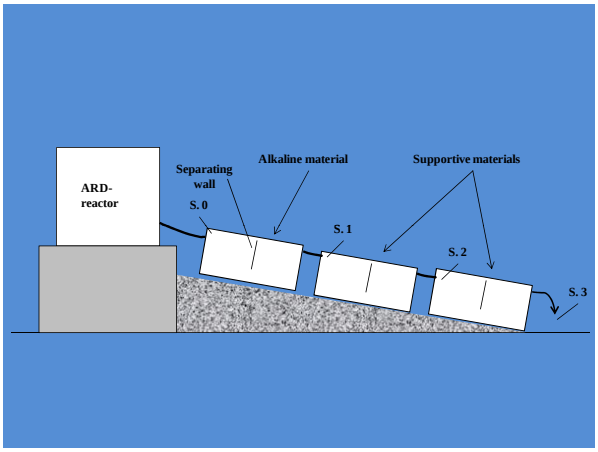
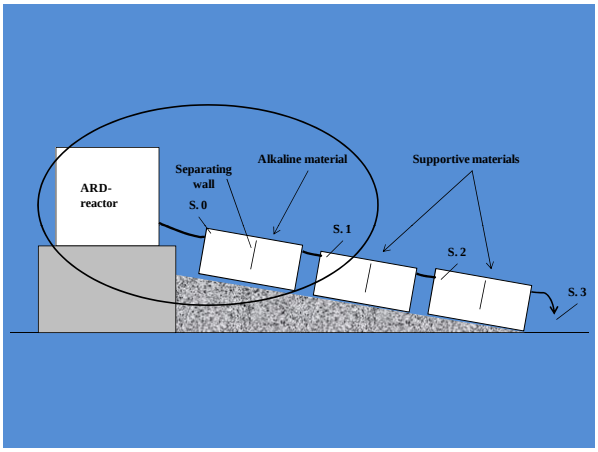
ARD treatment in sequential filter sections – efficiency of different alkaline by-products

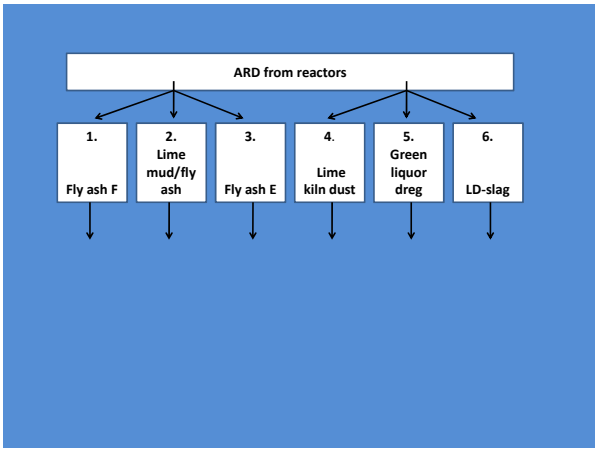
Lotta Sartz[1,2], Mattias Bäckström[1], Stefan Karlsson[1] and Viktor Sjöberg[1]

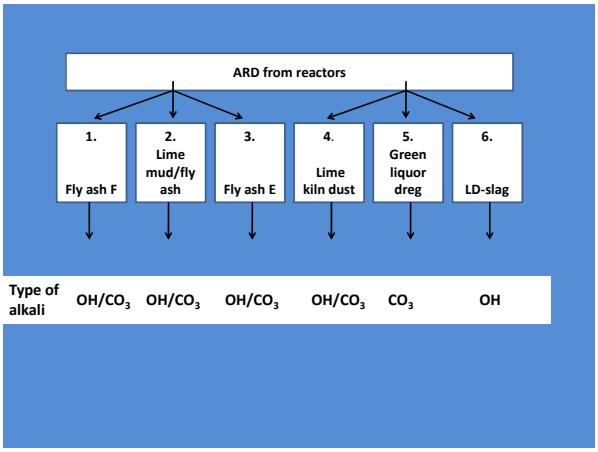
Man-Technology-Environment Research Centre,
Örebro University, Sweden
Bergskraft Bergslagen, Kopparberg, Sweden

