Evaluation of Soil Liming Materials

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Introduction

- Sources of high quality agricultural limestone are limited in the southeastern Coastal Plain.
- Some industrial byproducts are potential alternative liming materials, but their neutralizing ability is highly variable and may not be addressed by state lime laws regulating ground limestone.

The state of Alabama's lime law

- **Purity**
  ≥90% calcium carbonate equivalent (CCE)
- **Fineness**
  ≥90% pass10 mesh and ≥50% pass 60 mesh

- Relative neutralizing value (RNV) allows comparison of different lime products using standard product information, but this is untested on byproducts.

Objective

- Determine the neutralizing ability of industrial byproducts
- Evaluate whether RNV is indicative of the actual liming ability of industrial byproducts

Materials and Methods

- 10 products were evaluated.

Steel Slag	Byproduct from stainless steel manufacture
P Slag	Byproduct from P mining
K-lime	Mixture of ash and lime
Ash	Paper mill byproducts
Lime mud	
Primary Sludge	
Secondary Sludge	
Paper Sludge	
Calcitic lime	Mixture of 5 sources
Dolomitic lime	Mixture of 6 sources

- CCE and particle size were analyzed using AOAC Official Methods of Analysis.
- Total elements were analyzed by EPA-3051 method.
- A soil incubation study using three acid soils in Coastal Plain was performed to determine the actual neutralizing ability that is predicted by RNV.
- The effectiveness of RNV was evaluated by dividing the soil pH of each product by the pH of $Ca(OH)_2$ at the end of incubation.

Results and Discussion

- The CCE varied among the products tested. Only the steel slag and lime mud met the state requirement for purity (Table 1).
- K-lime, ash, and lime mud meet the particle size requirement.

Table 1. CCE, particle size, and total elements of liming materials evaluated

Name	CCE	Pass 10 mesh	Pass 60 mesh	Ca	Mg	Cr	Na
	----------%----------			-----g kg^{-1}-----		-----mg kg^{-1}-----	
Steel slag	91.7	64.3	27.2	337.9	47.6	1087.7	288.5
P slag	58.1	22.1	0.9	292.0	ND	23.5	1103.9
K-lime	39.4	96.5	60.5	107.5	6.0	13.4	3434.4
Ash	87.0	94.8	58.5	294.4	10.8	3.4	1780.4
Lime mud	102.3	99.9	95.9	385.0	4.8	10.6	3569.5
Primary sludge	12.5	0.7	0.1	37.4	7.7	5.8	440.0
Secondary sludge	35.3	42.6	6.4	90.8	ND	20.8	554.9
Paper sludge	36.9	17.9	0.7	144.1	ND	10.3	68.8
Calcitic lime	95.1	90.4	38.0	371.8	5.7	4.5	7.2
Dolomitic lime	97.4	93.5	46.5	242.4	94.7	ND	5.2

- The steel slag contained Cr levels near the EPA maximum limit (1200 mg kg^{-1}). However, the toxic form, Cr^{6+}, is <0.05 mg kg^{-1}, indicating this slag may not be hazardous materials.
- Sodium in byproducts may negatively affect soil quality if used repeatedly over time (Table 1).

$$RNV = \left(\frac{\%\ \text{between 10 and 60 mesh}}{2} + \%\ \text{<60 mesh}\right) \times CCE$$

- The ash and lime mud has comparable RNV to agricultural limestones (Fig. 1).

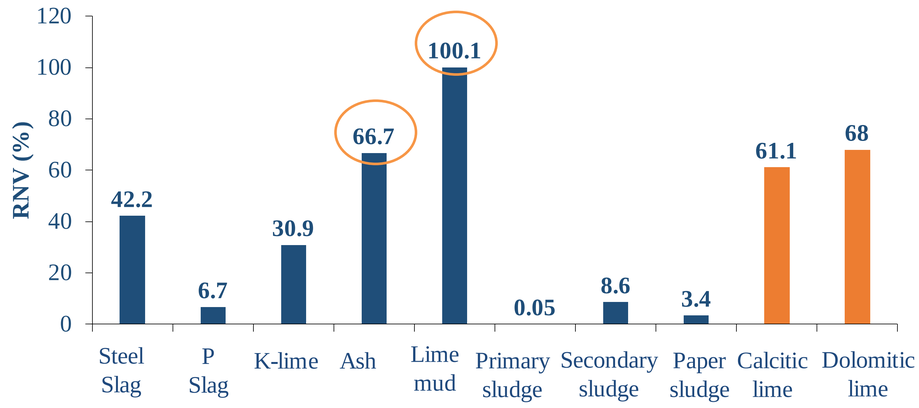

Figure 1. Relative neutralizing value of liming materials

- A pH buffer curve was used to estimate total alkalinity necessary to achieve a soil pH of 6.5. This was our lime rate targeting 6.5 (Fig. 2).
- Zero, half, and twice this rate were also used in incubation studies (half rate not shown, zero rate is control.

