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Utilization of different types of wastewater for production of electricity using non mediated microbial fuel cell

Abstract

Three wastewater samples, agro wastewater, diary wastewater, distillery wastewater from nearby Qasimabad Hyderabad, were utilized as substrate in microbial fuel cell (MFC) to generate electricity. Along with electricity generation the MFCs can successfully helps in treating same samples. The parameters like pH, TS, TSS, TDS, BOD and COD were analyzed for all four samples. The COD removal efficiency of the MFC was analyzed using standard reflux method. MFC was efficient in COD removal, 55%, 70% and 99% COD removal was observed after 5, 10 and 20days respectively of operation of MFC with municipal waste as a substrate. 50%, 75% and 99% COD removal was observed after 5, 10 and 20days respectively of operation of MFC with dairy waste as a substrate, 40%, 60% and 99% COD removal was observed after 5, 10 and 20days respectively of operation of MFC with agro waste as a substrate, 35%, 54% and 70% COD removal was observed after 5, 10 and 20days respectively of operation of MFC with distillery waste as a substrate.

Keywords: microbial fuel cell, wastewater, COD removal, nanowires, catholyte, adenosine tri-phosphate, pseudomonas aeruginosa, anode, cathode

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Abbreviations: ATP, adenosine tri-phosphate; NAD, nicotinamide adenine dinucleotide; BOD, biochemical oxygen demand; COD, chemical oxygen demand; MFC, microbial fuel cell; TSS, toxic shock syndrome

Introduction

Microbial fuel cells (MFCs) are electrochemical conversion devices (Figure 1), excepting that the voltage generated is derived from microbial metabolism.[1,2] MFCs combine the electricity generation with the wastewater treatment through the metabolic oxidation of organic and inorganic substances by microbial species living within a bio film.[3,4] MFC basically having two types mediator and mediator less MFC.[5] In mediated MFCs, microbes are suspended in the solution together with the nutrient and because of some sort of electron carries that is added to the liquid in the anode chamber, the electrons can be transported from the microbes through the liquid to the electrode.[6] Almost any type of microbes can be used in this type of MFC, but a lot of electrons and energy is however lost in the process, which limits the total efficiency of the MFC drastically.[7] The major parts of the MFCs are electrochemically latent. The electron exchange from MFCs towards the cathodic chamber is encouraged by mediators. Majority of the mediators are very costly and toxic.[8] Mediators less MFCs are devices that do not require any type of additional electron carrier (mediator) in the solution in order to transport electrons from the microbes to the electrode.[9] This process gives better control over the MFC and allows for a higher efficiency potential. However, they do require very special type of microbes.[10] There is an extraordinary capability of MFCs as an alternative energy sources, novel wastewater treatment process and biosensor for O2 and pollutants, extensive optimization is required to adventure the greatest microbial potential.[11] Bacterial can be in the MFC to catalyze the conversion of organic matter, present in the wastewater into voltage.[1] Although more research is being conducted, this process remains at the laboratory level.[2] How to develop at large scale applications to wastewater treatment plant and high COD industrial effluents is still big problem.[11] The aim of this research is to take the inwards assents of different types of wastewater, using dual chamber MFC for voltage generation (Figure 1).

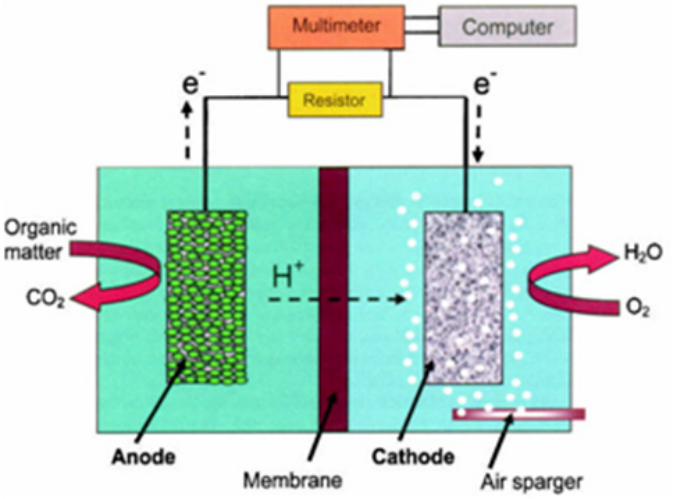

Figure 1 Basic components of MFC.

Materials and methods

Collection of waste samples

Three industrial waste samples namely Dairy waste, Distillery waste, Agro waste from Qasimabad Hyderabad and kept into the refrigerator for further research purpose.

