Using Mathematical Modeling to Create a New Pyramidal Compost Bucket Design

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Abstract

SUNY Geneseo's campus has a compost collecting program where students, faculty, and staff can empty their compostable items into bins which are emptied weekly. However, the bins release a putrid scent when opened, deterring SUNY Geneseo community members from using them. A phenomena commonly known as Pyramid Power claims that the pyramid shape, when exactly scaled to the size of the Great Pyramid of Giza, has properties that, once compostable items are put under it, can limit the growth of microorganisms and therefore reduce the foul smell. Using a 3-D printing device, we will scale and print the pyramid to the size of the current compost buckets. Then, we will test if microorganism growth and foul scent is decreased inside the pyramid shape as compared to inside the current compost bucket design.

Why choose the pyramid shape?

The Great Pyramids of Egypt are very mysterious structures. Their sheer size is impressive as well as their shape, which is very precise - the length of each side of the pyramid deviates by less than two feet from one another [4]. Because of this, many theories have arisen about these structures. For example, investigation into the Orion Correlation Theory reveals that the relative positions of the three pyramids of Giza coincide with the positions of the three stars in the Orion's Belt constellation [3].

The idea that the pyramid shape contains a mystical power with many different properties was first established by Antoine Bovis, a Frenchman in the early 1900s [1]. It is suspected that in the early 20th century Bovis visited the Cheops pyramid and noticed a garbage can filled with dead animals [2]. The animals, although having been in the chamber for an extended time, showed no rot and had no foul smell, as if they were mummified. This sparked Bovis' experiments using a cardboard pyramid under which he was able to mummify a dead cat. His further experiments on various foods showed that the pyramid structure could also reduce decomposition.

Other, more recently discovered properties of the pyramid shape, include its ability to make foods taste less bitter and acidic, sharpen razor blades, and stimulate psychic powers [4]. It is unknown what causes the pyramid structure to contain these properties, but it is the suspected the pyramid's response to the Earth's magnetic field plays a role, hence why in many pyramid power experiments the pyramid is aligned exactly along the Earth's N-S magnetic field line [2].

It is important to note that Bovis' trip to the Giza pyramids cannot be proven, which brings skepticism to his work. No primary source can confirm he was there. Bovis claims he only knew of the precise measurements and location of the pyramids, which sparked his beliefs and experiments [1]. Regardless, scientists still conduct research with pyramid power and some successful experiments suggest its validity.

Current Compost Buckets

The current compost bucket design is a square frustum shape of No. 2 plastic. See Table (1) and Figure (1).

Measure	Measurement
Base Length	6 in
Base Width	5.5 in
Top Length	8 in
Top Width	7.5 in
Side Length	13 in
Volume	2 gal

Table 1 (left): Dimensions of the current compost buckets.

Figure 1 (right): Image of the current compost bucket design.

Dimensions of the Great Pyramid

See Table (2) for the dimensions of the Great Pyramid used in our calculations.

Measure	Measurement
Base Length	755t
Height	481 ft
Volume	90,000,000 ft^3
Side Face Base Angle	51.8°

Table 2: Approximate dimensions of the Great Pyramid of Giza [4]

Computations

To find the volume of a pyramid, we used the following formula with r being the length of the bases and h being the height of the pyramid:

$$V_{pyramid} = \frac{1}{3}\pi r^2 h \qquad (1)$$

We need to scale our pyramid to the exact size of the Great Pyramid. Since we did not know the exact height and base length we want to use, we created a ratio of the two to eliminate one of the variables within the original volume formula.

$$\begin{aligned} \frac{h}{r} &= \frac{481}{755} \\ \frac{h}{r} &= .637 \\ h &= .637r \end{aligned} \qquad (2)$$

Using this ratio, we can eliminate the variable h from equation (1).

