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Using food processing plant waste on fields

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Food processors, such as dairy processing plants, are pretreating processing wastes to reduce waste loads discharged to municipal treatment plants. Many of these food processors have installed waste treatment facilities. These facilities may generate sludges that can benefit farmers when used as a liming material or as a nutrient additive to fields.

Sludge or biomass from treatment at dairy plants contains microbial matter, water and some minerals. The microbial matter contains nitrogen and phosphorus, which are usable plant nutrients that can benefit agriculture instead of just being landfill waste.

This guide, based on MU research, provides information on using the waste or lime stabilized biomass (LSB) from food processing plants for liming fields.

What is LSB?

Lime is added to the waste stream by several dairy processing plants in Missouri and a few municipalities. This lime – added following secondary treatment – aids in coagulation, settling and clarification of biological solids.

Secondary treatment is a biological process that may be aerobic (in presence of air) or anaerobic (in absence of air). During secondary treatment, microbes break up organic material in the raw waste by converting it in part to carbon dioxide, microbial biomass and other metabolites.

In aerobic systems, lime often is added to stabilize the resulting suspension by (1) allowing the solids to settle and (2) raising the pH of the suspension to above 12 to kill pathogens (disease organisms) and prevent odor development. Calcium hydroxide is the form of lime used because it is soluble and will raise the pH to 12 or more. Agricultural limestone is relatively insoluble and would not raise the pH of the sludge above 8.2.

LSB, therefore, is a sludge high in lime (pH>11.0) that also contains nitrogen, phosphorus and a small amount of other plant nutrients. The LSB varies between 5 and 10 percent solids on the weight basis. Table 1 gives a representative analysis of an LSB. This sample analysis will be used later in the calculations to demonstrate its use.

Table 1. Typical composition of LSB from a milk processing plant waste treatment facility.

Solids*	N	P	K	Ca	Mg
%	----------	----------	% of dry solids	----------	----------
7.5	2.4	2.0	0.2	36.0	1.9

*assumes 1 gallon weighs 8.35 lbs.

The method of presenting the analysis given in Table 1 is the preferred method. However, laboratories may differ in the units used to present their results. If there are questions, it is best to call the laboratory to clarify.

How might LSB be used?

The composition of LSB given in Table 1 shows that there may be considerable amounts of P (phosphorous) and Ca (calcium) but K (potassium) is quite low. These data demonstrate that LSB may be a source of P and Ca.

The P in the LSB is readily soluble so LSB can be used to increase the available P in soil. Thus, LSB may be used to increase available P in soils low in P as measured by soil tests.

Lime stabilized biomass by its very name contains lime. Lime in the biomass reduces odors but when applied to soil, the lime will neutralize soil acidity. Thus, LSB may be used as a liming material.

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Table 2. Effect of concentration of solids in LSB on quantity of Ca and P applied.

Quantity of LSB gallons/A	Solids Concentration %	Solid Applied lbs/A	Nutrients Applied* Ca	P
			-----lbs/A------	
6,000	5.0	2,500	900	50
6,000	7.5	3,750	1350	75
6,000	10.0	5,000	1800	100
9,000	5.0	3,760	1350	75
9,000	7.5	5,640	2030	53
9,000	10.0	7,520	2700	150

*Assumes 36% Ca and 2% P on dry matter basis and a gallon weighs 8.35 lbs.

The fineness of the lime in LSB makes it readily available for reaction with soil acidity, but the long-term effects likely will not be the same as agricultural limestone.

The nitrogen in LSB has proven to be readily available but limited in amount. The seedings made using LSB to supply P and lime, in comparison with P and lime from usual sources, have shown that the N (nitrogen) seems to enhance early growth.

The lack of a significant amount of K and Mg (magnesium) in LSB means that these two nutrients must be supplied from other sources, based upon needs shown by soil tests.

LSB can be used to increase the available P in soils and to supply lime. There have been no documented differences between the P and lime from LSB and the more conventional sources. The lime in LSB is quicker acting than agricultural limestone because of its fineness. Table 2 gives some examples of the quantities involved (Ca is an index of lime content.)

The work done by MU on LSB has clearly demonstrated that the material may be used for many of the same things that agricultural lime and super phosphate are used.

Most reasonable uses for LSB?

LSB can be used for

- broadcasting to supply lime and P for forage establishment
- topdressing on hay and pasture fields (**NOTE: There are some restrictions – see section "When and where to apply?"**)
- replacing agricultural lime and P fertilizer for soil corrective treatments for most field crops.