Formulation of setup

Two poly vinyl chloride containers having capacity of 500ml each were purchased from local market. The shape of containers was rectangle and thread top so it can air tied well. Containers are round holed just 5cm above their bottom to introduce a salt bridge (hollow glass rod) in it. In the center of the glass rod, an opening is provided to pore solution in the salt bridge.

Salt bridge preparation

In order to make a salt bridge solution, 5gm of agar power was mixed in 100ml of distilled water. The solution continues heated and agitated till it not gets properly mixed. After some time as the temperature of Agar solution was decreased to nearly about 50°C, 2.5ml of ammonia was added. The slurry is poured in salt bridge and after a certain time, this thick solution is converted into a semisolid layer. This helps to proton for the movement form the anodic chamber towards the cathodic chamber.

Anode & cathode chambers

Anode compartment consists of organic waste, which is prepared of sewage waste (500ml). Dilute Acetic acid was used as an electrolyte in cathode compartment. Thin Copper electrodes having dimensions ($1.5\times7cm^2$) were typically placed in both the compartments. Anaerobic decompose is done with the help of Saccharomyces cerevisiae culture in organic slurry on the anode side. To enhance the kinetic growth, a constant 37°C temperature was maintained with the help of incubator. To maintain anaerobic condition, every joint was fixed with m-seal. Continuous voltage and current values were taken with the help of multi-meter and same study was continued for 15days.

Data capture and calculations of efficiency

Output of the MFC operation was recorded in V and mv and current and power was recorded in mA and mW respectively against time (hours) by using a multimeter (mastch model no m 3900 with ± 2% error). The efficiency of the MFC was calculated by 2nd law of thermodynamics. Efficiency can be assessed by relating the hypothetical electromotive force (EMF) to the recorded MFC potential in light of the assumption that the simple reactions evaluated at the anode and cathode are similar to that of the more complicated reactions included with biodegradation of wastewater.

Construction and operation of MFCs

Four double chambered MFCs were constructed with salt bridge as mean for proton transfer and operated using four different wastewaters as substrates to generate electricity.

Physical analysis of waste samples

All the waste samples collected were analyzed physically with the parameters, pH, TS, TSS, TDS, BOD and COD (Table 1).

Table 1 Characterization of waste before and after incubation of 10days in MFC

Sr. no	Waste water samples	pH		TSS mg/l		TDS mg/l		TS mg/l		BOD mg/l
		Before	After	Before	After	Before	After	Before	After	
1.	Agro waste	8.5	8	6100	800	80000	120000	86100	120800	200
2.	Dairy waste	8.5	7.1	7600	3500	86000	112000	93600	115500	270
3.	Distillery waste	4.8	6.5	24400	11700	606000	718000	630400	729700	420
4.	Municipal waste	7.5	7.3	13000	9900	1400	324000	153000	333900	140

COD removal of waste samples during the electricity generation experiment by MFCs

Four waste samples mentioned above were fed batch wise for electricity generation in four separate MFCs constructed during research work. Power generation measured in terms of voltage after every 24h. All the samples were analyzed for COD removal efficiency by standard reflux method.COD measurement were carried out after 5^{th}, 10^{th} and 20^{th}day. COD removal efficiency can be calculated using formula

$$E_{COD}=[COD_{in}-COD_{out}/COD_{in}]X100\%$$

Result and discussion

Physical analysis of sewage is carried analyzing various parameters pH, TS, TSS, TDS, BOD and COD (Table 1). Minor change in pH of waste was observed during operation of MFCs with waste. There is slight reduction in pH of Agro, Dairy and Municipal waste water while there is increase in pH of Distillery waste. About TSS there is great reduction in TSS after treatment the appearance and color also changed during treatment .TDS values are observed to be increased it may be due to increase in number of microorganism during treatment BOD values are monitored by conventional method by samples after 5days of incubation in MFCs proving the fact that MFCs can be good BOD sensor. The COD removal efficiency of the MFCs was analyzed using standard reflux method (Table 2). All the MFCs were efficient in COD removal. 55%, 70%, 99% COD removal was observed after 5, 10, 20days respectively of operation of MFCs with municipal waste as substrate.

