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Generation of Current by using Microbial Fuel Cell and Simultaneously Treatment of Sugar Industrial Waste Water

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Abstract: **Water pollution is a major global problem. It is caused when contaminants are introduced into the natural environment like lakes, rivers, oceans and groundwater which causes waterborne diseases. Some of the industries which contribute to water pollution are Chemical and Pharmaceutical Industries, Sugar Industries, Steel Plants, Coal, Soap and Detergents, Paper and Pulp Industries, Distilleries, Tanneries, Foods Processing Plants etc. India is the world's largest sugar-consuming country and also second largest in sugar production. That's why the amount of wastewater generated from sugar industries has also increased. Wastewater from sugar industries contains carbohydrates, oil and grease nutrients, sulphates, chlorides, and heavy metals. The work was carried out to reduce various pollutants present in synthetic waste water of Sugar Industry using "Microbial Fuel Cell" Treatment Method.**

In the construction of a microbial fuel cell Salt-bridge is the economic alternative to highly priced proton-exchange membrane. By altering the concentration of agar in the fabrication of salt-bridge, performance of microbial fuel cells were observed using sugar industrial wastewater as the substrate.

In this study various concentrations of agar is taken in a salt bridge like 5gms, 7gms, 10gms to produce bacteria, NaCL is also used in salt bridge for the flow of electrons. Two different types of stainless steel rods and copper rods are used to generate electricity. The COD has been reduced from 147ppm to 45ppm. We have obtained that 7gms agar concentration with stainless steel rods have been generated more current when compared to 5gms and 10gms of agar with stainless steel and copper rods. We have also obtained that 7gms of Agar with stainless steel rods was reducing the more pollutants when compared to 5gms and 10gms agar with copper and stainless steel rods.

***Keywords:** Microbial Fuel Cell, Stainless Steel rods, Copper rods, Salt Bridge, COD.*

I. INTRODUCTION

While the world population is growing, both the energy and water resources are becoming limited. These issues are causing concerns about global food security for the first time since the Green Revolution of the 1960's (Baulcombe, 2010) [1]. An additional challenge is also associated with population growth i.e increase in wastewater generation and environmental pollution. To address these serious problems, some of the advances in research have been made to improve water management and to make wastewater treatment more effective and efficient. Also, alternative renewable energy sources (bio-energy, geothermal, solar, wind etc.) have been investigated and applied.

A microbial fuel cell is a device which converts chemical energy to electrical energy by the action of microorganisms. So these electrochemical cells are constructed using anode and cathode. Most MFCs contain a membrane to separate the compartments of the anode and the cathode. This two-chamber design of MFCs is frequently operated in batch mode and fed-batch mode. The purposes of proton exchange membrane (PEM), is to separate the liquids in each chamber and allow protons to flow from anode to cathode [2]. Sometimes, PEM can be replaced by cat-ion exchange membrane (CEM), as it is less expensive and stronger [3]. Furthermore, the CEM in two-chamber MFCs could be replaced by a salt bridge, which consisted of a tube filled with agar and salt and then capped with porous caps [4]. Microbial fuel cell (MFC) has potential to treat wastewater while

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producing electricity and thus providing a solution for water and energy shortages. Unlike some renewable energy sources competing with food production for land and water, MFC can use organics in waste streams as energy source and enhance food security by providing treated water that could be applied in irrigation. The bacteria on the MFC anode decompose organic matter in wastewater, liberating electrons that flow to the cathode through an external circuit and generate electricity [5-7]. Electrochemically active bacteria have been also known as exoelectrogens, electricigens, and anode-respiring bacteria (Torres et al., 2007) [8]. The isolated electro-chemically active bacteria belong to diverse genetic groups, including Firmicutes (Park et al., 2001) [9], α-Proteobacteria (Zuo et al., 2008 [10]; β-Proteobacteria(Chaudhuri and Lovley, 2003) [11], γ-Proteobacteria (Kim et al., 1999[12]; When grown as pure cultures, most of the microbes generate lower power than when grown as mixed cultures (Rabaey et al., 2004) [13]. This could be explained by the fact that mixed cultures are more tolerant to oxygen and can use a variety of substrates compared to pure cultures. Such properties of mixed cultures allow them to use wastewater as fuel source (Rittman et al., 2008) [14].

