SULFURE REMOVAL FROM URBAN SEWAGE IN BIOELECTROCHEMICAL PROCESS

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Abstract - Bio-electrochemical new technologies can, in wastewater treatment, convert the energy stored in the chemical bonds of biodegradable organic materials through the catalytic reaction of microorganisms into renewable electrical energy. The purpose of this study was to investigate the efficiency of a single-cavity bio-electrochemical system without catalyst as a simple and inexpensive method for removing corrosive and sedimentary sulfur compounds from urban sewage with indigenous bacteria. In this study, bacteria were isolated from urban sediment and sediments as Substrate was used. During the six months of the lead, the sulfate concentration reached at least 63 ± 57.2 mg / l, indicating the system's ability to remove 76.7% of sulphate from municipal wastewater and generate bioenergy. Maximum COD removal was 80% and maximum density was 54 W / cm3 and 82/1 W / cm2. The presence of elemental sulfur in sediments showed that these systems have the capability to optimize the recovery of elemental sulfur from urban sewage.

Index Terms - Sulfur Removal, Urban Sewage, Bio-electrochemical Process, Reducing Bacteria.

I. INTRODUCTION

Bio-electrochemical technologies for wastewater treatment and direct access to renewable energies from biodegradable organic materials are nowadays really considered (Wang et al., 2017; Rabaey et al. 2006; Qin et al. 2015; Zhang et al., 2016). In bio-electrochemical systems, energy stored in chemical bonds of organic materials is converted into electrical energy through the catalytic reaction of microorganisms (Li et al., 2017, Logan et al. 2015, Qin et al. 2015; Kellyet al. 2014). Types of bio-electrochemical systems include microbial fuel cells (MFCs), chemical electrolysis cells (MECs) and microbial desalting cells (MDCs) (Kelly, 2014).

Bio-electrochemical systems can be used in the treatment of sewage or as a power supply for remote sensors or the production of valuable products through electrochemical or electrochemical reactions (Kelly et al., 2014). The basis of these technologies is the ability of bacteria to supply their own energy while transferring the electron from the substrate to an electron receiver with a redox potential, it is higher. In these cells, the bacteria are forced to transfer electrons to electrodes that transfer electrons to the external circuit (Rabaey et al., 2006, 2007, Anglove et al., 2013). Various materials as substrates and electron receivers in BES are used, including soluble sulfate (Anglove et al. 2013 and Barua & Deka et al., 2010). The use of substrate, such as sewage as an electron source, is attractive because of the demand for water or sewage treatment systems with a low carbon footprint (Pant et al., 2010; Kelly & He, 2014). In MFCs, the purpose is to remove organic carbon, although a mixed substrate such as sewage contains other compounds such as nitrogen and sulfur (Rabaey et al., 2006).

The sulfate in the wastewater is generally converted to sulfide by Sulfate Reducing Bacteria (SRB) (Hyeong, 2011 Lee et al., 2011). In this system, the oxidation of organic sulfate reductase bacteria (including acetate, lactate, butyrate, etc.) is oxidized and the sulfate ion is reduced by the following reaction (Anglove et al., 2013).

$$(1)\ (CH_2O)n + SO_4^{2-} \rightarrow H_2S + 2HCO_3^-$$

Sulfides can act as an electron carrier from bacteria to the electron receptor, such as Fe (O) oxides (Rabaey et al., 2006) and the role of recovery mediator. The released protons can be resuscitated by the oxygen in the cathode and in The sulfide standard conditions of the Sulfur Oxidizing Bacteria (SOB) of sulfide can lead to an elemental SÃ at potentials higher than 0.274 on the Standard Hydrogen Electrode (SHE). If more potentials, S can be oxidized again to the sulfate which cannot be re-enriched revived by biofilm anode microorganisms (Zhang et al., 2014; Anglove, 2013; Lee et al., 2011). In single cathode-air cathode MFCs, sulfate can be reduced to S° according to Equation 2 and Sq is deposited, leading to electrodes clogging and reducing electricity generation (LI et al., 2017).

$$(2)\ SO_4^{2-} + 8H^+ + 6e^- \rightarrow S^{\ddagger} + 4H_2O$$

Thiobacilli are known chemo-ototrophic species capable of anaerobic sulfur oxidation by resuscitation of Fe (S) or nitrate as the final electron receptor (Zhang et al., 2014).

