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Reducing Decomposition Time in Landfills by an Aerobic Process

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by

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Abstract

This experiment was performed to determine if sludge produced by the paper industry could be composted faster by promoting the aerobic degradation process. To perform this experiment, I chose a sludge produced by a virgin pulp mill. Once I collected sludge, it was dewatered to a moisture content of sixty-five percent or less. As soon as the sludge was dewatered, I set up four separate composting systems, three of which were run under aerobic conditions and one that was run under anaerobic conditions. The anaerobic conditions only had sludge and plastic for its bulking agent. In the aerobic systems there were three different types of bulking agents used; pine bark, plastic and compost. In the aerobic systems air was introduced into the system. To determine how fast each of the processes was composting, I collected the gases that were produced by each of the systems. The gases that are produced by an anaerobic process are carbon dioxide and methane, whereas an aerobic process produces carbon dioxide and water. Therefore, by analyzing the gases produced by each of the systems periodically and determining the amount of carbon dioxide produced by each of the systems, one can determine the rate of decomposition of the sludge for each of the separate systems. Also the chemical oxygen demand (COD) was determined for each of the system, before and after the degradation occurred. COD was used to measure that content of organic matter in the sludge. This also helped in determining the degradation that has occurred in each of the systems.

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Objective

The objective is to reduce the decomposition time in paper industry landfills by an aerobic process. By reducing the amount of time the sludge is in the landfills, this will help the landfills be more profitable.

Problem Statement

The problem is that landfills are running out of space. Also these landfills are only being used once. This is due to the fact that the landfills operate in anaerobic digestion, which takes a long period of time to complete. By decreasing the time of degradation in landfills and making the end product beneficial in using as a land application, the landfills could be cleaned out and reused.

Experiment

The experiment is to reduce the decomposition time in paper industry landfills. This will be done by introducing air into the landfill, which will make the decomposition process an aerobic one instead of anaerobic. Also, in an aerobic composting process, methane gas is not an issue because it is not produced by the system. This is because an aerobic process produces water and carbon dioxide whereas an anaerobic process produces methane and carbon dioxide.

There are three main problems that need to be emphasized; dewatering the sludge, increasing its porosity and determining the rate of composting. The sludge coming into the landfill needs to be dewatered to a moisture content of sixty-five percent or less. The problem comes in that there is no quick method of dewatering the sludge. The water can not be squeezed out by using a press due to the fact that the sludge is too slippery and will be pressed out with the water. Therefore, the only way to dewater the sludge to the correct moisture content is to place the sludge somewhere so that the water can evaporate off. Another problem with the sludge is that it has a very poor porosity, therefore it will be hard to aerate uniformly. To eliminate this, a bulking agent is needed to make it easier to introduce air into the system and to prevent the air from channeling. With the sludge at the desired conditions, a way to determine the rate of decomposition for the biological processes was needed. To do this the amount of gases that are produced by each process for a given amount of time was determined. All the gases that are produced by each process were collected, and analyze for carbon dioxide and methane. Also the chemical oxygen demand (COD) will be determined for each of the system, before and after the degradation has occurred. COD is used to

measure that content of organic matter in the sludge. This also helps in determining the degradation that has occurred in each of the systems.

