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ELECTRICITY PRODUCTION FROM WASTE WATER BY MICROBIAL FUEL CELL

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ABSTRACT

A microbial fuel cell (MFC) is a bio-electrochemical system that converts the chemical energy in the organic compounds such as acetate, lactate, and glucose. It converts renewable energy sources to electrical energy under anaerobic conditions. So it is possible to produce electricity in a MFC from wastewaters. This process is an alternative methodology for generation of electricity. Here the MFC used three different wastewater samples which were achieved maximum power with Tannery effluent was obtained 414 mV followed by municipal wastewater 254 mV and domestic waste water 244 mV. It has been found that a mixture of cow dung can actually result in higher voltage than lechate and kitchen waste. MFC also used to treat the wastewaters under anaerobic process. The highest efficiency of DO removal has been achieved by Tannery waste water (57.14 %), followed by municipal wastewater (50 %) and pond water (44.4%). The Tannery effluent shows the highest efficiency for TSS (55.4 %), followed by municipal waste water (51.64 %) and pond water (46.98 %).

KEYWORDS: MFC, Organic compounds, Power, Voltage, TSS, DO.

INTRODUCTION

Microbial Fuel Cells (MFC) is a new form of renewable energy technology that directly converts the chemical energy stored in organic matter to electricity. This technology have been developed rapidly in the past decade. MFC can also be used to treat wastewater in treatment plants. In MFC, an anode respiring microbes digests the organic waste to carbon dioxide (CO_2) and transfers the electrons (e^-) released to the anode. The released electrons transfer from the microorganism to the anode by outer membrane cytochromes, mediators and nanowires. Then, the electrons travel from the anode to cathode through an external circuit to generate electrical energy. In cathode chamber the electrons are taken up by oxygen (O^-) and hydrogen ions (H^+) to form water (H_2O). There are many types of MFC reactors and many research teams throughout the world, all reactors have the same operating principles.

MATERIALS AND METHODS

GENERAL

Two double chamber MFCs were constructed with salt bridge for producing electricity from different types of waste water. It can be used for treating the waste water.

SAMPLE DETAILS

Tannery effluent was collected from Vishtech (ETP) at Visharam, domestic waste water was collected from Melvisharam and sewage sample was taken from collection point at Nawab lake at Arcot. So these are the samples were used as substrate in microbial fuel cell.

Figure 1. Collection point at Nawab lake

MATERIALS

1. Drill or drill press
2. Knife or scissors
3. Two plastic bottles
4. Low power aquarium air pump
5. 1 x 2" PVC pipe 1-2 feet long
6. Agar agar
7. Salt (NaCl)
8. Copper wires
9. Multi meter
10. Aluminum mesh
11. Methylene blue as mediator

PREPARATION OF SALT BRIDGES

A water solution containing concentrations of 3% NaCl and 1.6% agar was allowed to boil inside a microwave oven for nearly 3 minutes. The hot solution was poured into sawed PVC pipe sections each of length 4 inches by sealing one end with polythene. The setup was thereafter allowed to cool for nearly 2 hours inside a High Efficiency Performance Air Filter. The salt bridges were thus ready for use.

Figure 2. Preparation of salt bridge

MFC SETUP

A salt solution, in our case, of pure NaCl, would be added to each of the biowaste samples to make the mixture electrically conductive. This mixture would be placed in a sealed chamber to stop entering of oxygen, thus forcing the microorganism to use anaerobic respiration. An electrode would then be placed in the solution that would act as the anode.

In the second chamber of the MFC there would be placed another solution and another electrode. This electrode, called the cathode would be positively charged and would be the equivalent of the oxygen sink at the end of the electron transport chain, only now it would be external to the biological cell.

The solution would be an oxidizing agent that would pick up the electrons at the cathode. In our case, we shall use air pump which is used to supply of oxyzen to the cathode chamber.

