# LIME PASTEURIZATION, AN EXTENDED EVALUATION

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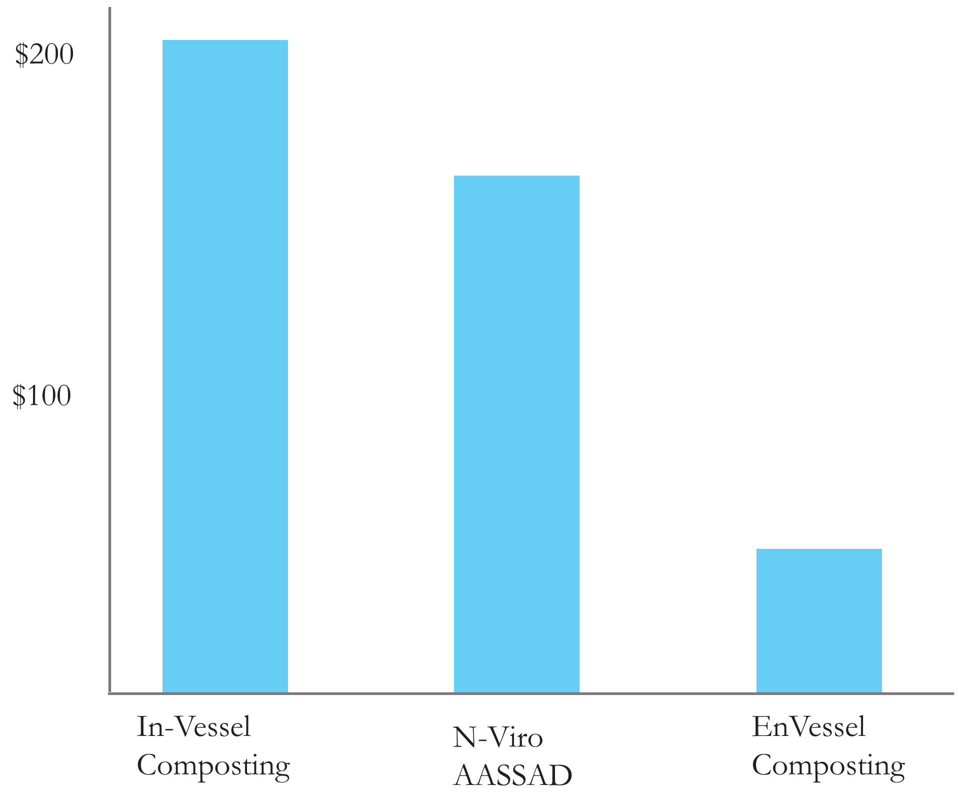
## Introduction:

Lime pasteurization promises to provide a low cost and effective treatment for converting biological sludge into beneficial agricultural products. When compared with other processes, lime pasteurization with supplemental heat, has the potential to greatly reduce cost for POTW.. This paper outlines an extensive test program which was conducted to test lime pasteurization for the effectiveness of the process to destroy pathogens, to quantify operating costs, and generate quantities of material for agricultural use.

## Federal Regulations

Lime pasteurization qualifies under the current Federal Regulations as a PFRP process. Lime pasteurization meets the requirements of PFRP by raising the pH to 12 or greater for a period of 2 hours and by concurrently raising the temperature above 70 degrees C for a minimum of 30 minutes.

Under the proposed 503 Regulations, lime pasteurization will qualify as a Class A pathogen reduction process as long as the temperature exceeds 70 degrees C for a minimum of 30 minutes and the stabilized product tests for less than 100 living organisms per gram of solids for fecal coliform and fecal streptococci. In response to the proposed Federal Regulations, the extended test program subjected many samples to determine if the process is effective for meeting the proposed Class A pathogen reduction.




**Theory of Lime Pasteurization:**

Lime pasteurization consists of the combination of high pH combined with raising the temperature of the sludge to 70 degrees C for 30 minutes in order to destroy pathogens. The heat generated from the exothermic reaction of the lime is used to increase the sludge temperature. The EnVessel Pasteurization™ process utilizes a supplemental heat source to reduce the lime dosage and obtain heat from a supplemental source.

The following formula can be used to predict the quantity of lime required to pasteurize sludge. The example is based on 1 ton of sludge cake at 18 percent dry solids.

2,000 lbs sludge cake @ 18% D. S.

