**UNIVERSITY OF WISCONSIN SYSTEM**
**SOLID WASTE RESEARCH PROGRAM**
***Undergraduate Project Report***

# The Feasibility of Composting the Waste By-products of Biodiesel Production

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# Composting

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# Executive summary

In February of 2008 the University of Wisconsin River Falls agricultural engineering department received its own biodiesel processor. Since then the department has been busy designing and testing the processes involved in creating biodiesel. In our efforts to explore positive environmentally friendly solutions we have explored several options for glycerin disposal. The main process that will be described in this report is the composting of the glycerin byproduct.

On the River Falls campus we have a current composting program that is used on the lab farm for disposal of animal waste and experimental purposes. This system is well established and was easily modified to accept glycerin in the process. With more than an acre of blacktop area devoted to compost, and drying pads, the composting of glycerin is easily tested in a secure setting that would closely mimic the real life conditions of other producers around the country.

In testing the glycerin byproduct in a composting system several areas were targeted to be observed. First was the completion of the composting reaction with glycerin in the system. The final product was not to be negatively affected by introduction of glycerin to the system. Second was the effect of glycerin on the rate of decay, and the occurrence of anaerobic pockets within a compost windrow.

# Introduction

The subject for this report is the disposal of glycerin byproducts. This is the removal and complete disposal of the glycerin from the UWRF campus in a way that must not conflict with ethical or financial restraints that are set by the Agricultural Engineering Department. The purpose of this report is to quantify the effects of glycerin and other biodiesel byproducts effect on compost.

In January of 2008 the UWRF Agricultural Engineering Department received a biodiesel processor. Since that time the department has been diligently working on manufacturing a system to completely recycle the used waste vegetable oil from the University Center to fuel campus vehicles. This was the Agricultural Engineering Departments contribution to the efforts to make our campus sustainable and “green.” In conjunction to this we were given the opportunity to test glycerin disposal with equipment readily available on campus.

# Methods

Several tests utilizing the campus composting system were used in the study of glycerin disposal. Listed are the three different tests used and the description of work done. All test windrows were allowed to reach 150degrees Fahrenheit before turning. All temperatures were recorded using a probe mounted thermocouple.

## Test 1 (glycerin rates)

To test the best rate of application of glycerin to compost the first step was to introduce the glycerin to the compost piles. The windrows that were used were made of bedding pack from a compost system for bedding dairy cattle. This was selected as it is relatively wide spread, and contains a favorable carbon nitrogen ratio of about 20:1. The windrows are arranged 5 feet apart in a north to west half moon shape. Piles are approximately six feet high sloped out to a 5 foot wide base. The compost was spread evenly across the pad with a skid steer loader and the glycerin was sprayed evenly across the entire area of the compost. After application the compost was immediately mixed and formed back into the windrow attempting to avoid compaction, or excessive heat loss.

To properly test the different rate of application of glycerin to the compost system glycerin was added in different portions of the windrows with control sections between each test area. The windrow was split 10 feet of testing area with 5 feet of control between each section. Different concentrations of glycerin were mixed thoroughly throughout the piles and marked for temperature testing. Rate of application was staggered from 4.5 gallons up to 13.5 gallons per 10 feet of windrow. 18 gallons was the upper limit for moisture content as the compost was nearing 65% moisture which is widely considered the upper threshold before negative anaerobic activity.

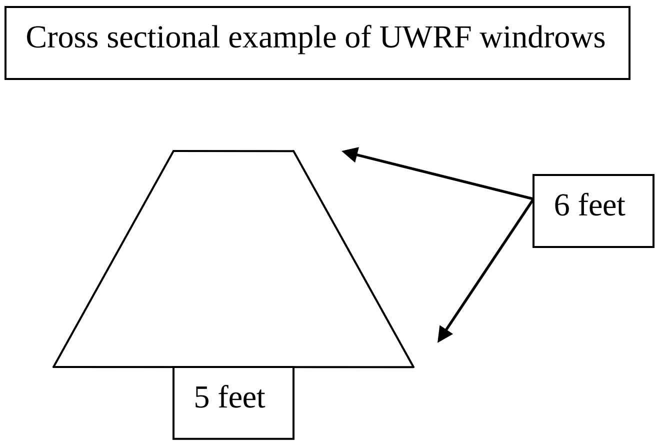


**Figure 1 Picture reference to windrow shape.**

Temperatures were taken on the different test areas as well as the control areas to calculate rate of decomposition and problems in heating.  The runoff and odor of the compost was monitored to ensure no leaching or excessive ammonia vapor form the piles.  Piles were tested weekly attempting to eliminate variations in rainfall, and other climate changes.