Main objective of the present study is to generate electricity and simultaneously treat industrial waste water containing recalcitrant or non biodegradable and toxic compounds which cannot be treated. In an attempt to increase the efficiency of degradation of the impurities present in the waste water to improve the economics of the treatment, the work was carried out to reduce COD present in waste water of Sugar Industry using "Microbial Fuel Cell" Treatment Method.

II. PROCEDURE

Sample collection

Sample was collected from sugar industrial waste water and kept in a refrigerator at 4^0C before to use. Standard sample (100% waste concentration) was diluted with distilled water and pH was adjusted in the range from 7 to 7.2 for the adaptation of microbial growth, further 50% sample was taken throughout the study.

MFC Components

MFC majority constitutes electrodes, anodic and cathodic chamber and salt bridge as shown in Fig-1.The salt bridge that forms a bridge between cathodic and anodic chamber facilities the transfer of ions (protons). Carbon and steel rods were used as anode and cathode.

A. Procedure to Prepare Salt Bridge

- Take 100ml of distilled water is in a measuring flask and pour it in a pan. Heat it for certain time until bubbles appear.
- Take 5gms 0f NaCL and pour it in that pan.
- After NaCL is dissolved take 5gms of agar and pour it in the pan, wait until agar powder is dissolved.
- After the agar is dissolved transfer that solution to 10cm PVC pipe, and keep that PVC pipe in a dark place for 24hrs and the agar becomes solidified.
- Repeat the same procedure for 7gms and 10gms agar.

B. Construction of MFC

Figure 1: Microbial Fuel Cell for the treatment of waste water

- First we take two 1.5lit boxes and put a hole for both the boxes to attach the PVC pipe.
- Agar was already solidified in the PVC pipe so that we can attach the PVC pipe in middle of the boxes with help of araldite.
- Pour 1lit distilled water in one box which is called as cathode and another 1lit waste water in anode.
- Copper or Stainless steel rods are attached to the electrical wires those electrical wires are connected to the multi-meter, which gives current.
- Run this for 10 days, After the 10 days run completed take the waste water and measure the water-treatment COD.

C. Water quality analysis

Sample was taken from sugar industry waste water and is treated by Microbial Fuel Cells. In the process, two bottles are taken; one bottle was having waste water sample and the other bottle having distilled water. Copper or Stainless steel rods are dipped into each bottle and a salt bridge is attached between two bottles. After the treatment was done samples were taken to determine Chemical Oxygen Demand. The COD was analyzed using closed reflux method. For every 48hrs of operation of the MFC, The outlet was collected and analyzed for the above mentioned parameters

D. Electrical measurements

The current (mA) was measured with a digital multimeter connected to the line between the anode and the cathode. The corresponding current across the resistor was recorded with time.

III. RESULTS AND DISCUSSION

A. Effect of Microbial Fuel Cells

In the present operation, the value of COD has reduced from 147ppm to 45ppm. Besides reducing the toxicity MFC also produces Current. The current produced can be checked by connecting electrodes to the Multi-meter. The maximum current found out to be 0.77mA. The Figure 2, 3, 4 shows that maximum amount Current generated over a period of 10days.

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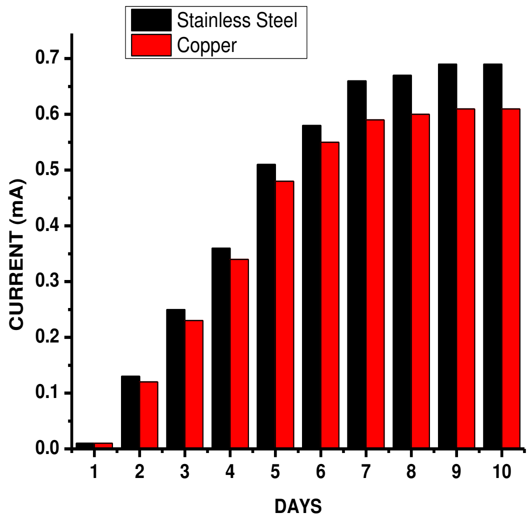

Figure 2: Current of MFC with Sugar industry waste water for 5gms Agar

When experiment has been carried out for copper and stainless steel rods with 5gms of agar for 10 days of run, we have observed that stainless steel rods have been generated more current than the copper rods. The maximum amount current obtained for 5gms Agar with stainless steel rods is 0.69mA