1. Calculate heat required to elevate temperature from 60 degrees F to 160 degrees F.

Lb's x Spec. Heat x Temp. Rise = Btu's

360 x 0.30 x 90 deg. F= 9,720
1,640 x 1.0 x 90 deg F= 147,600
Total = 157,320 Btu's

2. Calculate lime required based on 490 btu's/lb. of CaO

157320 divided by 490 = 321 lbs CaO or 344 Ibs. lime @ 93% Cab

3. Approximate Cost:

By using a supplemental heat source, the quantity of lime required is significantly reduced. In addition, supplemental heat reduces the operating cost. The effect of supplemental heat can be calculated by modifying the previous calculation as shown below:

4. Reduce lime addition to 3096 on a dry solids basis

360 lbs. D.S.. x 30 = 180 Ibs. lime

5. Heat available from lime

108 lbs. X 93% CaO x 491 btu/lb. = 49,316 btu's

6. Supplemental heat required

(From Step 1) 157320 btu's -49,316 = 108,003 btu's

7. Cost per ton of cake

108 Ibs. lime @ $75/ton = $4.05

108,003 btu @ .075 per kw hr. = $2.43

Total cost: $4.05 + $2.43 = $6.48

**Description of Pilot Unit:**

The pilot unit consists of a sludge feeder, sludge/lime mixer, lime storage bin and volumetric feeder, and a pasteurization vessel. The system is designed to process approximately 15 pounds per minute of cake. The pilot unit was built using the same materials and tolerances full scale equipment in order eliminate scale up factors.

The sludge feeder consists of a feed hopper and single 6 inch diameter screw feeder. The drive unit has a variable speed motor to adjust the sludge feed rate. The feed screw section was heated with a 10 kw electric resistance heater. The heater was then covered with insulation and a light gauge steel jacket.

The sludge lime mixer consists of a twin auger mixing shaft. Three types of mix augers were available in order to optimize mixing. The sludge/lime mixer was heated with a 20 kw heat system and insulated. The mixer was controlled by a variable speed motor.

Lime is added to the system with a variable speed volumetric screw feeder with lime storage hopper. The hopper holds approximately 150 pounds of lime.

The pasteurization vessel holds approximately 2 cubic feet of sludge. The vessel was insulated similarly to the feeder and the sludge/lime mixer to retain the heat within the sludge.
Description of Test Procedure:

The pilot tests were conducted in 4 different cities. The tests were done at each waste water treatment plant with the assistance of the plant personnel. The tests were conducted to gather the following information:

1. Test each plant's actual sludge.
2. Test for overall appearance of the end product.
3. Effectiveness of the process to reduce pathogens & to comply with the proposed US EPA 503 regulations.
4. Produce a quantity of material which can be stored on site for long term pathogen reduction.
5. Quantify the amount of lime and heat required to pasteurize the sludge.
6. Quantify operating cost for lime and heat.

The tests were conducted by metering the sludge and lime at controlled rates into the mixer. The ratio of lime to sludge was adjusted to produce 70 degrees C in the pasteurization vessel. The initial tests run were done without the use of supplemental heat. Once the quantity of lime was established without supplemental heat, the heat system was turned on. The sludge feed rate was not changed so that the only variable was the use of supplemental heat.

The lime rate was then reduced to the point wherein the sludge temperature was again at 70 degrees C in the pasteurization vessel. The difference or reduction in the lime dosage was then converted into btu's and the quantity of heat provided by the supplemental source is determined.
Sample and Testing Methods:

All sampling and testing were done in accordance with US EPA approved procedures. Samples were placed in sterilized glass bottles and properly labeled. Chain of Custody forms were used to transmit the samples for laboratory testing.

All samples were tested by an independent analytical laboratory. Samples were tested for fecal coliform using Standard Method 908. Tests for fecal streptococci were conducted using Standard Method 910A. The methods used in testing have a lowest detectable limit of 20 organisms per gram. Therefore, the best results will result in a reported number of organisms of 20 or less.

**Results of Test:**

One reported concern with lime pasteurization is the possibility of producing an end product of pasty consistency.

The mixing step can liberate the bound water within the sludge resulting in a plastic or paste consistency. A paste-like end product would be difficult to spread on land using conventional fertilizer or manure spreaders.

By controlling the mixing variables, each test run was able to produce a granular soil-like end product. The Clearwater sludge was only 12 percent dry solids and even at the higher water content the process was able to thoroughly mix the sludge and lime and produce a granular product. Initially, the end product is "spongy", however after several days of storage the end product looses the spongy texture and becomes more friable or compactable. The drier sludges tested, 18 percent dry solids and greater, were much less spongy and became compactable much quicker.

All samples contain a slight ammonia odor. Generally speaking, the ammonia is not objectionable and required placing the material within 3 to 4 inches of your nose in order to be detected.

The process testing produced phenomenal results for pathogen reduction. The lab testing had a lowest detectable limit of 20 organisms per gram. EPA regulations required less than 100 organisms in order to meet Class A require-

| | Sludge Feed % Solids | Lime Dosage (lbs. lime/lb. cake) | Cost for Lime $ per ton cake | Cost for Heat $ per ton cake | Total Cost |
|---|---|---|---|---|---|
| Topeka | 24% | 0.095 | 7.12 | 1.06 | 8.18 |
| Aiken | 22% | 0.13 | 9.75 | 0.75 | 10.50 |
| Durham | 19% | 0.05 | 3.75 | 2.76 | 6.51 |
| Clearwater | 12% | 0.10 | 7.86 | 1.49 | 9.35 |

A summary of lime dosage, heat required, and cost is shown on Table 1. The pilot unit showed an extremely high level of efficiency in retaining the heat from the lime within the sludge. The test also indicated a high level of effective heat transfer from the supplemental source into the sludge. The process was able to operate consistently at under $10.50 per ton of cake. The drier the sludge feed, the lower the operational cost.

