Microbial Fuel Cell an Alternative for Treatment of Textile Wastewater

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Abstract - *The textile industry is considered to have one of the most polluting wastewater effluents in the world, with regards to volume and composition, and large quantities of dye used for colouring fabrics are present in the effluent. Most wastewater treatment facilities apply the well established and efficient activated sludge process to decrease chemical oxygen demand (COD) in the wastewater. Microbial fuel cell is an emerging approach for treat wastewater and also generating electricity. Textile industrial wastewater is highly polluted. So, Textile wastewater requires most sophisticated and expensive methods for treatment. In my project develop a novel technique to remove pollutants and to generate electricity from textile industrial wastewater by using a single chambered microbial fuel cell. And here also determine the percentage removal of concentration of BOD, COD and total solids. Textile wastewater was diluted to get different concentrations from 790 mg COD/L to 1350mg COD/L and this was given as feed to microbes present in MFC. The COD removal efficiency increased with the increase in feed concentration. The maximum COD removal of 77.03% was achieved at the feed concentration of 1350 mg COD/L. MFC produced a maximum current of 4.8 mA and power density of 16.8 mW/m2.*

***Key Words*: Microbial fuel cell (MFC), Wastewater treatment, Microbial degradation, Bioelectricity generation, Single chambered MFC,**

1. INTRODUCTION

Environmental issues associated with water sanitation are not confined to developing countries alone but are the most basic human and environmental necessities all over the world. Wastewater sources are major causes for environmental pollution in surface and ground water bodies. Current wastewater treatment technologies are not sustainable to meet the ever growing water sanitation needs due to rapid industrialization and population growth, simply because they are energy- and cost-intensive leaving latitude for development of technologies that are energy-conservative or energy-yielding. For the present and future context, microbial fuel cells technology may present a sustainable and an environmentally friendly route to meet the water sanitation needs. Microbial fuel cell based wastewater systems employ bioelectrochemical catalytic activity of microbes to produce electricity from the oxidation of organic, and in some cases inorganic, substrates present in urban sewage, agricultural, dairy, food and industrial wastewaters [10].

Textile wastewater is one of the most complicated wastewaters to treat because of the complex pollutants that it is composed of. That contains high concentration of colour, COD, suspended solids and others pollutants. Because it is a complex type, Textile wastewater requires most sophisticated and thus expensive treatment methods which are not affordable to Textile industries in developing worlds [5]. Physical, chemical and biological methods are used to treat Textile wastewater. Some of them are effective treatments but some are not that efficient. Some of the methods such as reverse osmosis, nano-filtration and ultra-filtration, are very expensive and many developing countries cannot afford the cost of installAation and operation. Therefore, a new type of treatment technology, which would be effective in pollutant removal and affordability, is inevitable for growing industry [5].

Microbial fuel cell (MFC) technology is the latest method for producing electricity from biomaterial by using microorganisms. MFCs convert the chemical energy stored in organic material to current energy by microorganisms which act as biocatalysts in anaerobic condition. Therefore MFC are also called as electrochemical converters. Microorganisms in the anode chamber oxidize the substrate added to the system such as Textile wastewater and produce electrons and protons. Free electrons are transferred to the anode electrode and through the external circuit they reach the surface of the electrode cathode. The produced protons pass through the proton exchange membranes or salt bridges and reach the cathode surface and in the presence of oxygen and electrons from water molecule. In this process along with the production of electric power, the wastewater in the anode chamber is used as a substrate for treatment. The function of microbial fuel cells is affected by several factors such as the amount of oxidation and electron transfer to the electrodes by microorganisms, loading rate, the nature of the used carbon source, the nature of the proton exchange membrane, proton transfer through the membrane to the cathode chamber, oxygen supply in the cathode, the nature and type of electrodes, circuit resistance, the electrolyte used, pH and sedentary time [5]. Industrial Textile wastewater is an important source of organic material for electricity production by using MFC. In this project, treatment of textile wastewater is done by using single chambered MFC technology and showing the electricity production directly from Textile wastewater.