Broadcasting to supply lime and P for forage establishment. The lime and P in the LSB are very quick acting when applied to soil so LSB may be applied prior to tilling the soil in preparation for forage seeding. There is no need to apply six months before seeding, as with agricultural lime, to allow for reaction with the soil. The nitrogen in the LSB is organic and is slowly released, which benefits the new seeding. MU results were especially good with red clover and alfalfa seedings (Table 3).

Table 3. Effect of LSB on alfalfa establishment yields in the establishment year — 1986 Texas County

Establishment Treatments* LSB	Commercial Lime and P	Alfalfa
		T/A
6,000 gal/A Plowed down	None	1.42
6,000 gal/A After plowing	None	1.38
6,000 gal/A Split	None	1.76
None	Equal to 6,000 gal LSB	0.77
None	Mo. Ext. plowed down	0.88
None	Mo. Ext. after plowing	0.84
None	Split	0.92
None	None	0.76

*Plowed in early March and seeded 3/27/88 (Cimarron). Mo. Ext. refers to recommended limestone and P based upon soil tests. Lloyd Taff Farms, Cabool, Mo.

Topdressing on hay and pasture fields. The original use of LSB was as a topdressing on established tall fescue fields to correct lime and P deficiencies. In cases where increased production is needed, LSB plus supplemental nitrogen and potassium significantly increased fall fescue yields in southwestern Missouri (Table 4). This effect on yield occurred whether compared with no LSB treatment or with no added N.

Replacing agricultural lime and fertilizer. Soil tests taken four seasons after the use of LSB have shown marked increases in soil pH and extractable P and Ca (Table 5).

How much to use?

The quantity of LSB to apply depends upon

- soil needs
- composition of LSB
- application method
- regulatory restrictions to protect surface and ground water.

An example and a worksheet will be given later because these four variables make it necessary to consider each situation individually if the application of LSB is to be agronomically and environmentally sound.

What are soil needs?

If you are considering the use of LSB, be sure to have current soil test information available for the field to be treated. It is just good, sound management to do so and to keep files on the treatments applied to the field. The soil test report will indicate the recommended quantities of P, K, and ENM (Effective

Table 4. Effect of supplemental N + K on LSB treated tall fescue.*

Added N	Added K	LSB gallons/acre	Average Yields 1982-1983	Average Yields 1984-1985
			T/A	T/A
0	0	0	1.64	0.95
		6,400	1.96	1.17
yes	0	0	3.06	1.86
		6,400	3.46	2.63
0	yes	0	1.82	1.01
		6,400	2.01	1.24
yes	yes	0	3.10	2.05
		6,400	3.84	3.06

*MU Southwest Center

Table 5. Effect of LSB on selected soil tests four harvest seasons after application.*

Quantity of LSB gallons/acre	Soil Tests pH	Soil Tests P (lbs/A)	Soil Tests Ca (lbs/A)
0	5.0	7	1,540
10,000	6.4	29	2,440
13,000	6.7	54	2,500
20,000	7.1	66	3,210

*Surface applied to tall fescue. MU Southwest Center.

Neutralizing Materials) per acre for the crops designated when the soil sample was submitted. The P recommendation is designed to raise the soil P to a target level based upon the crop. Current Missouri recommendations call for this to be done over a four- to eight-year period because of cost of processed phosphate.

How will LSB help?

However, if LSB is used, it will likely be just as well to raise the soil P to the target level with one or two applications. Table 6 provides the total amount of P (expressed as lbs P_2O_5/A) needed to reach the target level in one application.

As shown earlier, the K recommendation must be covered with commercial fertilizer because LSB is essentially void of K.

The ENM recommendation is used to correct acid soil problems. ENM reflects the neutralization needs of the soil. Lime materials must be sold or delivered based upon their ENM content (lbs/ton) by state statute.

ENM is another term for effective calcium content (ECC) and is based upon the calcium carbonate equivalent and fineness. The lime in LSB is nearly all from calcium hydroxide and is sufficiently fine that no fineness factor is needed. Therefore, the percentage Ca in LSB can be used to easily obtain an estimated ENM value of the LSB solids. For example, the LSB described in Table 1 has 36 percent Ca ,which would be equivalent to an ENM per ton of approximately 720 lbs. The needs of the field for ENM is based upon the pH and the amount of neutralizable acidity in the soil. The crop and location in the state (for alfalfa) also is considered. Table 7 was compiled from the equations used for the ENM calculations to provide some values for selected situations.

