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العدد 23

مجلة التربوي

مجلة علمية محكمة تصدر عن كلية التربية

جامعة المرقب

العدد الثالث والعشرون
يوليو 2023م

- المجلة ترحب بما يرد عليها من أبحاث وعلى استعداد لنشرها بعد التحكيم .
- المجلة تحترم كل الاحترام آراء المحكمين وتعمل بمقتضاها .
- كافة الآراء والأفكار المنشورة تعبر عن آراء أصحابها ولا تتحمل المجلة تبعاتها .
- يتحمل الباحث مسؤولية الأمانة العلمية وهو المسؤول عما ينشر له .
- البحوث المقدمة للنشر لا ترد لأصحابها نشرت أو لم تنشر .

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ضوابط النشر:

يشترط في البحوث العلمية المقدمة للنشر أن يراعى فيها ما يأتي :

- أصول البحث العلمي وقواعده .
- ألا تكون المادة العلمية قد سبق نشرها أو كانت جزءا من رسالة علمية .
- يرفق بالبحث تزكية لغوية وفق أنموذج معد .
- تعدل البحوث المقبولة وتصحح وفق ما يراه المحكمون .
- التزام الباحث بالضوابط التي وضعتها المجلة من عدد الصفحات ، ونوع الخط ورقمه ، والفترات الزمنية الممنوحة للتعديل ، وما يستجد من ضوابط تضعها المجلة مستقبلا .

تنبيهات :

- للمجلة الحق في تعديل البحث أو طلب تعديله أو رفضه .
- يخضع البحث في النشر لأولويات المجلة وسياستها .
- البحوث المنشورة تعبر عن وجهة نظر أصحابها ، ولا تعبر عن وجهة نظر المجلة .

Information for authors

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Performance analysis of different anode materials of double chamber Microbial Fuel Cell technology using different types of wastewater

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Abstract : Wastewater sources are increasing significantly worldwide due to growing population and industrial activity. It is one of the world's most serious environmental and public health issues. Current wastewater treatment technologies are not sustainable to meet the ever growing water sanitation needs due to because they are energy- and cost-intensive . Microbial Fuel Cells (MFCs) technology may present a sustainable and an environmentally friendly .They are an developing technology that uses bacteria to break down organic content and simultaneously generate bioelectricity, thus achieving sustainability.

Anode performances as the governing support for the growth of biofilm to transfer the electrons. In general, anode materials must have a reasonable surface area for bacterial growth, good conduction, excellent biocompatibility, chemical stability, high mechanical strength, and low cost.

In this work ,zinc , and Aluminum foil were tested as an anode .The comparative performances them were analyzed in a double chambered MFC with graphite bar as cathode and salt bridge((KCl and NaCl) separating the two chambers with respect to waste removal efficiency of MFCs. Two wastewater samples, sewage wastewater (*Sebiadja beach discharge line*) and industrial wastewater from *The Libyan Fisheries Company (shrimp washing water*) in Alkhoms City were used as substrate in Microbial Fuel Cells (MFCs) In this work, zinc and Aluminum foil were tested as an anode. The comparative performances of them were examined in a double chambered MFCS containing industrial and sewage discharge wastewater with respect to waste removal efficiency of MFCs. The parameters like Total Dissolved Solids(TDS), Biological oxygen demand (BOD)and Chemical oxygen demand (COD) were examined for all the four sample. The 10 days of MFCS operation resulted in a maximum removal efficiency of BOD 82.73% (aluminum foil as anode with industrial wastewater) and 72.3127% (zinc material as anode and with industrial wastewater). In addition, Zinc material anode provided better removal efficiency of COD with industrial wastewater and TDS with sewage wastewater that up to 25.4789% and 22.222% respectively.

The results showed that dairy industry wastewater and sewage wastewater treatment by a double chamber microbial fuel cell (MFC) are a good alternative for treating wastewater

Keywords: MFC , Anode, COD,TDS,BOD, sewage wastewater, industrial wastewater, bacteria.

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Introduction

The demand for water purification has been increased with modern life due to the increase of the pollution of water sources with an increase in world population and industrial revolution .The pollution is the source of release of numerous organic and inorganic elements into the environment [1-2].

Untreated industrial and domestic wastewater are harmful to population at site of disposal whether it is human, animal, plant or microbial population every one suffers pollution hazards. It is necessary to wastewater treatment before disposal as it is hazardous to environment [3].

