CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
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Project Number
S0808

Project Title
Design for Biodegradation: Harnessing Natural Decay by Managing Physical and Chemical Dynamics

Abstract

Objectives/Goals
The goal of this project was to determine how key physical and chemical parameters such as carbon:nitrogen ratio, moisture, and aeration, affect biodegradation efficiency and decomposition rates for organic material, impacting our ability to recycle organics and reduce the amount sent to landfills.

Methods/Materials
To assess biodegradation efficiency, small bioreactors were constructed for composting samples with varying carbon:nitrogen ratio, moisture, and aeration design (9 variations with duplicates per run, replicate runs). Temperatures produced were measured by probing samples in 3 mid-pile locations 3-5 times daily. To look at decomposition rates of organic samples, oxygen uptake and therefore CO2 emission was measured by monitoring liquid displacement in custom-built constant pressure respirometers.

Results
Optimum carbon:nitrogen ratio was 30:1, a lower ratio (20:1, increased nitrogen) resulted in a 41% drop in averaged net temperature, and a higher ratio(40:1,increased carbon) resulted in a 51% drop. Measured CO2 emission rates were up to 8 times higher for organics high in nitrogen during initial decomposition, and 4 times higher for optimum moisture (55%) versus high moisture (70%). A 55% initial sample moisture produced optimum average temperatures, 40% sample moisture had average temperatures 21% lower, and 70% sample moisture produced average temperatures were 56% lower. Low to medium aeration design yielded optimum results, with high aeration reducing the net temperatures by 56%.

Conclusions/Discussion
Results stressed the need to design for efficient biodegradation by showing very significant drops in temperature, produced by composting systems with design parameters deviating from the extracted optimums. Samples too high in nitrogen had high initial decomposition rates consistent with steep ramp-up to peak temperature, but were unable to maintain their high temperature probably because not enough carbon was available to support rapid bacteria growth. The higher moisture level (~70%) slowed biodegradation down by a great amount, probably because the excess moisture not only inhibited the decomposition rate, but also cooled down the decomposing samples. Results for optimum aeration showed that contrary to popular opinion, low to medium aeration yielded similar results, while high aeration had a very negative impact on the system, probably because of cool air it introduced.

Summary Statement
This research work determined the impact of several key parameters that should be managed to improve the efficiency of the biodegradation process of organic waste.

Help Received
I consulted with LabPro staff, Renee Jacowitz, and my mother on materials and measurement techniques. My mother helped me acquire materials.