1.1 Objective of the study

The main objective of this project is to remove pollutants from textile industrial wastewater by single chambered microbial fuel cell. The primary objectives by which that could be achieved were;

- To determine the percentage removal of COD & BOD
- To determine the electricity generated
- To determine the removal of solids

2. METHODOLOGY

2.1 Sample Collection

Textile industrial wastewater is collected from calicut district and kept it in a refrigerator at 4^0C before use. Collected the sample in an air tight container and take it to KMCTCEW environmental laboratory for further procedure. To obtain maximum accuracy the project procedure will carry at the same day of sample collection.

2.2 Treatment Using Microbial Fuel Cell (MFC)

Single chambered Microbial fuel cells is fabricated for the treatment of Textile wastewater.

2.2.1 Materials used for the construction of MFC

Various materials use for the construction of MFCs are follows:

- A Non-Reactive glass box of 15L capacity
- Agar agar bacto (for bacteriology)
- Carbon rods of 4mm Diameter & 47mm length extracted from battery cells.
- PVC pipe
- Sealant: M-seal, silicon
- Digital Multimeter
- Copper wire

2.2.2 Construction of MFC

Step 1: Selection of Anode Chamber

Non-reactive glass box is select as anode chamber.

Step 2: Preparation of Agar Salt Bridge

The Agar salt bridge is construct using common salt, agar and water. 650ml of water is boiled in a beaker, 65 grams of agar and 75 grams of salt are added to the boiling water, and the mixture is further boiled for 3-5minutes. Later on the mixture is filled in PVC pipe and allow to solidify and is kept in the refrigerator for 24hours.

Step 3: Electrode Assembling

From battery cells extract 27 numbers of carbon rods and are inserted in the flexible plastic pipe for the construction of Anode. The arrangement of Anode (electrode) is done on a flexible plastic pipe in such a way that it looks like a carbon brush. There is no cathode chamber in single chambered MFC. Instead, the carbon rods extracted from Battery cell is placed on one end of the agar salt bridge which is exposed to the air and the copper wire is wound on it, is act as cathode for MFC. The oxygen from air would help in accepting the electrons from anode chamber.

Step 4: Assembling Of Microbial Fuel Cell

The assembled electrodes is placed into the Anode chamber, a circular hole is made on the side of the working volume of the center of the glass box for fitting the PVC pipe containing agar salt, then the pipe is seal and made air tight. The reactor is checked for water leakage. Experimental set-up of Single Chamber Air Cathode MFC is shown in figure 1.

Fig-1. Experimental set-up of Single Chamber Air Cathode MFC

2.2.3 Operation of MFC

2 L volume of the reactor is fill with cow dung slurry. 7.5 L working volume is fill with Textile wastewater. In the beginning the Anode chamber of MFC is loaded with 30% dilution of 7.5L of textile waste water. And the removal of pollutants are noted and also the electricity generated is measure for 4 days. Similarly the same process will carry for other 4 sets of readings till the final loading of 0% dilution of 7.5L with an decrement of 10% of dilution for each loading.

3. RESULTS AND DISCUSSION

3.1 General

Textile industrial wastewater was collected from vadakara city and kept in a refrigerator at 4^0C before use. Wastewater is classified as nontoxic due to low hazardous chemicals and high amounts of biodegradable organics in comparison to other industrial wastewater. Some of the characteristics of both the wastewater are shown in Table 1. In order to evaluate the efficiency of wastewater treatment through the MFC system, the effluent from the anode chamber is examined with regard to COD, BOD_5, Total solids, Dissolved solids and pH according to the standard methods in the textbook of standard methods for water and wastewater examination. Similarly Current, Voltage and power is also measured.

3.2 Characteristics of Textile Wastewater

The characteristics of textile wastewater are presented in Table -1

Table -1 Characteristics of textile waste water

Sl No	Characteristics	Units	Textile Wastewater
1	Ph	-	7.9
2	Color	-	Dark greenish blue
3	Total Solids	mg/L	4900
4	Dissolved Solids	mg/L	3800
5	Suspended Solids	mg/L	1100
6	COD	mg/L	1350
7	BOD_5@20^0C	mg/L	890
8	Chlorides	mg/L	1420

3.3 Results of Textile Waste Water Treatment

The textile waste water is treated with single chambered microbial fuel cell to remove the pollutants and to generate electricity. The treatment is done by diluting 30%, 20%,10% & 0% of the 7.5L volume.

30% dilution

In this cycle load wastewater with 30% dilution of 7.5L volume. The results are shown in the table 2 below.

