Anaerobic Dechlorination and Mercury Methylation in Raritan Bay Sediment

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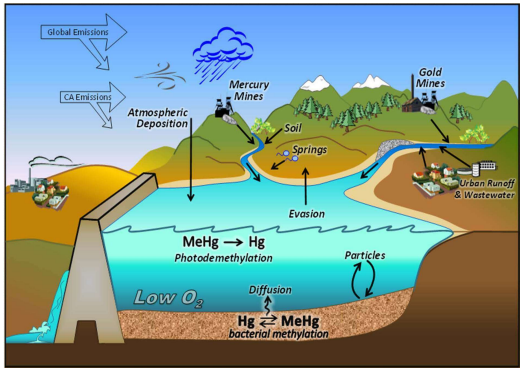
Introduction

Industrial and military operations along with accidental spills have unfortunately resulted in an increase of mercury levels in the environment. Mercury (Hg) emission contaminates food sources because watershed iron and sulfate reducing bacteria in addition to methanogens convert mercury into methylmercury. Now that it is in a more digestible form, methylmercury (MeHg) easily bioaccumulates in the food web causing a host of environmental and physiological issues. The toxin targets the nervous, digestive and immune systems, in addition to the lungs, kidneys, skin and eyes. Mercury is considered by the World Health Organization as one of the top ten chemicals or groups of chemicals of major public health concern.

Background

Neurotoxic methylmercury (MeHg) is produced by anaerobic bacteria and archaea possessing the 38 genes hgcAB, but it is unknown how organic molecules and electron acceptor availability impact proliferation and abundance of these organisms. Tetrachloroethene (PCE) is among other ground water contaminants; it specifically breaks down in anaerobic conditions. .



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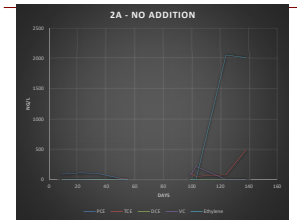
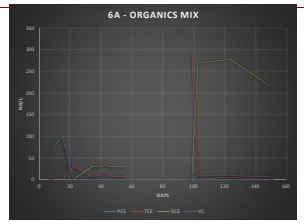
Methodology and Analysis

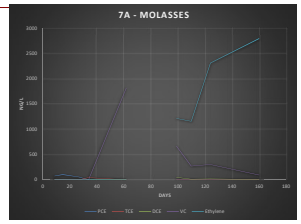
Certain organisms can inhibit or neutralize the methylmercury production. Although primarily synthesized in aerobic environments, this lab is conducted in anaerobic conditions for two reasons. The rationale being that oxygen is an electron acceptor, so the microbes would have less energy to undergo reactions, in addition to efficient tetrachloroethene (PCE) degradation in anaerobic conditions. Monitoring the PCE degradation using a gas chromatogram enabled us to track the growth of the microbes in the sediment obtained from the Raritan Bay. Each amendment was made six times resulting in 36 environments each in 100 ml serum bottles, half of which had the addition of PCE.

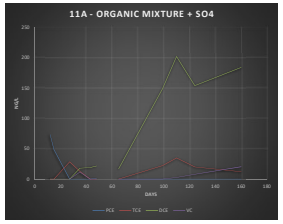
1-3: NO ADDITION
4-6: ORGANICS
7-9: MOLASSES
10-12: ORGANICS + SO4
13-15 :MOLASSES + SO4
16-18: SO4

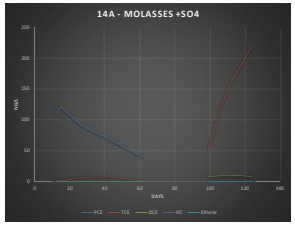
When concentrations of PCE and its monomers were too low in the bottles to continue to monitor microbe growth we added the monomer of PCE, trichloroethylene (TCE) instead of PCE because it would be more time efficient. This continued until the final monomer of PCE, vinyl chloride (VC), showed up in the gas chromatogram indicating abundant proliferation of the culture. The next step is to pick an environment that has shown stimulation at varying levels to analyze for methylmercury production. Taking the bred culture, inorganic mercury is added to monitor the amount of methylmercury created then an analysis of methylmercury production in each environment will occur.

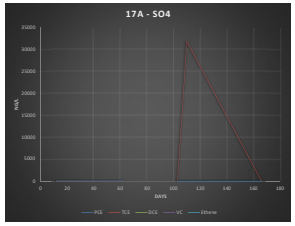






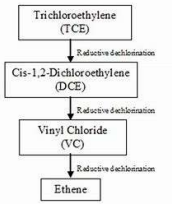


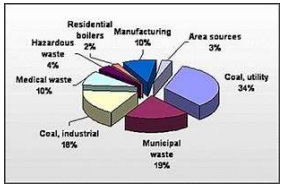




Discussion

Molasses is an organic polymer that is more viscous than the standard organic mixture. This allows for a slow and steady rate of its monomers to be released for microbial consumption, so the production of PCE monomers is not expected to be as fast as the bottles with the organic mixture. By SO4 being an electron acceptor, a molecule that can take and hold in energy available to be used for various subsequent reactions, the floating electrons will be taken up by it rather than the microbes that can need to break down the TCE. This explains why the amendments with SO4 show less dechlorination when compared to the amendments without SO4. PCE degradation still shows in the no addition mixtures because the cultures still have dechlorinating bacteria; the fact that the no addition cultures were not fed any organic solution means that the Raritan Bay sediment has dichlorination potential.





Conclusions and Directions for Future Research

After monitoring the VC produced, an analysis of the MeHg potential must occur. The culture will be split into three bottles for the mercury analysis for further comparison. The data will also be compared to the no TCE cultures, utilizing previous mercury-methylating microorganism identification methods, and will be important for identifying strategies to control MeHg production. In order to better manipulate MeHg production, RNA will have to be extracted from the cultures to find out which markers can be altered to have the desired result of decreased methylation. Quantifying the differences in methyl mercuration within a single amendment, followed up with analysis and RNA extraction techniques which determine the specific genetic makeup of the chosen microcosm, opens up possibilities for environmental toxic management for the surrounding areas.

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