How much is needed?

An illustration will be used to demonstrate how

Table 6. Recommended build up needs for phosphorus based upon soil test results for three crop groups.

Soil Test	Crop Group: Row Crops Cereal Crops Alfalfa	Crop Group: Red Clover	Crop Group: All Other Forages
lbs P/A	lbs P_2O_5/A	lbs P_2O_5/A	lbs P_2O_5/A
5	493	450	358
15	312	270	177
25	188	145	52
35	87	44	0
45	0	0	0

to calculate how much LSB to use. We will assume the LSB has the composition in Table 1. We will also assume the field to be treated is in tall fescue with a pH_s = 4.8, a neutralizable acidity content of 5.0 me/100g and a P soil test of 5 lbs P/A.

LSB is usually applied as gallons per acre so the LSB analyses for P, Ca and solids may be used to determine the number of gallons per acre to apply. Table 8 provides the necessary information based upon Table 1.

Assuming 1 gallon of LSB weighs 8.35 lbs, the 7.5 percent solids given in Table 1 mean that there will be 0.626 lbs of dry solids per gallon (0.075 x 8.35 = 0.626). This 0.626 lbs of dry solids is 36 percent calcium and 2 percent phosphorus (P not P_2O_5). Note that some laboratories will report Ca as percent CaO (calcium oxide) and P as phosphate or P_2O_5. The word "phosphate" likely means P_2O_5 but check with the laboratory for clarification.

The soil will need 358 lbs P_2O_5/A to reach the desired target level for tall fescue (Table 6). P_2O_5 is the unit used in the fertilizer trade, but P is the unit used in lab analysis (Tables 1, 8).

The appropriate conversion is lbs P_2O_5 x 0.43 =

Table 7. Limestone recommendations for various Missouri crop programs.

a. Alfalfa and alfalfa mixtures (southern Missouri): 400 x N.A.(me/100g) = lbs. ENM/A

b. All other forages (except alfalfa)(Target pH_s = 5.5 to 6.0)

Neutralizable Acidity	pH_s 4.0	pH_s 4.8	pH_s 5.2
me/100g	lbs ENM/A		
1.0	314	262	216
3.0	942	787	647
5.0	1,570	1,311	1,078
7.0	2,198	1,835	1,509
9.0	2,826	2,360	1,941

c. Alfalfa (northern Missouri) and all grain crops (Target pH_s = 6.0 to 6.5)

Neutralizable Acidity	pH_s 4.0	pH_s 4.8	pH_s 5.2
me/100g	lbs ENM/A		
1.0	352	328	283
3.0	1,055	983	850
5.0	1,758	1,639	1,417
7.0	2,461	2,293	1,984
9.0	3,164	2,948	2,551

lbs P; therefore, our sample soil will need 154 lbs P/A (358 lbs x 0.43).

Each gallon of LSB contains 0.013 lb P (Table 8). The appropriate calculation to determine the gallons of LSB needed to meet the needs of the soil is:

154 lbs P/A + 0.013 lbs P/gallon = 11,846 gallons/acre.

What are Missouri guidelines?

This quantity of LSB exceeds the 9,000 gallons per acre per year suggested in the Missouri Department of Natural Resources Guidelines. Therefore, if P were the only consideration, the needs for P would be spread over two years.

Our sample soil requires 1,311 lbs ENM per acre to raise the pH into the desired range of 5.5 to 6.0 (Table 8). The Ca content of LSB is essentially equivalent to ENM so to calculate the needs for LSB to satisfy the soil needs, the following calculation is used:

1,311 lb ENM/A + 0.225 Ca/gallon = 5,827 gal/A

Table 8. Quantity of components per gallon of LSB example in Table 1.

Solids	Ca	P
lbs/gallon		
0.626	.225	.013

This sample of LSB, therefore, will meet the needs for the fescue very easily. Another concern is too much lime. The pH desired for alfalfa will not damage tall fescue; the lower pH limit for fescue is used because no further yield responses have been observed from fescue when pH is raised above 6.0. The alfalfa needs can serve as a tentative upper limit in this case (Table 7):

400 x 5 = 2,000 ENM/A

2,000 ENM + 0.225 = 8,889 gallons

Our decision on application of LSB in this situation is to apply the limit of 9,000 gallons per acre this year. This provides 75 percent of the recommended P needs, meets DNR guidelines, and is at the upper limit for lime. A second treatment of 3,000 gallons per acre or so may be made the following year.

