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Bio-Generation of Electrical Energy from Wastewater Using Microbial Fuel Cell.

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ABSTRACT

The main aim of this research was to evaluate the ability of microorganisms to produce the electrical power and biological treatment of municipal wastewater in MFCs. The current intensity was measured using digital Avometer. COD (chemical oxygen demand), TSS (total suspended solids) and coilform group were determined according to standard methods. The obtained experimental results showed that municipal wastewater treated in MFCs had a maximum produced current were 17.1mA/m³. Regarding, the results COD, TSS, total and fecal coilform removal from treated effluent for 21 days of operation were 320 mg/L, 103 mg/L, 2.9x10² and 1.5x10² MPN-Index/100ml. Results concluded MFCs is promising technology for electricity production from wastewater and it can be biologically treatment of this waste. In addition to that, more investigation of this point must be study in the future.

Keywords: Bioelectricity, wastewater, microbial fuel cell, COD, bacteria.

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INTRODUCTION

Overall the world, the demand to energy is rapidly increasing. Furthermore, there are many countries depends on fuel as energy source but this source are not friendly to the environment due to a huge amount of CO₂ producing [1-2]. In case of manufacturing and population increasing, a large volume of wastewater can be rapidly produced which need a highly cost and energy [3-4].

Globally, the needing to new energy sources to replacement the scorbutic energies are encourage, this, may be due to shortage of energy and climate change [5-6]. In addition to this, the great attentions to generate energy from wastewater and decline the cost operation are highly interesting [7-8]. Because of these, several scientists work to produce bio-energy from wastewater rich in organic matter by microbes like production of ethanol, methane, hydrogen and electricity, but the production of ethanol, methane and hydrogen have some limitation which are low energy production and expensive. Thus, bio-electricity generation by using microbial fuel cells (MFCs) has several advantages that considered environmental friendly, clean, effective, recyclability and not producing toxic by-products [9-10].

The organic substances that containing chemical energy can be converted using power produced bacteria in well technology (MFCs device) to clean electrical energy. [11–12]. The converted electrons are received to both positively charged electrode via bacteria and negative electrode using copper connection. Then, the difference of redox reaction is occurred due to the diffusion of electrons between buffer and non-homogeneous solutions. While, the negative chamber are received the protons and water is produced when protons react with oxygen and electrons [13–14]. Therefore, the main aim of this research was to evaluate the ability of microorganisms to produce the electrical power and biological treatment of municipal wastewater in MFCs.

MATERIALS AND METHODS

Wastewater sample

Municipal wastewater sample were collected from Zennin wastewater treatment plant located in Giza, Egypt. Physical, chemical and bacteriological characteristics were determined according to APHA [15].

MFC Construction and operation

The MFC technology used in this study was designed as two chambers according to Mansoorian *et al* [16]. Then, the potential current measurements were recorded using a Digital Multimeter (Avometer). COD measurements for treated effluent were conducted using standard methods according to APHA [15]. The experiment was done at ambient temperature.

Enumeration of coliform group

Total coliform (TC) and fecal coliform (FC) in treated effluent were counted using multiple tube fermentation technique according to APHA [15].

Statistical analysis

The statistical analysis was carried out using SPSS version 14.0 ,computer application .All the data were transformed in decimal logarithms and processed. This is beside determination of the correlations between many dependent) operation period (and independent factors) current intensity, COD, total and fecal coliform using Bivariate person correlation.

RESULTS AND DISCUSSION

Characterization of municipal wastewater sample

The production of energy resource while minimizing the waste in wastewater is considered one of the best ways for sustainable energy resource management practices. Application of MFCs may represent a completely new approach to wastewater treatment with production of sustainable clean energy. From the obtained results shown in Table 1, it can be demonstrated that, the level COD and BOD for raw municipal wastewater. The general characteristics of municipal wastewater which initially inoculated to MFCs were as a following pH (7.4), COD (257mg/L), BOD (1372mg/L), TSS (302 mg/L), ammonia (21 mg/L), NO₂ (0.02 mg/L), NO₃ (0.30 mg/L), TP (1.3 mg/L), oil and grease (50 mg/L), total and fecal coliform (6.8×10^6 and 2.3×10^6 MPN-Index/100 ml) (Table 1).