Among various wastewater treatment techniques, such as chemical treatment, aerobic treatment, anaerobic digestion, and membrane filtration, MFC is considered as a promising technology with the dual purpose of pollutant removal and energy recovery [3].

MFCs is a bio-electrochemical device that converts chemical energy contained in organic substrates into electrical energy by the activities of microbes. The use of organic material such as wastewater in MFC makes it an eco-friendly device that offers a dual benefit of bioelectricity generation and waste management [5]

Architecturally MFC consists of anode and cathode separated by a cation specific membrane. Microbes in the In MFCs, the bacteria as fuel is oxidize on the anode which must be grown in an anaerobic environment in order to produce a higher power output. The anode electrode plays an important role in the performance and cost of MFCs The selection of the right anode materials is essential to optimize the performance of MFCs. anode oxidize fuel here bacteria gain energy for metabolism by transferring electrons from an electron donor, such as glucose or acetate to an electron acceptor such as oxygen and the resulting electrons and protons are transferred to cathode through the circuit and the membrane respectively. Electrons and protons are consumed in the cathode, reducing oxidant usually oxygen. Since the microbial cells are electrochemically inactive due to nonconductive cell surfaces structure, mediators are employed to facilitate electron transfer from the microbial cells to the anode in MFCs [4-5].

Conventional MFC double chamber is showed in fig (1)

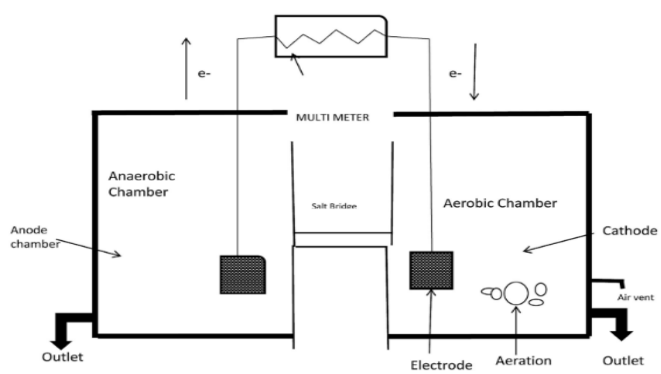

Figure 1 schematic diagrams of MFC double chamber(8)

Considering a simple MFC (see Fig. 1) using glucose as a substrate in the anode and oxygen as the terminal electron in the cathode, reactions (1) to (3) are presented [(5)]

Anodic reaction : $CH_3COOH + H_2O \rightarrow 2CO_2 + 8H^+ + 8e^-$ (1)

Cathodic reaction : $8H^+ + 8e^- + 2O_2 \rightarrow 4H_2O$ (2)

Overall reaction : $CH_3COOH + 2O_2 \rightarrow 2H_2O + 2CO_2$ (3)

In this present study, double chamber MFC was designed. Two chambers were selected in order to avoid mixing solutions of electron acceptors and electron donors and thus loss of electrons. In all experiments anaerobic conditions were employed over the duration of time period about 10 days, for making salt bridge PVC pipe was employed to take a solution of agar salts and other common salts such are KCl, NaCL.

The present work aims at investigating the capability of MFC wastewater treatment of two different wastewater types and to study by construct a working two-chamber microbial fuel cell .

In this study, discharge and industrial wastewater was used as a substrate for waste water purification in a MFC. Furthermore, comparative performance of anode materials zinc and Aluminum foil electrode on pollutant reduced.

The exploration of various materials used in electrodes that balances efficiency and cost-effectiveness is the key to the potential large scale use of MFC particularly in wastewater treatment plants which is hoped to be a power generating plant as opposed to a power consuming plant.

Methodology

In aerobic ambiance of cathode chamber, the oxidizing agent O2 produces water by combining with hydrogen ions migrated through salt bridge. The oxidizing agent was reduced by receiving the electrons. The bio-electrochemical process was harnessed by the aerobic environment of cathode. The environment maintained the concentration of dissolved oxygen to trigger the redox reaction. In the anaerobic ambiance of anode chamber the metabolic activity of the microorganisms produces electron and proton which had advantages over the aerobic media. Alternatively, aeration produces carbon di-oxide and water in anode chamber instead of electrons, protons, and carbon dioxide. Besides, the aeration would decrease the thickness of biofilms around anode. [11]

Anode to be anaerobic to get feasible results. Glucose was used as nutrients in anode chamber for the stable growth of microbes [7] . Eventually, the pH and temperature of the electrolytes were maintained properly.

