To neutralize the residual acidity

- You have to neutralize all the Al and H that are on the colloid surfaces
- The more surface area, the greater the lime requirement

How much lime will this be?

- Buffer methods
  - Add buffer solution that contains weak acid + its associated salt to soil
  - Measure pH
  - Decrease in pH will correspond to buffering capacity of soil, and its lime requirement
  - SMP buffer, Adams - Evans buffer

Titration
Fixed amount of soil, increments of lime

Rough calculation

- Current pH
- Cation exchange capacity
- Percent base saturation

Increase base saturation

- Say you want to increase % base saturation by 60%
- CEC = 10 cmol/kg
- 10cmol/kg x 60/100 = 6 cmol charge/kg soil
- As each mol of Ca has 2 mol of charge
- Need 3 mol Ca/kg soil
- FW CaCO3 = 100
- Need 300 g lime per kg soil

Which is the sandy soil?
So what type of liming material will you use?

Lime Sources

- **Agricultural Lime**
  - \( \text{CaCO}_3 \) (pH 8.3)
- **Hydrated Lime**
  - \( \text{Ca(OH)}_2 \) (pH >11)
- **Burned Lime**
  - \( \text{CaO} \) (pH >11)

Reaction

- \( \text{CaCO}_3 + 2\text{H}^+ \rightarrow \text{Ca}^{2+} + \text{H}_2\text{O} + \text{CO}_2 \)
- \( \text{Ca(OH)}_2 + 2\text{H}^+ \rightarrow \text{Ca}^{2+} + 2\text{H}_2\text{O} \)
- \( \text{CaO} + 2\text{H}^+ \rightarrow \text{Ca}^{2+} + 2\text{H}_2\text{O} \)

Spreading lime

Commercial Lime Sources

- \( \text{CaO} \) (burnt lime), \( \text{Ca(OH)}_2 \) (hydrated lime)
  - Soluble- fast acting
  - Caustic, pH > 11
  - Waiting period before planting
You don’t put your hand in it

Over Time Reaction

\[
\begin{align*}
\text{CaO} + \text{H}_2\text{O} + 2\text{CO}_2 & \rightarrow \text{Ca(HCO}_3\text{)}_2 \\
\text{Over time, all lime sources will become similar to ag lime}
\end{align*}
\]

Calcium Carbonate Equivalent (CCE)

- 1 Mol CaCO\(_3\) = 1mol CaO, 1 mol Ca(OH)\(_2\), 1 mol MgCO\(_3\)
- Figure out the formula weight of different compound
- Percent purity

For example

- Using CaO at 80% purity
- FW CaO = 56
- 100/56 = 1.786
- 1.786 x 0.8 = 1.429
- So 1 Mg of burnt lime = 1.429 Mg of limestone

Let’s look at pictures

Residuals as Lime Sources

Wood Ash

- CCE 20-30%
- pH, chemical form dependant on burn temperature
- At higher temperature
  - \(\text{CaCO}_3 \rightarrow \text{CaO}\)
  - pH increases from 8.3 to 12
Lacustrine deposits, oyster + egg shells

Cement Kiln dust
- By product of cement manufacture
- Fine particle size
- Contains range of Ca species

Residuals from pulp and paper processing

Sub Soil Acidity
- Generally high Al saturation is the problem
- Limit root growth
- Increased water stress
- In metal contaminated soils, can increase metal availability

Biosolids and Lime
- Can reduce sub-soil acidity
- At high pH, organics are more soluble
- Fulvic acid complexes in biosolids bond with Ca complexes
- Mobile in the soil profile
- Demonstrated in lab and field studies
- Precise loading rates not known

Soil pH - Galestown Sand
15 years after biosolids addition

Control
224 Mt ha
448 Mt ha
High Metals Soil Remediation

- Complexation, precipitation increases as pH increases
- Solubility, availability decreases as pH increases
- Raise and keep that pH > 7

Biosolids and Wood Ash

Bunker Hill, ID

Subsoil Extractable Zinc
Remember how certain elements are more soluble at low pH?

High Sulfur Tailings

- As sulfide minerals are exposed to air:
  - FeS $\rightarrow$ Fe(OH)$_3$ + H$_2$SO$_4$
  - Account for unoxidized S in lime requirement

Leadville, CO
Leadville, CO

Lime and biosolids amended areas

Leadville, CO