**Long Term Analysis:**

At the completion of testing at 3 sites, small piles were left to evaluate the long term stability of material to pathogen regrowth. Approximately every 3 months, samples were taken and sent back for analytical testing. The piles were left outside in uncovered areas to simulate the most severe storage exposure. All samples tested showed no pathogen regrowth. All samples resulted in reports of less than 20 living organisms per gram. At the time of writing, the longest storage time is 6 months. Monitoring of samples will continue for a maximum of 1 year.

**Comparison with Cement Kiln Dust Stabilized Sludge:**

The pilot testing conducted in Durham, NC was run simultaneously against the N-VIRO ASSAAD process. Detailed results are presented in other papers. However, some interesting results were obtained in final metal content of the sludge and the agronomic value of the end product. Table 2 shows a comparison of nutrient and metal content of the raw sludge, the lime stabilized sludge, and the CKD (cement kiln dust) stabilized sludge.

Cement or lime kiln dust is a byproduct of the process of manufacturing cement or lime. The product consists of essentially flyash and amounts of calcium oxide. One metal of particular concern is lead (Pb). Lead will precipitate out with kiln dust.

Cement kiln dust contains a lower concentration of CaO than high calcium lime. As a result, the quantity of kiln dust required is approximately 4 to 6 times the amount of lime. The large quantity of kiln dust results in a dilution of the sludge. This reduces the nutrient value of the end product. The plant available nitrogen was reduced to 1/5 the available nitrogen for lime stabilized sludge.

When looking at metals content, 3 out of 10 metals are higher with CKD stabilized sludge than with the sludge feed. With lime stabilization, the metals concentration of the end product is always lower than the metals concentration of the sludge feed.

| ***All units mg/kg unless noted.** | **Sludge Feed** | **Lime Stab.** | **CKD Stab.** |
|---|---|---|---|
| Arsenic | 75 | 45 | 85 |
| Cadmium | 35 | 2 | 85 |
| Chromium | 535 | 275 | 48 |
| Copper | 665 | 2,625 | 215 |
| Lead | 58 | 44 | 570 |
| Mercury | 3.7 | 1.6 | 1.45 |
| Molybdenum | 88 | 56 | 78 |
| Nickel | 245 | 14 | 185 |
| Selenium | 255 | 7 | 8 |
| Zinc | 1900 | 772.5 | 650 |
| Alkanlinity | 6,150 | 262,500 | 42,000 |
| Phosphorus | 25,500 | 10,825 | 7,850 |
| Potassium | 2,350 | 1,250 | 15,000 |
| Kjeldahl | 8,800 | 2,150 | 825 |
| Ammonia Nitrogen | 5,700 | 1,350 | 245 |
| Nitrate | 5 | 11 | 2 |
| Plant Avail. N | 6,326 | 1,521 | 364 |
| **Total Solids** | **19.4%** | **41%** | **50.9%** |

**Ascaris Egg Testing:**

One concern with all chemical stabilization processes is the ability to destroy ascaris eggs. Ascaris eggs come in many forms. The shell of the egg can prevent chemical stabilization from destroying the egg embryo. The use of both heat and chemical stabilization has, in the past, been extremely effective in destroying the egg shell and embryo. Additionally, ascaris eggs occur in varying numbers and often the ability to quantify the amount of eggs in a given sludge is almost impossible. Since it is difficult to quantify the number of viable eggs in the sludge prior to treatment, we cannot be sure of the effectiveness of sampling to determine the quantity of viable eggs after testing.

In order to accurately quantify the ascaris egg kill, approximately 5 pounds of sludge were spiked with over 1 million viable ascaris eggs. The spiked sludge was marked with dye and run through the pilot unit. The treated sludge was then examined and no viable eggs were found. It is estimated that the capture rate of the test was in excess of over 90 percent.

Summary:

Lime pasteurization with supplemental heat was--shown to be an effective process to reduce pathogenic organisms. The process will meet the proposed US EPA requirements for Class A sludge pathogen reduction. The process will produce a spreadable product with a cost of approximately $10 per wet ton or less. The use of lime results in an end product with known metals content and will reduce the concentration of metals of the original sludge feed.

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Footnotes

1. US EPA Summary Report: 625/8-89/016.

2. a. "Goldcoast Community Strikes Paydirt with Advanced Alkaline Pasteurization."

   b. US EPA Technology Evaluation Report: 68-C8-0022.

   c. Proposal for Pasco County, Florida.