Zhao et.al. study , 2008 In 2008, on active carbon coatings as an anode for the removal of sulfate in a

microbial fuel cell, the use of Desulfovibrio desulfuricans sulfate reducing bacteria allowed the generation of electricity in a microbial fuel cell (MFC) and at the same time eliminated 99% sulfate Provides. This approach is based on the non-oxidative reduction in the sulfide produced by D. desulfuricans in the anode. In addition to sulfide, compounds such as Fe2 +, Cystein and AHQDs can take on the role of electron carrier, which, depending on their ability to oxidize and regenerate, causes a difference in electricity production (Pozo et al., 2017; Zhang et al., 2014).
However, the concentration of the electron carrier at the anandic side is higher, more electricity is produced. Electricity production in the system can indicate the amount of sulfide production (Hyeong, 2011). In studies, electrolytes have been detected up to 101 mV by oxidation of sulfide and elimination of 98% sulfide at 514 mg / day (Rabaey et al., 2006; Pozo et al., 2017; Izadi et al., 2014)

The purpose of this study is to investigate the efficiency of MFC without catalyst as a simple and inexpensive method for removing corrosive and sedimentary sulfur compounds from urban sewage with indigenous bacteria.

II. MATERIALS AND METHODS

A. Materials and Procedures

Isolation and culture of electrolyte sulfate reductase bacteria. In the first stage, anaerobic sediments were collected from the Anzali Wetland bed and Ashgabat wetland, and the aerobic and anaerobic sludge samples of urban wastewater treatment plants were collected at a ratio of 1: 1. By closing a simple sedimentary cell consisting of a carbon-captcha atom and a cathode, and after stationary flow, electrodes were washed as the source of electrogens in the physiologic serum (to prevent the breakdown of the bio-film) and in an Lb medium And BHI in a cavity of 35.5 ° C were cultured in an aerobic and anaerobic manner.

Mixed cropping of anodic microorganisms under anaerobic conditions by inoculation of 0.5 dcm at 20 dm. Lurita Bertani Netting medium (310 gr / dm 310, gr / dm 3 5 yeast extract and gr / dm 3 5 NaCl at pH: 7) contains gl / dm of 15 glucose. After 96 hours of cell growth, the culture of the enriched culture in a new culture medium (LB without glucose to prevent fermentation) is mixed (Ralitza et al., 2017).

An anode culture was performed in a BHI medium under aerobic conditions. After 48 hours for aerobic species and 72 hours for anaerobic species, dilution and bacterial suspension were performed to inoculate the cell. The solution was introduced into a pilot cell and allowed to grow microorganisms for ten days.

B. Construction and commissioning of microbial fuel cells at laboratory scale.

In the laboratory phase, a glass container of 1500 ml was used. Since the growth of anaerobic bacteria is very slow, in order to prevent the bio film from being washed, the pilot was designed as a SBR in the lab. The structure of the single electrode the air-catheter chamber was constructed according to Cheng et al., 2006. Double-walled 200g double carbon composite corrugated composite company 0.2mm thick, used as an electrode and stainless steel grid 304 as an electric collector. Materials used as cathodes in microbial fuel cells are like materials. Which is used in anode, with the exception that catalyst is usually required when these materials are used in the cathode (Pant et al., 2010; Zhang et al., 2016). Since microorganisms can play a catalytic role in the cathode and accelerate the transfer and consumption of electrons (Song et al. 2015, Gude et al., 2013), this study used aerobic biotas. Intrusive layers on the surface of the cathode electrode can prevent oxygen penetration into the anodic chamber and reduce the power output of the microbial fuel cell and reduce the water loss of the cell. Polyfluorosulfonic acid (nephion) and polytetrafluoroethylene as the binding agent in fuel cells and used in this case.

