Acid mine drainage treatment using by-products from quicklime manufacturing as neutralization chemicals

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Introducation

By-products from quicklime manufacturing were investigated as substitutes for commercial quicklime (CaO) or hydrated lime ($Ca(OH)_2$), which are traditionally used as neutralization chemicals in acid mine drainage (AMD) treatment.

Four by-products (BP A-D) were studied and the results were compared with quicklime and hydrated lime. The studied by-products were partly burnt lime stored outdoors, partly burnt lime stored in a silo, kiln dust and a mixture of partly burnt lime stored outdoors and dolomite(Fig. 1). Present application options for these by-products are limited and they are largely considered waste.

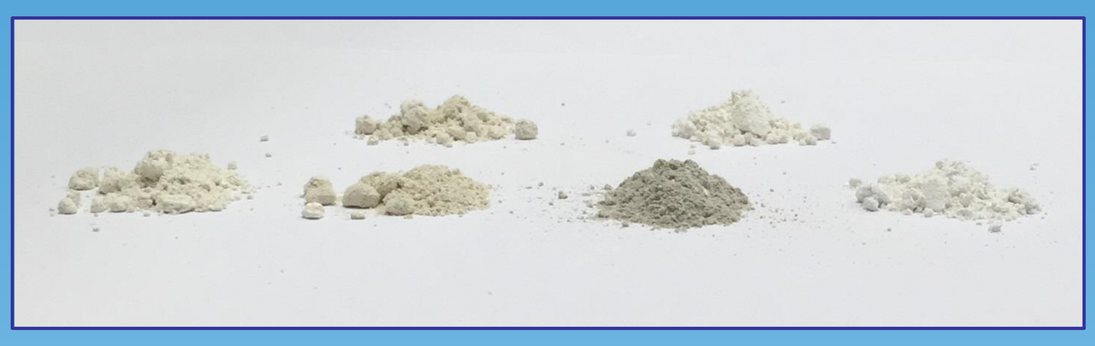

Fig. 1 From left to right in the foreground by-products A-D, in the background quicklime and hydrated lime.

Methods

Chemical precipitation experiments were performed with the jar test (Kemira Kemwater, Flocculator 2000) with 800 mL sample volume. The by-products as well as quicklime and hydrated lime were dosed as 10 % by-weight slurries. The appropriate amount of slurry was added to raise the AMD sample pH from 2.6 to 9.5. After that, the sample was rapid mixed at 150 rpm for 1 min, followed by slow mixing at 50 rpm for 5 min and then left to settle for 30 min. After settling water samples from the supernatant were taken for sulphate and metal analysis. The sludges were filtered and air dried prior to X-ray diffraction (XRD) analysis.

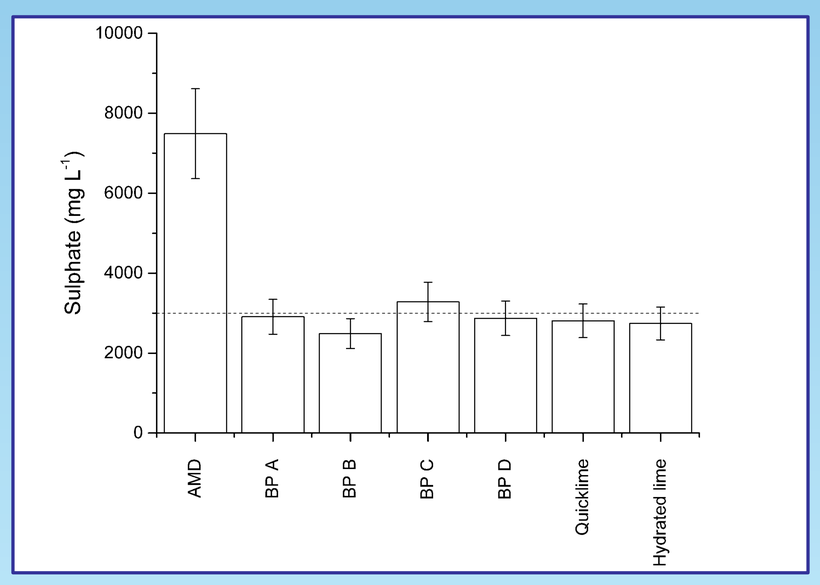

Fig. 2 Sulphate analysis by IC for untreated AMD and AMD treated with by-products A–D, quicklime and hydrated lime. Error bars represent the uncertainty of measurement.