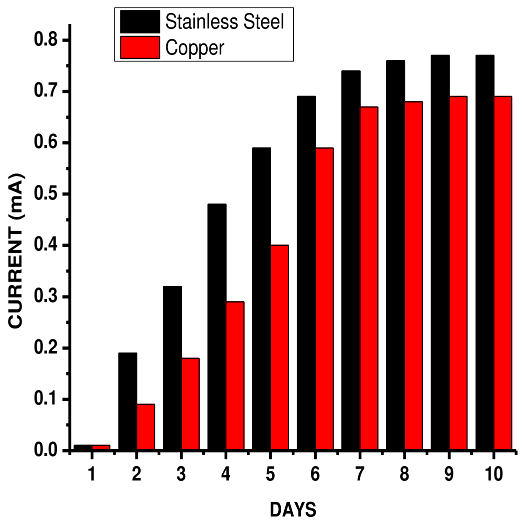

Figure 3: Current of MFC with Sugar industry waste water for 7gms Agar

When experiment has been carried out for copper and stainless steel rods with 7gms of agar for 10 days of run, we have observed that stainless steel rods have been generated more current than the copper rods. The maximum current obtained for 7gms Agar with stainless steel rods is 0.77mA

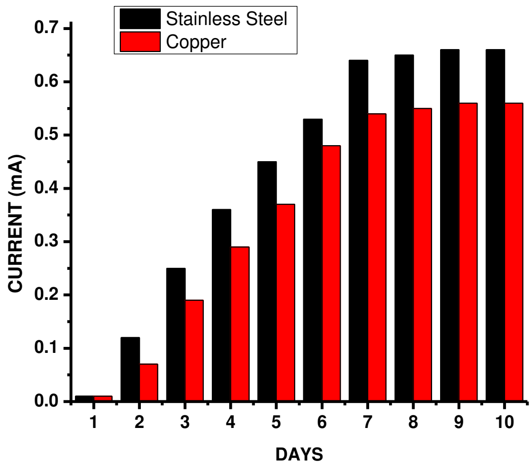

Figure 4: Current of MFC with Sugar industry waste water for 10gms Agar

When experiment has been carried out for copper and stainless steel rods with 10gms of agar for 10 days of run, we have observed that stainless steel rods have been generated more current than the copper rods. The maximum current obtained for 10gms Agar with stainless steel rods is 0.66mA

B. Effect of Chemical Oxygen Demand (COD)

The Chemical Oxygen Demand (COD) determines, the oxygen required for chemical oxidation of organic matter with the help of strong chemical oxidant. The COD is a test which is used to measure pollution of industrial waste. The waste is measured in terms of equality of oxygen required for oxidation of organic matter to produce CO_2 and water. COD test is useful in toxic condition and presence of biological resistant substance. For COD determination waste water samples were preserved using H_2SO_4 and processed for COD determination after the entire sampling operation was complete. COD of the waste water sample at different time intervals are presented in the Figures 5, 6, 7, when the experiment has been carried out for copper rods and stainless steel rods with 5gms, 7gms and 10gms of agar for 10 days of run. Results show that COD of the waste water has decreased from an initial of 147ppm to 45ppm for 7gms of agar with stainless steel rods. This decrease in COD indicates bioremediation of the waste supporting the concept of microbes utilizing the organic waste for microbial oxidation.

