Effective Use of Calcium Reagents in Abandoned Mine Drainage and Abandoned Mine Land Reclamation

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Outline

1. Summarize calcium reagents that are used to treat abandoned mine drainage and mine land reclamation applications

2. Summarize reagents' suitability and use in abandoned mine drainage and abandoned mine land reclamation

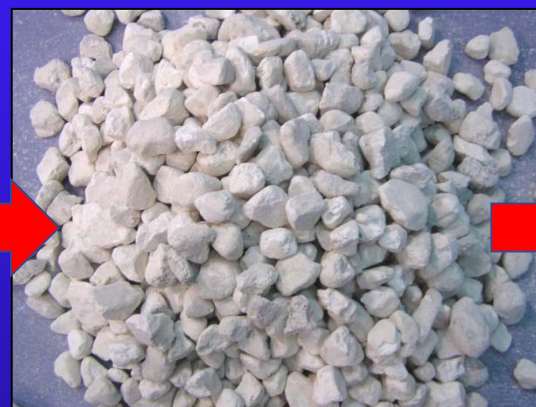
3. Application methods for calcium reagents

4. Effect preparation and mixing has on utilization efficiency of calcium reagents

Calcium reagents used to treat AMR and AMD

- Lime: Generic term applied to several different materials
  - Limestone by definition is $CaCO_3$
  - Quicklime, aka lime by definition is CaO
  - Hydrated lime by definition is $Ca(OH)_2$

Limestone
$CaCO_3$



Pebble Quicklime
CaO

Hydrated Lime
$Ca(OH)_2$

- Limestone ($CaCO_3$) is the raw material from which quicklime is made
- Quicklime is the raw material from which hydrated lime is made

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LIMESTONE

- Limestone = combination of $CaCO_3$ and $MgCO_3$
- Types of Limestone:
  - High Calcium Limestone
  - Magnesian Limestone
  - Dolomitic Limestone
- Sizes of Limestone
  - Fines
  - Screened pebble
- Limestone is used in passive treatment applications

QUICKLIME

- Quicklime= combination of CaO and MgO
- Types of Quicklime:
  - High Calcium Quicklime
  - Magnesian Quicklime
  - Dolomitic Quicklime
- Sizes of Quicklime
  - Pebble
  - Granular
  - Fines
- Quicklime is used in active treatment applications

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- There are different types of hydrated lime:
  - High Calcium Hydrated Lime
  - Dolomitic Hydrated Lime
- High Calcium Hydrated lime, $Ca(OH)_2$ is made when quicklime is combined with:
  - A stoichiometric, controlled amount of water to form a dry product
    - Hydration
    - Dry slaking

  or
  - An excess of water to form a wet slurry
    - (wet) Slaking with quicklime-Milk of lime slurry
    - Making slurry with hydrated lime and water
- In both processes, the same chemical reaction occurs
  - $CaO + H_2O \rightarrow Ca(OH)_2$
- Products are distinguished by the physical difference of the final material

Hydrated lime – Dry Slaking

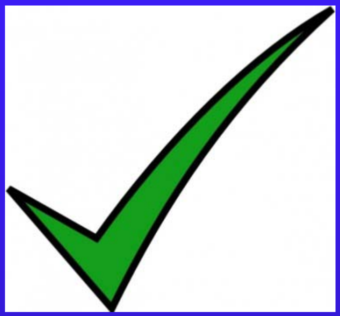
Hydrated Lime Slurry - Slaking

- Lime Kiln Dust is a byproduct of calcination
- Depending on kiln operation
  - Many different forms
    - Finely divided powder that varies in color depending on the limestone fired, type of kiln used and kiln fuel
    - Mulled, wetted product that resembles a wetted soil
- Lime Kiln Dust can contain
  - Limestone
  - Lime (Calcium and Magnesium oxides)
  - Fly Ash (if kiln is coal fired)
  - Small levels of gypsum

Waste Lime

- Waste lime or yard waste is a co-product from the manufacture of quicklime
- Usually collected from typical product streams or from spills, off spec material or start up and shut down material
- Depending on the progress through the kiln the material made and storage, waste lime typically contains and resembles:
    - un-reacted limestone
    - quicklime
    - hydrated lime
    - lime kiln dust
    - waste lime can resemble a wet or dry product

