A Novel Method to Accelerate the Degradation Rate of Plant-based Tableware Using Compost Tea

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Abstract

Compost tea is a leachate of food scraps and soil that can be brewed in under 48 hours, producing bacteria rich material significantly faster than traditional compost. It is proven to more rapidly and efficiently increase nutrient and microbial concentration in the soil, while also promoting plant growth, health, and disease resistance. This study, however, focused on the tea's effect on the degradation of plant based materials. It was hypothesized that aerated compost tea will increase the degradation rates of plant based tableware while also increasing nutrient content in the soil used. After the experiment was completed, it was confirmed that the hypothesis was true, and that aerated compost tea can help entire sugarcane bagasse bowls degrade completely in 30 days.

Introduction

Composting is the process of decomposing organic matter for the purpose of creating a natural fertilizer. Green matter, such as leaves and food scraps produce nitrogen, while brown materials, made up of wood chips, provide carbon for the compost. This results in a more rich soil that facilitates the growth of healthier and more resistant plants. While this is a great source of nutrients for plants, compost could take anywhere from a few weeks to over a year to make, depending on the size and materials used.

Aerated Compost Tea (ACT, or simply compost tea) is a possible solution to this issue. Ready in 24 to 36 hours, compost tea is a leachate of compost and food scraps, which contains thousands of active bacteria, protozoa, and fungi. The food scraps are placed in a mesh "tea bag" and submerged into the water, which is circulated for the desired amount of time. The aeration of the water keeps the tea at the ideal condition in which microbial growth is promoted. These microorganisms will then help develop stronger roots and resistance to disease when used on plants. When the tea is brewed for 24 hours or less, it produces a bacterial dominated tea, while tea brewed for more than 24 hours yields a more fungal dominated extract (Ingham, 2005). To facilitate the growth of each, differing ratios of molasses and humic acid can be used to feed the developing bacteria and fungi, respectively. Also, due to its liquid state, it can more easily be spread across a wider range.

There has been very little research revolving around compost tea in general, most of which tests the growth and/or disease resistance of plants. Previous research has shown that compost tea helps increase the growth rate of plants, but the tea must be applied in different ways based on the type of tea and the stage of growth the plant is currently in. For example, one paper on the growth promotion of lettuce, soybeans, and sweet corn showed that growth promotion was at its highest when the tea was watered to the plant while it was a sprout, and sprayed on the plant once it began growing more mature leaves (Kim, 2015). Another research paper tested the efficacy of compost tea and biological fungicides on disease rates in plants. It was concluded that compost tea lowered disease ratings and symptoms, with a 5.23% disease rating compared to the control, at 26.15% (Kouyoumjian, 2007).

Every day, thousands of pounds of plastics are polluted into the ground and the oceans. Anywhere from 60 to 95 percent of ocean pollution is plastic waste (Le Guern). According to National Geographic, every year the amount of plastic pollution is equivalent to five garbage bags full of plastic for every foot of coastline on Earth (Parker). To combat plastic pollution, plant based tableware are being introduced into the market, with guarantees that they will degrade in 60 to 90 days.

Considering there is little to no research regarding compost tea and degradation, the research question posed was: Does Aerated Compost Tea Affect the Degradation of Plant-based Tableware and the Nutrient Concentration of the Soil Used? Considering that previous research has proven that compost tea significantly increases microbial density and NPK values of soil (Scheuerell, 2002), it would be hypothesized that the degradation rates of plant based tableware will indeed be increased, while also increasing the nutrient concentration in the soil used.

Methods

The materials used in this experiment are as follows:

- Sugarcane Bagasse Bowls
- 5 Gallon Bucket + Lid
- Polyethylene Pipes
- Braided PVC Hose
- Brass Hose Nozzle
- 50 Watt Aquarium Aerator
- Molasses
- Humic Acid
- Chlorine Removal Solution
- Food Scraps
- Compost
- Paint Strainer Bags
- Soil Humidity Meter
- Handheld Shovel
- NPK Test Kits

The first stage of this experiment was to build a compost tea brewer. First, a 5 gallon bucket lid was taken and 4 holes of ½ inch diameter were drilled equidistant from each other along the circumference of the lid, each being 1 inch from the edge of the lid. Four 12 inch cross-linked polyethylene pipes were then fit into the bottom of each of the four holes. Four brass nozzles were connected to the pipes via the top side of the lid, with HVC braided PVC hoses connected to each nozzle. Each hose was then connected to a 50 Watt aquarium aerator, which helps the tea aerate during the brewing process.

