Nitrate removal in MFC using algae in heterogenic condition

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Abstract: In this study, the potential of a using a dual chamber microbial fuel cell (MFC) to remove nitrates in the cathode chamber of the microbial fuel cell was studied. Cathode chamber contained algae solution and anode chamber contained bacterial solution. The nitrate removal rate in the cathode chamber was 41.2 mg/L/day and it increased to 79.5 mg/L/day with addition of 0.5g/L of sodium acetate. Addition of 0.5g/L of sodium acetate also increased the current and power production in the two chamber MFC.

1. Introduction:

Nitrates are commonly found in domestic and industrial wastewaters, and farmlands (Wan et al.,2012) Industrial waste water contains 200mg/l NO^{-3}(Foglar et al.,2005) .Discharging of such effluents directly to the natural water bodies cause serious environmental problems. In USA, the incidence of NO^{3-} contamination tends to increase in areas west of central Iowa and NO concentrations are high in many sections of the Great Plains. Groundwater beneath irrigated, row-cropped areas with well-drained soils and permeable zones in Minnesota, Washington, Arizona, California, and Nebraska is most impacted by NO^{3-} contamination. (Spalding and Exner,1993). High nitrate concentrations cause blue baby syndrome or methemoglobinemia, mainly in infants (Golden and Weinstein). Therefore, removal of nitrate from wastewater is necessary before discharging it into the clean natural water resources.

Microalgae are photosynthetic microorganisms that can grow rapidly and live in harsh conditions due to their unicellular or simple multicellular structure (Mata et al.,2010). They provide a way for contaminants-removal (nitrogen, phosphorus and carbon) from wastewater while producing biomass that could find use for the production of high-value chemicals and biogas through anaerobic digestion (Munoz and Guieysse,2006)

Some species of microalgae use organic compounds in the growth medium as carbon and energy sources. They do not need light as an energy source (Sharma et al.,2016) This growth condition is called heterogenic condition. Acetate has been proved to be a carbon source for microalgae. But higher concentration might stunt the growth of algae (Pearce and Carr, 1967)

2. Objective:

Overall objective was to investigate the effect of adding sodium acetate on the chlorella vulgaris and the removal of nitrate from the waste water placed in the cathode chamber.

3. Methods:

A dual chamber microbial fuel cell was used in the study.it had anode chamber and cathode chamber. The anodic solution consisted of 300 mL of bacterial growth medium sparged with Nitrogen gas, 0.5 g/L of yeast extract, 20 mL/L of used vegetable oil, and 20 mL of bacterial inoculation. The used vegetable oil was the carbon source for bacterial metabolism. The cathode chamber consisted of $NaNO_3$ and chlorella vulgaris. The anode and the cathode were separated by a commercial cation exchange membrane (CMI-7000). The anode and cathode electrodes were carbon fiber brush connected to a 1000 ohm external resistor. The working volume of each chamber was 500 mL. The closed circuit voltage (CCV) of the system was also constantly monitored. The nitrate content in the cathodic solution was measured with the

help of nitrate ion selective electrode from Hanna Instruments**.** Sodium acetate (CH_3COONa) was used as organic carbon source for algae growth. It was mixed at concentrations of 0.2 g/L, 0.5 g/L and 1 g/L with algae to select the optimum concentration of acetate.0.5 g/L of sodium acetate was selected as the optimum and algae was mixed with that concentration of sodium acetate to evaluate the growth rate of algae. Microalgae growth was determined by measuring the optical density at 680 nm (OD680) using UV–visible spectrophotometer daily and related to algal biomass (g/L).

4. Results and Discussion:

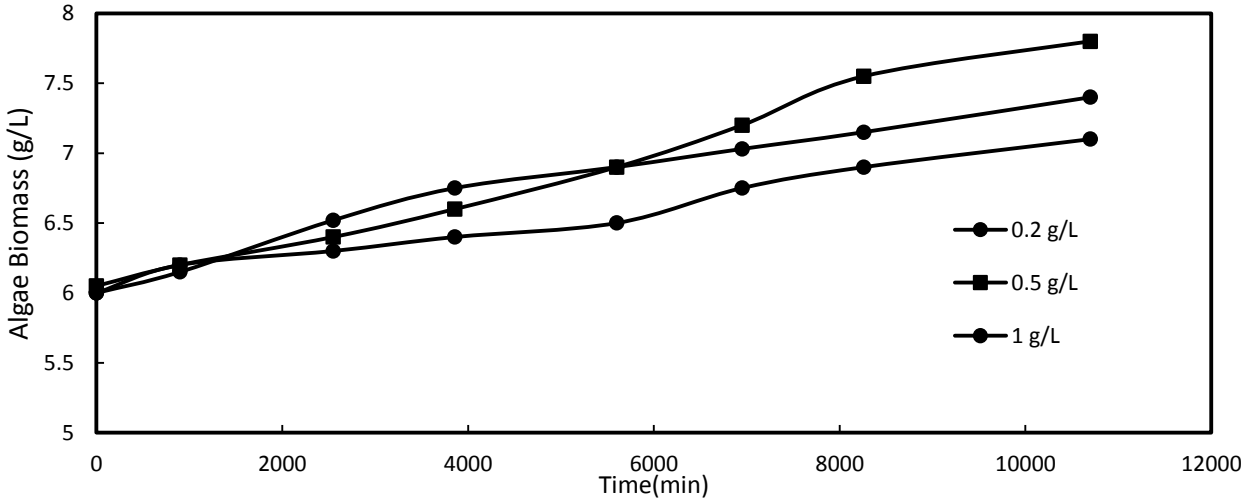

Figure 2*:* Variation of nitrate concentration in cathode chamber with time

With the addition of sodium acetate the algae growth rate increased upto 0.5 g/L. When the the sodium acetate concentration was increased to 1g/L ,the growth decreased after 7 days. 0.5 g/L acetate gives better growth rate of algae. Therefore, it was chosen as the optimum concentration for chlorella vulgaris.