Figure 3. MFC with wastewaters

A copper wire was used to connecting the two electrodes and completing the circuit and a salt bridge was used to connecting the two chambers. To pickup the electrons from the biowaste, aluminum mesh were used , the tips of mesh had been soldered to copper wires, which was traveling from one chamber to the other.

PHYSICO - CHEMICAL ANALYSIS OF WASTE SAMPLES

MFC is not only used for power production but also used for treatment process of wastewater. All the waste samples collected were analyzed physically with the parameters, pH, DO, TSS, TDS, chlorides, Hardness and Turbidity.

Figure 4. Testing of Physico-Chemical Parameters

RESULTS AND DISCUSSION

GENERAL

Voltage was generated by MFC using three different types of wastewaters with the mixture of different bio wastes and the physico-chemical parameters were tested before and after incubation of 5 days in MFCs.

DIFFERENCE IN VOLTAGE GENERATED FROM WASTEWATERS

Table 1. Voltage Generated (Micro-Volt) Using Different Bio-wastes

Samples	Day 1	Day 2	Day 3	Day 4	Day 5
Municipal waste water	172	270	254	195	170
Tannery effluent	300	414	302	261	210
Domestic waste water	140	195	244	224	206
Cow dung	110	205	275	231	201
Kitchen waste	95	120	165	132	121
Leachate	119	165	254	221	192
Tannery effluent + Cow dung	405	456	514	**560**	512
Tannery effluent + Kitchen Waste	383	452	501	473	398
Tannery effluent + Leachate	375	468	545	512	468

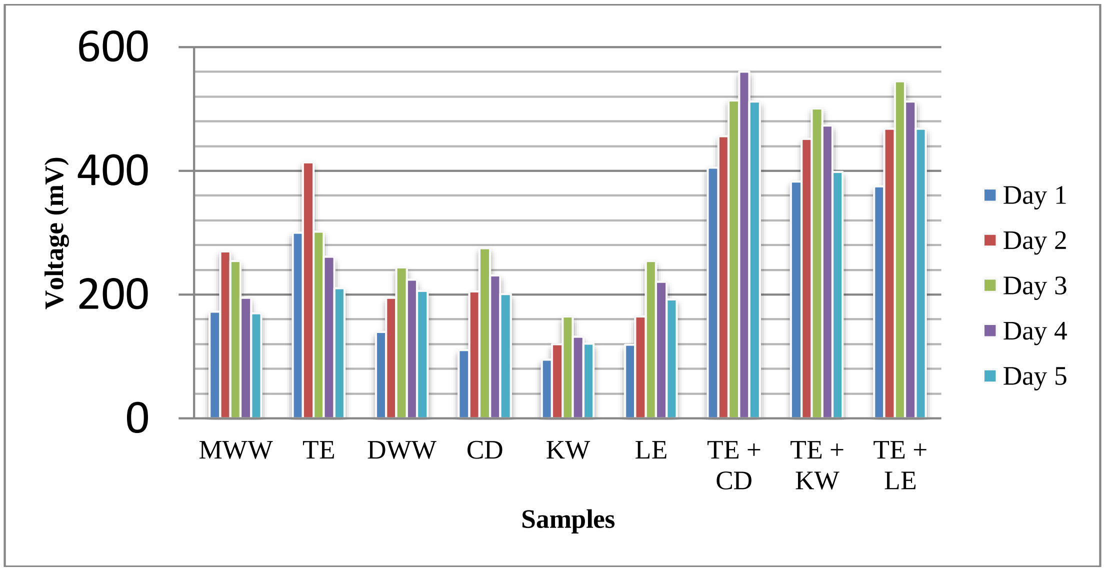

Figure 5. Comparison of voltage generation

COMPARISON OF THE THREE WASTEWATER SAMPLES USED IN THE MFCs

After each of the samples is run in the MFC for 96 hours each, the results of the open-circuit voltage (OCV) recorded are studied and compared. Based on the graph pattern for the comparison between the result of the electric voltage shown by the three samples in Fig 5 , from this experiment we found that the difference in voltage depends upon the amount of substrate present in the bio waste waters. The range of electric voltage produced by domestic waste water is between 0.140 V to 0.244 V. Next, the use of tannery effluent in the MFC gives values for the electric voltage in the range of 0.300 V to 0.414 V. Finally, the electric voltage production when using municipal wastewater is in the range between 0.172 V and 0.270 V shown in table 1. The study shows that among the three results shown, tannery effluent produces the highest voltage recorded. However, by observing the graph pattern, we can conclude that the rate of electric voltage production by using tannery effluent is the most consistent comparing to pond and municipal waste water, which show inconsistency in their rate of voltage production.

