Evaluation of Different Microbial Seeds on the Carbon Dioxide Production and Weight Loss of Sugarcane Bagasse Composting

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Abstract:

Natural biomass-based adsorbents have potential as an inexpensive tertiary wastewater treatment and may be degraded afterwards. The objective of this study is to evaluate several microbial inoculum sources; compost, activated sludge, cow manure and white rot fungi, for lignocellulosic biodegradation by monitoring carbon dioxide production and weight loss of a sugarcane bagasse adsorbent. Cow manure was forecasted as the best inoculum with a predicted 120% mass loss at 60 days and white rot fungus consortium next with a 74% mass loss.

Introduction

Adsorption is a common tertiary wastewater treatment for industry in which natural adsorbents have been researched regarding their potential for activated carbon (AC) replacement. Generally, these adsorbents have a lower adsorption potential, but are a more abundant and cheaper alternative to AC. Sugarcane bagasse is a promising material as a natural adsorbent.[1]

Once any adsorbent has reached its maximum capacity for contaminants – it has to be handled as a hazardous material. Currently, there is a lack of data on how these novel adsorbents will be either treated or managed after they are spent – although composting is a viable disposal technology for waste lignocellulosic biomass.

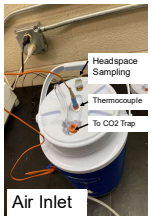
A prior study on sugarcane bagasse composting by Ansari, et. al. used compost to inoculate a feedstock mixture containing sugarcane bagasse in roughly a 2:1 by weight inoculum to feedstock ratio, resulting in with a low biodegradation rate over 112 days. This was hypothesized due to it's low water holding capacity due to the lignin content.[2]

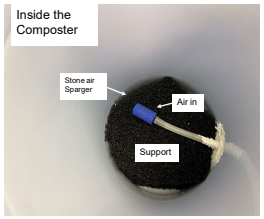
Biodegradation rates of sugarcane bagasse were increased by using pure cultures such as *Bacillus* strains as inoculants which resulted in a 91.37% organic matter loss from an initial 79.5% organic matter content[3]. Currently, to the authors' knowledge, there is no study that compares actual mass loss/biodegradation of purely sugarcane bagasse using different inoculum. Most literature uses sugarcane bagasse as a bulking agent or for co-composting purposes.

This study aims to initiate a series of experiments on compost-based biodegradation as a management and treatment method for spent, natural adsorbents using sugarcane bagasse as a model material.

Objective

Evaluate mass reduction and carbon dioxide production during composting of sugarcane bagasse inoculated with various naturally found microbial consortia.





Methodology

Reactors

The reactors were constructed using 1 gallon insulated containers with fitted ports for a thermocouple, a septum for GC gas analyses along with vents and tubing for aeration.

Sample Preparation

A control of compost from LUS' Dean Domingues Compost Facility and five seeds mixed with sugarcane bagasse samples were tested: compost, activated sludge, cow manure, a consortium of rot fungi, and no seed. Duplicate reactors were used in all cases except the control.

Sugarcane bagasse was mixed with compost, activated sludge, and cow manure in a 3:1 weight ratio, and in a 1:1 volume ratio for rotting wood believed to contain white rot fungi consortium. For the mixtures below 50% moisture, water was added to increase to 50%. No other amendments were added.