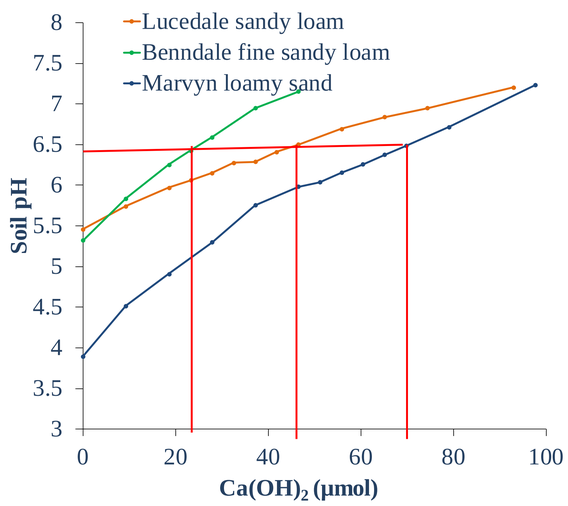

Figure 2. Soil pH buffer curve

- The lime rate targeting pH 6.5 did not raise the soil pH to 6.5, except for the paper sludge (Fig. 3A).
- Twice the lime rate targeting pH 6.5 was able to raise the pH to near 6.5 for steel slag, ash, and secondary paper sludge (Fig. 3B)

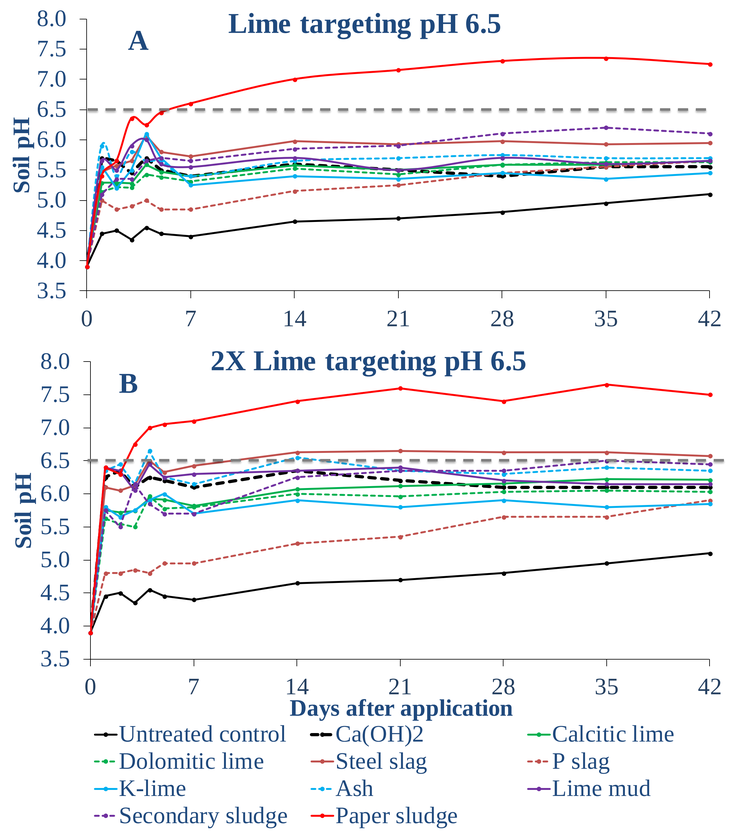

Figure 3. Incubation study evaluating the effect of liming materials on soil pH at rate targeting pH 6.5 (A) and twice that rate (B) in the Marvyn loamy sand. Dashed grey line indicates pH 6.5 target.

- Calculated RNV is effective in predicting final pH except for paper sludge (Table 2).

Table 2. Relative effectiveness compared to $Ca(OH)_2$

Name	Benndale	Lucedale	Marvyn	Average
	----------%----------			
Steel slag	101	108	104	104
P slag	97	99	98	98
K-lime	92	96	96	95
Ash	101	104	100	102
Lime mud	102	101	98	100
Secondary sludge	106	106	104	105
Paper sludge	119	123	121	121
Calcitic lime	101	103	100	101
Dolomitic lime	100	102	100	101

Conclusions

- Ash and lime mud may be suitable alternative liming materials, whereas primary sludge and stainless steel slags have considerable limitations to use.
- The RNV is a good indicator of actual liming ability of agricultural limes and byproducts.

Acknowledgement

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