To determine if an aerobic process will help in reducing the time of decomposition compared to that of an anaerobic process, I performed four different experiments that operated separate from each other. Three of the systems were aerobic and one was anaerobic. Each of the four composting processes were performed in a closed system, so that all the gases produced by each separate system were collected and analyzed. To make each of the systems closed, I used four separate PVC pipes that could be sealed at each end. These PVC pipes were two feet tall with a diameter of eight inches. For the three systems running under aerobic conditions, I had hoses that were attached to the tops of each of the PVC pipes. At the end of each of these hoses there was a vacuum bag attached, so that all the gases produced by each of the systems could be collected and analyzed. They were also modified so that a constant stream of air could be introduced into the composting system. I did this by putting a hose in the other end of the PVC pipe, which flowed through a screen. This screen allowed the air to flow freely through and did not allow the sludge to penetrate it. This helped distribute the air more evenly through the sludge, thereby eliminating channeling. Since the aerobic systems had a lot of air passing through them and the vacuum bags did not have the capacity to hold that amount of volume, these systems were sampled by composite sampling. The composite sample that was done in this experiment was each bag was opened for half an hour each day. By knowing the volume in each of the vacuum bags and the time it took to collect, the flow rate was determined. Then testing the bags with a gas spectrometer and using the flow rate, the amount of gas produced by the system was determined. The PVC pipe that contained the system that was going to be run under anaerobic conditions also had

this same screen in it; this helped the PVC pipe to have a reservoir for the collection of leachate. This PVC pipe will also had a hose coming out of the top of it, instead of composite sampling like the aerobic systems; the gas was collected constantly throughout the whole experiment.

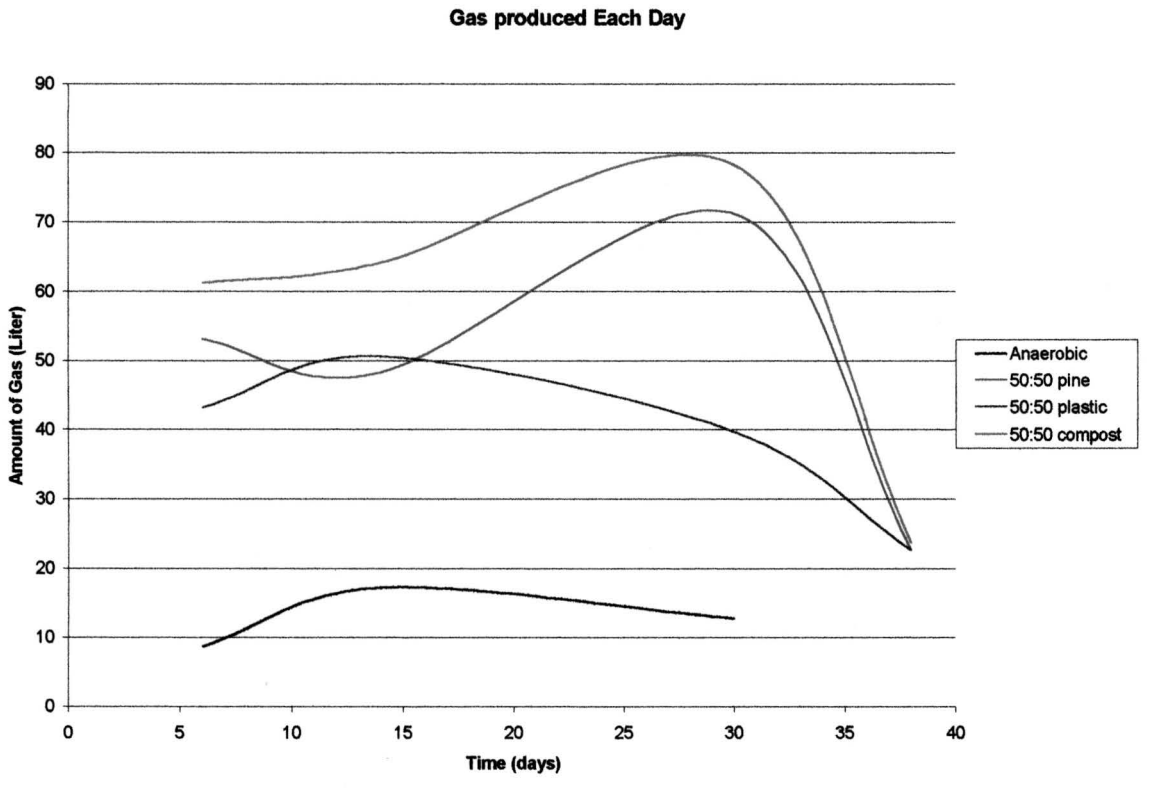
Once the separate systems were ready, I used a sludge that was produced by a virgin pulping mill to perform my experiment. This sludge needed to be prepared before it can be placed into each of the systems. First the sludge needed to be dewatered to a moisture content of sixty-five percent or less. Then, after the sludge was dewatered, a bulking agent was added to increase the porosity and help air entrapment in the system. The amount of bulking agent that was added is one part sludge to one part bulking agent. The bulking agents that I used were pine bark fines, compost, and plastic. Pine bark was used because it contained bacteria that attacks diseases contained in the sludge. Compost was used to see what different effects that the bulking agents had on the composting rate. Plastic was used so one could determine the effects that the pine bark or compost had on the decomposition rate. The bulking agent was the only additive that I added to the sludge. When I set up the four different systems I varied the type of additive added in the sludge for each of the four systems. In the three aerobic systems there was one with plastic as the additive, the other had compost added, and the third one had pine bark as its bulking agent. The anaerobic system had just the plastic added into the sludge.