When MFC operated with mixture of bio wastes (cow dung, kitchen waste and lechate) to the waste waters in five days incubation, the combination of tannery with cow dung produces maximum of 0.560 V than other combinations.

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From that, the difference in the consistency of the rate of voltage production may be due to the formation of different types of microorganisms that exist in the sample and the rate of electron transfer.

CHARACTERIZATION OF WASTEWATERS BEFORE AND AFTER INCLUBATION OF 5 DAYS IN MFCS

Table 2. Physico-chemical analysis of Municipal Waste water

SAMPLES	BEFORE (mg/l)	AFTER (mg/l)
pH	6.4	6.2
Turbidity	72 NTU	54 NTU
Chlorides	350	300
Total Hardness	670	520
Total Dissolved Solids	0.047	0.050
Total Suspended Solids	0.091	0.044
DO	8	4

Table 3. Physico-chemical analysis of Tannery Waste water

SAMPLES	BEFORE(mg/l)	AFTER(mg/l)
pH	7.2	6.6
Turbidity	120 NTU	77 NTU
Chlorides	7205	6897
Total Hardness	2232	1800
Total Dissolved Solids	0.058	0.062
Total Suspended Solids	0.094	0.042
DO	14	8

Table 4. Physico-chemical analysis of DomesticWaste water

SAMPLES	BEFORE(mg/l)	AFTER(mg/l)
pH	5.8	5.5
Turbidity	67 NTU	52 NTU
Chlorides	200	150
Total Hardness	630	540
Total Dissolved Solids	0.033	0.043
Total Suspended Solids	0.083	0.044
DO	18	8