The brewing process started by adding water to the bucket. Once the bucket was 75% full, 5 ml of chlorine removal drops was added to ensure the water was clean of any toxins. Two tablespoons of unsulphured molasses was diluted in two cups of hot water, and added to the water. Then, two tablespoons of humic acid were diluted in two cups of water (at room temperature) and added to the bucket. Lastly, 190 grams of compost and 190 grams of food scraps were mixed and placed in a mesh paint strainer bag. The bag was lowered into the bucket and tied to the bucket's handle. The aerator was turned on and the tea was allowed to brew for 24 hours. After 24 hours, 2 cups of the tea were distributed to each of the 9 test samples. 3 additional plates were kept in soil separately as a control group, and did not receive any tea.

On each day of the trial period, the soil moisture and pH was measured with a soil moisture meter and a soil pH meter. This data is vital for the analysis stage, as they provide connections between degradation patterns and soil conditions. At the end of each 10 day interval, a new batch of tea is made and distributed between the samples. Also at this time, a soil nutrient test was administered to determine the nitrogen, phosphorus, and potassium values of the soil. This data will also be used later, and will allow for better understanding of the sample's progression as the soil's nutrient concentration changes.

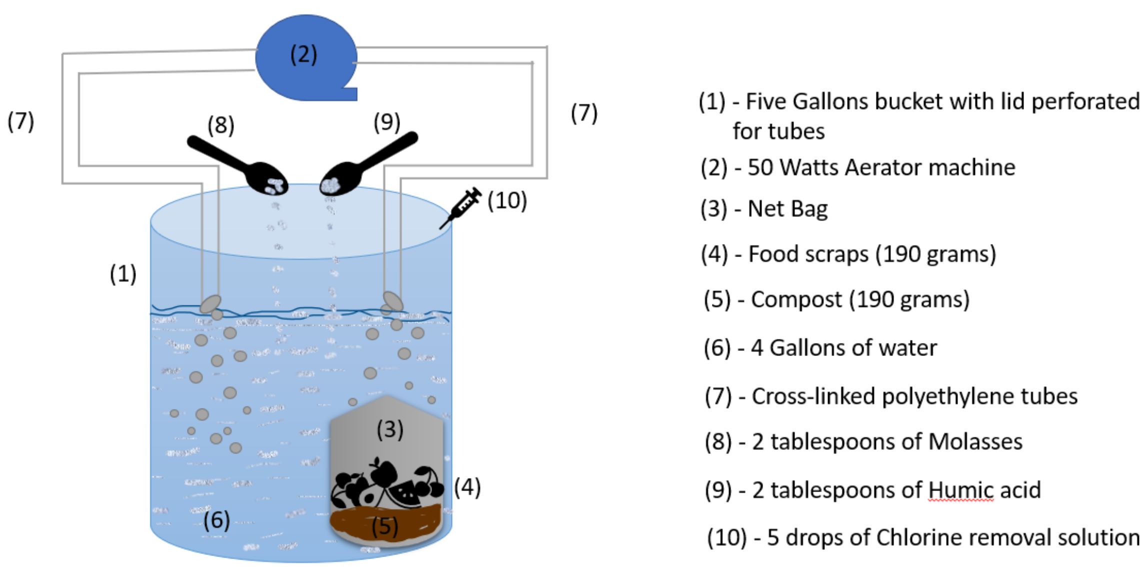
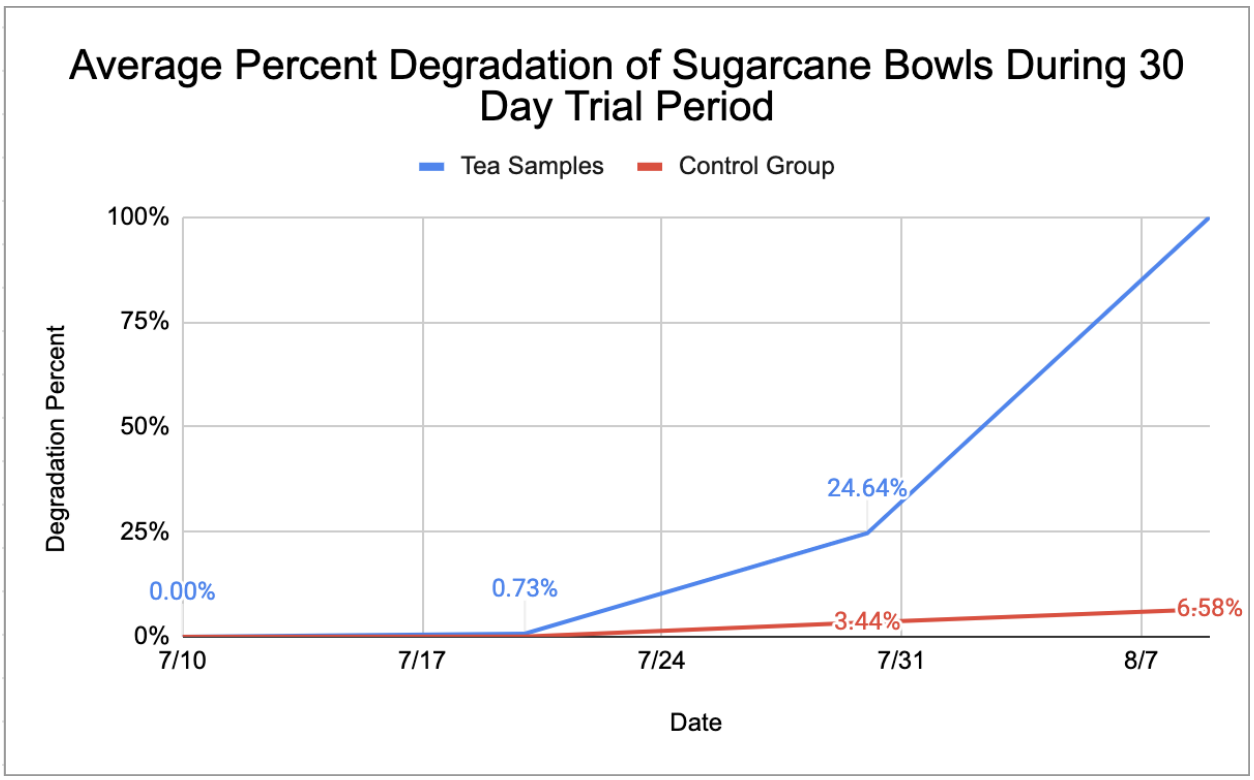


