



# LAND APPLICATION OF PULP MILL LIME MUD

## What is lime mud?

Lime mud is a byproduct produced in pulp mills as part of the process that turns wood chips into pulp for paper. The pulp mill cooks wood chips with sodium hydroxide to extract the wood fiber used to make paper from the lignin that binds the wood together. During this process, sodium hydroxide is converted to sodium carbonate. The pulp mill then adds calcium oxide, also known as quicklime, to convert the sodium carbonate back to sodium hydroxide in order to use it again. In the process, calcium carbonate is formed.

Calcium carbonate is the major component of “lime” or ground agricultural limestone. Although lime mud is largely calcium carbonate, there are small amounts of magnesium carbonate and other trace minerals (Table 1).

**Table 1.** Typical concentrations of nutrients and minerals in lime mud from pulp and paper mills compared to agricultural lime.

<i>Minerals</i>	<i>Lime Mud*</i>	<i>Agricultural Lime</i>
Nitrogen (%)	0 - 0.2	0.01
P <sub>2</sub> O <sub>5</sub> (%)	1 - 1.2	0.06
K <sub>2</sub> O (%)	0.2 - 1.4**	0.13
Calcium (%)	28 - 50**	31
CCE (%)	91 - 100	80 - 100
Magnesium (%)	0.2 - 1.0**	5
Sulfur (ppm)	0.19***	na
Boron (ppm)	7.91***	na
Copper (ppm)	3 - 66	10
Zinc (ppm)	4 - 93	113

\* Data from Morris et al. 2000 except where noted.

\*\* Data from South Carolina mills. Camberato et al. 1997.

\*\*\* Data from Alabama mills. Muse and Mitchell 1995.

na - not available

## Does lime mud have any harmful components?

Chemical analyses of lime mud have shown that it is relatively free of any contaminants. A study in Canada found organic contaminants were generally not present or found at very low concentrations. Other analyses of lime mud from mills in Georgia show the metal content is low and usually about the same or lower than that of agricultural lime (Table 2).

**Table 2.** Trace metals concentrations in lime mud and agricultural lime.

<i>Minerals</i>	<i>Lime Mud*</i>	<i>Agricultural Lime***</i>
Arsenic (ppm)	1.71**	<1 - 3
Cadmium (ppm)	bd - 0.5	<0.1 - 1.1
Lead (ppm)	bd	1.3 - 130
Mercury (ppm)	<0.05**	<0.01 - 0.02
Molybdenum (ppm)	bd - 0.1	0.3 - 0.5
Nickel (ppm)	3.3 - 71	7.0 - 17
Selenium (ppm)	bd - 7.6	<1

\* Data from Morris et al. 2000 except where noted.

\*\* One sample from a Georgia mill.

\*\*\* Data from McBride and Spiers 2001.

bd - below detection.

## How does lime mud affect soil pH and plant growth?

Soils in Georgia naturally have a low pH that can decrease crop production. Regular soil testing can determine the amount of lime needed to raise the soil pH to the desired level. For most crops in Georgia, this pH is 6.0 to 6.5.

Several studies have shown lime mud to be very effective in raising soil pH to desired levels. Lime mud that was applied on the surface of an Alabama pasture increased the soil pH more

quickly than agricultural lime, and was more effective than agricultural lime in raising the pH to the desired level of 6.5. Another study in the Georgia Piedmont found lime mud incorporated into the soil was as effective as agricultural lime in raising soil pH. Yields of corn, wheat, soybeans, and pearl millet on test plots in Tifton and in Athens were the same or better from the lime mud plots than the agricultural limestone plots (Figure 1).

