Renewable Energy Generation Using Sargassum Spp Substrate and Natural Catalyst to Achieve Zero Carbon Emission Energy Generation Technology

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Abstract

As per the Kyoto Protocol, the burning of fossil energy sources for energy affects a critical mass of greenhouse gas exhausts that is put into global warming, which requires to be managed through carbon foot printing regulation. Many resources of green energy lead to minor to zero exhausts, even though pondering the entire life cycle of the systems. Renewable energy produces zero or low air pollutants. During the proposed research, samples of the rotten Sargassum found at the beaches causes adverse health impact on humans due to toxic gas release. Because of the rise in Sargassum bloom over coastal regions, there is an urgent need for identification of alternate use of Sargassum instead of investing cost and efforts in dumping huge blooms. As microbial fuel cells (MFC) can covert biomass into electricity, it can be used to convert biogenous marine sediments to electricity with organic catalyst actions. For the first time, the effect of organic catalyst materials on Pico single chamber microbial fuel cell with Sargasso and biogenous marine sediments is investigated in this paper. The experimental evaluation suggests that organic catalysts and salt water can be used to neutralize the impact of toxic gases produced by rotten Sargassum. Furthermore, we performed in-depth analysis for electricity generation and results suggest that anaerobic treatment can be boosted in MFC with use of rotten Sargassum and subsequently the organic catalyst can boost energy generation with the corresponding maximum recorded values of the generated parameters are 0.814 V, 0.0112 µA, 0.009116 µW and 0.000101 mW/m2.

Keywords: Microbial fuel cell, carbon foot printing, renewable energy, clean energy, Kyoto protocol

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1. Introduction

Organic tiny pollutants will be as well hardly ever analyzed to claim that there are world-wide toxins. Nevertheless, study research concentrated on Sargassum spp. disease verified external risks. Dangerous algal blooms (HABs) caused by means of Prorocentrum donghaiense happen regularly and trigger a severe danger to the marine environment. [1, 2] Since 2011, pelagic Sargassum offers overwhelmed Caribbean, Western African, as well as north Brazilian shorelines in raising quantities. In Aug 2018, Sargassum protected a region of 1,697 kilometers2, likened to a historic common of 292 kilometer2 between 2011 and 2017. Latest inundation occasions possess triggered hundreds of thousands of dollars of misplaced income in the tourism market, specifically in harming little Caribbean parts of the world in whose economies will be extremely reliant on tourism [3].

As an electron sacrificer, photosynthetic oxygen introduced through algae may total

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however, the maximum current was first lower than that created within illumination due to low exoelectrogenic process of biofilm [4].

Microbial fuel cells will be unique bio-electrochemical converters able of transforming damp organic waste materials straight right into electric power nevertheless; quickly electron transfer is usually required for MFC strength era. For improvement in power density and electron transfer speed, number of researchers have been investigated many chemical catalyst as α-Fe 2 O 3 /polyaniline nanocomposites, the combination of Fe-AAPyr and GNS as an effective catalyst [5 - 8].

Researchers also investigating impact of temperatures, pH, salinity on performance of MFC [9 - 11], effect of substrate type and substrate concentration [12], performance improvement by analysis of electrode surface type [13, 14]. The investigation for high performance electrode materials has been conducted by many researchers and it is summarized that the cobalt oxide/carbon cloth is cost-effective alternative for platinum and also performing best with current generation of 0.15 mA [15 - 19].

Despite the most recent improvements in MFC sensors, the application of these products in useful applications provides come qualified due to the utilization of costly components. The elements influencing the efficiency of MFCs consist of microbes' populace, exchange membrane, electrodes, substrate attention, electrode spacing, etc. Membrane layer changes may efficiently increase the proton conductivity and water preservation of the membrane layer, decrease the inner level of resistance of MFCs, to improve electric power era functionality as well as , wastewater cure impact of MFCs. Exoelectrogenic organisms, many of these as Geobacter spp. and Shewanella spp., happen to be the important microorganisms to make use of organic subject as an electric power resource to operate bioelectrochemical devices [20 - 22].

