POSITION PAPER:

LIME ONLY PASTEURIZATION & ENVESSEL PASTEURIZATION™

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INTRODUCTION

Lime pasteurization is an excellent process to produce a PFRP/Class A quality sludge product. A lime stabilized sludge offers the highest value and most marketable sludge product as a direct result of the inherit value of the lime.

During the 1970's and 80's, the Environmental Protection Agency conducted extensive research on various wastewater treatment plant processes to evaluate their effectiveness in destroying pathogenic organisms that cause diseases such as cholera, pneumonia, hepatitis, diarrhea, dysentery and hook worms. Lime stabilization and pasteurization has proven to be highly cost effective method of effective sludge stabilization. As a result, the E.P.A. approved lime stabilization and pasteurization as a Class A/PFRP process with two requirements:

1. keep above 11.5 for an additional 22 hours pH of the solids must be raised above 12.0 for a period of 2 hours and
2. 30 minutes the temperature of the solids must be maintained above 70° C./158° F. for 30 minutes

Most farmers need to add lime to their fields in addition to fertilizers. Using a lime stabilized sludge provides the required liming of the fields with a natural organic fertilizer. All of this is spread at one time instead of multiple passes. The combination of sludge and lime has been evaluated to be worth $50 to $100/acre. Approximately half of the value is directly related to the lime in the sludge.

RDP's EnVessel Pasteurization™ Process utilizes electrical energy to generate the heat required to reach the pasteurization temperature of 158° F. for 30 minutes. Other processes utilize the heat of hydration to generate the heat required. This is often referred to as Lime Only Pasteurization. There are several technical issues that deserve consideration when evaluating Lime Only Pasteurization and RDP's EnVessel Pasteurization™ Process.

LAND APPLICATION CONSIDERATIONS

To achieve Class A/PFRP pasteurization requires that the sludge be heated to 158° F. for 30 minutes. To raise 2,000 pounds of cake by 100° F. (58° to 158°) requires about 200,000 BTU. Quicklime has 457 BTU's/pound, therefore, 437 pounds of lime are required per ton of cake.

Most soils do require some lime to make up for the calcium and other micro-nutrients that are absorbed by the crops during growing seasons. Generally, lime is applied to fields to maintain a pH at about 6.5 to 7.0. As a result, the annual liming rate is about 1.5 tons of lime per acre.

When land applying municipal sludges that are lime stabilized, the amount of lime in the sludge will determine the land application rate. For a dewatered cake at 20% dry solids, a 20% lime addition rate, on a dry basis, is about optimal.

Lime Only Pasteurization will require a 20% to 30% lime dosage on a cake solids basis. As a result, the land application rate will be about 7.5 tons of stabilized cake per acre.

RDP's EnVessel Pasteurization™ Process (EVP) uses lime for pH adjustment and electric energy for heat. The resulting lime dosage, for pH adjustment, is typically 5% on a cake solids basis. For example, 2,000 pounds of 20% cake will require 100 pounds of lime to raise the pH above 12.0. Therefore, if you land apply EVP stabilized cake, the rate is 37.5 tons of cake per acre based upon 1.5 tons of lime per acre.

The consulting engineering firm of J.R. Wauford of Nashville, Tennessee conducted a pilot study in November of 1993 to quantify the end product from both processes. Testing was conducted over a one-week period. Both processes were operated in parallel during the week. The end products were then sent to an independent laboratory for analysis. The following chart summarizes the effect of the lime dosage upon the amount of land that is required to handle the end product. Copies of J.R. Wauford's report are available upon request.

1 RDP EnVessel Pasteurization™ i.e. EVP

2 Rates provided by MOP #8, page 1524

The application of sludge to the land is greatly affected by the crops that are being grown on the particular fields and the weather. Sludge must be applied in between crops which generally means that the sludge will be applied during the spring and fall. In addition, the trucks that are used, are generally quite heavy and therefore, cannot be driven on a wet field because they will sink into the mud and damage the field. For these other considerations, it is generally accepted that a prudent land application program requires having available three times as many acres as your require for your yearly land application requirement. This additional land is required to accommodate the effects of crop patterns, weather and other realities of land application.