Figure A: Aerated Compost Tea Brewing System (ACTBS)

Figure A: Shows a diagram of the Aerated Compost Tea Brewing System (ACTBS) created for the experiment. All steps and materials are labeled on the side.

Results

Every 10 days, the samples were briefly removed and degradation progress was calculated. This was done by taking photographs of each sample, placing the outlines on a grid, and calculating the percent degraded. Once the 30 day trial period came to an end, all samples were retrieved from the ground and once again calculated for the percent of degradation. All the sugarcane bowl tea samples started out with 0.00% degradation at day 0. On day 10, the average degradation percentage was 0.73%. On day 20, the average degradation percentage rose significantly to 24.64%. On day 30, the last day of the trial period, all 9 bowls had completely degraded. When looking at the control group, the average degradation percentage was 0.00% for day 0, 0.02% for day 10, 3.44% for day 20, and 6.58% for day 30.



(Figure B)

Figure B: Graph showing the average percent degradation of both the control and test groups of sugarcane bowl samples. The points mark every 10 days in the 30 day trial period, including the day the samples were placed and the first tea batch was distributed (day 0).

Also every 10 days, a small sample of the soil was taken, and nutrient tests were conducted on the soil using NPK testing kits. The soil started out on day 0 at level one for nitrogen and phosphorus, meaning there was a deficient amount of both in the soil. Potassium was at level two on day 0, meaning there were “traces” of potassium in the soil. At day 10, phosphorus levels remained the same at level 1, and potassium levels remained at 2. Nitrogen increased from deficient to level two. On day 20, nitrogen remained the same at level two, while phosphorus increased to level two. Potassium increased to level 3, meaning there was a sufficient amount of potassium found in the soil. Lastly, at day 30, there was a surplus (level four) amount found for nitrogen, phosphorus, and potassium in the soil.