$$\begin{aligned} V_{pyramid} &= \frac{1}{3}\pi r^2 h \\ V_{pyramid} &= \frac{1}{3}\pi r^2(.637r) \\ V_{pyramid} &= .212632r^3 \end{aligned} \qquad (3)$$

The current compost buckets hold a volume of 2 gallons, which is equal to 462 in^2. Plugging this into our formula we find:

$$\begin{aligned} V_{pyramid} &= .212632r^3 \\ 462 &= .212632r^3 \\ r &= 12.957514 \end{aligned} \qquad (4)$$

Lastly, we used our calculated r-value and equation (2) to solve for h.

$$\begin{aligned} h &= .637r \\ h &= .637 * 12.957514 \\ h &= 8.255052 \end{aligned} \qquad (5)$$

New Compost Bucket Design

The new compost bucket design is a square pyramid with base length, r, approximately equal to 12.96 in., and height, h, approximately equal to 8.26 in. See Figure (2).

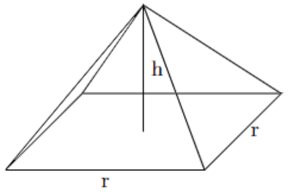

Figure 2: Base shape for new compost bucket design.

Using a 3-D printing device, the new design was printed from Polylactic Acid (PLA). It is made of two parts, the base and the lid, which are connected by a movable hinge. The hinge is placed at two thirds of the height of the pyramid for ease of cleaning and handling the bucket. There are also attachments on the base frustum that can be used for a handle. See Figure (3) and (4).

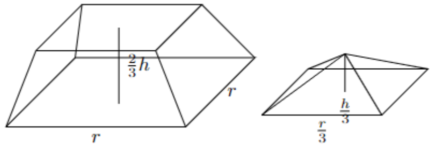

Figure 3: New compost bucket design as a base and lid.

Figure 4: 3-D printed new compost bucket design from the side (left) and top (right).

Methodology

Decomposition will be compared between the original and new compost bucket design. Each will have the same compostable materials (i.e., banana peels, apple cores, orange rinds, paper compostable trays, etc.) and the same amounts of these materials within the buckets. Samples will be held in the same conditions (i.e., temperature, humidity) and collected within 10 minutes of each other.

A scent test will include at least 6 test subjects. Subjects will be asked to smell the compost immediately after it is placed in the current compost bucket design and rate the smell based on "foul," "slightly foul," or "neutral" (no scent). Before smelling the compost in the new compost bucket design, subjects will wait for a period of five minutes to allow their sinuses to clear of any lingering scent. The subjects will be asked to return once a day for five days and repeat the same smelling process.

Along with a scent test, a visual test will be performed by the experimenter to see if there is any visible fungal or bacterial growth in the sample. The experimenter will view the samples once per day and determine whether the samples are moldy (over 75% of the sample is rotten), moderately moldy (50-75% of the sample is rotten), slightly moldy (25-50% of the sample is rotten), have little mold (0-25% of the sample is rotten), or if there is no mold (zero visible rot).

We will compare data from both the scent and visual test, then perform a statistical analysis to determine if the results from our experiment were statistically significant.

Follow-Up Research

Because scent is subjective, we will further this experiment by quantifying microbial growth in the compost buckets. Each of the five days where the samples are tested, we will collect small samples of compost from each bucket and send them to a facility for molecular identification. The facility will be able to quantify the bacterial growth by providing information on species abundance. Significance tests will be used again to determine the effectiveness of the new design.

Regardless if the pyramidal compost bucket shape significantly reduces the smell produced by the rotting compost, further experiments will be done to lessen the smell. It is commonly known that baking soda reduces scent; however, it is not compostable. We will use spent coffee grounds, which are believed to reduce smell, from the Starbucks on campus as a compostable alternative for baking soda. The lid will be split in two, similar to the new compost bucket design, and a removable filter, attached to the lid, will be printed. Coffee grounds will be placed above the filter and similar testing will be carried out on the new design containing coffee grounds.

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References

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