To evaluate the cell performance, the following parameters were calculated,

1. Chemical Oxygen Demand (COD):
   It is the amount of oxygen required to oxidise the polluting chemicals to CO2 and H20. Normally, the discharge effluent should contain a maximum COD of 90 ppm [3].
2. Biological Oxygen Demand (BOD):
   It is the amount of oxygen required by the biological microbial mass during the effluent treatment to oxidise the biologically oxidizable pollutants and for their

own sustenance. It is measured by the oxygen consumption of a pre-inoculated sample at 20-250C in darkness over an incubation period of five days [3].

3. Total Dissolved Solids (TDS):
Many inorganic salts, which are soluble in water, are difficult to remove since they are totally dissolved and show high solubility in water [3].

The percentage degradation of each pollutant was therefore calculated usin was calculated using the expression:

$$\% \text{ Degradation} = \frac{C\ initial(mg/l}{C\ initial\ (mg/l - C\ final\ (mg/l} * 100\%$$

Where $C_{initial}$ and C_{final} are the concentration at a given time.

Materials and Methods

1. Collection of Waste Samples

The sewage wastewater (Sebiadja beach discharge line) and industrial wastewater from The Libyan Fisheries Company (shrimp washing water sample from area of Alkhoms city were collected and kept into the refrigerator for further research purpose. Glucose $C_6H_{12}O_6$: used as substrate for microorganisms in anode chamber.

2. Electrods:

In this experiment, zinc metal was and aluminum foil was used as anode electrode with dimensions of (3.5cm * 3.4cm) . The graphit bar was used as cathode with dimension of (D=3mm, L=3cm). Copper metal was used as cathode electrode with the dimensions of 5 cm in length and 5 cm in width. The copper wire connected to piece of zinc and copper plate. In the anode chamber, the copper wire was passed. Figure 2 show the electrodes.

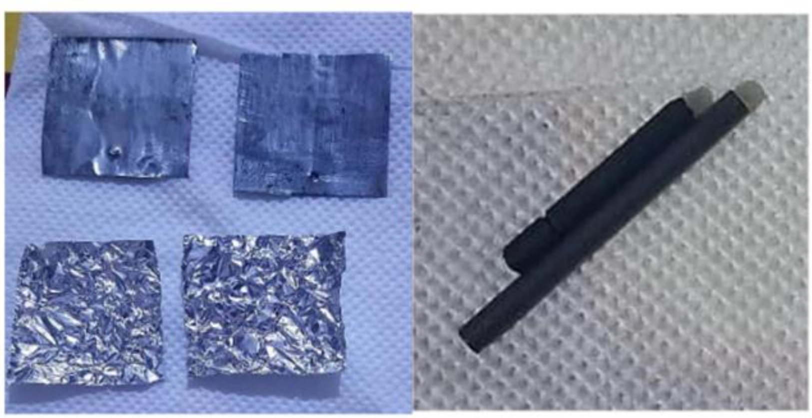

Figure 2 Different types of electrods employed in MFCs ,Graphite bar (cathode), Aluminum foil and zinc as anode.

3. **Electrical circuit** Following materials were used for this circuit: Two copper wires where used to connect electrodes of the MFCs , two alligator clips ,

resistance with value is 220.5mΩ, and a digital multimeter. The black wire was for the anode and red wire for the cathode.

4. **Salt bridge** For the Preparation of salt bridg following materials were used: agar 10g (at concentration of 1000g/L), NaCl salt 10g and distilled water 100ml. in a beaker, 100ml of distilled water was heated until it reached 100^{o}C. Then the agar salt mixed to the boiling H_2O. Sodium chloride salt mix with the mixture. At that time mixture put into the PVC pipe, while it was hot and before it started to thicken. One end of PVC pipe was fixed and mixture was permitted a short time later to cool and solidify. Subsequently, the PVC pipe was connected to sides of the bottles and sealed with epoxy [9].

   The cathode chamber the aerobic chamber (cathode) of MFC was filled with distilled water and graphite bar as a cathode (Two different anode materials were investigated for their performance, e.g. zinc and aluminum foil electrode inserted into the anaerobic anode chamber that filled with the wastewater sample

(MFC) set- up

Four a dual-chambered MFCs were constructed by connecting two plastic bottles (total volume of 500 mL) with a polyvinyl chloride (PVC) pipe of 5 cm length and a diameter of 2 cm. Anode and cathode connected by salt bridge and each electrode connected to multimeter device via wires

Figure 3 Double chambered waste water microbial fuel cells MFCs

Results and Discussion

Wastewater samples were collected for biotreatment by using MFC technology . The experiments conducted using MCF were performed at room temperature (25 C°). Physical analysis of sewage and industrial wastewater samples(before and after evolution) are carried analyzing various parameters pH, TDS, BOD and COD in (Table 1).