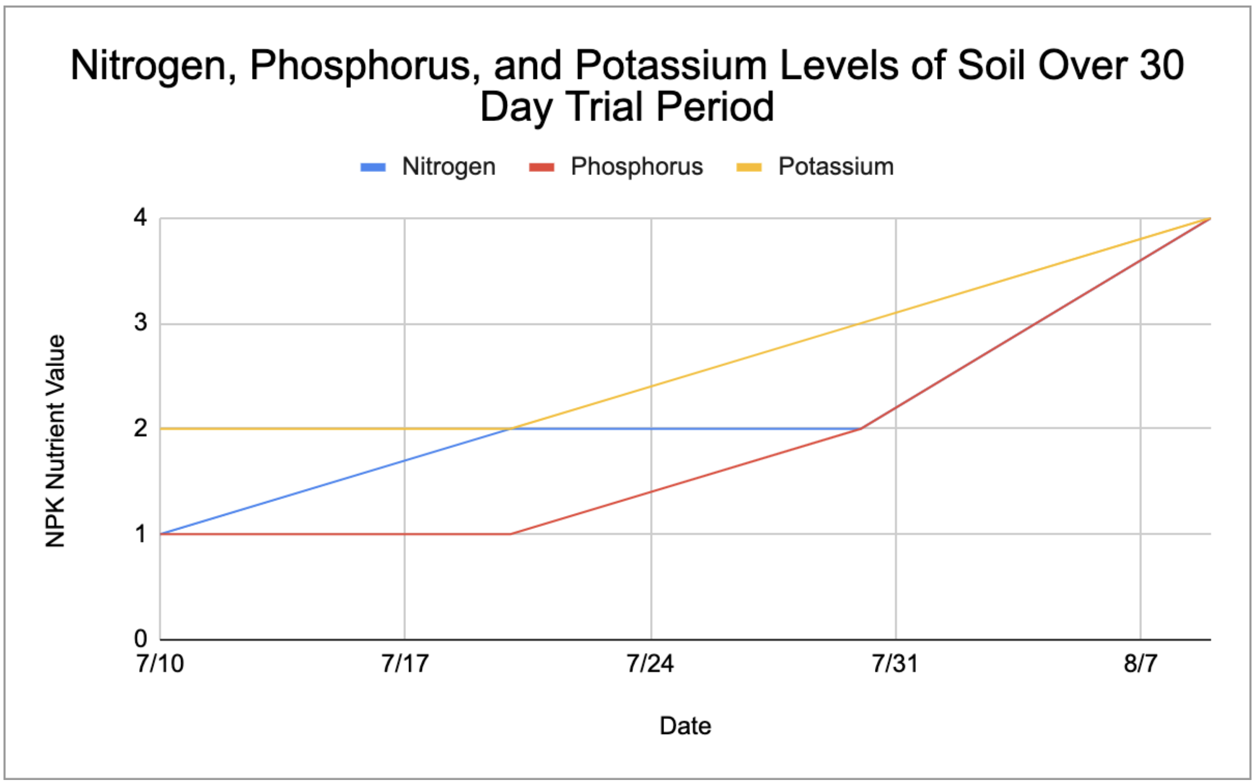


Figure (C)

<u>Figure C</u>: Graph showing the change in nitrogen, phosphorus, and potassium levels in the soil over the 30 day trial period. The points mark every 10 days in the 30 day trial period, including the day the samples were placed and the first tea batch was distributed (day 0).

Lastly, on every day of the 30 day trial period, the soil moisture levels and ph levels were recorded for the soil. This was mainly to find any patterns between degradation percentage and soil moisture/pH during the analysis phase.