C. Analytical Methods

First, the effect of key parameters and optimal conditions was investigated by Design Expert 11 software by RSM method. Hydraulic time of 40 hours was determined at neutral pH and optimum temperature. In the next step, samples of the input and output of the system were collected for measuring COD, sulfate, sulfide at 1, 5, 1, 3, 7, 24, 48 and 72 hours and centrifuged for 8 minutes at 5 minutes (8000 rpm). Benchtop centrifuge, Rotina380, Andreas Hettich GmbH & Co. KG, 78532 Tuttlingen, Germany) COD. , Sulfate and sulfide were analyzed by standard method (APHA). A portable meter MultiLine® Multi 3510 IDS.WDW.Germany for measuring DO, temperature and opacity, and pH meter (pH meter. Crison Basic20 crison instrument.SA) for measuring pH and condensation. Became each test was repeated twice. Inoculum in two concentrations of 0.5 and 10 McFarlane to monitor the effect of microorganisms in the process of generating electricity into the pulp and the voltage of the cell is recorded by the multi thermal machine (mastec mas830L.china) every ten minutes and each time the voltage is less than mv 50 new feeds were added to the pool (Q.Tao, 2015). The current (I = V / R) and power (P = IV) are based on Ohm's law, power density (Pd = IV / A), where A is the surface area of operation and CE is based on the method presented by Chen et al., 2014, and the polarization curve was plotted with an external resistance of 10 to 2000 Ω at 1-minute intervals to reach a constant voltage. The internal resistance and maximum power

density were obtained by analyzing the polarization curve (Q.Tao, 2015).

III. RESULTS AND DISCUSSION

A. Generation of electricity and bacterial growth curve

The first step in this study was to select the appropriate microbial source in optimum temperature conditions for the growth of microorganisms. The mixture of aerobic and anaerobic sewage from Tehran's Ekbatan treatment plant and Anzali wetland sediments (37 ° 27'51.7 "N 49 ° 28'19.0" E) and Ashkhabad Varamin (35.4592169, 51.4542183) as two separate microbial sources of insemination And then the growth curve of the anaerobic and aerobic mixture was studied at ambient temperature (25 ° C) (Fig. 1).

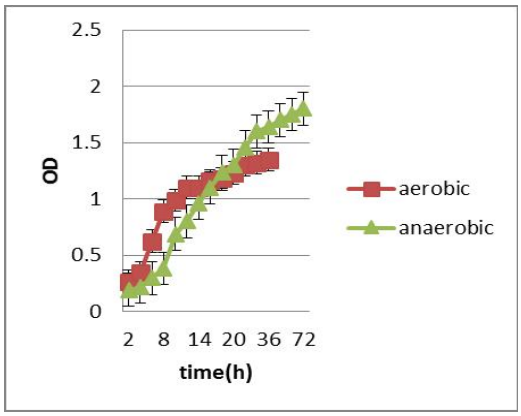


Fig 1: The growth curve of aerobic and anaerobic

In the selection of microbial source, in addition to proper growth of the source in environmental conditions, the potential of its use as an inoculum in bio-electrochemical and electrical power generation has also been evaluated.

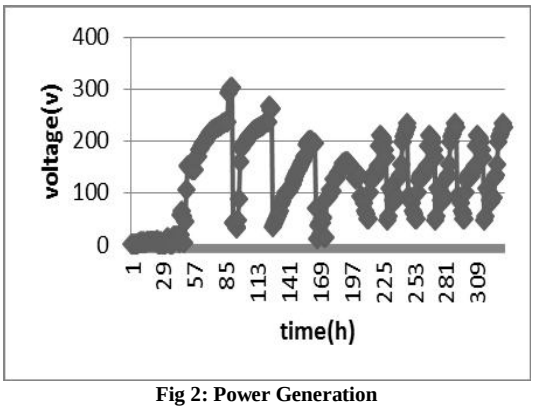


Fig 2: Power Generation

The maximum produced voltage was 304 mV, which is comparable to the previous findings (Li et al., 2017). The circuit voltage was up to 72 hours, followed by a sudden increase in voltage, followed by a voltage drop. These results indicate that Electricity from organic compounds in municipal sewage sludge is produced as a substrate without initial flow, and therefore, BES can be introduced into municipal sewage systems without auxiliary devices.

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B. Investigating the Effect of Microbial Consortium Concentration on Electricity Production

In two separate experiments, two concentrations of inoculum (equivalent to 0.5 and 10 McFarlins standard) were evaluated in the cell compartment. In each experiment, the culture mixture was inseminated as an inoculum to the LBI culture medium, and the launching and production of flow and power were examined (Figures 3a and 3b). Although the inoculum concentration did not significantly change the production capacity, the concentration of 10 had the highest production capacity (54 W / cm3 and 82/1 W / cm2).