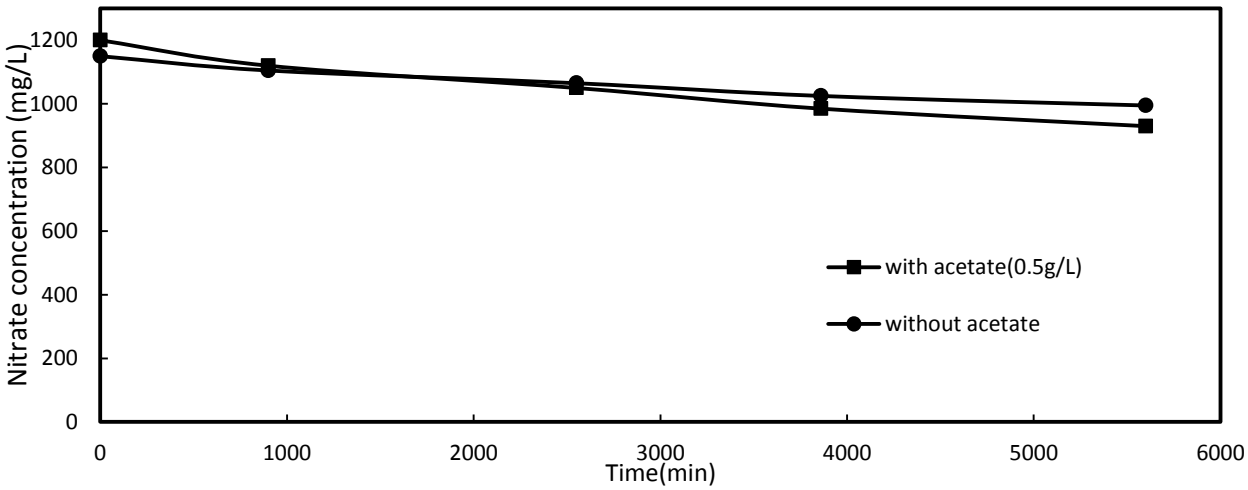

Figure 2: Variation of nitrate concentration in cathode chamber with time

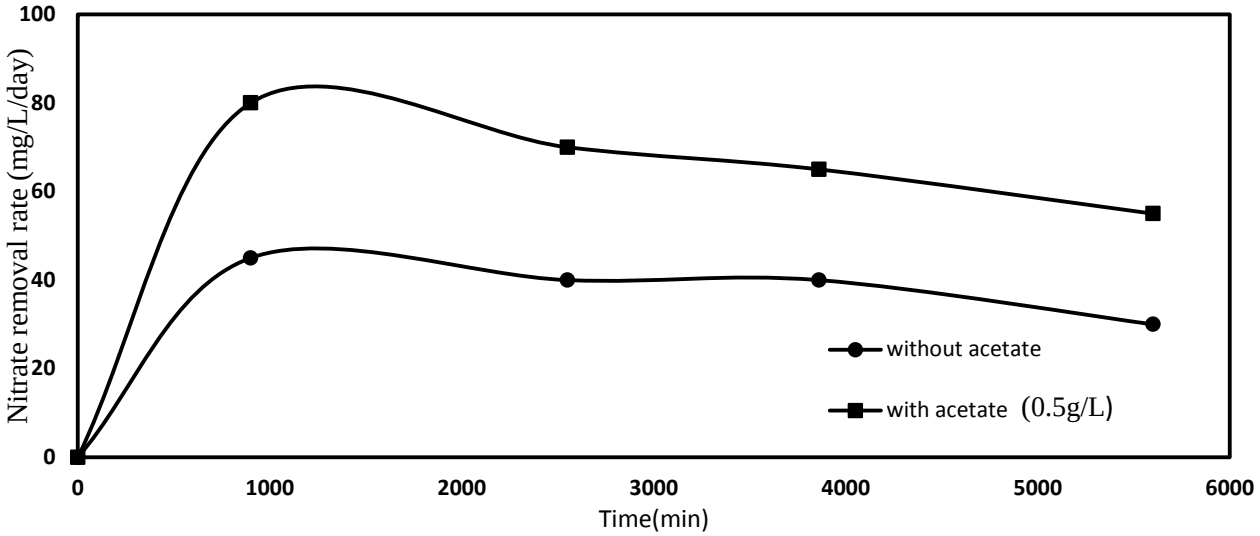

Figure 3: Variation of nitrate removal rate with time

Nitrate removal rate increased when sodium acetate was added. But the rate decreases with time. There was almost 200% increase in nitrate removal rate after 16 hours.

5. Conclusion:

Based on the two chamber MFC study following conclusions are advanced.

1.05 g/L sodium acetae gives better growth rate of algae compared to 0.2g/Land 1g/L sodium acteate

2. The nitrate removal rate increased from 41.2mg/L/day to 79.5mg/L/day when 0.5g/L sodium acetate was added

6. Acknowledgements: The study was supported by the Texas hazardous Water research Center (THWRC) and the Center for innovative grouting materials and Technology (CIGMAT).

7. References

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