Natural rainfall will have started to lower the pH so extra lime will have no effect on plant. The soil will be at the recommended P level. Repeated applications may be made in future years based upon soil tests.

The maximum amount of LSB that may be applied will be the lowest amount calculated on each of the following:

1. soil pH_s after application
2. extractable soil P after application
3. total N applied– depends upon the crop requirements (usually not a limit with LSB)
4. runoff hazard (see section "When and where to apply?")

Guidelines of the Missouri Department of Natural Resources may change in the future. Calculations should be used to restrict LSB application to 1.5 x desired ENM/A or total corrective P needs, whichever is smaller.

When and where to apply?

There are three restrictions to the decision on when to apply. The first is obvious — the waste treatment plant must have a supply. There is demand for LSB so at times there may not be material available. Plan ahead for the needs.

The second restriction is agronomic. The crop program will dictate when best to apply. If a new seeding is to be established, the LSB may be applied whenever the soil is being tilled to prepare a seedbed. Application to hay or pasture fields should consider soil moisture, the stage of growth, and the intended use. The latter is most important.

The third set of restrictions relate to regulatory rules and guidelines. The LSB may be applied to level forage fields at any time the application equipment can get on the field without leaving compacted tracks in wet soil. LSB should not be applied on top of snow or ice on slopes. LSB contains no pathogens, but it is good practice to apply LSB after hay has been cut.

Application to cropped fields can be done anytime that runoff will not occur. There are few restrictions for fields of less than 6 percent slope, but a buffer of at least 150 feet should be maintained between the application and the stream or ditch leading to a stream.

On sloping fields of 7 percent or more, the buffer zone should be extended to 300 feet or more, and this buffer should be in grass. Caution about runoff should guide applications to fields with slopes in excess of 12 percent.

How to apply?

Most of the LSB in southern Missouri must be applied on the soil surface. Injection may be used on rock free soils and is especially desirable for application to fields used for grain crops.

Time, method and location of application should be based on the fact that odors for even friendly neighbors can cause problems. Although the lime content and high pH of LSB minimizes odor development, the sight of a truck spreading LSB evokes negative mental images and imagined odors.

WORKSHEET

The calculations in this worksheet are based upon the recommendations of P and ENM, which are based upon soil tests (see the example and explanations given elsewhere in this guide). An analysis of the LSB is required and must include at a minimum: (a) weight per gallon wet LSB, (b) percent solids (weight basis), and (c) percent N, Ca and P in the dry solids.

Phosphorus

_________ lbs P/A needed = 0.43 x lbs P_2O_5/A total build up

_________ gallons LSB/A = lbs P/A needed ÷ (lbs LSB/gal x $\frac{\%\ Solids}{100}$ x $\frac{\%\ P\ in\ Solids}{100}$)

Note: Annual application should not exceed 9,000 gallons/A.

ENM

_________ gallons LSB/A = lbs ENM/A needed ÷ (lbs LSB/gal x $\frac{\%\ Solids}{100}$ x $\frac{\%\ Ca\ in\ Solids}{100}$)

Upper limit = 1.5 (Neutral. Acidity x 400) ÷ (lbs LSB/gal x $\frac{\%\ Solids}{100}$ x $\frac{\%\ Ca}{100}$)

Note: Wait 2 years and retest soil after the upper limit has been applied.

In most cases, the maximum quantity of LSB calculated for either P or ENM may be applied so long as the limit of 9,000 gallons per acre per year is followed.

How frequently apply?

Soil tests should be used to regulate frequency of application if either lime or P is the restriction to one time application. MU research in Texas and Lawrence counties suggest that if either soil pH or P are brought to recommended levels with LSB, the pH and P will slowly decline with cropping. Use soil tests to follow this decline to determine when best to reapply.

What are grazing restrictions?

According to DNR regulations, grazing of animals or hay harvest should not occur for 30 days after application. The Missouri Division of Health and the State Milk Board recommend that at least one year pass after sludge application before lactating animals graze a sludge treated pasture. Consult the local extension office for up-to-date regulations.

What does the future hold?

LSB is an asset to agriculture and will be even more so in the future as fertilizer and lime costs rise. Research is underway to improve LSB. Removal of water would make the material less costly to transport from the plant. Dewatering technology is available but is not at present cost effective.

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