- The effect of electrode type with different wastewater samples on the performance of microbial fuel cell:

  Cell 1 (sewage wastewater with Al-Foil electrode).
  Cell 2 (sewage wastewater with Zinc electrode).
  Cell 3 (industrial wastewater with Al-Foil electrode).
  Cell 4 (industrial wastewater with Zinc electrode).

The results for the pH value for each of the samples after the MFC process is shown in Table(1). There is high reduction in pH for both wastewater samples . TDS values are observed to be decreased BOD values are monitored by samples after 10 days of incubation in MFCs proving the fact that MFCs can be good BOD sensor [8]. The COD removal efficiency of the MFCs was analyzed (Table 2)

Table 1 **:** Characterization of wastewater samples before and after evalution of 10 days in 4 MFCs

S.N.	parameter	sewage	industrial	Cell(1)	Cell(2)	Cell(3)	Cell(4)
1	pH	8.15	6.76	4.62	4.54	4.25	3.67
2	COD mg/l	522	492	416	389	438	373
3	BOD mg/l	700	307	492	383	53	85
4	TDS mg/l	2700	1567	2155	2100	1462	1417
5	E.cond	3.58	2.52	3.42	3.49	3.35	2.28
6	Ca mg/l	Over range	52.0	168	66	47	53
7	K mg/l	20.7	20.5	3.3	21	20.8	21.8
8	Na mg/l	180.9	95.5	145.5	186.5	90.3	95.8
9	S mg/l	0.65	0	0.65	0.60	0.40	0.45
10	N mg/l	0.466	0.55	0.445	0.933	0.850	0.880
11	No3 mg/l	2.064	2.435	1.971	4.11	3.77	3.905
12	NH3 mg/l	0.34	0.1	0.17	0.94	0.16	0
13	NH4 mg/l	0.36	0.12	0.18	1.01	0.17	0

Table 2 BOD, TDS and COD removal ability of MFCs For different wastes and anodes

Cells	Removal of BOD (%)	Removal of TDS (%)	Removal of COD (%)
1	29.71429	20.18519	20.3065
2	45.28571	22.22222	25.4789
3	82.73616	6.700702	10.9761
4	72.3127	9.572431	24.18699

The effect of different anode electrode materials (zinc and Aluminum foil) on BOD ,COD and TDS removal efficiency indications on figure 4,5 . Zinc and Al-Foil electrodes can provide better conductivity and surface area so that the chemical oxygen demand (COD) and (TDS) can be removed more efficiently. Therefore, it can provide more suitable positions specifically for the adsorption of contaminants through microbial metabolism. The growth of microbes and electron transport system require considerable surface areas to make the flow continuous [11]

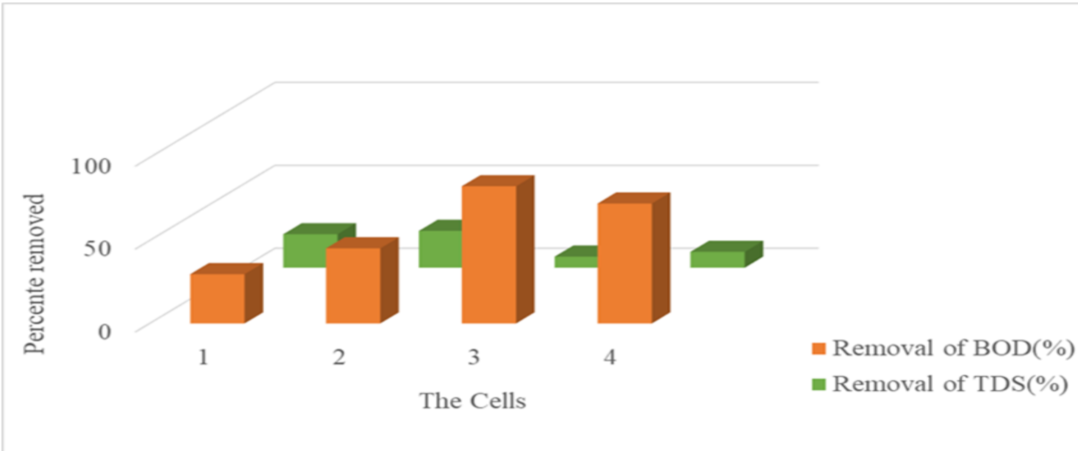

Figure 4 BOD and TDS removal ability of MFCs

Figure 4 shows BOD and TDS removal percent .Aluminum foil anode with industrial wastewater gave a higher BOD reduction than others . The changes in chemical parameters revealed an initial BOD of 307 mg/L. This was reduced by 82.73616% to 53 mg/L in cell3 after day 10. The initial high BOD value was probably due to the greater oxygen consumption in breaking down the organics in the wastewater