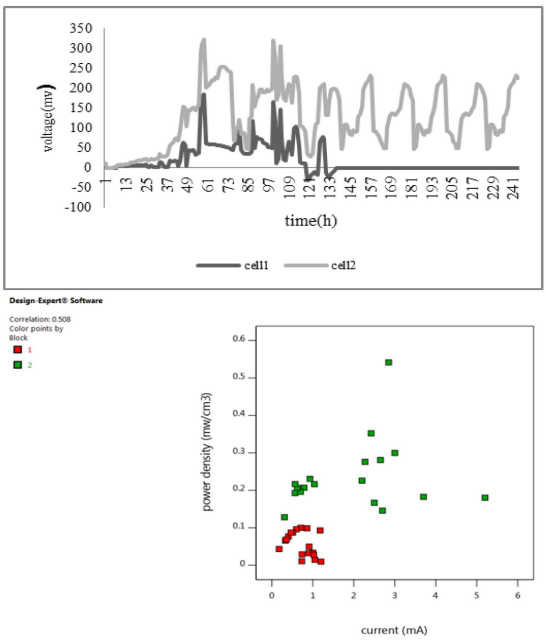


Fig. 3a. Comparison of the voltage during two systems with a concentration of inoculum of 0.5 and 0.01, Fig 3b. Comparison of the flow and density of the two systems with the concentration of inoculum of 0.5 and 0.10

Inoculation of 0.5 microorganisms is not provided to carry out catalytic activities in the Andi chamber, which reduces the production capacity. However, in high inoculation (concentration 10), although microorganisms are required to carry out the reaction in an anandic chamber, the accumulation of microbial

in the anodic chamber reduces the mass transfer and thus reduces the production power (Zhang et al. , 2016; Logan et al., 2015).

C. Sulfur behavior

The changes in sulfate and sulfide concentration in terms of time were as shown in Fig. 4. The sulfate concentration decreased to 52% in the first 3 hours (from 224 mg / l to 84 ± 57 mg / l) and then remained constant until the end of the steady state period The limitation of sulfate reducing bacteria is in the conversion of sulfate to sulfide. This can be due to the potential for reduction of iron reduction bacteria, which plays an important role in generating electricity according to previous studies (Li et al, 2017). The concentration of sulfide increased over the first 24 hours, which according to previous reports (Pozo et al., 2017) can indicate the activity of an electro-detective sulfate reductase bacteria and autotrophic reduction of sulfate in biochemical systems and then, due to the limited activity of these bacteria, Reducing the soluble sulfide concentration in the cell.

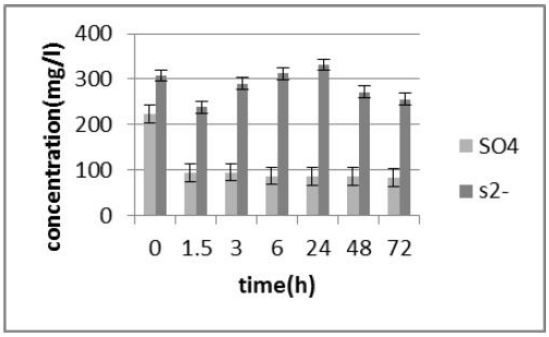


Fig. 4. Correlation between sulfate removal and time b9 Correlation between sulfide removal and time c) Investigating variations of solute sulfate and sulfide concentration in sewage during 72 hours of lead polarization

CONCLUSIONS

This research was conducted to investigate the efficiency of electricity generation as a smelter indicator of sulfur compounds or their control by a bio-electrochemical system as a single-compartment MFC. The sulfate concentration reached at least 63 ± 57.2 mg / L, indicating the system's ability to remove 76.7% of sulfate from urban wastewater and generate bioenergy. The maximum COD removal rate was 80% and the maximum density was 54 W / cm3 and W / cm2 1.821, which is acceptable due to the use of urban sewage instead of synthetic sewage used in most previous studies.

Sulfide concentration, as in previous Pozo 2017 studies, was involved in increasing the voltage. This correlation proves that the generation of electricity in a microbial fuel cell can be a marker for tracking the source of smells from sulfur compounds or controlling them in sewage treatment. Such tools can be used in urban sewage systems, including manholes, rainwater drains, sewage ducts, and so on. The presence of elemental sulfur in cell sediments was consistent with the findings of Li et al., 2017 and Rabaey et al., 2006, and these systems have the capability to optimize the recovery of elemental sulfur from urban sewage.

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