The effects of added amounts of *Escherichia coli* on the electrical conductance of pond water

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Abstract

Microbial fuel cells (MFCs) use bacteria to catalyze the material in water and we observed whether pond water with the addition of *Escherichia coli* (E.coli) would have a change in electrical conductance and whether pond water with *E.coli* should be further tested for electricity generation in MFCs. We used eight-mL samples of the same pond water and added 200 µl, 100 µl, and 0 µl of *E.coli* to 35 samples for each *E.coli* amount. The pond water samples with 0 µl of *E.coli* served as the control. After the *E.coli* was transferred into the sample, every sample rested in the same indoor room temperature environment for 48 hours before reading the conductance levels. There was a significant difference in the conductance levels of the pond water ($F = 8.38$; df = 2; $p = 0.000427$), and the electrical conductance for the control sample was observed to be lower than both the samples with 100 µl and 200 µl of added *E. coli* to pond water. Therefore, pond water with *E.coli* could produce higher energy outputs in MFCs because of the higher electrical conductance of the pond water. Different amounts of *E.coli* should be tested in pond water to determine the optimal amount of *E.coli* for the highest conductance.

Introduction

Microbial fuel cells (MFCs) use bacteria as catalysts to oxidize organic and inorganic matter and generate electron transfers; the electricity produced from MFCs makes MFCs a possible alternative biofuel source. (Logan et al., 2006). MFCs intake wastewaters and use bacteria to convert the substrates, the organic materials in the water, into carbon dioxide which causes an electron transfer. MFCs were tested with wasters that contain sulfate-reducing bacteria and this caused in voltage and efficiency (Zhang, Fu, & Zhang 2019). Similarly, wastewaters were treated at ionic conductivities causing sulfide oxidizing bacteria, and the sulfur-driven current also resulted in the MFCs producing low energy outputs (Xiao et al., 2021). However, sulfide and sulfur-oxidizing bacteria (SOB) produce sulfuric acid which increases the electrical conductance of stream water, and the electrical conductance further increases with organic matter in the water (Hassan et al., 2013). *Escherichia coli* (E. coli) converts cysteine to hydrogen sulfide (Tomasova et al., 2016). SOB bacteria were tested for electrical outputs in MFCs however the effects of *E. coli* on the conductance of pondwater have not been examined. We will observe whether the addition of *E. coli* in pondwater influences whether pondwater is a viable water type to be tested in MFCs for long-term electricity generation, by measuring the electrical conductance of pond water, containing organic material, with three different amounts of *E. coli.*

Methodology

We collected water samples from the Illinois Math and Science Academy's pond and each sample contained 8 mL of pond water in test tubes. We inoculated *E.coli* in nutrient broth and incubated the nutrient broth for 24 hours. Next, we added 100 µL of *E.coli* to 35 samples of pond water, 200 µL of *E.coli* to 35 samples of pond water, and 35 samples of pond water, with no added *E.coli,* to serve as a control. After transferring the *E.coli* into the water samples, every test tube was capped and undisturbed in a room temperature environment for a period of 48 hours. The Vernier electrical conductance probe was used to record all the conductance data. We performed a one-way ANOVA to determine whether different amounts of *E. coli* affected pond water conductance.

