Shoreline Oil Spill Remediation by Using Microbial Fuel Cell Technology

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Abstract: The possibility of microbial fuel cell (MFC) technology's application in shoreline oil spill remediation was investigated in this study. Results showed that 96% and 75% of engine oil were reduced in the anode chamber of MFC with soil medium and aqueous medium respectively after 10 days of operation. Also about 500 mV of open circuit voltage was produced with both medium using a volume of contaminated water and soil of 600 mL.

1.Introduction

The cleanup of oil spill in ocean is more difficult and time-consuming when it reaches shoreline areas. Fate and transport of oil in the beach should be investigated before cleanup and restoration. Influence factors are type of oil (eg. light oil, crude oil), amount of oil, degree of weathering of the oil, temperature, tide and waves, and type of beach like soil type (sand, clay, rock) or biota type. Many methods like manual removal, mechanical removal, flooding/washing, sorbents or burning have been used for oils on the surface of beaches. For buried oil or light to medium oils which can transport through pore spaces into one meter deep (Fingas 2001), bioremediation is one way to be used with addition of nutrients, while only 10%~30% of the oil is removed in one to two years (Fingas 2001).
Microbial fuel cell (MFC) has been used for mixed hydrocarbon degradation in groundwater (Morris and Jin 2008). Electrochemical remediation has been a feasible method for organic contamination removal in soils, sediments and groundwater (Reddy 2009). This makes it possible for MFC technique to be used for hydrocarbon contaminants in soils. Further, as the difference of beach soil and common soil lies mostly in the salt content, salt tolerant bacteria should be screened or acclimated to be used in the anode chamber of MFC.

2.Objective

Investigate the potential of using the MFC technology to remediate the oil spill in shoreline area.

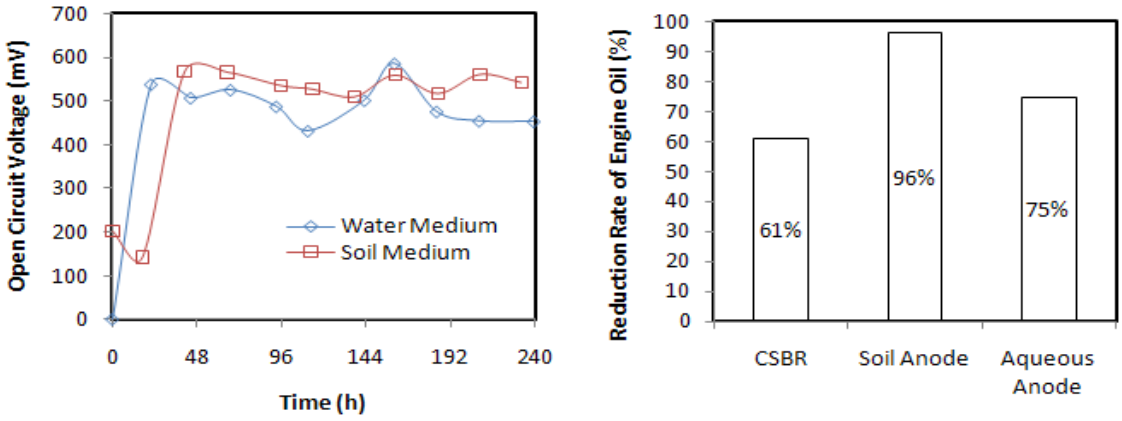
3.Materials and Methods

Used engine oil was used in this study to represent the light and medium components of the oil spill. Mixture of bacteria from activated sludge from a Houston wastewater treatment plant and soil from the UH campus was acclimated with 1% of the engine oil, 0.35% of NaCl, and other nutrients. After the acclimation, the bacteria mixture was injected into the anode chamber of a MFC. Same set up of two chamber MFC using liquid medium was used as indicated in Liu and Vipulanandan (2011), except that oxygen was injected into the cathode chamber as electron taker. Saturated sand was also used as the medium in the anode chamber of MFC instead of aqueous medium to mimic the beach environment. Open circuit voltage (OCV) and engine oil concentration were monitored. The engine oil was extracted by dodecane and its concentration was measured using a gas chromotography (GC) before and after each treatment and for the control of using a continuous-stirred batch reactor (CSBR). In the MFC setup, the anode chamber operating under anaerobic condition can be deemed as the deeper soil layer environment where oil spill contaminants were buried or transported into, and the cathode chamber

with oxygen injection can be deemed as the surface environment of the beach which was exposed to air and winds. In the field application, one electrode can be buried underground, and the other one exposed on the beach surface, and with the connection of the two, electricity can be generated at the same time of oil degradation. And the method can degrade the oil faster as oxygen is indirectly provided to the contaminants underground which need oxygen to be degraded.

4.Results and Discussion

For both the soil and aqueous medium used in the anode chamber of MFC, about 500 mV of OCV was achieved for both during 10 days of operation, which means that the oil has the possibility to be degraded both in groundwater and in soil with the MFC technology. The result also shows that soil medium gives a more stable voltage output, which shows more promising application for MFC technology in the shoreline oil spill remediation. Though the engine oil used in this study cannot represent all the oil components in the oil spill, as most of the oil transported into the soil are light to medium oil, the result here can still indicate some trend for the total reduction of shoreline oil contamination. The GC test showed that after 10 days of operation only, the reduction rate of engine oil was 96% with the soil medium anode, and 75% with the aqueous medium anode, compared to 61% of the CSBR method.



5.Conclusions

A group of salt tolerant and engine oil degrading bacteria was enriched. The engine oil was reduced faster with the MFC technology compared to the CSBR which represents nature attenuation or biodegradation methods in the field. Only after 10 days, as high as 96% of engine oil was reduced in the soil medium in the anode chamber. And about 500 mV of electricity was generated lasting for one week. The experiment indicated the feasibility of shoreline remediation using MFC technology.

6.Acknowledgments

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7.References

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