Summary of Calcium Reagents for AMR and AMD



1. Summarize calcium reagents that are used to treat abandoned mine drainage and mine land reclamation applications
   - Limestone $CaCO_3$
   - Quicklime CaO
   - Hydrated Lime $Ca(OH)_2$
   - Lime Kiln Dust
   - Waste Lime

2. Summarize reagents' suitability and use in abandoned mine drainage and abandoned mine land reclamation

3. Application methods for calcium reagents

4. Effect preparation and mixing has on utilization efficiency of calcium reagents

Limestone $CaCO_3$ suitability and use in AMD

- Passive Treatment AMD Types:
  - Anaerobic Wetlands
    - Water, Organic Matter and Limestone
  - Alkalinity Producing System
    - Water, Organic Matter and Limestone-Drainage
  - Anoxic Limestone Drain
    - Soil, Limestone, Plastic Liner
  - Limestone Pond
    - Water and Limestone
  - Open Limestone Channel
    - Water and Limestone
  - Variations

Photos courtesy of http://anr.ext.wvu.edu/land_reclamation/passive_treatment

Limestone $CaCO_3$ suitability and use in AMD

- Recommendations for Limestone use in Passive Treatment AMD:
  - Recommend to use limestone to mimic and take advantage of natural processes
  - To combat armoring: vary slope to prevent or minimize armoring-20%
  - Recommend to mix, supplement or replace limestone when necessary
  - Recommend to use with low acid load, but not with high acid loadings
  - Recommend combination of passive treatments or active treatment if limestone cannot achieve required treatment performance

Photos courtesy of http://anr.ext.wvu.edu/land_reclamation/passive_treatment

Limestone $CaCO_3$ suitability and use in AMR

- Limestone use in treatment of AMR:
  - Blend Limestone with acidic rock spoil to neutralize acid drainage, add alkalinity
  - Blend Limestone in soil to raise pH and add alkalinity for plant regrowth and raising pH in water bodies
- Recommendations for Limestone Use in AMR:
  - Mix as thoroughly as possible; this will yield good utilization
  - If possible excavate material, mix, then replace
  - Limestone fines may mix better than large limestone but would react away faster