FLOW CHART FOR PHYSICO-CHEMICAL ANALYSIS

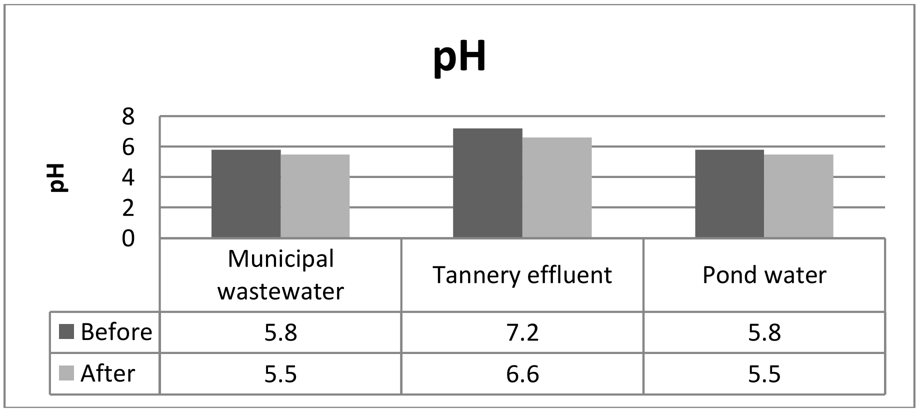

Figure 6. Variation in pH before and after MFCs

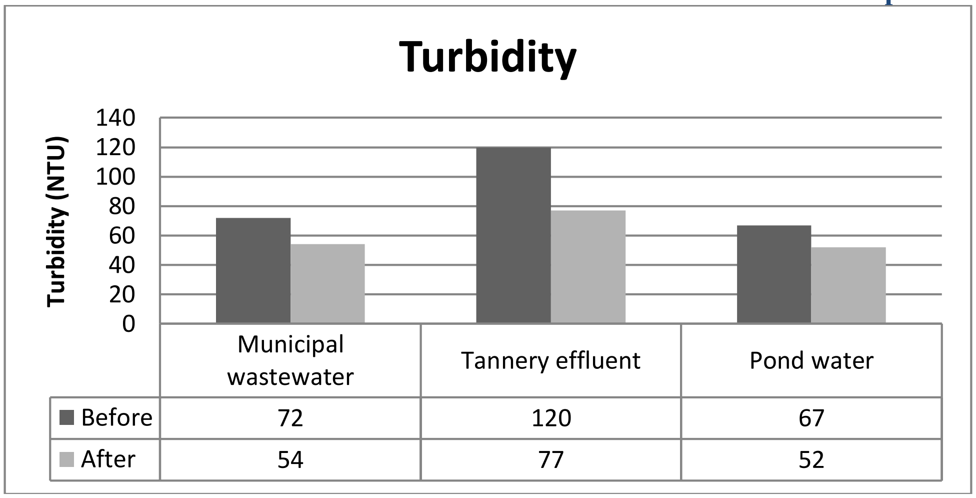

Figure 7. Variation in Turbidity before and after MFCs

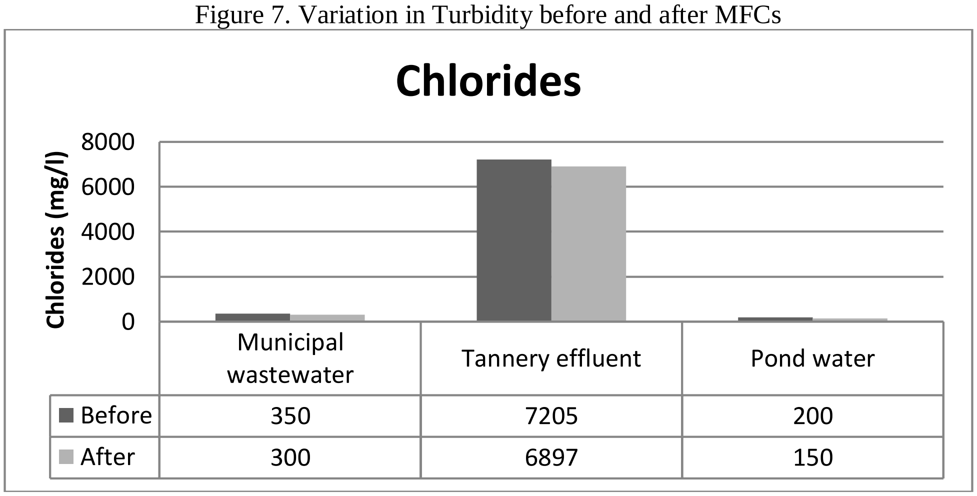

