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BioTransformation of Halogenated Flame Retardants

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Introduction

The objective of the Biotransformations in the Tropics, Temperate and Sub-arctic Environments REU is to compare decomposition of halogenated organic compounds in three different climates. Guangzhou in Southern China was the site of the tropics research. In conjunction with graduate students of South China University of Technology the biotransformation processes of anaerobic microbes on compounds were examined.

Approximately 10% of waste in developed countries is electronic waste or 'e-waste': computers, cell phones, batteries, household appliances etc.[3]

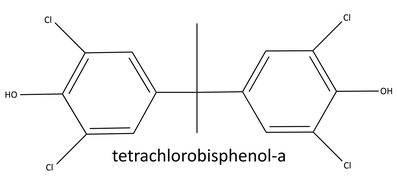
Even though the Basel Convention stipulates that it is illegal to export e-waste, about 70% of the world's e-waste is transported to China.[1]

There, open-flame burning and acid digestion directly into soil are methods used to harness the valuable materials found in e-waste

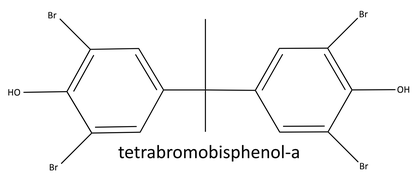
Dioxins and halogenated flame retardants are consequently released directly into the environment

The health effects are mostly unkown but they are likely endocrine disruptors. Brominated flame retardants are already widespread in biota and humans in the region.

TCBPA comes from large appliances while TBBPA is a flame retardant used in printed circuit boards, important components of many electronic devices.



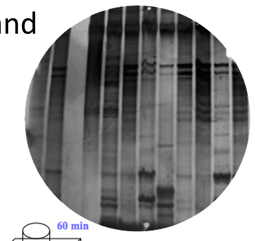
tetrachlorobisphenol-a



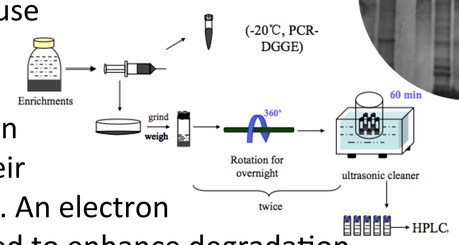
tetrabromobisphenol-a

This study examines two approaches to remediation of the potentially harmful compounds found in sediments throughout the Guangdong Province.

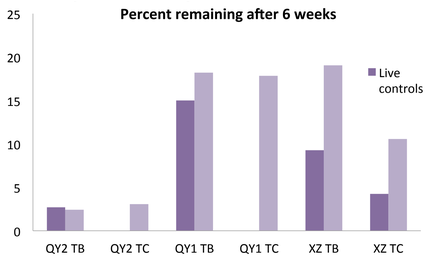
Biological Remediation



Sediment samples from 2 e-waste sites and one control were inoculated with TBBPA and TCBPA. Microbes in the sediment are thought to use Halogenated compounds as their electron acceptors in their metabolic cycle. An electron donor was added to enhance degradation.



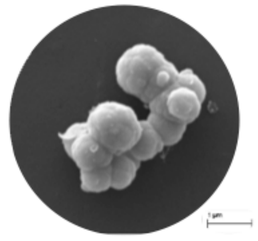
The biodegradation was observed using a method adapted from Voordecker's et al[5]. In total there were 54 microcosms: 2 compounds, 3 sites, 3 treatments and triplicates of each condition. Each site tested for both contaminants, TBBPA and TCBPA. The three conditions were: the live control, dead control and an enriched electron donor. Samples were taken weekly for six weeks and underwent through HPLC analysis. Further, PCR-DGGE analysis was performed for Week 0 and Week 5 samples. Ultimately it was found that all treatments degraded the compound by 80%.



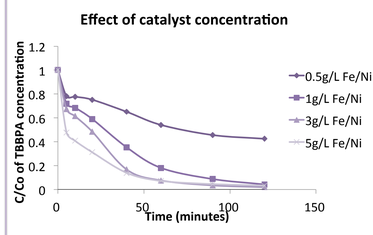
Conclusion

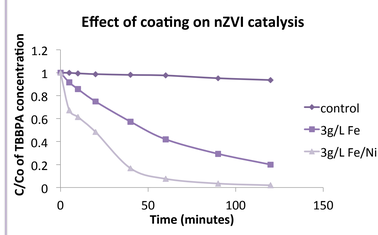
Significant degradation suggests that there may be other sources of loss besides microbial activity. DNA analysis suggest the magnification of certain preexisting microbes in week five and shows the same microbial community among all soil samples that were 80 km apart.

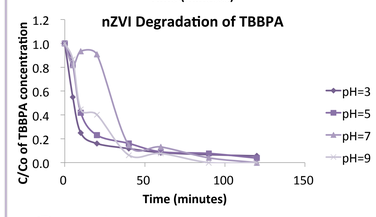
Abiotic Remediation



Abiotic Nano-Zero Valent Iron (nZVI) reactions were performed to compare methods of potential in-situ remediation of TBBPA at contaminated sites. nZVI catalysts are used as a commercial treatment for waterwaste plumes where a permeable reactive barrier is installed at a groundwater site[6]. The iron nanoparticles are formed in the following reaction: $2Fe^{3+}+3BH4-+9H2O \rightarrow 4Fe^{+3}\ H2BO3^{-}+12H^{+}+6H2$







The nanoparticles were vacuumed stored, observed with a scanning electron microscope, and used with a week to prevent oxidation effects. HPLC analysis was used to detect concentrations of TBBPA.

Degradation was observed in 3 experiments in hopes of determining the ideal conditions for dehalogenation:

1) Comparison of catalyst concentration
2) Effects of nickel coating on particles
3) Effect of PH

Conclusion

The ideal conditions for TBBPA degradation in the lab involve nickel-coated iron catalysts at a concentration of 1g/L in acidic conditions

Suggestions for Future Investigation:

- Test nanoparticles on various contaminated sediment samples
- Detect subsequent de-halogenated compounds to see if BPA is a final product
- Test various acidic PH levels to find optimal conditions for dehalogenation
- Sequence the DNA of the surviving microbial community
- Assay potential costs of enforcing these various remediation techniques

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