INVESTIGATING THE ABILITY OF MICROBIAL SOLAR CELL FOR WASTEWATER TREATMENT

Zahraa Raad Khanjer, Ahmed Hassoon Ali, Nagam Obaid Kariem

Environmental Engineering Department, College of Engineering,
Mustansiriyah University, Baghdad, Iraq.

ABSTRACT

The present research aims at investigating the ability of Microbial Solar Cell (MSC) in order to treat wastewater by using mixed algae culture. Algae cultures offer an elegant solution for the treatment due to the ability of algae to use inorganic nitrogen and phosphorus for their growth. And also, for their capacity to remove heavy metals, as well as some toxic organic compounds, In the current review we investigating the removal efficiency of the (NO_3 , PO_4 , COD, Cd, Cr, Pb, Mg and Ca) by using the batch mode and it was found that the minimum concentration of the of nitrate (NO_3), phosphate (PO_4), and chemical oxygen demand (COD) was recorded at the 23th day of the experimental work to be 1.087, 0.734, 36.2, for heavy metals; chromium (Cr), lead (Pb) and cadmium (Cd) (0.033, 0.045, 0.0127) respectively finally for the hardness Mg and Ca (33.09 and 59.061).

The variation of pH was observed during the treatment process and found that pH level in the natural range level of allowable concentration to throw in the river.

Keywords: Microbial solar cell, Waste water, Algae, Wastewater treatment, Removal efficiency.

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1. INTRODUCTION

Among the various known forms of pollution, water pollution is a great concern since water is extremely essential for the survival of all living organisms. However, years of increased industrial, agricultural and domestic activities have resulted in the generation of large amount of wastewater containing a number of toxic pollutants, which are polluting the available fresh water continuously. With the realization of that pollutants present in water adversely affect human and animal life, domestic and industrial activities; pollution control and management is now a high priority. The availability of clean water for various activities is becoming the most challenging task globally. In general, treated wastewater is discharged to the natural

water environment or reused, Treatment of wastewater depends on the regulated discharge requirements to preserve the natural environment and to protect human health (1). The presence of (nitrate/nitrite and Phosphate) in wastewater is a concern and must be treated before discharge in the environment. Moreover, denitrification process (nitrate/nitrite reduction to nitrogen gas) is highly dependent on the influent carbon to nitrogen ratio. Nowadays this ratio is unbalanced limiting the removal efficiency. On the other hand, wastewater contains heavy metals which can be a concern due to their biological degradation. Heavy metals will not degrade into harmless end products and considered toxic for many life forms, causing various diseases and disorders (2). It's also worth noting that Ca^{2+} and Mg^{2+} are the main contributors to the total hardness (TH) of water and wastewater which is considered to be an important factor in fish culture and can affect the fish growth inversely due to their high concentration (3). Therefore, the removal of the previse elements from wastewater is important to protect public health and ecosystems.

Globally , several methodologies with varying degrees of success have been developed to manage water pollution. Some of them involve coagulation, foam flotation, filtration, ion exchange, sedimentation, solvent extraction, adsorption, electrolysis, chemical oxidation, disinfection, chemical precipitation and membrane process (4). However, these methods have advantages and limitations. Among various available technologies for water pollution control, biosorption is one of the alternative means of treating wastewaters by various biological materials (5,6). Biosorption involves the use of biomass or natural substrates such as agricultural residues, microorganisms, algae which was used in this study.

2. MATERIALS AND METHODS

2.1. Wastewater Samples

Wastewater samples were collected from the influent of Al-Rustamiyah wastewater treatment plant. The location of Al-Rustamiyah wastewater treatment plant - the old project is in Baghdad (33°16'30.8"N, 44°31'57.4"E). The physical and chemical characteristics of wastewater for some important parameters were measured at the sanitary laboratory, Faculty of Engineering, Mustansiriyah University and in the central service laboratory of Baghdad University – Collage of Education for Pure Science – Ibn -AL-Haitham using different analysis devices, All tests were done according to the American Public Health Association (7).

2.2. Algae Samples

2.2.1. Algae Collection

Algae was collected from a water channel at Baghdad University. and the species found in the collected samples were examined and identified.

2.2.2. Algae Preparation

The collected algae were washed with 10% HCL concentration, then rinsed with distilled water.

2.2.3. Algae Identification

To identify non-diatoms algae, prepare a permanent slide for the sample and test it at 40X zoom power by using an electric microscope (8). diatoms algae was identified by using a drop of sample putted in the center of glass slide and dried on a hot plate at 70°C, then a drop of nitric acid are added to clear diatoms structure, after drying a glass cover that contain Canada balsam are placed over, and left to the next day for testing (9).

2.2.4. Algae Purification

Purification of algae aims to get an axenic culture empty of bacteria, fungi, and viruses.