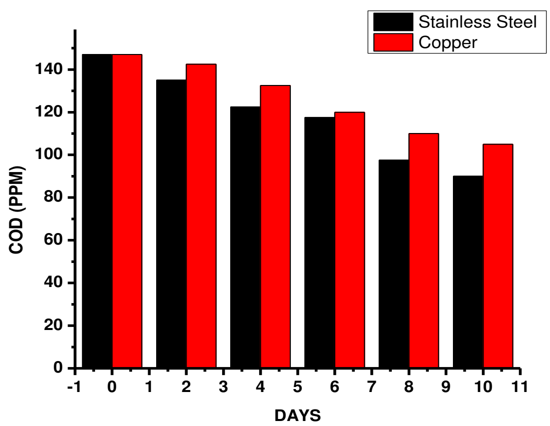

Figure5: Variation of COD with time for 5gms agar

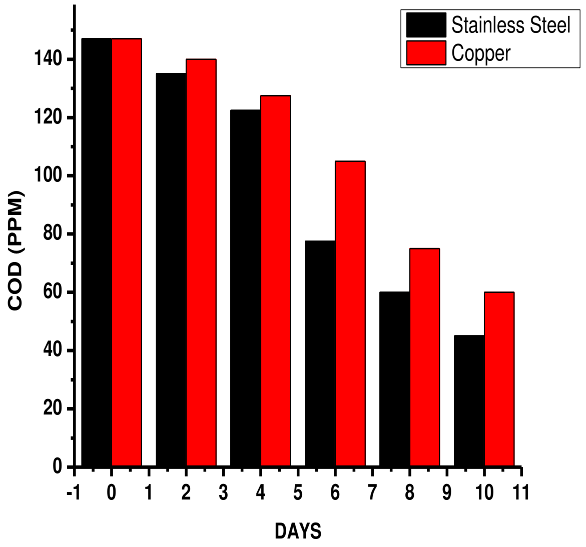

Figure 6: Variation of COD with time for 7gms agar

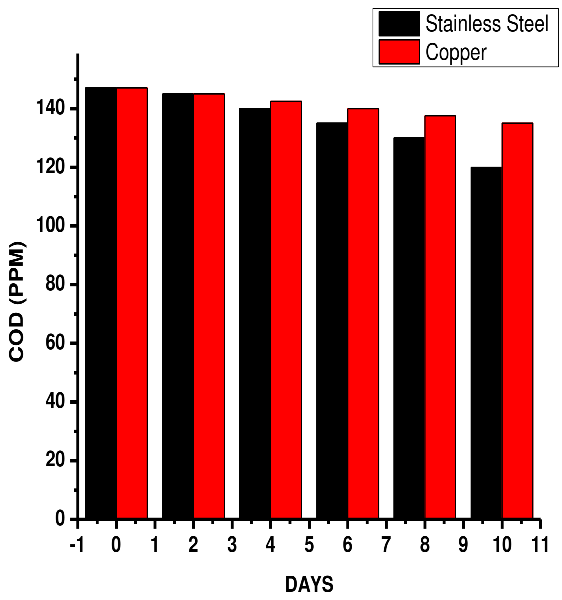

Figure 7: Variation of COD with time for 10gms agar

IV. CONCLUSION

The work was carried out to reduce various pollutants present in waste water of Sugar Industry using "Microbial Fuel Cell" treatment method. Various concentrations of agar is taken in a salt bridge like 5gms, 7gms, 10gms, NaCL is also used in salt bridge for the flow of electrons. Two different types of rods such as stainless steel rods and copper rods are used to generate electricity and to reduce the pollutant levels. When the generation of current is increased the amount of pollutants are decreased. After measuring the water treatment COD, we have obtained that 7gms of Agar with stainless steel rods was reducing the more pollutants when compared to 5gms and 10gms agar with copper and stainless steel rods. And the current was also generating more for 7gms agar with stainless steel rods when compared to 5gms and 10gms agar with copper and stainless steel rods. The MFC being a promising resource for the future has to be further investigated for improvements in its performance and capabilities to treat waste water with high organic loads.

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G Rushi Varma is a graduate in B.Tech (Chemical engineering) from Gayatri College (A), Visakhapatnam. He also completed his M.Tech from the Department of Chemical Engineering, Andhra University, Visakhapatnam. Rushi Varma is extremely fascinated by the increasing growth in the field of Chemical Engineering, with an unceasing enthusiasm; he grabbed the opportunity to work as a summer internship trainee in Coke-Oven plant department of Visakhapatnam steel plant. Further, he has done his projects on waste water treatment in B.Tech and Microbial Fuel Cell in M.Tech. He is highly-driven towards piloting more research

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Dr. V. Sridevi is Professor having an experience of 21 years in teaching and more than 10 years of Research experience from the Department of Chemical Engineering, Andhra University College of Engineering (A), Andhra University, Visakhapatnam. Dr. V. Sridevi has significantly contributed in the field of Industrial Pollution and Control Engg. She has worked on Biodegradation, Bio reactor design and Industrial Pollution & its control. She has successfully guided 40 M. Tech students and 13 Research scholars were pursuing PhD (03 Awarded & 02 submitted) under her guidance. She has published more than 150 papers in National & International Journals. She is serving as Quality Management System Internal auditor for ISO 9001:2015 certification. She is also serving as Departmental Research Committee member & a member of departmental development, Examinations committee and Industrial Training & student activities.