Table 1: General characteristics of municipal wastewater

Parameters	Unit	Results
pH	--	7.4
COD	mg/L	257
BOD	mg/L	1372
TSS	mg/L	302
Ammonia	mg/L	21
NO ₂	mg/L	0.02
NO ₃	mg/L	0.30
Total phosphorous (TP)	mg/L	1.3
Oil and grease	mg/L	50
Total coliform	MPN-Index/100 ml	6.8×10^6
Fecal coliform	MPN-Index/100 ml	2.3×10^6

Measurement of the potential current

Several studies were done for electricity production from high load of organic material by using MFCs; these MFCs may be in continuous flow and/or in batch model [17]. The results illustrated graphically in Fig. 1, the maximum current intensity which produced form municipal wastewater was 17.1mA/m³ at 17 days of operation period.

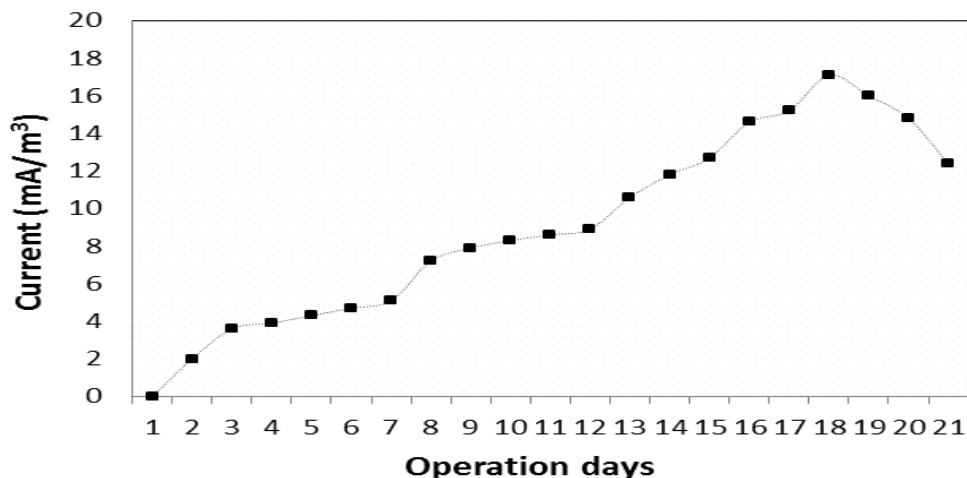


Figure 1: The rate of produced current intensity during MFCs operation from municipal wastewater

The efficiency of COD and TSS removal

In this study, both COD and TSS were determined in the system effluent to understand the MFC treatment efficiency during defined period. Fig. 2 shows that the high removal efficiency was observed after 21 operation day. These results in agreement with Mansoorian *et al* [16] they found that, MFCs system able to reduce the COD and TSS concentration in the effluent samples.

These results combatable with many researches work in which used different substrate to generate power by using MFCs. In 2005, low power (45 mW/m²) and voltage (120 mV) has been generated from animal

wastewater, also in the same year the bio-electricity production from cysteine substrate with the generation power of 39 mW/m² and voltage of 130 mV was produced. While, in 2007, more power were obtained by generation power and the voltage reached up to 400 mV and COD 440 mW/kg. In 2009 the electricity power was generated by using organic matter as a substrate and bacteria as a microorganism the generated power was reached up to 150 mW/m² and voltage 350 mV. Some researchers improved the MFCs by using ultrasonic pretreated inoculated sludge with generation power 400 mW/m² and voltage 750 mV [18].