Nevertheless, certainly, there possess been quite few research that particularly treat the concentrations of base in MFC. Likewise, the microbial variety of biofilms in MFCs features have been demonstrated to differ substantially based on the kind of substrates utilized. The probable of macroalgae Laminaria digitata as substrate pertaining to bioelectricity production was first analyzed within the gift study using a large amount of sugar and so mannitol in the hydrolysate [23]. Mexican authorities spent 17 million dollars in the getting rid of 522,226 plenty of Sargassum in 2018, and 2.6 million dollars for the removal of 85,000 loads in 2019 [24]. The biodiversity of seaweeds consists of which the alginophytes Sargassum spp., Cystoseira spp. and Turbinaria spp. are typically used [25-27].

We have demonstrated Pico MFCs which use Sargassum spp as a substrate with different concentration models, as well as investigation reveals the performance analysis with addition of natural catalysts to boost the energy generation process. However, the effect of concentration of Sargassum spp substrate on Pico MFCs with use of natural catalyst material hasn't been studied to date. In this paper, we report the first study of Sargassum spp with natural catalyst effect on a Pico-MFC. Research outcome shows that the Pico-MFC can produce energy with Sargassum spp.

2. Material and Method

In line with the threat of Sargassum bloom in Mexico, we recognized future risks for Indian coastal territory in 2014 when we identified and initially gathered Sargassum spp. Samples at Diveagar coastal area, Maharashtra. (Refer to Fig.1 for the research site map)

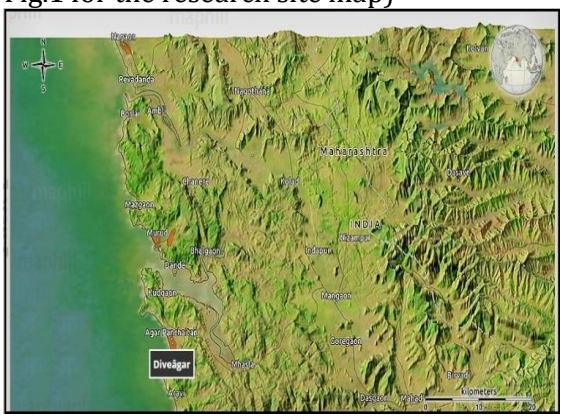

Fig. 1: Research Site "Diveagar, Maharashtra" Coastal Region Map (Source: Google Map)

On the other hand, Alappuzha in Kerala also experiences many of these samples of diverse

types of algae blooms. Alappuzha is sandwiched in between the wetland, the lagoon, and the Arabian Sea and is famous for its massive network of waterways that meander through the town. (Refer to Fig. 2)

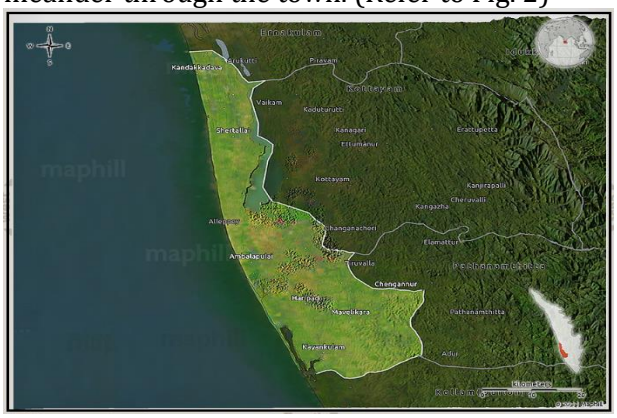

Fig. 2: Alappuzha, Kerala Coastal Region Map (Source: Google Map)

The proposed study can be applied to utilize such huge, harmful algae blooms for energy generation. The float out bloom of brown seaweed, Sargassum spp (Fig. 3) were collected from Diveagar (Lat. 18.1920° N, Long. 72.9789° E) village which is located in Raigad district, Maharashtra, India.