Monitoring and Maintenance

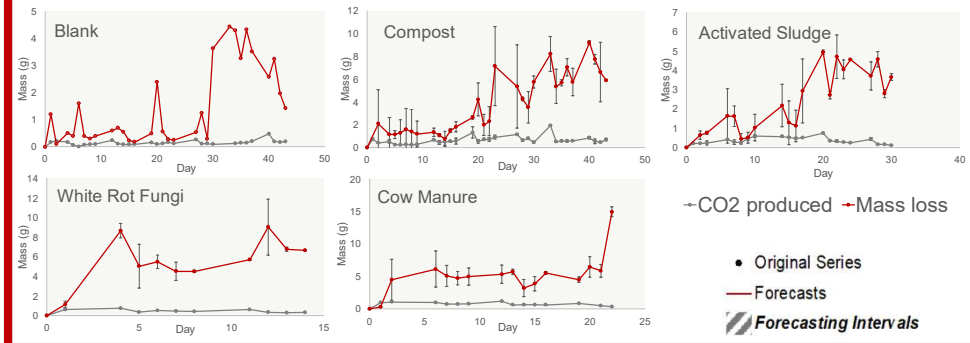
For each reactor, the following measures were taken daily to monitor the progress biodegradation: a) Weight of the reactor over time; b) Temperature data collected using thermocouples; c) Carbon Dioxide production within the compost reactor gas volume; and d) Oxygen uptake. After monitoring each reactor, the reactors were aerated for about 20 minutes to ensure aerobic conditions.

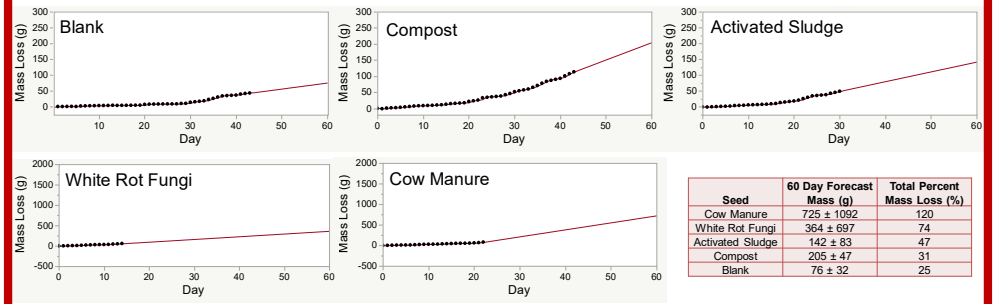
Data Analysis

Weight loss data was forecasted using an exponential smoothing model in JMP SAS over a 60 day simulated incubation and percent weight losses after 60 days were compared.

Results

The top graphs show the daily mass lost and mass of CO_2 produced for each inoculum. Below are the total mass loss and the forecasted mass loss for 60 days.





Seed	60 Day Forecast Mass (g)	Total Percent Mass Loss (%)
Cow Manure	725 ± 1092	120
White Rot Fungi	364 ± 697	74
Activated Sludge	142 ± 83	47
Compost	205 ± 47	31
Blank	76 ± 32	25

Conclusions

The projected mass losses indicate that cow manure was the best seed for degrading sugarcane bagasse due to its heterogeneous and highly populated microbial consortia present,[4] with an estimated 120% weight loss which is unrealistic (indicating rapid degradation in less than 60 days). White rot fungi was the next best at 74%, likely because white rot fungi contains ligninase enzymes which degrade lignin.[5] For both cow manure and white rot fungi values, there is a lot of uncertainty due to smaller number of sampling days and/or because of the high rate of biodegradation. In conclusion, the microbial consortium from cow manure then white rot were the best at degrading SCB.

Future Work

Future work will investigate the potential inhibition effect of adsorbed 2,4-dichlorophenol (DCP) on spent adsorbent composting using both cow manure and rot fungi as a inoculum. Also, composting optimization of other natural adsorbents with different structural compositions need to be evaluated.

References

[1] Andrade Siqueira et al., "Sugarcane Bagasse as an Efficient Biosorbent for Methylene Blue Removal."

[2] Ansari et al., "Comparison of Composting of Chemically Pretreated and Fermented Sugarcane Bagasse for Zero-Waste Biorefinery."

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[4] Gupta, Aneja, and Rana, "Current Status of Cow Dung as a Bioresource for Sustainable Development."

[5] Dong et al., "Sugarcane Bagasse Degradation and Characterization of Three White-Rot Fungi."

Acknowledgements

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