## Test 2 (glycerin infiltration)

To test the amount of mixing required to allow proper air flow, two test areas were established.

First the pile was set up and layers of glycerin product were pored without mixing.  Approximately 9 gallons of glycerin was used for a 10 foot section of windrow. The windrow was spread out and rebuilt in three sections.  The glycerin was pored in three different horizontal layers approximately 18 inches apart. Temperature and runoff tests were conducted in the same manner as rate testing.

The second method of testing was directly poring of glycerin on top of the existing compos. The windrow was set up first and glycerin was evenly pored across the entire length of the testing section. Approximately 4.5 gallons of glycerin was used to poor across the top and allowed to soak into the pores. This was repeated in weekly intervals for three weeks. Temperature and runoff tests were conducted in the same manner as rate testing.

# Results

All results are available in appendix A, in table form.

## Test 1

Test one was the main focus of my study into glycerin composting. I was mainly concerned with finding the level of application which most efficiently decomposed the glycerin without negatively affecting the compost system. The results will be separated and highlighted in the separate application rates.

First application rate tested was 4.5 gallons per 10 feet of windrow. My original prediction for this rate was little to know change in heating of compost due to the small amount of material being used. 4.5 gallons of glycerin was over 400 times smaller in volume than the glycerin it was being applied to and was actually challenging to evenly spread without running out of glycerin.

After testing the average of the temperature increase was surprising. Over the course of testing the average temperature tested was increased over two degrees. This is a significant increase. With a two degree increase in temperature over the course of a week that would decrease the time between turning by three days. Over a summer of use this would result in a whole week earlier compost than the control.

The second rate to be tested was 9 gallons per section of windrow. Heating was completed with very minimal issues in anaerobic activity. The last two times the pile was turned and glycerin added there were a small number of fist sized areas in which air was not penetrating. The overall result was an increase in temperature of nearly four degrees per testing cycle.

The third rate to be tested was 13.5 gallons per ten foot section of windrow. This was chosen as the upper threshold of application for the tendency to over moisten sections as it was mixed into the compost. The compost when agitated required twice the work to evenly disperse the glycerin throughout the material. After the material was piled the material felt very close to the 65% upper limit of recommended moisture content. Despite the extra work, and seemingly sloppy wet condition of the compost the pile was able to heat up an average of just over three degrees quicker than the control. This was not without troubles. There were a significant number of anaerobic pockets that had to be separated by hand upon turning the pile and exposed to oxygen.

## Test 2

Testing the infiltration of glycerin was a failure. The layering method which was tested first was discontinued after the first turning of the pile. The glycerin created moist layers and failed to flow downward after being piled. This was a disappointing result as the pile was then spread out and had to be spread back out by hand to mix the dry and wet sections to save the compost.

Testing of the pouring method was much more promising. Although the heating of the pile was not positively effected, the rate of decomposition in the upper layer of the pile were the compost usually dries down rather quickly was much greater than the control. The glycerin was not found within the pile upon turning, and the only evidence of glycerin in the pile was the distinct crusting on the surface were it was poured.

# Conclusions

After a summer of practice I was able to develop several theories for further study. I was able to conclude that the use of glycerin in a composting system will have positive results if the proper ratio of product is used, and the system is tended to frequently to ensure proper air infiltration. The largest factor in maximizing the glycerin's effect on compost was properly mixing the material to allow all areas to be in contact with it. The use of glycerin to simply get rid of it in a compost pile can easily be accomplished by pouring it on the surface of the compost and letting it soak into the pours of the material.

The largest concern for disposing of glycerin in composting systems is the over use of material within the system. It is not a matter of too much methanol, soap, or and other glycerin materials, but the ability of the sticky substance to plug the natural air pores and eliminate oxygen from the system.

# Recommendations

This testing should be continued through repetition of the tests. The results should be duplicated before recommendations can be made for application rates for commercial use.

Also necessary testing to be completed is a test into the different temperatures throughout the compost windrow. The thermocouple that was used for this test was mounted on a four foot probe at approximately one foot intervals. It was very challenging to create a constant pattern that tested temperatures in a similar position between cycles. I would recommend a system in which the probes could be left submerged within the windrow to test the actual temperature increase of a particular point.