Fig. 3: Collected fresh seaweed Sargassum spp. (Generated by the Author)

The collection carried out for fresh and rotten samples of Sargassum spp. The *fresh* sample is kept in bamboo basket with bottom layer with sand. Further, the bamboo basket is kept in pot containing sea water in such a way that salt water can float through bamboo basket. In this way, there is less possibility of damage to freshly collected samples. The *rotten* samples are collected from beach areas and kept in an air tight container. For sample preparation for analysis, the rotten samples are stored in 3 different containers A, B and C with addition of sea water 10%, 20% and 30% of container volume respectively.

The initial set up includes 6 food grade plastic containers of dimension 3" X 4.6" X 3.3" with lids. Teflon tape is used to cover the container lid to ensure anaerobic process. As proposed model of Pico MFC is membrane less, single chamber MFC container with 50 µL capacity is used (Fig. 4). One meter insulated copper (Cu) wire with diameter 11.684 (mm) is used for electrode connections for hacker board, 2 mg/cm^2 carbon cloth electrodes; SSR brand miniature Alligator clips.

Fig. 4: Single chamber membrane less MFC unit (Generated by the Author)

Furthermore, we developed we developed own carbon cloth for development of cathode and anode for experiment. We used 5cm2 natural jute material and layered it with the organic honey (C6H12O6) which further dried for 2 days and burnt this pre-processed jute cloth using dry coconut mesocarp. Due to heat the honey wax melts and gives the appropriate porosity which boosts the current density.

Porosity = (Total Sample Volume – Sample Volume of the Solid) / (Total Sample Volume)

These cathode and anodes increases porosity which helps to increases the current density. Investigation is conducted in two modules: for fresh seaweed Sargassum spp sample and Rotten seaweed Sargassum spp samples with use of combination of sea water (10 µL), fruit vinegar (10 µL) and buttermilk (10 µL). Pico MFC is tested for maximum values of parameters with use of newly developed carbon cloth electrodes.

3. Research Methodology

Initially, 40 gm of fresh (chopped) sample is

kept in Pico single chamber MFC with 10 µL sea water without any kind of external catalyst (refer Table 1). So, this test gives the result for pure substrate i.e. the combination of fresh Sargassum spp with sea water.

To perform anaerobic experimentation the inner side of container lid is enclosed with Teflon tape. The Pico MFC is kept in room temperature and readings are recorded for 15 days with 2 hrs interval. Similarly, the rotten sample is also tested with similar process as mentioned above (refer Table 2). The investigation is carried out for Sargassum spp as a key substrate and performance has been tested with natural catalyst.

4. Results and Analysis

When packets fail to reach their destination, end users may experience disruptions such as slow service

Table -1: Fresh Sargassum spp Test Setup

Test No.	Substrate	Natural catalyst(10µL each)	Electrode Material
1	Fresh Sargassum spp (gm)	Sea water, Fruit waste Vinegar -(CH3COOH), Organic Lactic acid - Butter milk ($C_3H_6O_3$)	Newly developed carbon cloth 5cm2
2			
3			
4			

Table 2: Rotten Sargassum spp Test Setup

Test No.	Substrate	Natural catalyst(µL)	Electrode Material
1	Rotten Sargassum spp (gm)	Sea water, Fruit waste Vinegar -(CH3COOH), Organic Lactic acid - Butter milk ($C_3H_6O_3$)	Newly developed carbon cloth 5cm2
2			
3			
4			

To neutralize the Hydrogen sulfide release through Sargassum, we found that sea water bicarbonate ions can be used with organic (waste fruit) vinegar (CH_3COOH) and Butter milk ($C_3H_6O_3$) for production of Sodium bicarbonate in a natural way instead of using chemicals. So, the Pico MFC performance is boosted.