Table-2: Results of wastewater treatment in 30% dilution

Sl No	Characteristics	Units	Day 1	Day 2	Day 3	Day 4
1	COD	mg/L	790	680	400	320
2	BOD	mg/L	620	480	390	240
3	Ph	-	7.5	7.61	7.7	7.8
4	Voltage	V	0.59	0.75	0.98	1.2
5	Current	mA	1.1	1.96	2.2	2.5
6	Power	W/m²	0.649	1.47	2.156	3
7	Dissolved Solids	mg/L	2400	2100	1700	1200
8	Suspended Solids	mg/L	800	620	590	370
9	Total Solids	mg/L	3200	2720	2290	1570

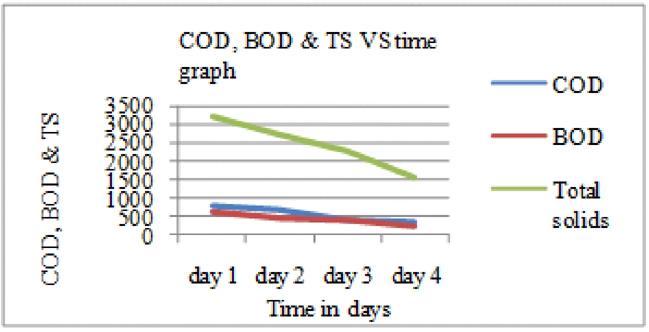

Chart-1: COD, BOD & TS removal of textile wastewater in 30% dilution

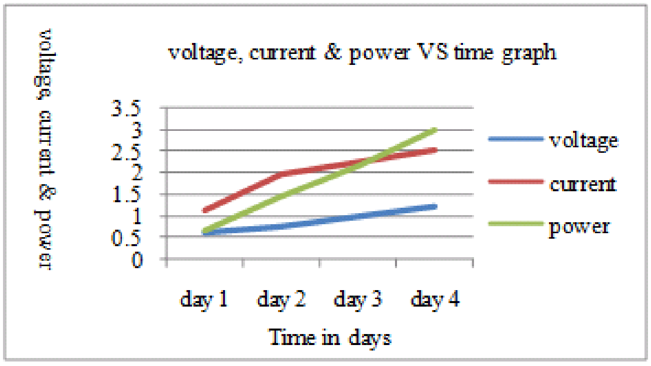

Chart-2: Voltage, current & power generation of textile wastewater in seventh cycle

Chart-1 shows the reduction of COD, BOD, & TS of textile waste water in 30% dilution. COD reduced from 790mg/L to 320mg/L. BOD reduced from 620mg/L to 240mg/L. TS reduced from 3200mg/L to 1570mg/L. Chart-2 shows the generation of voltage, current & power of textile waste water in 30% dilution. Maximum voltage, current & power of 1.2V, 2.5mA & 3W/m² are produced.

20% dilution

In this cycle load wastewater with 20% dilution of 7.5L volume. The results are shown in the table 3 below.

Table-3: Results of wastewater treatment in 20% dilution

Sl No	Characteristics	Units	Day 1	Day 2	Day 3	Day 4
1	COD	mg/L	980	750	510	310
2	BOD	mg/L	725	620	430	220
3	pH	-	7.6	7.7	7.75	7.8
4	Voltage	V	0.7	0.96	1.25	1.8
5	Current	mA	1.9	2.2	2.5	3
6	Power	W/m²	1.33	2.112	3.125	5.4
7	Dissolved Solids	mg/L	2800	2150	1700	1300
8	Suspended Solids	mg/L	900	750	570	395
9	Total Solids	mg/L	3700	2900	2270	1695