Figure 8. Variation in Chlorides before and after MFCs

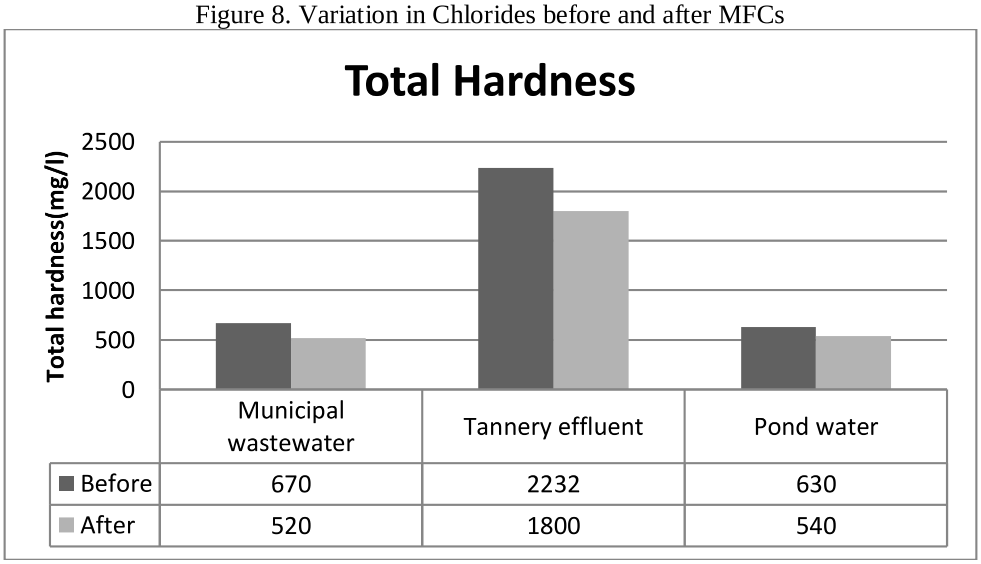

Figure 9. Variation in Total hardness before and after MFCs

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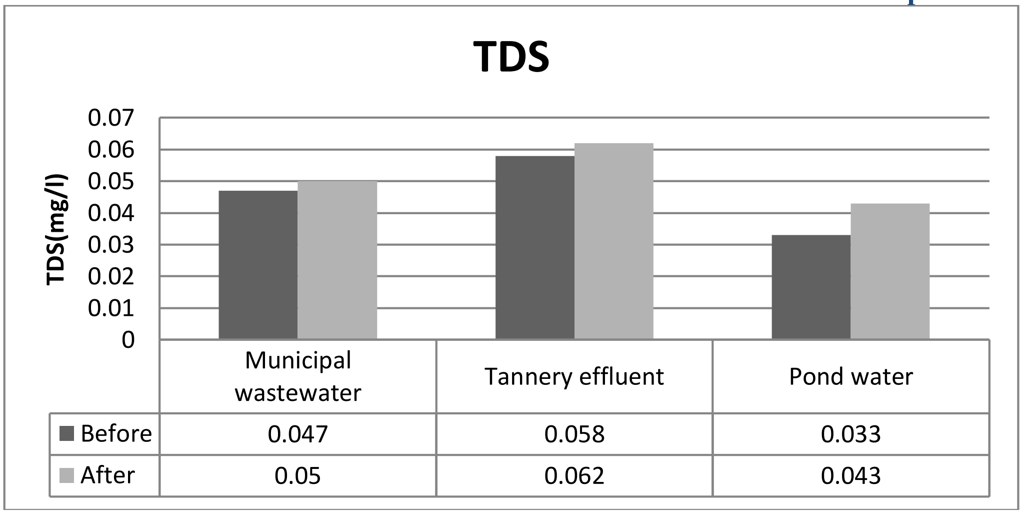