Activated carbon gets rid of a range of water pollutants, incorporating hydrogen sulfide, by means of adsorbing the gas on the surface area region of the carbon contaminants. Therefore, the coating of carbon fabric electrodes utilized in this test takes away Hydrogen sulfide.

Table -3: Recorded parameter values for 15 days (R_{int}=75 Ω)

Day	Voltage V (V)	Current I (µA)	Current Density (uA /m2)	Power = V2/R (uW)	Power Density = Voltage*current density (uW /m2)
1	0.258	0.0077	0.00154	0.000887	0.00039732
2	0.376	0.0050	0.00100	0.001885	0.00037600
3	0.461	0.0061	0.00122	0.002833	0.00056242
4	0.487	0.0064	0.00128	0.003162	0.00062336
5	0.631	0.0081	0.00162	0.005308	0.00102222
6	0.633	0.0084	0.00168	0.005342	0.00106344
7	0.680	0.0090	0.00180	0.006165	0.00122400
8	0.683	0.0091	0.00182	0.006219	0.00124306

9	0.756	0.0101	0.00202	0.0076204	0.00152712
10	0.795	0.0106	0.00212	0.008427	0.00168540
11	0.811	0.0108	0.00216	0.0087696	0.00175176
12	**0.818**	**0.0108**	**0.00217**	**0.00894347**	**0.00178541**
13	0.763	0.0101	0.00203	0.0077622	0.00154889
14	0.670	0.0089	0.00178	0.0059853	0.00119260
15	0.506	0.0067	0.00134	0.0034138	0.00067804

4. Discussion

It is observed that parameter values took 12 days to reach the optimum level of acceptance. Further to Day-12, the sediment lowers the electron generation. If more catalyst material or substrate is injected into the fuel cell, this can again boost energy generation. Further to energy generation, we tested the proposed model to identify the performance of new carbon cloth developed from jute material, as discussed previously.

The test shows (refer to Fig. 4 below) that the porosity is higher using a newly developed jute carbon cloth electrode, which improves the electron transfer speed. The voltage measured was first open circuit voltage seeing that the external resistance is usually not really utilized.

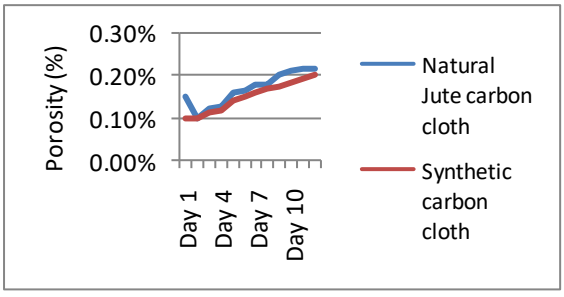

Fig. 4: Power density comparison between fresh and rotten Sargassum spp. substrate (Generated by the Author)

Therefore the voltage generated was first credited to inner impedance, which appeared to become extremely large in the selection of mega ohms. Fig. 5 shows generated voltage for proposed setup of the MFC.

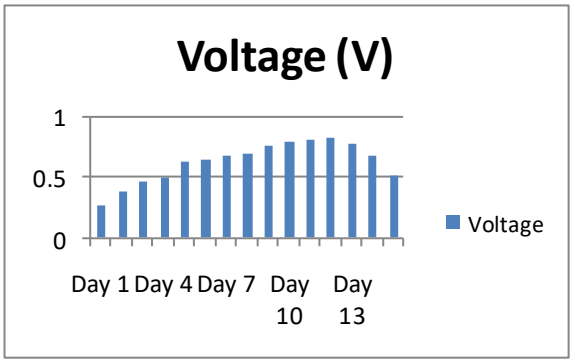

Fig. 5: Generated voltage (Generated by the Author)

The current measured was first open circuit voltage seeing that the exterior resistance is usually not really utilized. Therefore the voltage generated was first credited to inner impedance, which appeared to become extremely large in the selection of mega ohms. Fig. 6 to 8 shows the parameter tests.