Results

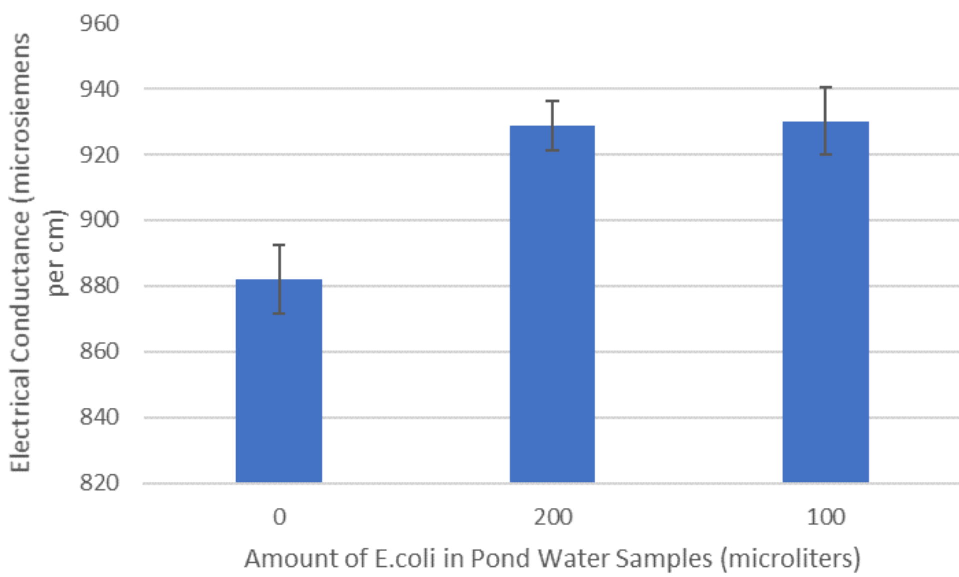

Figure 1. The average electrical conductance of pond water after adding either 200, 100, or 0 microliters of *Escherichia coli.* Identical eight-mL pond water samples with 35 samples for each amount of added *Escherichia coli* were left to rest in the same room temperature environment for 48 hours before measuring the conductance. Error bars represent Standard error.

The results of our experiment are shown in Figure 1. The electrical conductance for the control sample was observed to be lower than both the samples 100 µl and 200 µl of added *E. coli* to pond water. The samples of pond water with 100 µl of added *E. coli* had the highest electrical conductance. There was a significant difference between the groups ($F = 8.38$; df = 2; $p = 0.000427$). A Turkey test showed that a significant difference occurred specifically between samples with 100 µl of added *E. coli* and the control samples; a significant difference also occurred between the samples with 200 µl of added *E. coli* and the control.

Discussion

We found a significant difference in the conductance of the pond water due to an increase in the conductance of pond water with 100 µl of added *E. coli* and 200 µl of added *E. coli*. when compared to the control. Our results agreed with the findings presented by Hassan (2013) that SOB and organic matter in stream water increase electrical conductance. However, our results differed from Xiao et al. (2021) when SOBs were used to generate power with MFCs, lower energy outputs were observed which differed from our results. This may be due to the electricity produced by the MFCs in Xiao's experiment being generated by a sulfur-driven current in the saline wastewaters Xiao tested. When Xiao increased the salinity of the wastewater, SOB bacteria were induced, however, the higher salinity of the water suppressed the fermentation of the bacteria and its ability to catalyze the substrates in the water. However, in our experiment, we did not change the salinity of the pond water at all and we allowed the pond water, once the *E.coli* was transferred, to rest for 48 hours. By maintaining the natural salinity of the pond water where bacteria could already grow in and allowing the *E.coli* to remain in the pond water for 48 hours, the *E.coli* had the optimal water salinity and time to grow using the substrates naturally occurring in the pond water and therefore producing hydrogen sulfide which led to the higher conductance levels shown in Figure 1.

Our results indicate that pond waters with added *E. coli* could be a water type that would produce higher voltage levels in MFCs because of the higher electrical conductance observed in Figure 1. The higher electrical conductance output could produce higher energy outputs when used in MFCs for electricity generation. This is supported by Hend et al. (2016) observing that cultures and microorganisms already present in wastewater, like our pond water, are an effective bio-anode for MFCs. In addition, MFCs with electrogenic bacteria, like *E.coli*, were found to contribute to the electrical current generation (Guotao et al., 2019) and in the high energy outputs of double chamber MFCs (Lee et al., 2016). Pond water with *E. coli* could be utilized in full-scale wastewater treatment plants using MFCs for electricity generation due to the MFCs relying on catalyzing the naturally occurring substrates in water (Hiegemann et al., 2016). Also, wastewaters when mixed with freshwater, like pond water, had the highest power outputs in MFCs rather than just the wastewater by itself in MFCs (Karthikeyan et al., 2016).

We used 200 µl and 100 µl of added *E. coli.* In future studies, experiments could be conducted using a higher amount of *E. coli* to see whether an increase in electrical conductance, like in our experiment, is the same for all amounts of *E.coli.* Additionally, we only used *E. coli* which produced hydrogen sulfide but many other SOBs produce other types of sulfates and have not been tested. More information regarding other types of sulfates' effects on electrical conductance is still needed in order to observe whether there is a bacteria that has higher electrical conductance outputs and could be a better water treatment type for sustained use of MFCs.

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