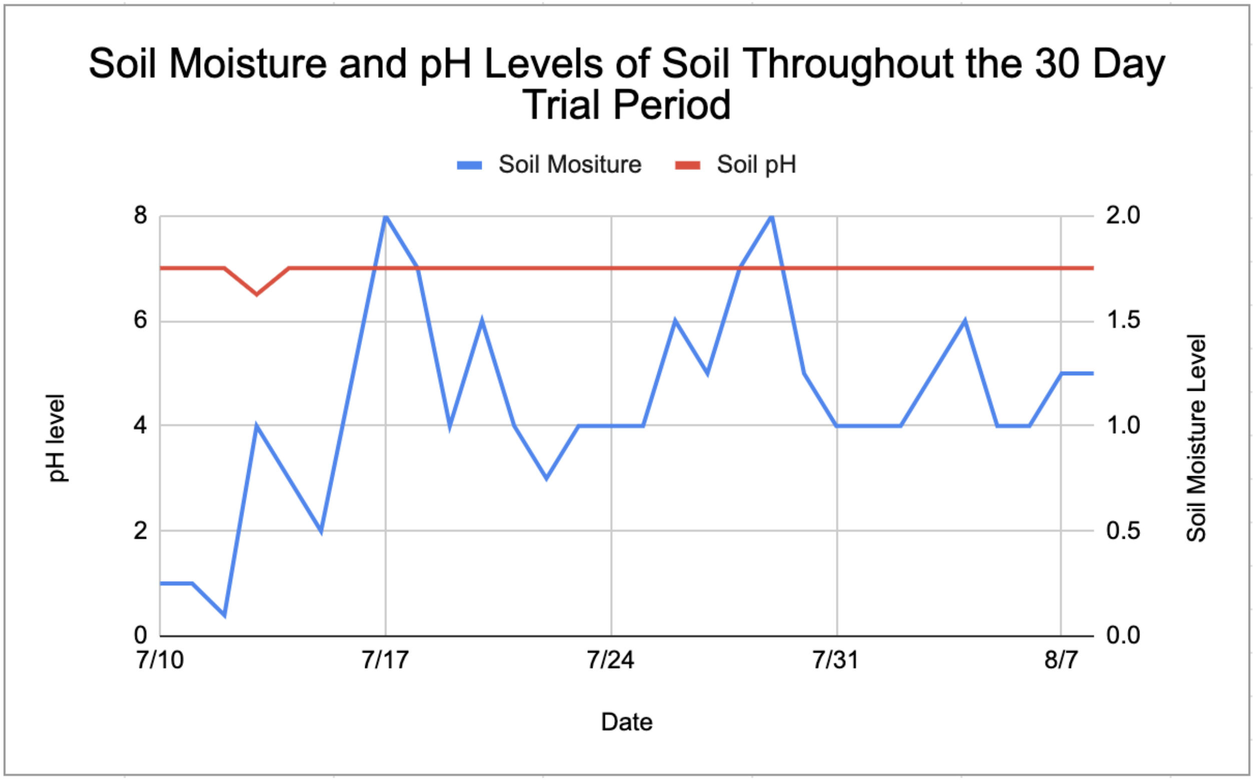


Figure (D)

<u>Figure D</u>: Graph showing the change in soil moisture and pH levels in the soil over the 30 day trial period. The points mark every day in the 30 day trial period, including the day the samples were placed and the first tea batch was distributed (day 0).

Discussion and Conclusions

Soil erosion is the degradation of topsoil caused by wind, water, and natural life. However, climate change has drastically increased the prevalence of this throughout the world (Borrelli, 2020). Topsoil, approximately the upper 10 inches of the earth's surface, is where most of the soil's biological activity occurs. Since most plants have roots in topsoil, when soil is eroded, it can kill off microbial life and dry out the soil, rendering the soil unusable. In 2007, the US had reported an average soil loss rate of 0.95 millimeters per year (Montgomery, 2007), a figure that would surely be greater in 2022.

Compost tea is a promising possible solution to this problem. Not only does it provide a means to increase the nutrient content of soil, but it also does so in a much shorter period of time, since the composting process is cut down to under 2 days. If this research was funded, it could quantify the efficacy of compost tea on improving soil, and could possibly lead to large scale brewing being implemented in farms across the globe.

It can be concluded from the experiment that the compost tea resulted in an increased degradation rate of sugarcane bagasse tableware. When compared to the control group, the sugarcane samples which had compost tea applied to them degraded at a much faster rate. From the data and the graph, it can be inferred that both the degradation rate in the test groups and nutrient content in the soil experienced a significant increase after day 10, and a greater increase in degradation rate after day 20. Most of the degradation occurred in the last 10 days. Using the data from the NPK tests, it can be seen that there was a deficient amount of both nitrogen and phosphorus, and traces of potassium found in the soil when the experiment was started. By the end of the 30 days, all three of these nutrients had increased to level four, a surplus in the soil. This serves as evidence to prove that compost tea also increases the nutrient content in the soil, overall improving the soil quality, and aiding the degradation process. It can also be concluded that the variety of bacteria produced by the tea kept the soil at a relatively neutral pH, while the tea itself increased the average moisture levels of the soil, something water was not able to do alone in the summer heat.

Looking to the future, with the recent plastic bag bans in New Jersey, the ban of other plastic materials, such as tableware, is increasingly prospective. If this were to become a reality, the use of biodegradable alternatives would surge, but would pose problems of its own. Not all biodegradable products will be guaranteed to end up in a recycling center (Bulkeley, 2009). Assuming landfills sort items by size and weight, and considering that biodegradable materials degrade best in aerobic conditions (Polman, 2021), large piles of material could restrict access to oxygen and significantly decrease the degradation rate. However, compost tea could once again prove useful in this situation, increasing the range in which the waste comes into contact with microbial life, and hence speeding up degradation. The same large scale brewing proposed for farms could be used in landfills as well.

Overall, compost tea has been concluded to increase both the degradation rates of commonly used plastic tableware alternatives (sugarcane bagasse bowls) and the nutrient (nitrogen, phosphorus, and potassium) content in the soil.

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