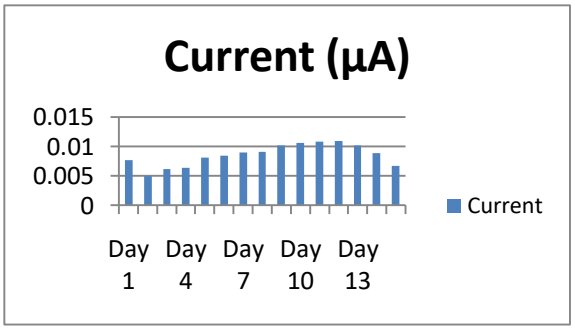

Fig. 6: Generated Current (Generated by the Author)

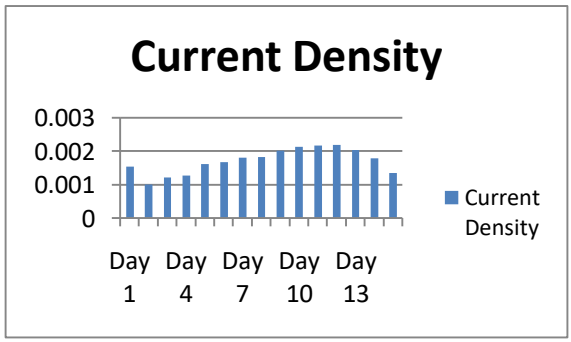

Fig. 7: Generated Current Density (Generated by the Author)

The power measured was first open circuit power seeing that the exterior resistance is usually not really utilized. Therefore the power generated was first credited to inner impedance, which appeared to become extremely large in the selection of mega ohms.

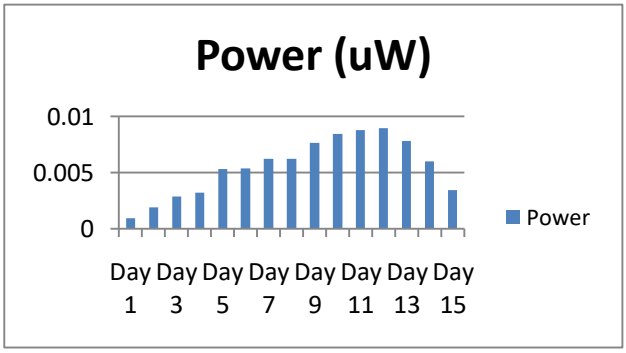

Fig. 8: Generated power density (Generated by the Author)

As a summary, research recorded maximum values of the generated parameters like voltage, current, current density, power and power density using Sargassum spp as substrate are 0.818V, 0.0108μA, 0.00217 mA/m^2, 0.00894347 μW and 0.00178541mW/m^2 respectively.

5. Conclusion

The proposed research successfully uses Sargassum spp for energy generation and testing, validating that rotten Sargassum spp. can produce more electricity with newly developed carbon cloth. The critical problem in the coastal region is moving huge Sargassum spp, which floated out of the sea and settled at the seashore. It starts the contamination process very fast after moving out of seawater, which is dangerous for marine habitats. By way of the energy generation using rotten Sargassum spp., the air pollution and health hazards because of harmful gases released by rotten Sargassum spp. can be handled. The proposed research contributed to resolving the Sargassum spp blooms problem (which floats in huge dimensions and affects marine biodiversities) by developing an innovative microbial fuel cell for the cheapest energy generation with the replacement of costly chemical catalysts, electrodes, and membranes. Research also discussed the process of developing new cheap carbon cloth electrodes using the waste jute material, which further cut downs the overall cost of the energy generation model. This model can be further developed to generate a high-capacity energy generation unit. Further, the proposed research suggested regional renewable energy policies that can support national policy development

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