50%, 75% 99% COD removal was observed after 5, 10, 20days respectively of operation of MFCs with Dairy waste as substrate, 40%, 60%, 99% COD removal was observed after 5, 10, 20days respectively of operation of MFCs with Agro waste as substrate, 35% 54%, 70% COD removal was observed after 5, 10, 20days respectively of operation of MFCs with Distillery waste as substrate (Table 2). During current research goal of recirculation of waste to minimize pollution hazards can be achieved along with power generation by novel microorganism in MFCs. Figures 1 & 2 show the MFCs set up constructed during current research successful COD removal (Table 2) of all the four waste samples were observed while operating MFCs for electricity generation. Maximum 75% COD removal and maximum electricity generation of 700mv (Table 2) were observed during operation of MFCs as compare to other waste recirculation. Local area waste samples were applied for isolating electrogenic bacteria and the most occurring strains are traced out for COD removal as well as electricity generation efficiencies of isolates (Mathuriya & Sharma 2009). During the operation of double chambered MFCs the current research successful in generation of electricity as well as COD removal similar type goal can be achieved by various researchers

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using single chambered MFCs Domestic wastewater treatment using single chambered MFCs were carrying out by Liu et al. the results are 50% to 70% COD removal efficiency. Current research successfully progressing toward goal of achieving good electricity generation using mediator less MFCs which confirms the fact that the bacteria did not require soluble mediators,[11] but can donate electrons directly by adhesion to the electrode surface perform the work operating the MFCs with a proton exchange membrane and the results are 55% COD removal while 75% COD removal operating the MFCs without a proton exchange membrane (Figure 3-8).

Table 2 COD removal ability of MFC for different waste

Wastewater samples	COD (%) removal efficiency after			Maximum power generation after
	5Days	10Days	20Days	10Days
Agro waste	40%	60%	99%	599mv
Dairy waste	55%	75%	99%	900mv
Distillery waste	35%	54%	70%	656mv
Municipal waste	55%	70%	99%	678mv

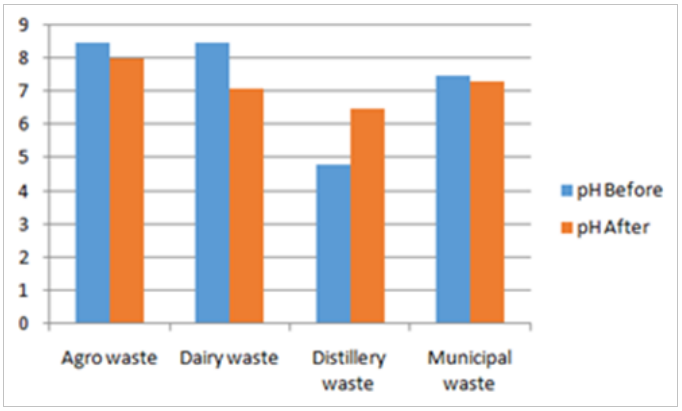

Figure 2 pH of the wastewaters.

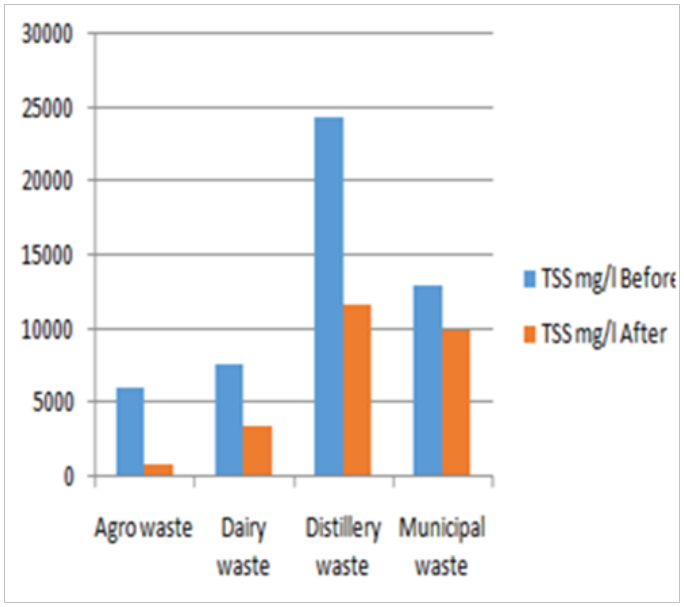

Figure 3 Total suspended solids of wastewaters.

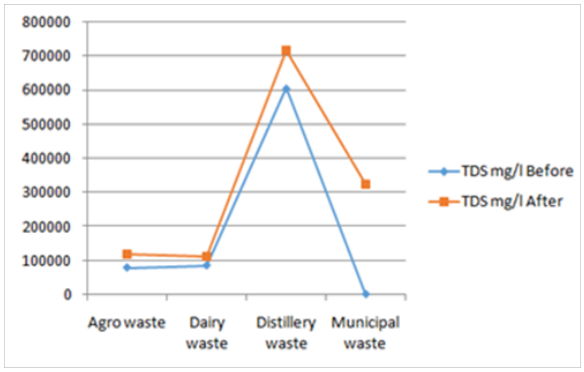

Figure 4 Total dissolved solids of wastewaters.