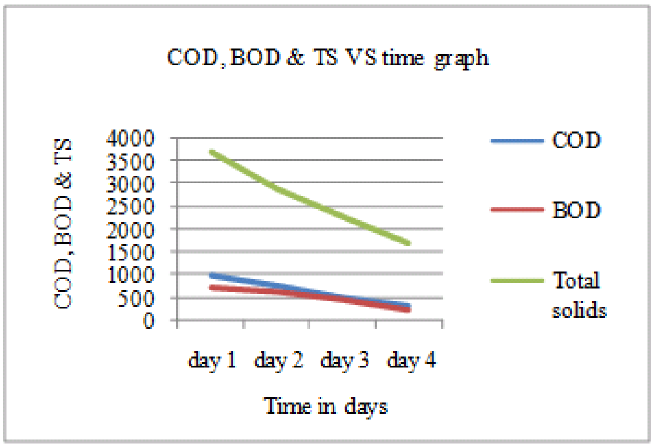

Chart-3: COD, BOD & TS removal of textile wastewater in 20% dilution

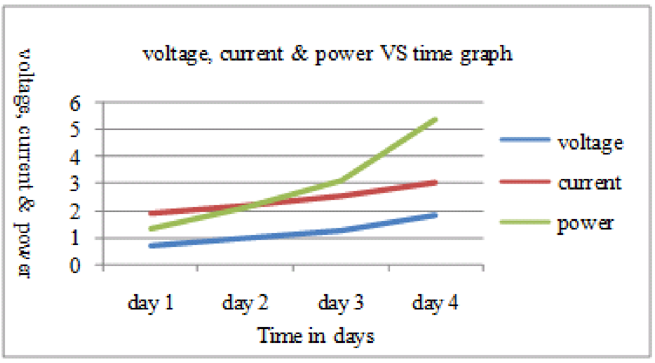

Chart-4: Voltage, current & power generation of textile wastewater in 20% dilution

Chart-3 shows the reduction of COD, BOD, & TS of textile waste water in 20% dilution. COD reduced from 980mg/L to 310mg/L. BOD reduced from 725mg/L to 220mg/L. TS reduced from 3700mg/L to 1695mg/L. Chart-4 shows the generation of voltage, current & power of textile waste water in 20% dilution. Maximum voltage, current & power of 1.8V, 3mA & 5.4W/m^2 are produced.

10% dilution

In this cycle load wastewater with 10% dilution of 7.5L volume. The results are shown in the table 4 below.

Table-4: Results of wastewater treatment in 10% dilution

Sl No	Characteristics	Units	Day 1	Day 2	Day 3	Day 4
1	COD	mg/L	1250	860	550	305
2	BOD	mg/L	850	620	390	230
3	Ph	-	7.68	7.7	7.75	7.89
4	Voltage	V	0.9	1.86	2.26	2.9
5	Current	mA	2.9	3.46	4.01	4.3
6	Power	W/m^2	2.61	6.53	9.06	12.47
7	Dissolved Solids	mg/L	3500	2800	1950	1350
8	Suspended Solids	mg/L	1000	810	520	375
9	Total Solids	mg/L	4500	3610	2470	1725

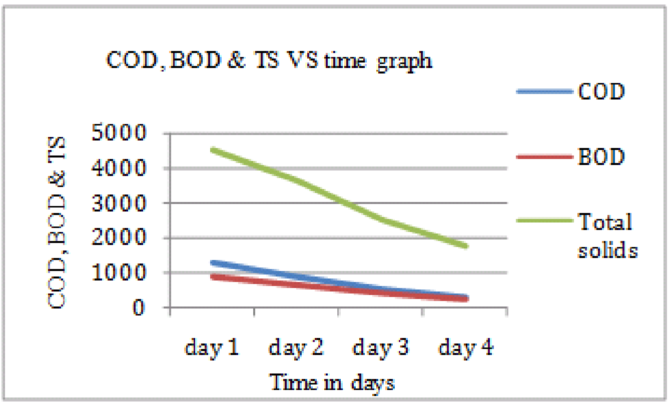

Chart-5: COD, BOD & TS removal of textile wastewater in 10% dilution

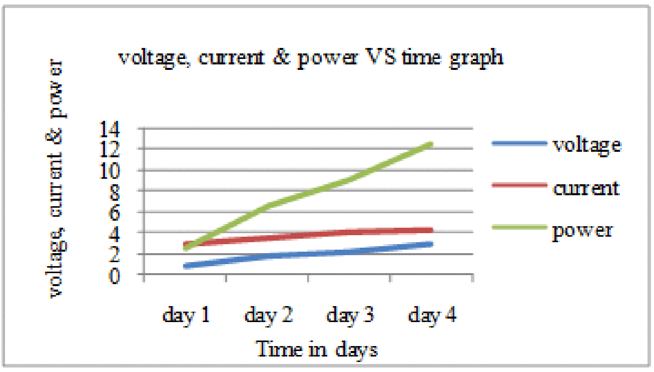

Chart-6: Voltage, current & power generation of textile wastewater in 10% dilution

Chart-5 shows the reduction of COD, BOD, & TS of textile waste water in 10% dilution. COD reduced from 1250mg/L to 305mg/L. BOD reduced from 850mg/L to 230mg/L. TS reduced from 4500mg/L to 1725mg/L. Chart-6 shows the generation of voltage, current & power of textile waste water in 10% dilution. Maximum voltage, current & power of 2.9V, 4.3mA & 12.47W/m^2 are produced.