Lime stabilized sludge is an excellent organic liming agent that provides the farmer with a value of $50 to $100 per acre. Lime is generally applied at a rate of 1.5 tons per acre. The amount of lime in the sludge cake typically sets the land application. For example:

a) Lime Only Pasteurization at 7.5 tons of cake per acre

b) EnVessel Pasteurization™ at 37.5 tons of cake per acre

Process	Lime Dosage	Land Required Acres	Land Available Acres[2]
EVP[1]	5%	1005	3,015
Lime Only	21%	2114	6,342

ODOR CONSIDERATIONS

Ammonia gas is an inevitable reaction in any lime stabilization process. The amount of ammonia released will be a function of:

a) sludge characteristics

b) lime dosage

c) processing temperature

Ammonia (NH3) is a colorless gas with a sharp, intensely irritating odor; lighter than air. The amount of ammonia gas generated in a lime stabilization process is a function of the chemical composition of the sludge and the lime dosage utilized in the stabilization process. Increased lime dosages generate greater amounts of ammonia gas.

The nitrogen compounds contained in wastewater sludge can be quantified by the Total Kjeldahl Nitrogen (TKN) analysis. The summary equation for this is:

TKN = Ammonium/Ammonia (NH4+/NH3) + Organic Nitrogen

The key factor in the production of a TKN in typical wastewater sludge (secondary) is the ammonium/ammonia factor. Ammonium ions are converted into ammonia gas in alkaline conditions as follows:

$NH_4^+ + {}^-OH$ Þ $NH_3 + H_2O$

Ammonium Ions Ammonia Gas

The pH equilibrium at 25° C. for this ammonium to ammonia gas conversion is approximately the following:

-1% Conversion of ammonium to Ammonia at pH 7.0
-10% Conversion of ammonium to Ammonia at pH 8.4
-50% Conversion of ammonium to Ammonia at pH 9.4
-90% Conversion of ammonium to Ammonia at pH 10.4
-99% Conversion of ammonium to Ammonia at pH > 11.4

Therefore, at high pH values, more ammonium is converted to ammonia gas.

The evolution of ammonia gas from alkaline stabilized biosolids is constrained and limited by the solubility of ammonia in the contained water of the biosolids. Also, physical and chemical entrapment accounts for a lowered rate of diffused ammonia from a treated biosolids mass.

The evolution of ammonia gas, on the other hand, is enhanced as the temperature of the mass from which it is evolving is raised. Due to the increase in the ion product constant of water (Kw), as temperature rises (will rise from $1x10^{-14}$ to $1x10^{-12}$ as temperature increases from 25° to 100°C.), aqueous solutions of ammonia gas will have increased alkalinity. This will shift initial evolutions of ammonia gas to lower energy levels. As temperature levels increase, ammonia gas evolution will increase as compared to similar pH levels at lower temperatures.

Using Lime Only Pasteurization will lead to greater ammonia generation due to the increased lime dosage. For example, at Cookeville, Tennessee, EVP used 5% whereas Lime Only Pasteurization used a 21% dosage. There is simply more lime used in Lime Only Pasteurization and therefore, more ammonia is generated.

In addition, if an open pile method is used, then even more lime will be required for Lime Only Pasteurization in order to overcome the effects of ambient cooling. In the case of Charlotte, North Carolina, the open pile method resulted in a 30% to 40% dosage. Again, more lime leads to more ammonia being generated.

Additionally, as the ammonium ions are converted to ammonia gas (NH_3), there is less nitrogen in the sludge cake. As a result, the fertilizer value is decreased proportionally.

The high fertilizer value and lowest ammonia odor problems are a result of operating at the lowest possible temperature and with the lowest possible lime dosage. The EVP process inheritably produces a higher value fertilizer product and generates less of the irritating ammonia gas.

OPEN PILE vs. INSULATED CONTAINER

All Class A/PFRP pasteurization processes are required to raise the pH and maintain temperatures for 30 minutes. Some processes use an open pile method, similar to conventional static pile composting. Other systems recommend an enclosed vessel, similar to EnVessel composting.

The EnVessel systems offer advantages for process control and monitoring. Additionally, all of the off gases are trapped and easily contained.

The open pile systems have little or no control over the naturally occurring ammonia odor. In addition, there is no systematic means of measuring the temperature at the perimeter of the pile.

It is important to note that it can easily be demonstrated that the pile will be hot within 12" to 18" of the surface. It is the perimeter that cools most rapidly. This can be easily illustrated by monitoring the temperature of a cup of coffee when sitting on a desk. Left on a desk, it will cool by about 1° F. to 2° F. per minute. The cooling, or lapse rate, is initially high and slows as the cup cools. This is consistent with known principles of thermodynamics and general theories of equilibrium.

Considering that dewatered sludge cake is 75% to 80% water, it is reasonable for the same phenomenon to occur naturally in an open pile lime stabilization process. The temperature in the pile will seek equilibrium with the ambient conditions and the colder the environment, the faster the pile will cool.

It has generally been shown that an insulated container will be cost effective in reducing the required lime dosage. Typically, the payback period will be about 2 years.