Quicklime CaO suitability and use in AMD

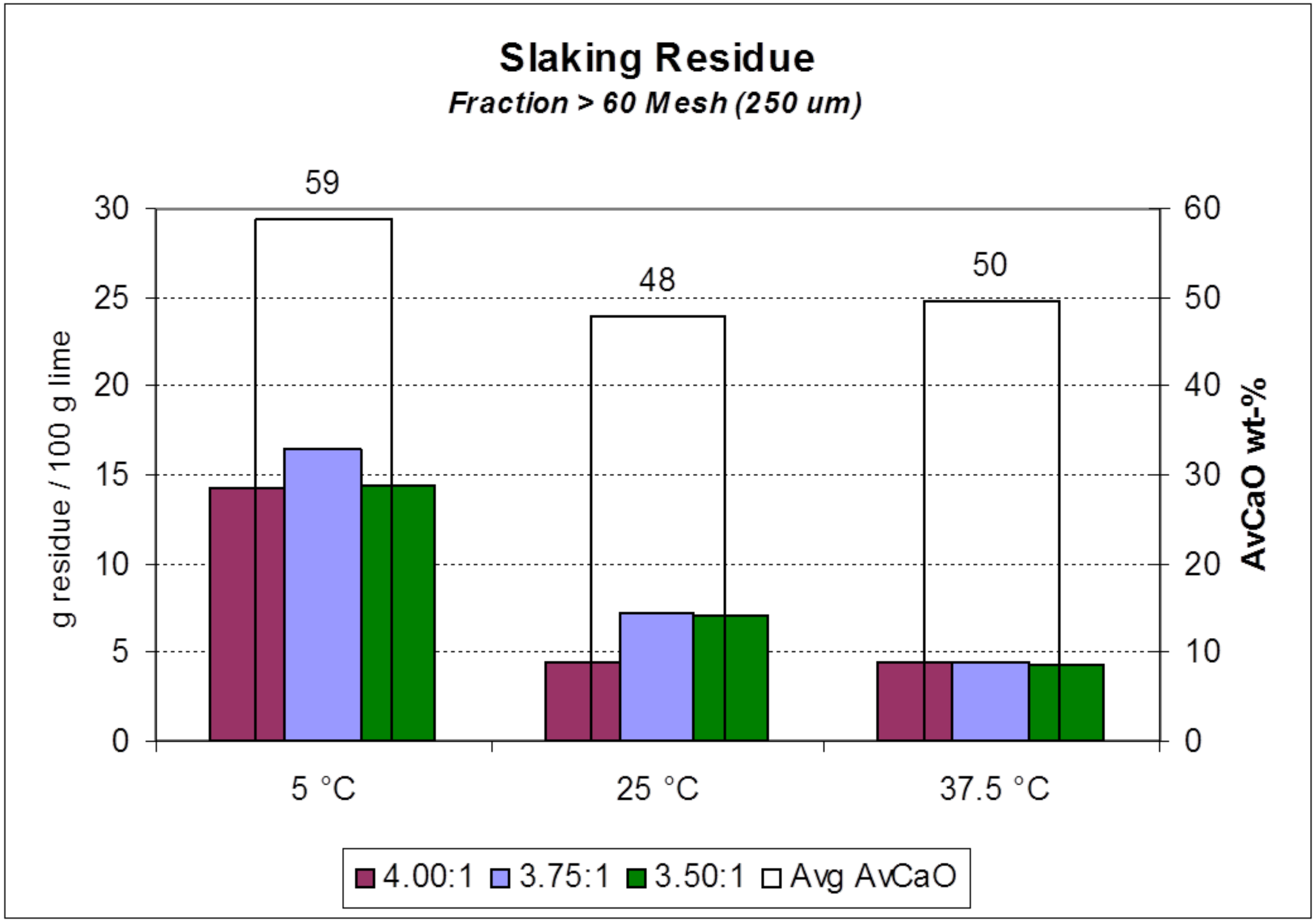
- Quicklime Uses in AMD:
  - Slake Quicklime
    - Slaker
    - Produce lime slurry, mixture $Ca(OH)_2$ and water
    - Lime Slurry can be used to dose into mine drainage streams or ponds to treat Iron, Manganese, Aluminum, raise pH, add alkalinity
  - Dry Dose Quicklime
    - Dose into streams of ponds to treat Iron, Manganese, Aluminum, raise pH, add alkalinity

Quicklime CaO suitability and use in AMD

- Quicklime Uses in AMD:
  - Slake Quicklime vs. Dry Dose Quicklime
  - Water chemistry and temperature effects
  - Much better treatment efficiency is achieved when lime is slaked with good quality water, water is heated before slaking, and slurry is mixed before and during contact with AMD
  - Will yield less residue, less available lime in residue, more money saved and faster treatment