To determine how fast the decomposition process was going, the gases that were produced by each of the systems were collected and analyzed. By analyzing the amount of carbon dioxide that was given off by each of the systems compared to the amount of time the system was operating, it was determine how fast the decomposition process was proceeding.

Also the chemical oxygen demand (COD) was determined for each of the system, before and after the degradation occurred. COD was used to measure that content of organic matter in the sludge. This also helped in determining the degradation that occurred in each of the systems.

Results

This experiment showed that aerobic methods had the greatest change in degradation as compared to anaerobic methods. This was proved by the amount of gas that was produced by each system and the change in the chemical oxygen demand in each of the composting systems. The amount of gases that were produced by each of the systems is shown in the graph below.



This shows that aerobic composting system with the compost added as a bulking agent produced the most gas per day. This was closely followed by the system with the pine bark added. The anaerobic system did not produce a large amount of gas, as seen in the chart. Also by looking at the percent change in the chemical oxygen demand (shown in the table

below), it can be verified that the gas produced is a good indicator as to how much the sludge is being composted.

Percent Change in Chemical Oxygen Demand	
Anaerobic (plastic)	10.64%
Aerobic (pine)	61.53%
Aerobic (plastic)	49.66%
Aerobic (compost)	58.64%

This shows that the aerobic systems had the greatest change in chemical oxygen demand, with the pine bark and compost having the greatest changes. This is also shown in the above graph, which had these two systems producing the greatest amount of gas. Also in the chart above, the amount of the gas being produced at the end of the four weeks for each of the aerobic systems drops off, which is good indication that the degradation process is coming to an end. Therefore by looking at the change in chemical oxygen demand and the amount of gas produced by the systems, it can be determined that the aerobic systems compost the sludge at a much faster rate than the anaerobic system. So by using this information one can conclude that the aerobic process would be a viable option in reducing the decomposition time in landfills.

Comments

During the research I discovered that if I was going to apply this technique of aerobic composting to a paper mill, I will have to first find a mill that uses virgin pulp in their process so that there are less contaminates in the sludge. Also, because of the strict regulations from the EPA, one has to design their own separate process for each separate mill. I presume that the mills will be interested in applying this technique to their process because in their current process of land application, they are only allowed a certain amount of sludge for a given area. This is due to the chemicals that are still contained in the sludge. But after the sludge has been composted by aerobic means, the sludge becomes inert, therefore a mill can pile the composted sludge as high as they want with out worrying about the ill effects that the sludge might do to the environment. In fact, the sludge that is composted can actually be used to grow plants and trees. By looking at that, one can propose that composted sludge could be placed on a field where the mill could grow trees to be used in their process. By doing this it could make the whole paper making process a closed system where it is self-supporting.