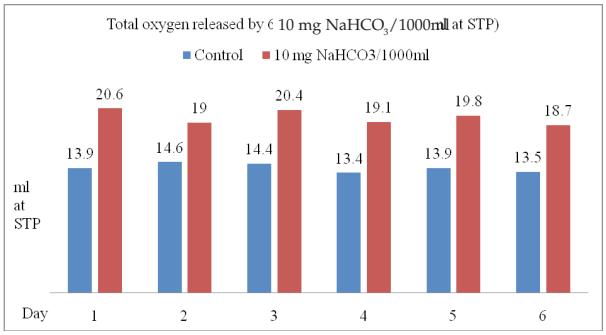

Fig. 1. Total oxygen generation (ml) by Hydrilla from 60 cm^2 area at STP

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Conflict of interest None

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