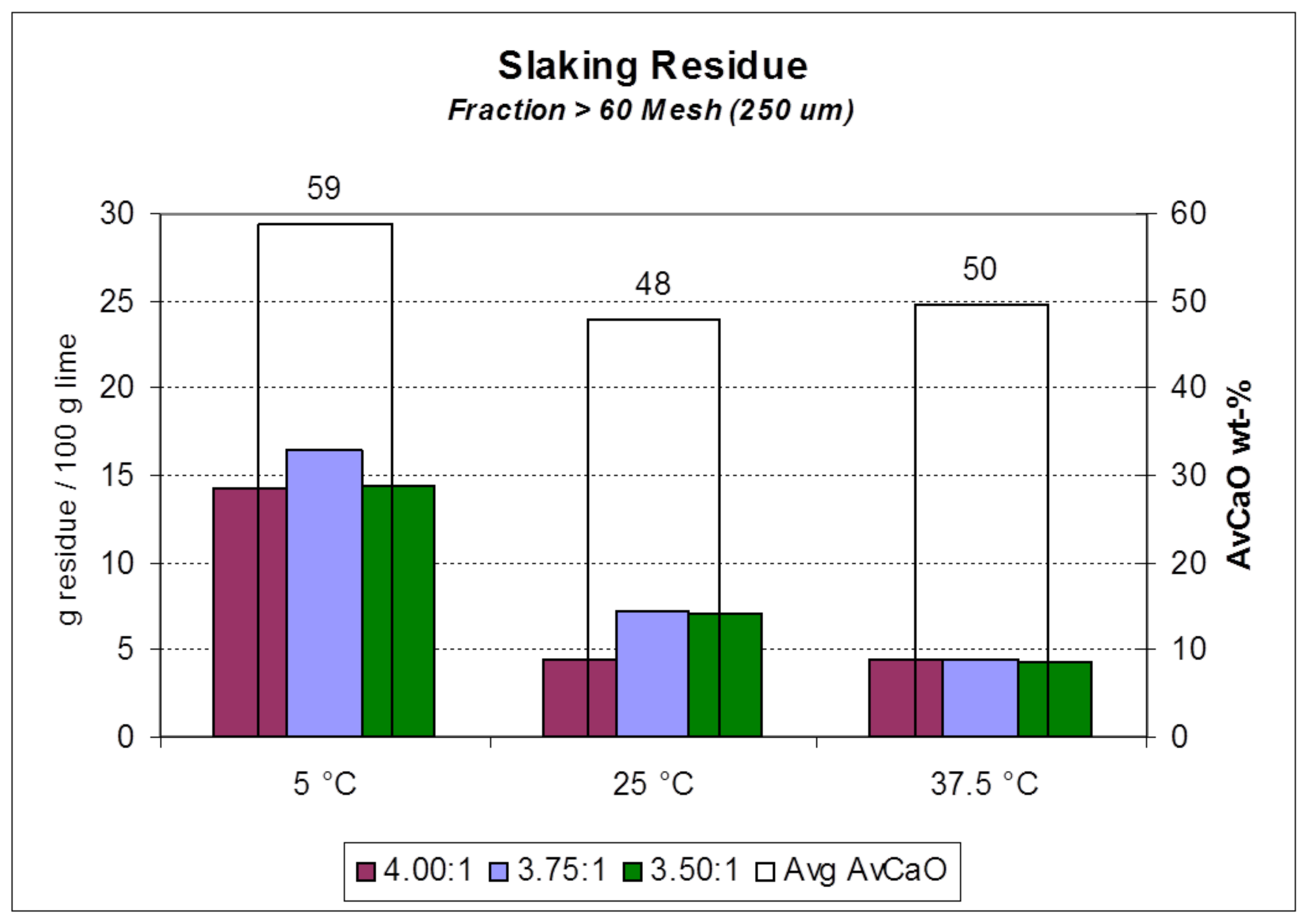
Quicklime CaO suitability and use in AMD

- Results of Carmeuse Research and Development Study May 2009 - May 2011
- 14 Lime samples, slaked 140 times total
- Effects of starting water temperate correlate to quicklime dry dosing into AMD, slaking with cold water and consequences of poor utilization



Quicklime CaO suitability and use in AMD

- Decreasing slaking water temperature increases quantity of residue and the available lime (unslaked lime) in residue
- Poor slaking conditions can result in large amounts of wasted lime exiting a system
  - Poor reagent utilization wastes money
  - Dredging and disposal costs



Quicklime CaO suitability and use in AMD

- Recommendations to increase utilization of quicklime in AMD:
  - Slake with good quality water (SO_4^{2-}, HSO_3^-, SO_3^{2-} under 500 ppm, not high in alkalinity, TDS or dissolved CO_2)
  - Slake with high temperature water 70˚F+
  - Slake at high temperatures 180˚F, control slaker by temperature not water to lime ratio
  - Mix slurry well with appropriate retention time in slaker
  - Mix slurry with AMD stream to facilitate even distribution and faster reaction times
  - To decrease residue use a more pure quicklime
  - Will create highly reactive slurry, which slakes quickly, reacts well, creates minimal residue and wastes little lime

- Good utilization of lime slurry dosed in a pond:
  - Lime slurry dosed into a pond with a spreader bar
  - Aerated the pond after lime slurry dosed pneumatically
  - Good utilization because lime slurry was slaked correctly, spread evenly over the pond, then mixed well

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Quicklime CaO suitability and use in AMR