The insulated vessel

1. provides continuous monitoring of time/temperature;
2. provides invaluable documentation to demonstrate compliance with the time/temperature requirements.

E.P.A. issued a guidance document in August of 1993 entitled, Preparing Sewage Sludge for Land Application or Surface Disposal. This document refers the reader to specific details for compliance as described in E.P.A. Control of Pathogens and Vector Attraction in Sewage Sludge (E.P.A./625R-922/013). This publication states on Page 17, "The potential for regrowth of pathogenic bacteria in Class A sludges makes it important to insure that substantial regrowth has not occurred."

For lime stabilization, the E.P.A. states the following:

"This alternative may be used when the pathogen reduction process use specific time-temperature regimes to reduce pathogens. Under these circumstances, time-consuming and expensive tests for presence of specific pathogens can be avoided. It is only necessary to demonstrate that:

* Either fecal coliform densities are below 1,000 MPN per gram of solids or salmonella bacteria are below detection limits...
* And the required time-temperature regimes are met.

Importantly, this E.P.A. document continues to specifically advise “the time-temperature requirements apply to every particle of sewage sludge processed.”

The promulgation of the 503 Regulations has ushered in a new era of performance based regulations that are “self-implementing”. The POTW must now demonstrate compliance with the regulations. 503.27 - Recordkeeping - provides the mechanism for the E.P.A. to place the burden of proof upon the POTW to demonstrate pH and that the POTW has maintained 158° F. for 30 minutes. This applies to all of the sewage sludge and not just a representative sample. It reads as follows:

503.27 Recordkeeping

(a) When sewage sludge (other than domestic septage) is placed on an active sewage sludge unit:

(1) The person who prepares the sewage sludge shall develop the following information and shall retain the information for five years.

(i) The concentration of each pollutant listed in Table 6 in the sewage sludge when the pollutant concentrations in Table 6 are met.

(ii) The following certification statement:

“I certify, under penalty of law, that the pathogen requirements in [insert 503.32(a), 503.32(b)(2), 503.32(b)(3), or 503.32(b)(4) when one of those requirements is met] have been met. This determination has been made under my direction and supervision in accordance with the system designed to ensure that the qualified personnel properly gather and evaluate the information used to determine the [pathogen requirements and vector attraction reduction requirements if appropriate] have been met. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment.”

(iii) A description of how the pathogen requirements in 503.32(a), 503.32(b)(2), 503.32(b)(3), or 503.32(b)(4) are met when one of those requirements is met.

(iv) A description of how one of the vector attraction reduction requirements in 503.33(b)(1) through 503.33(b)(8) is met when one of those requirements is met.

Finally and often most importantly, the use of an insulated container will reduce the required lime dosage. This

1. reduces the lime cost;
2. reduces ammonia generation because of operating at a lower temperature as described in Section II; and
3. lowers the lime dosage which also allows for higher land application rates as described in Section I.

ENVESSEL PASTEURIZATION™ vs. LIME ONLY PASTEURIZATION

RDP's EnVessel Pasteurization™ process shares many of the advantages of Lime Only Pasteurization because EVP uses lime for pH adjustment. The difference between the two processes lies on the method of generating heat.

EVP uses electric energy to generate heat while using lime to simply raise the pH above 12.0. Since the hydration reaction of lime and water is exothermic, this heat of hydration is captured in the EVP process. The bulk of the heat is, however, generated electrically.

The cost effectiveness of electrical energy is easy to quantify:

Given 1 Ton of Lime = $75.00

1 Pound/Lime = 457 BTU

Electrical Cost = $0.075/kw.ltr

To generate 10,000 BTU requires:

Lime = (10,000/457) x ($75.00/2000 pounds) = $0.82

Electricity = 10,000 x .000293 x $0.075 = $0.22

Electric energy costs approximately 27% of the cost of lime for generating heat. In many parts of the country, the cost of lime is even higher and the cost of electricity is lower, so the difference is even greater.

The use of electric energy results in RDP's EnVessel Pasteurization™ Process having a lower operating cost than Lime Only Pasteurization. In addition, the lime dosage for pH adjustment is typically about 5%. This dosage minimizes odors as discussed in Section II and maximizes the land application rate as demonstrated in Section I.

EnVessel Pasteurization™ and Lime Only Pasteurization are two excellent Class A/PFRP processes that produce good marketable end products at a reasonable cost and with proven mechanical equipment. EVP utilizes electrical energy to generate heat and is, therefore more cost effective and

1. can be land applied at 5 times the application rate of Lime Only Pasteurization;
2. produces less odor because it uses less lime than Lime Only Pasteurization; and
3. incorporates an insulated container to positively control odors and provide process performance documentation.