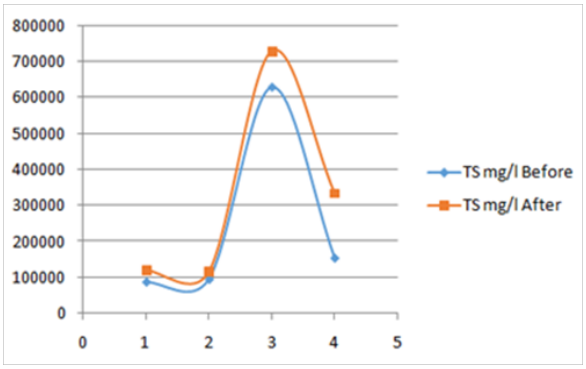

Figure 5 TS of wastewaters.

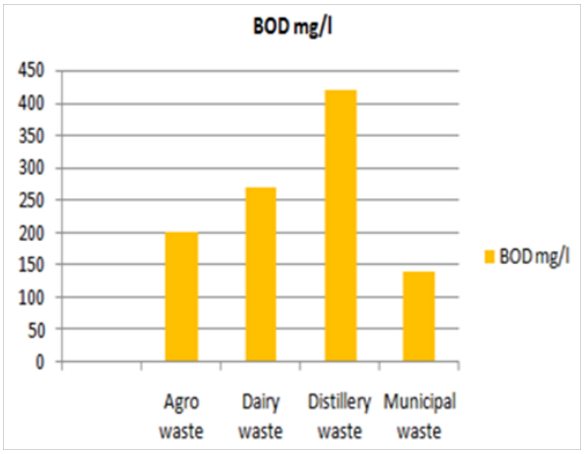

Figure 6 BOD of wastewaters.

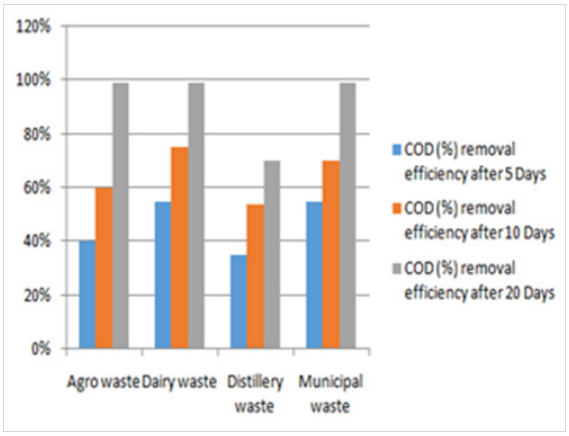

Figure 7 COD removal of wastewaters.

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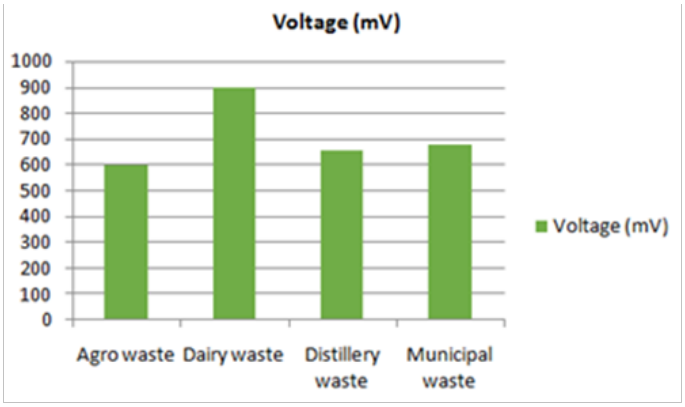

Figure 8 Maximum voltage generated from wastewaters.

Conclusion

During the current research three industrial wastes and a municipal waste water sample from Qasimabad Hyderabad were analyzed for electricity generation and COD removal efficiency successfully. 75% maximum COD removal was achieved after 10days by utilizing Dairy waste as substrate for MFCs constructed during current research. So it is concluded that the electrogens isolated from MFCs reactors are successful mean for waste water treatment along with generation of electricity. The parameters like pH, TS, TSS, TDS, BOD and COD were analyzed for all four samples. The COD removal efficiency of the MFC was analyzed using standard reflux method. MFC was efficient in COD removal, 55%, 70% and 99% COD removal was observed after 5, 10 and 20days respectively of operation of MFC with municipal waste as a substrate. 50%, 75% and 99% COD removal was observed after 5, 10 and 20days respectively of operation of MFC with dairy waste as a substrate, 40%, 60% and 99% COD removal was observed after 5, 10 and 20days respectively of operation of MFC with agro waste as a substrate, 35%, 54% and 70% COD removal was observed after 5, 10 & 20days respectively of operation of MFC with distillery waste as a substrate.

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None.

Conflict of interest

The author declares no conflict of interest.

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