- Quicklime Uses and Recommendations in AMR:
  - Lime Slurry can be spread on acidic spoil to neutralize runoff quickly, odor & bacteria control
  - Will not last a long time like limestone, waste lime or LKD but can be used as a quick fix
  - Recommend mixing to increase utilization, because lime slurry could be washed away unreacted if not distributed evenly and mixed

  - Lime Slurry can also be injected insitu (underground) to neutralize acidic drainage
  - Recommend mixing of lime slurry underground with contaminated spoil if possible to increase utilization

  - Lime could be dry dosed into acidic spoil for dry up but be aware there may be dust formation and more reagent may have to be added to combat poor utilization
  - Could dry dose quicklime to dry spoil for handling and landfilling
  - Recommend mixing thoroughly

Hydrated Lime $Ca(OH)_2$ suitability and use in AMD

- Hydrate Lime use and Recommendations in AMD Treatment:
  - Hydrated Lime can be dry dosed into AMD or slurried then dosed
  - Better utilization can be achieved if hydrated lime is slurried then dosed into AMD because of more controlled distribution, better pH control and better oxidation control
  - Recommended to slurry hydrated lime then dose into a pond or stream where slurry is mixed with AMD

Picture of a hydrator at a lime plant

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Hydrated Lime $Ca(OH)_2$ suitability and use in AMD

- Hydrated Lime vs. Quicklime Selection

- Hydrated lime products can cost more on a weight basis than quicklime, but often times offer higher utilization efficiencies than quicklime

- 1 ton of high calcium quicklime is theoretically equivalent to about 1.3 tons of high calcium hydrated lime

- To determine the real economic advantage of one form of calcium reagent versus another should consider:
  - Lower residue production (pond dredging & disposal)
  - Differences in capital cost of equipment and operating costs
  - Differences in ease of storage and dispensing

- Recommend to use hydrated lime in applications where reagent requirements are not very high and economically would not justify quicklime slaking (Typically use 2,000 tons/year or less)

Hydrated Lime $Ca(OH)_2$ suitability and use in AMR

- Hydrated Lime use and Recommendations in AMR:
  - Hydrated Lime slurry can be used in AMR to treat spoil above ground the same way as lime slurry
  - Will not last long time; quick fix
  - Recommend mixing insitu to increase utilization and allow pH adjustment to last longer
  - Recommend Limestone, Lime Kiln Dust or Waste Lime for long term acidic spoil neutralization rather than hydrated lime or quicklime
  - Recommend not to dry dose Hydrated Lime into acidic spoil, because Hydrated Lime would not dry spoil and create dust

  - Hydrated lime can also be used to stop bacterial growth and decrease odors
  - Recommend to distribute as a slurry to prevent dust formation

7th inning stretch

Lime Kiln Dust (LKD) and Waste Lime suitability and use in AMD

- Lime Kiln Dust and Waste Lime can be used to neutralize acidic streams and ponds in active and passive treatment applications
- Active:
  - Lime kiln dust has been used in dosers with some handling difficulties due to dusty and unpredictable nature of lime kiln dust. Lime kiln dust and waste lime is a low cost alternative and can be used for stream and pond pH adjustment.
- Passive:
  - Lime kiln dust and waste lime could be used as a component of treatment media to supplement limestone alkalinity.
- Recommend to investigate lower cost reagents with your lime supplier

Lime Kiln Dust (LKD) and Waste Lime suitability and use in AMR

- Lime Kiln Dust and Waste Lime can be used to:
  - Neutralize acidic spoil/overburden/land remediation
  - Kill bacteria growth and stop odors
  - Cap/Fill material
  - As a component of grout to seal mines
  - Placed over hot spots
  - Injected underground to increase alkalinity before water surfaces
  - Solid waste treatment
- Applications are diverse

Lime Kiln Dust (LKD) and Waste Lime suitability and use in AMR

- Recommendations for increasing utilization of Lime Kiln Dust and Waste Lime:
- Incorporation and mixing is key because chemical composition can vary
- I-99 Job in State College
- Cost effective compared to other calcium reagents if mixed properly

- Summarized calcium reagents that are used to treat AMD and AMR applications
- Summarized reagents' suitability and use in AMD and AMR
- Recommended ways to increase utilization efficiency
- Engage lime suppliers early in the design process, regardless of type of project to increase utilization efficiency

Questions? Please Contact Us

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