Sediment Microbe Respiration and Pollutant Response Using Differential Scanning Calorimetry

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Introduction

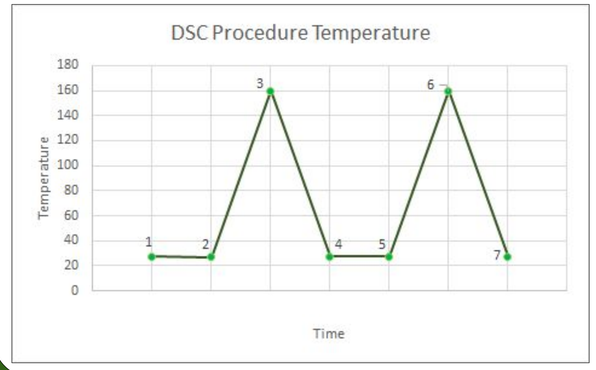
The differential scanning calorimeter (DSC) is able to quantify the amount of energy required to maintain two sample pans at the same temperature. Therefore, the DSC can be used to measure the amount of heat generated by the respiration activity of microorganisms in sediment samples taken from Bayboro Harbor. The goal of this project is to develop a protocol for measuring the respiration rate of the microorganisms in the sediment. That will produce an indicator of the sediment health (Lixia, 2007). This will be accomplished by testing the effect of pollutants on the energy produced by the microbes in the sediment, in order to determine the effect of pollutants on microbial respiration rates.

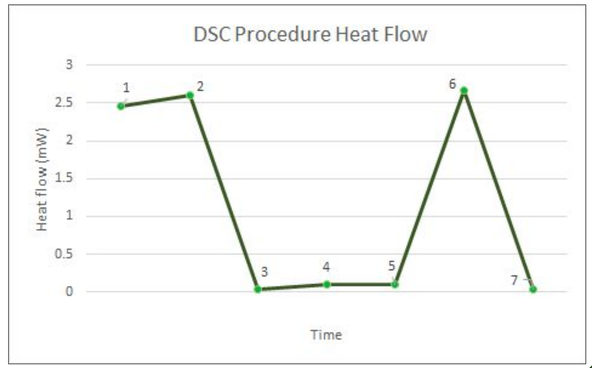
By comparing heat generated by respiration carried out by the microorganisms in polluted samples of sediment to that of unpolluted samples, a general assessment of the effect of the pollutant on the health of the sediment can be made. A larger amount of heat generated by respiration would reflect more microbial activity, and thus a healthier sample of soil. If a consistent rate of respiration can be isolated and quantified, then other conditions of disruption to the respiration of microorganisms in the sediment can be tested.

Calorimetry has been used in other experiments to quantify microbial activity. One experiment employed the DSC to detect the presence of probiotic microbes in cheese. The experimenters wanted to distinguish probiotic microbes from non-probiotic microbes, but it was difficult to do so as they all shared cocci morphology. The microbes did generate different amounts of heat, so the experimenters were able to use a DSC to differentiate the probiotic microbes from the non-probiotic microbes (Szily, 2005).

Methods

1. Set sample to measured outside temperature
2. Contaminate sample with pollutant
3. Heat sample to 160℃
4. Cool sample back to outside temperature
5. Rehydrate sample with water
6. Reheat sample to 160℃
7. Cool sample back to outside temperature





Results

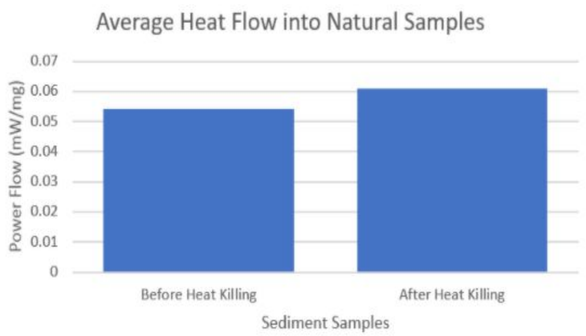


Figure 1. Mean power flow pre and post heat killing.

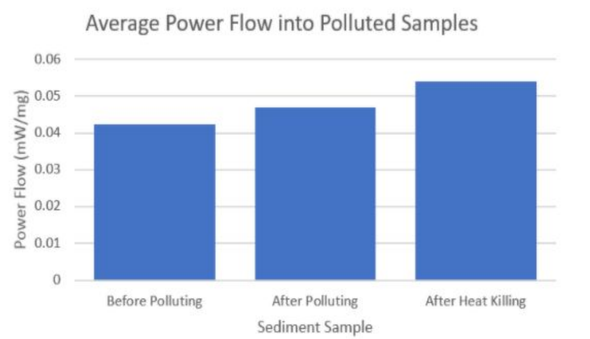


Figure 2. Mean power flow into sediment samples.

Figure 1: Observations show after the sediment was heat killed, the machine used an average of 0.00475 mW/mg more power to keep sediment samples at the same temperature as before the sample was heated. It is hypothesized this is due to elimination of an energy source, likely the respiration of microbes living in the sediment.

Figure 2: The average amount of power required to keep unadulterated samples at their natural temperature during collection was 0.543 mW/mg, and the average amount of power to keep them at this temperature after heat killing was 0.0539 mW/mg. The average amount of power required to keep unpolluted samples at natural temperature during collection was 0.0424 mW/mg, and the average power flow to the polluted samples was 0.470 mW/mg. The average power flow into polluted samples after heat killing and rehydrating was 0.0539 mW/mg. By weighing samples before and after drying in an oven at 100℃ overnight, the percentage of water in sediment was found to be around 21.8%. This percentage was used to approximate how much water would be lost, and therefore how much water was required to rehydrate the sample.

Conclusion

While more research is needed to reliably quantify sediment respiration rate with the DSC, this research showed that there is promise in the area, as this study indicated that some source of energy could be significantly reduced by heating then rehydrating the sample with water to maintain a constant mass. This reduction was postulated to be the elimination of microbial respiration.

The average power difference to the sample before and after being 'heat killed' was 0.00475 mW/mg. This was considered to be the energy provided by the respiration of organisms in the sediment. Then, the samples were polluted before being heat killed. This allowed the energy flow to the sample while in the presence of a pollutant to be measured and compared to what was expected to be no respiration, which was the energy flow to the sample after heating.

Samples polluted with hexane had an average energy difference of 0.0115 mW/mg between the normal and heat killed samples, and an average difference of 0.0046 mW/mg between the normal and hexane-polluted samples. This suggests hexane may reduce the respiration rate of microbes in sediment by about 40%. Further research should be done to obtain more accurate measurements of respiration rates in sedimental organisms. One improvement that could easily be made is the use of a hermetically sealed pan, which would reduce water loss by evaporation significantly, and could be used to more accurately see differences in respiration (Shalaev & Steponkus, 2000).

Bibliography

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