Another valuable asset to this study would be a chemical analysis of the finished compost to ensure there were no unwanted chemical reactions within the compost leaving an undesirable pH or excessive soap buildup, which would negatively affect the resulting compost.

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# Glossary

*Glycerin-* OH-CH2-CH(OH)-CH2-OH, the chemical equation for glycerol, which when combined with other residue from the biodiesel reaction creates glycerin.

*Windrows-* Formation of composting material into long units that have 60 degree side angles and are approximately 6 feet tall containing approximately 45 cubic feet of material per linear foot.

# References

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## Appendix A

The fallowing is a copy of the tables attached to this report. These were copied from notes kept from test completed on the composting of the glycerin product.

# Control

| Test | Temp | Appearance | Notes |
| --- | --- | --- | --- |
| 1 | 133.2 | freshly turned dry | |
| 2 | 141.1 | outer crust layer of dry material | pile turned |
| 3 | 151.2 | outer crust layer of dry material | |
| 4 | 147.3 | outer crust layer of dry material | pile turned |
| 5 | 149.3 | outer crust layer of dry material | |
| 6 | 144.5 | outer crust layer of dry material | pile turned |
| 7 | 143 | outer crust layer of dry material | pile turned |
| 8 | | | |
| Average | 144.22857 | | |

# 4.5 gallons glycerin

| Test | Temp | Appearance | Notes |
| --- | --- | --- | --- |
| 1 | 134.1 | same as control | |
| 2 | 141.4 | same as control | pile turned |
| 3 | 151 | same as control | |
| 4 | 148.2 | same as control | pile turned |
| 5 | 160.4 | same as control | |
| 6 | 142.9 | same as control | pile turned |
| 7 | 148.1 | same as control | pile turned |
| 8 | | | |
| 9 | | | |
| 10 | | | |
| Average | 146.58571 | | |
| Average increase in temperature | 2.3571429 | | |

# 9 gallons glycerin

| Day | Temp | Appearance | Notes |
|---|---|---|---|
| 1 | 134.7 | same as control | |
| 2 | 151.2 | same as control | pile turned |
| 3 | 141.2 | same as control | |
| 4 | 147.3 | same as control | pile turned couple fist sized anerobic pockets |
| 5 | 161.2 | same as control | |
| 6 | 155 | same as control | pile turned couple fist sized anerobic pockets |
| 7 | 144.7 | same as control | pile turned |
| 8 | | | |
| 9 | | | |
| Average | 147.9 | | |
| Average increase in temperature | 3.6714286 | | |

# 13.5 gallons glycerin

| Test | Temp | Appearance | Notes |
|---|---|---|---|
| 1 | 133.6 | same as control | |
| 2 | 141.1 | same as control | pile turned with some fist sized anerobic pockets |
| 3 | 150.2 | same as control | |
| 4 | 161.3 | same as control | pile turned with approximatly 25 fist sized anerobic pockets |
| 5 | 140.2 | same as control | |
| 6 | 149.3 | same as control | pile turned with 15-20 anerobic pockets |
| 7 | 155.2 | same as control | pile turned with 30-40 anerobic pockets |
| 8 | | | |
| 9 | | | |
| Average | 147.27143 | | |
| Average increase in temperature | 3.0428571 | | |

# Layered glycerin

| Test | Temp | Appearance | Notes |
|---|---|---|---|
| 1 | 148.1 | freshly turned dry | |
| 2 | 143.1 | Same as control | pile turned with deffinate anerobic activity |
| 3 | | | bottom 1/3 of pile was scattered with anerobic pockets |
| 4 | | | Test was discontinued after first turn. |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| Average | 145.6 | | |
| Average increase in temperature | 1.3714286 | | |

# Top dressed with 4.5 gallons of glycerin

| Test | Temp | Appearance | Notes |
|---|---|---|---|
| 1 | 140.3 | freshly turned dry with distict glycerin lines were it was poured | |
| 2 | 143.1 | Glycerin lines were still there with much dryer aperance | pile turned |

| | | | |
|---|---|---|---|
| 3 | 125.1 | Same as control with glycerin residue were poored | |
| 4 | 147.3 | Same as control with glycerin residue were poored | pile turned |
| 5 | 151.4 | Same as control with glycerin residue were poored | |
| 6 | 144.2 | Same as control with glycerin residue were poored | pile turned |
| 7 | 147.2 | Same as control with glycerin residue were poored | pile turned |
| 8 | | | |
| 9 | | | |
| Average | 142.65714 | | |
| Average increase in temperature | -1.5714286 | | |