2.3. Wastewater Experiments

Wastewater treatment experiments were conducted using conventional MSC which was fabricated using one plastic container with total volume of 10 liters and working volume of 8 liters. The upper side of the container was open to the atmosphere in order to allow the system to receive light and CO₂. In this research the algae was used as adsorbent material for waste water treatment, 7 important parameters were studied: NO₃, PO₄, COD, Cd, Cr, Pb, Ca, Mg, after the algae was mixed with waste water, Samples of wastewater were taken in different times to measure the reduction in the initial concentrations.

Figure 1 Schematic Diagram for MSC

3. RESULTS AND DISCUSSION

3.1. Nutrients and Organic Pollutants

Removal Minimum concentrations of nitrate (NO₃), phosphate (PO₄), and chemical oxygen demand (COD) in the Microbial Solar Cell were recorded at the 23th day of the experimental part of this research were found to be (1.087, 0.734, and 36.2 mg/L) respectively, where the removal efficiency was 92.522, 92.667 and 92.03 respectively. The effluent concentrations were lower than the maximum allowable concentration to throw in the river which is 50, 3, and 100 mg/L for NO₃, PO₄ and COD (10). The nitrogen removal occurs into two ways, indirect removal through stripping of NH₄⁺-N when pH levels are raised; In algal wastewater treatment systems, photosynthesis process of algae leads to consuming CO₂ and HCO₃⁻, thereby increasing the pH to 11 or greater (11). Direct nitrogen removal indicates assimilation of nitrogen constituents into algal biomass (12). In aquatic environments, higher nitrogen removal results from increased retention times in two ways: 1-increased nitrification and 2-ammonia volatilization at elevated pH levels (13). Phosphorus removal in algal wastewater systems occurs during the algal growth when the photosynthesis process consumed CO₂ and alkalinity typically leads to elevate pH levels thereby promoting a process known as auto-flocculation (14). Increasing in the dissolved oxygen of the water happens as a result of this photosynthetic activity. Figures (2), (3) and (4) show the concentration and removal efficiency of NO₃, PO₄ and COD with time.

Figure 2 Nitrate concentration reduction and removal efficiency relationship

Figure 3 Phosphate concentration reduction and removal efficiency relationship

Figure 4 Chemical oxygen demand concentration and reduction efficiency relationship

3.2. Removal of Heavy Metals

Minimum concentrations of Cadmium (Cd), Chromium (Cr) and lead (Pb) were measured at the 23th day of operation for MSC and it was found to be (0.033, 0.045 and 0.0127 mg/L) respectively. Removal efficiency of Cr, Cd and Pb was 90.07%, 90.2% and 97.4% respectively. The effluent concentrations of Cr, Cd and Pb is lower than the maximum

allowable concentration to throw in the river; 0.2 and 0.1 mg/L (10). In the MSC, biosorption is an important mechanism for the heavy metal removal. Both living and non-living cells can remove metals by biosorption mainly due to the functional groups (carboxylate, hydroxyl, phosphate, amine and sulfate) of polysaccharides, proteins and lipids on the bacterial cell walls (15). Figures (5), (6) and (7) show the concentration and removal efficiency of heavy metals.

Figure 5 Cadmium concentration and removal efficiency relationship

Figure 6 Chromium concentration and removal efficiency relationship

Figure 7 The relationship of lead concentration and removal efficiency

3.3. Removal of Mg and Ca

The minimum concentrations of Mg and Ca were measured to be (33.09 and 59.06 mg/L) respectively, where the removal efficiency was 59.06 % and 70.47% respectively. The effluent concentration is lower than the maximum allowable concentration to throw in the river 200 mg/L and 150 mg/L respectively (10). As shown in Figures (8) and (9). Calcium and Magnesium are considered to be two of the essential nutrients for any plant growth. This explains why these two elements were removed with reasonable percentage.

Figure 8 The relationship of magnesium concentration and removal efficiency

Figure 9 The relationship of Calcium concentration and removal efficiency

4. CONCLUSION AND RECOMMENDATION

The present study employed MSC to treat wastewater by mixing it with mixed algae culture, it was found that Microbial solar cells show potential for a sustainable route to mitigate the growing energy demands for wastewater treatment and environmental protection. Algae was found to be efficient in removing a wide range of pollutants present in wastewater studied in the present work. Pollutants removal efficiencies range from 69.94 % for Mg to 97.4% for Pb. Although the efforts for research over the last decade have increased in this field, further breakthroughs are required to promote these systems into large scale practical applications. The following issues should be given priority for significant developments in MSC technology:

- - Electrode surface areas and low cost materials of construction should be incorporated for cost-effective electricity production in MSCs.
- - Experimental outcomes should be reported in well-known and acceptable units allowing comparison between different configurations.
- -Understanding of the electron release transfer acceptance mechanisms and minimizing electron transfer losses by developing novel configurations in the anode cathode architecture should be given proper attention to maximize the benefits.
- - More in-depth studies focusing on life cycle impact analysis of the microbial solar cell technology should be developed to identify critical areas of development. Large scale system demonstrations are urgently required but they may present new challenges and limitations which need to be addressed in a systematic manner.

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