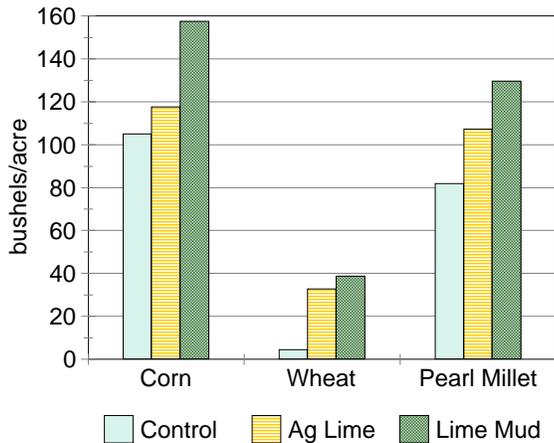


Figure 1. Crop yields (bushels/acre) using lime mud compared to agricultural lime and an unlimed control at Tifton. (Adapted from Miller and Sumner, 1999)

## How should lime mud be used?

The effectiveness of lime materials is measured by the calcium carbonate equivalent or the CCE. The CCE percentage tells you how much neutralizing power each pound of that material has compared to pure calcium carbonate. A CCE near 100%

means that a pound of the lime material has nearly the same ability to raise soil pH as a pound of pure calcium carbonate. Because the percentage of calcium carbonate in lime mud is high, the CCE of lime mud is also high, usually around 99%.

The particle sizes found in a lime material affect how the material can react with the soil. Materials with many fine particles raise the soil pH more quickly than those with a higher proportion of coarse particles.

Lime mud typically has a high proportion of fine particles, and consequently, reacts quickly with the soil. This means you need to treat lime mud with care to avoid high pHs that can prevent good crop growth. Agricultural limestone has coarser particles that react with the soil over a longer period of time. Lime mud reacts more like quick lime or hydrated lime and can raise the soil pH quickly. When using lime mud, you should take care to apply the correct amount. Overapplication may raise the soil pH to levels that could create crop growth problems.

Lime mud should be applied based on soil test recommendations for lime, because the CCE of lime mud is typically near 100%. However, you may need to adjust for moisture content. The moisture content of lime mud is usually around 30%, but can be as high as 50%. Lime muds with a moisture content near 50% may be difficult to spread and you will need to apply more tons per acre to correct for the water weight. The formula below can be used to correct for moisture content. Onsite storage of lime mud should be avoided in

### Moisture Content Correction

Moisture content can be reported as Percent Moisture or as Percent Solids. If Percent Moisture is reported then change the Percent Moisture to a decimal by dividing by 100. Then subtract the decimal Percent Moisture from 1.00 to obtain the Percent Solids. Divide the recommended lime mud application rate by the decimal form of the Percent Solids.

#### Example:

Percent Moisture is 40%.

$40 \div 100 = 0.40$  (decimal form of Percent Moisture)

$1 - 0.40 = 0.60$  (decimal form of Percent Solids)

Correct for moisture content :

Lime mud application rate (tons/acre) =  $2 \text{ tons/acre} \div 0.60$   
3.3 tons/acre

If we round this number to a rate that we are able to spread, **the correct application rate is 3.5 tons of lime mud per acre.**

areas where crops will be grown, because it can create areas of very high pH soils. You should also be careful to store lime mud so that runoff from the pile will not move into nearby streams or ponds.

## Are there any regulations involved in the use of lime mud?

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The Environmental Protection Division of the Georgia Department of Natural Resources regulates the land application of industrial and municipal wastes. If a by-product can be shown to have a beneficial reuse, it is not regulated as an industrial waste. Lime mud is beneficially reused in many places as a liming material. If applied at the recommended agricultural rates, it is not considered an industrial waste by the Georgia Environmental Protection Division and can be used without having to apply for specific permits.

The Georgia Department of Agriculture requires people who distribute liming materials in the state to be licensed and to register each product. Proper labeling includes guarantees for CCE, calcium content, particle size, and moisture content. It is the supplier's responsibility to see that the Department of Agriculture's requirements are followed.

In summary, lime mud is a by-product of the pulp mills that is useful as a soil liming agent. Studies have shown it is effective at raising soil pH, and

crop yields are similar to those where agricultural lime has been used. Agricultural use of lime mud keeps a useful material out of landfills and may provide a lower cost lime alternative for the farmer.

## References

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