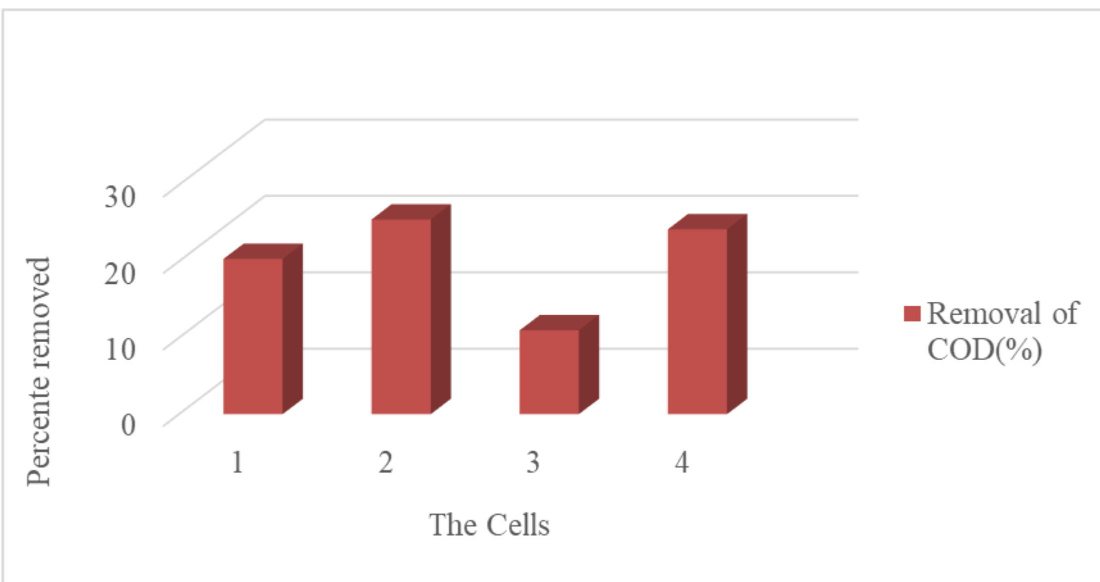

Figure 5 COD removal ability of MFCs

The initial COD value recorded before the MFC process for the sewage was 522 mg/L and for industrial was 492 mg/L. from figure 5 and based on the COD removal after the MFC process, the highest carbon removal efficiency was demonstrated by sewage with zinc as anode, which had a value of 25.4789%, followed by the industrial sample, which

shows a carbon removal efficiency of 24.18699 %. However, the COD value for both samples recorded 10.9761 % and 20.3065 % removal with Aluminum foil .
The changes in the amount of BOD removed and COD removed would give the data about the concentration and biodegradability of organic matter fed into the MFC. BOD and COD removal were the function of detention time of waste water in the chambers

Conclusion

In this study, sewage and industrial wastewater were as substrate, they contain organic matter available for microbe's energy recovery. The performance of the laboratory scale double chambered Microbial Fuel Cells (MFCs) were perpetually enhanced by comparative study and research on construction materials of electrodes (Graphite rod as cathode and zinc, aluminum foil as anode) and salt bridge as a membrane which is more economic than proton exchange membrane, as it is cost effective and easily available.
This work evidently presented the interactive effect and mechanism of microbial presence in removing pollutant from wastewater and confirmed the active metabolism (anaerobic) of microbes during cell operations. Consequently, the aluminum foil anode and zinc anode with industrial wastewater contributed to the cell performance efficiently which resulted in a maximum values , 82.73% and 72.3127% removal of COD respectively . In addition, Zinc material anode provided better removal efficiency of COD with industrial wastewater and TDS with sewage wastewater that up to 25.4789% and 22.222% respectively.
The results showed that dairy industry wastewater and sewage wastewater treatment by a double chamber microbial fuel cell (MFC) are a good alternative for treating wastewater.

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