Results

All the studied by-products removed approximately 60 % of sulphate(Fig. 2) and over 99 % of Al, As, Cd, Co, Cu, Fe, Mn, Ni, Zn (Table 1) from the AMD.

However, the neutralization capacity of the by-products and thus the amount of by-product needed as well as the amount of sludge produced varied.

Table 1 Metal concentrations by ICP-OES of AMD before and after treatment with by-products (BP A-D), quicklime and hydrated lime.

Element ($mg\ L^{-1}$)	AMD	BP A	BP B	BP C	BP D	Quicklime	Hydrated lime
Al	360	6.6×10^{-1}	8.8×10^{-1}	5.2×10^{-1}	6.6×10^{-1}	5.2×10^{-1}	5.3×10^{-1}
As	2.1×10^{-2}	$< 1.5 \times 10^{-2}$	$<1.5 \times 10^{-2}$	$< 1.5 \times 10^{-2}$	$< 1.5 \times 10^{-2}$	$< 1.5 \times 10^{-2}$	$< 1.5 \times 10^{-2}$
Ca	500	593	609	785	645	609	616
Cd	8.1×10^{-1}	6.0×10^{-3}	3.0×10^{-3}	$< 2.0 \times 10^{-3}$	4.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
Co	5.3×10^{-1}	$< 3.0 \times 10^{-3}$	$< 3.0 \times 10^{-3}$	$< 3.0 \times 10^{-3}$	$< 3.0 \times 10^{-3}$	$< 3.0 \times 10^{-3}$	$< 3.0 \times 10^{-3}$
Cu	35.3	$< 5.0 \times 10^{-3}$	$< 5.0 \times 10^{-3}$	$< 5.0 \times 10^{-3}$	$< 5.0 \times 10^{-3}$	$< 5.0 \times 10^{-3}$	$< 5.0 \times 10^{-3}$
Fe	443	$<1.5 \times 10^{-2}$	2.5×10^{-2}	$< 1.5 \times 10^{-2}$	$< 1.5 \times 10^{-2}$	2.0×10^{-2}	$< 1.5 \times 10^{-2}$
Mg	771	478	359	401	387	446	419
Mn	29.3	2.1×10^{-1}	6.2×10^{-2}	1.0×10^{-1}	1.4×10^{-1}	1.0×10^{-1}	1.2×10^{-1}
Na	158	151	150	152	138	152	152
Ni	1.26	$< 5.0 \times 10^{-3}$	$< 5.0 \times 10^{-3}$	$< 5.0 \times 10^{-3}$	$< 5.0 \times 10^{-3}$	$< 5.0 \times 10^{-3}$	$< 5.0 \times 10^{-3}$
Zn	410	1.1×10^{-2}	$< 1.0 \times 10^{-2}$	$< 1.0 \times 10^{-2}$	1.3×10^{-2}	1.8×10^{-2}	1.2×10^{-2}

Conclusions

- The results indicate that among the studied by-products partly burnt lime stored outdoors and partly burnt lime stored in a silo could be used as an alternative to quicklime or hydrated lime for AMD treatment.
- This could lead to cost savings in chemicals at the mine and in waste disposal at the lime plant.
- Further research should be performed to evaluate cost savings for the usage of by-products for full-scale active mine water treatment.

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References

Acid mine drainage treatment using by-products from quicklime manufacturing as neutralization chemicals, Tolonen, E-T., Sarpola, A., Hu, T., Rämö, J., Lassi, U. Chemosphere 117 (2014), 419-424.

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