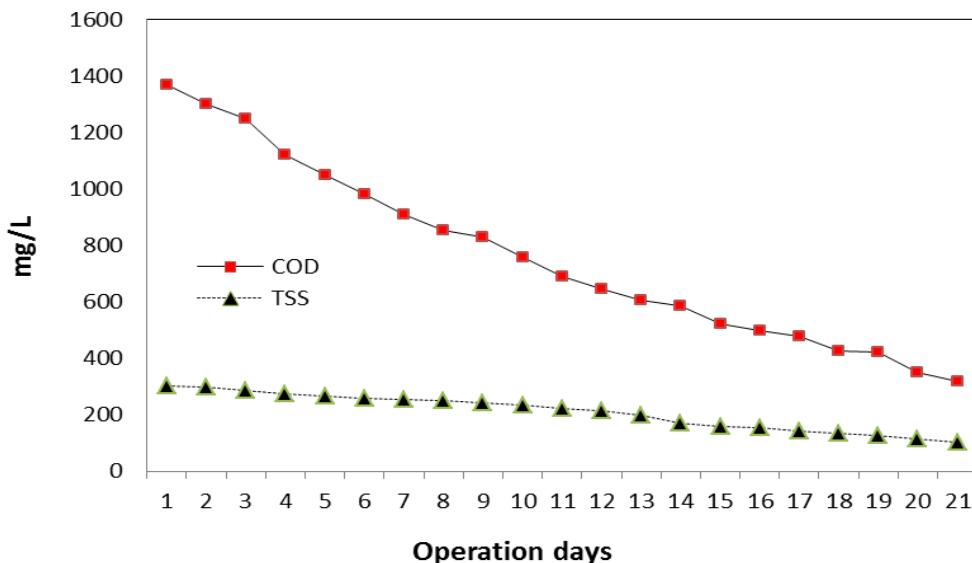


Figure 2: The rate of COD and TSS removal during MFCs operation from municipal wastewater

Reduction of coliform group densities

The results in Fig. 3 indicated that, the reduction rate of both total and fecal coliform during 21 days of the experiment. Also, the experiment started with 6.8×10^6 and 2.3×10^6 MPN-Index/100 ml and ended with 2.9×10^2 and 1.5×10^2 MPN-Index/100 ml for total and fecal coliform. This is may be due to decreasing of organic matter level, whereas, the bacterial activities can be degrading the organic matter which present in wastewater then shortage in organic nutrients. Also, Mansoorian *et al* [16] demonstrated that, during MFC mechanism the degradation of colloidal and complex organic material revealed to the biologically catalyzed process.

Statistically, the obtained results found that, there is a positive correlation with significant between operation period and both the current intensity, COD, total and fecal coliform (Table 2).

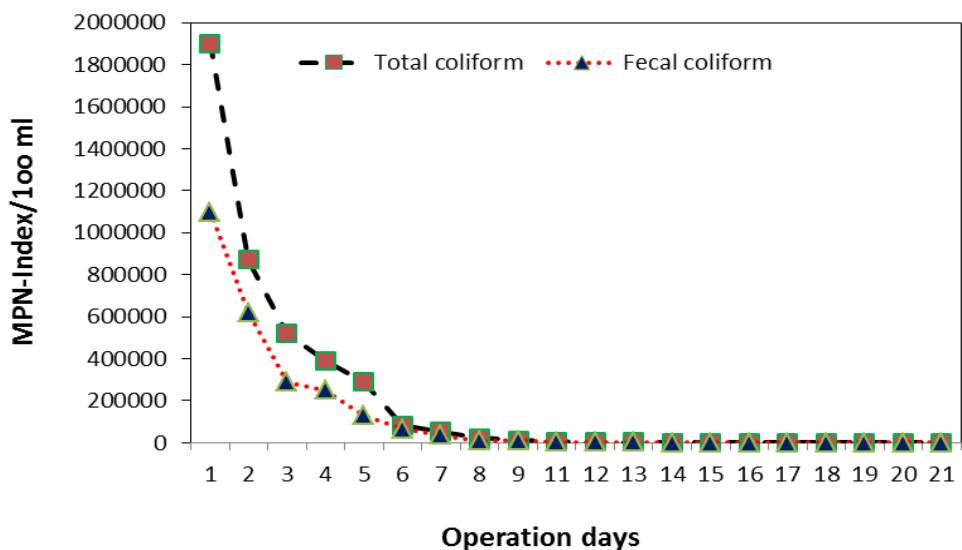


Figure 3: The reduction rate of coliform group densities during MFCs operation from municipal wastewater.

Table 2: Bivariate correlation between the current intensity, COD, total and fecal coliform.

	Current intensity	COD	TC	FC
Pearson Correlation	1	-.943-**	-.641-**	-.646-**
Sig. (2-tailed)		.000	.002	.002
N	20	20	20	20
Pearson Correlation	-.943-**	1	.755**	.766**
Sig. (2-tailed)	.000		.000	.000
N	20	20	20	20
Pearson Correlation	-.641-**	.755**	1	.995**
Sig. (2-tailed)	.002	.000		.000
N	20	20	20	20
Pearson Correlation	-.646-**	.766**	.995**	1
Sig. (2-tailed)	.002	.000	.000	
N	20	20	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

CONCLUSION

MFCs are considered as one of novel method for the electrical power production from wastewater containing high level of organic material. Moreover, MFCs able to produce the treated wastewater and electricity with well value. It is a low cost, environmental-friendly and don't required to charge in comparing another technologies. Additionally, MFCs can be solving the shortage in energy in the developing countries.

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