0% dilution

In this cycle load wastewater with 0% dilution of 7.5L volume. The results are shown in the table 5 below.

Table-5: Results of wastewater treatment in 0% dilution

Sl No	Characteristics	Units	Day 1	Day 2	Day 3	Day 4
1	COD	mg/L	1350	990	530	310
2	BOD	mg/L	890	720	410	225
3	pH	-	7.8	7.81	7.86	7.9
4	Voltage	V	1.5	2.12	2.85	3.5
5	Current	mA	3.1	3.9	4.6	4.8
6	Power	W/m²	4.65	8.268	13.11	16.8
7	Dissolved Solids	mg/L	3800	3950	3250	1440
8	Suspended Solids	mg/L	1100	780	520	390
9	Total Solids	mg/L	4900	4730	3770	1830

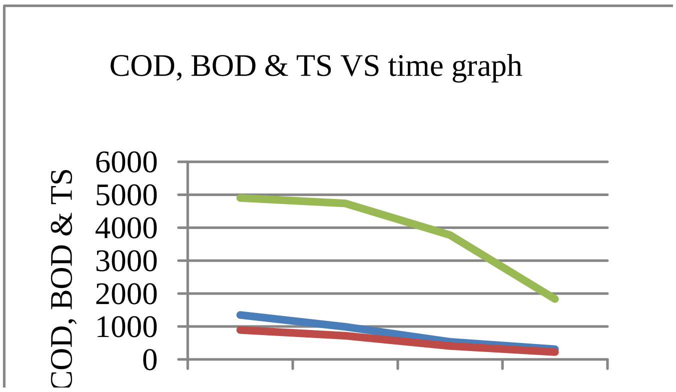

Chart-7: COD, BOD & TS removal of textile wastewater in 0% dilution

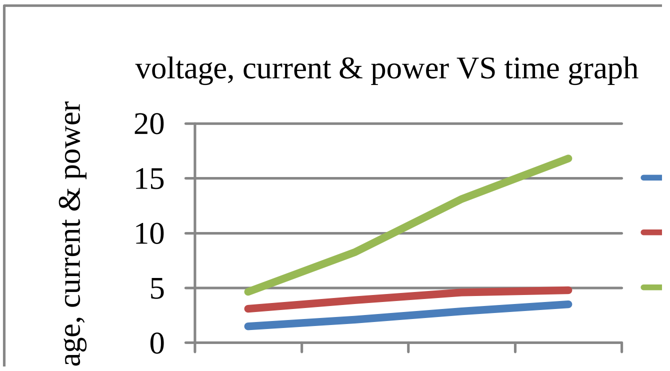

Chart-8: Voltage, current & power generation of textile wastewater in 0% dilution

Chart-7 shows the reduction of COD, BOD, & TS of textile waste water in 0% dilution. COD reduced from 1350mg/L to 310mg/L. BOD reduced from 890mg/L to 225mg/L. TS reduced from 4900mg/L to 1830mg/L. Chart-8 shows the generation of voltage, current & power of textile waste water in 0% dilution. Maximum voltage, current & power of 3.5V, 4.8mA & 16.8W/m² are produced.

3. CONCLUSION

Single chambered microbial fuel cell has been tested using textile effluent and the output of three different concentration was compared. The current work has proved successful in implementing the textile effluent as a fuel source for the MFC and further has proven that the MFC help in the reduction of COD level of the effluent. Though the power produced was low there is scope for further improvement by using an electron mediator in the anode chamber and the use of catalyst in the cathode chamber for the easy oxygen facilitation to the protons. The study demonstrated the removal efficiency of Textile wastewater of different feed concentrations from 790 mg COD/L to 1350 mg COD/L is increased.

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