Figure 10. Variation in TDS before and after MFCs

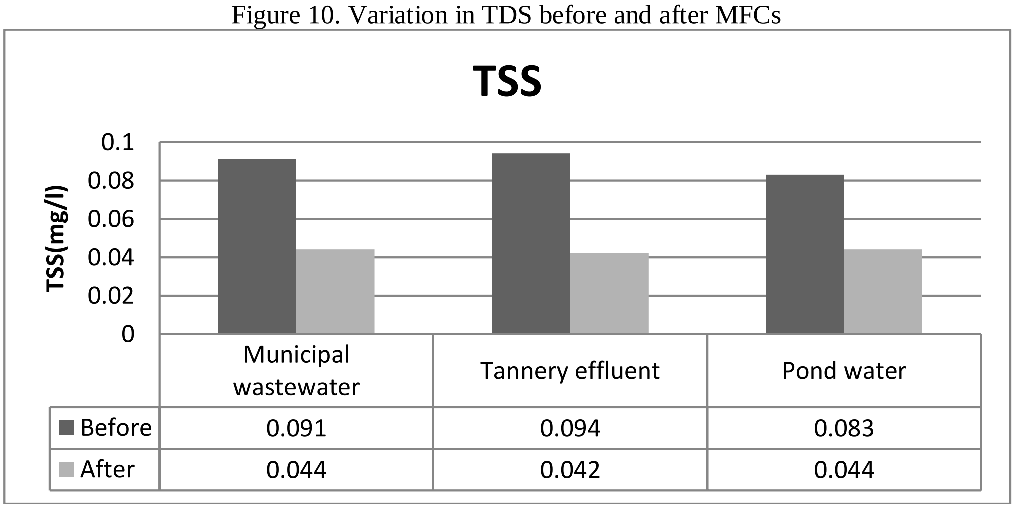

Figure 11. Variation in TSS before and after MFCs

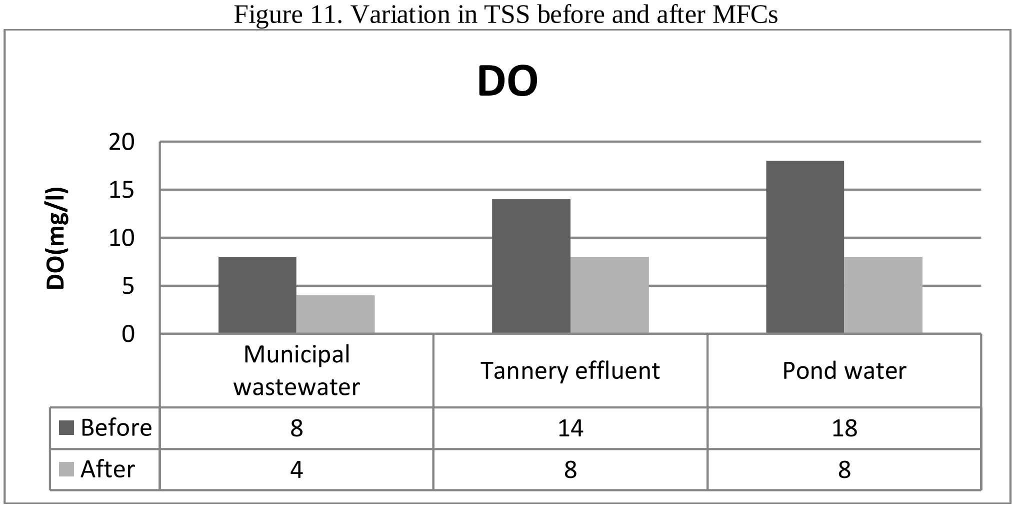

Figure 12. Variation in DO before and after MFCs

DISCUSSION OF PHYSICO-CHEMICAL PARAMETERS

The waste water samples were tested before and after the microbial fuel cell reactor. The physico-chemical analysis of wastewaters carried out with various parameters pH, TS, TSS, TDS, DO, chlorides, hardness and turbidity. Minor change in pH of waste water was observed during operation of MFCs with waste water. There is slight reduction in pH of domestic, tannery and Municipal waste water. About TSS there is great reduction in TSS after treatment the appearance and color also changed during treatment. TDS values were observed to be increased it may be due to increase in number of microorganism during treatment. Turbidity of the biowaste samples almost reduced 30% to 50% shown in Fig 7, because of settling process of degraded substrates at the bottom of MFC chamber. As well as the dissolved oxygen present in the biowaste reduced upto 50% in 5 days treatment.

CONCLUSION

Voltage was generated using three different type of waste water by microbial fuel cell (MFC). The highest rate o voltage generation has been achieved when the MFC was operated with tannery effluent + cow dung (0.560 V), followed by kitchen waste (0.501 V) and lechate (0.545 V). However, based on a study of the graph pattern generated, tannery effluent + cow dung provides the most consistent record for the electricity generation. The highest efficiency of OD removal is achieved by tannery waste water (42.85 %), followed by municipal wastewater (50 %) and domestic waste water (55.5 %). The tannery also showed the highest efficiency for TSS (55.31 %), followed by municipal waste water (51.61 %) and domestic waste water (46.98 %). The Electricity Voltage generation and the rate of the dissolved oxygen and total suspended solids removal for the tannery effluent have been shown to be the most efficient among the three types of samples.

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