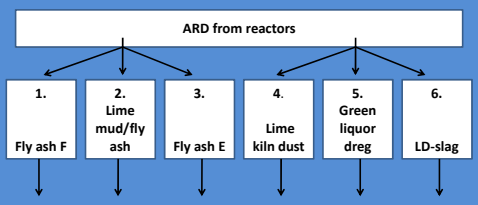
lotta.sartz@oru.se



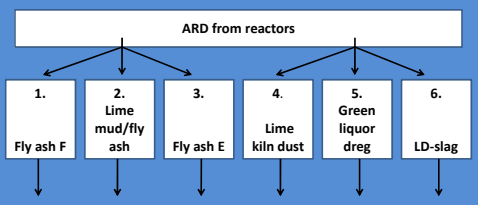




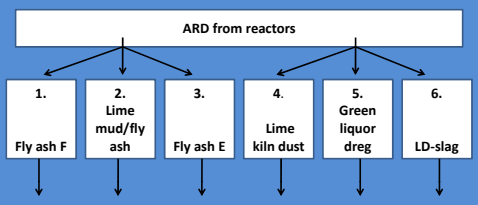




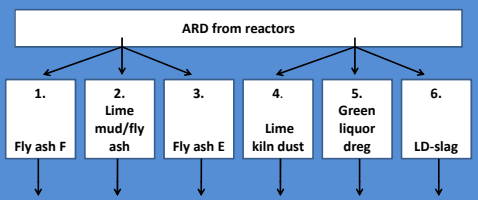
- Total buffering capacity in the filters
- Acidity loadings from reactors



Tot.alk. (meq/kg)	3 200	6 600	2 500	9 000	7 400	1 600



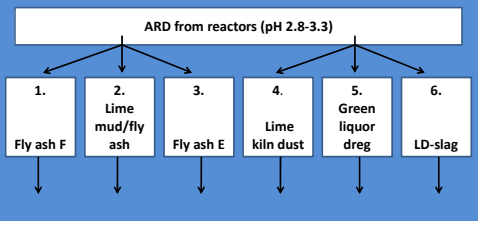
Tot.alk. (meq/kg)	3 200	6 600	2 500	9 000	7 400	1 600
N.cap. (eq)	1 024	3 762	775	5 490	2 442	1 536



Tot.alk. (meq/kg)	3 200	6 600	2 500	9 000	7 400	1 600
N.cap. (eq H^+)	1 024	3 762	775	5 490	2 442	1 536
Ac. Load (eq H^+)						
2008	3	3	3	2.5	2.5	2.5
2009	0.6	0.6	0.6	0.6	0.6	0.6

Results

pH

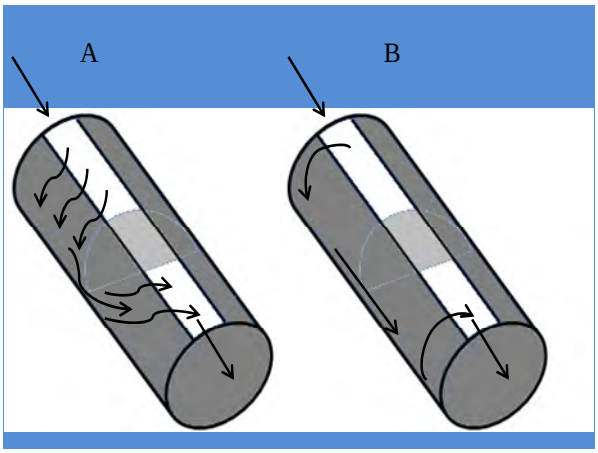


2008	5.7	3.6	3.4	5.8	3.7	4.9
2009	5.0	3.8	5.0	10.7	5.5	9.7

pH

ARD from reactors (pH 2.8-3.3)

	1. Fly ash F	2. Lime mud/fly ash	3. Fly ash E	4. Lime kiln dust	5. Green liquor dreg	6. LD-slag
2008	5.7	3.6	3.4	5.8	3.7	4.9
2009	5.0	3.8	5.0	10.7	5.5	9.7



- **pH increase season 2 for all filters except fly ash F**
- **Net alkalinity**
  - Lime kiln dust and LD-slag both seasons
  - Fly ash F both seasons, but low alkalinity (0.1 meq/L)
  - In season 2, also green liquor dreg and fly ash E
- **Net acidity**
  - Lime mud/fly ash F

pH, Eh (mV)

ARD from reactors (pH 2.8-3.3, Eh 200-80 mV)

	1. Fly ash F	2. Lime mud/fly ash	3. Fly ash E	4. Lime kiln dust	5. Green liquor dreg	6. LD-slag
2008	5.7	3.6	3.4	5.8	3.7	4.9
2009	5.0	3.8	5.0	10.7	5.5	9.7
2008	147	168	211	-45	147	3
2009	-41	32	-24	-147	5	-132

Iron and aluminum, % removed from solution

Conc. from reactors: Fe 90 mg/L, Al 25 mg/L)

	Fe 2008	Fe 2009	Al 2008	Al 2009
• F1, fly ash F	88	80	85	80
• F2, lime mud/fly ash F	31	14	12	13
• F3, fly ash E	21	30	13	19
• F4, lime kiln dust	24	71	0	64
• F5, green liquor dreg	29	18	0	12
• F6, LD-slag	6	79	0	73

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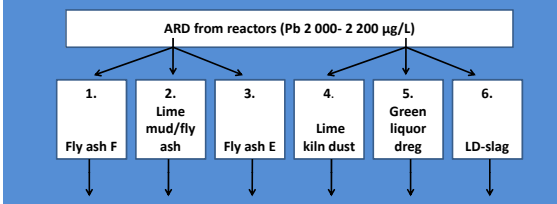
Discussion

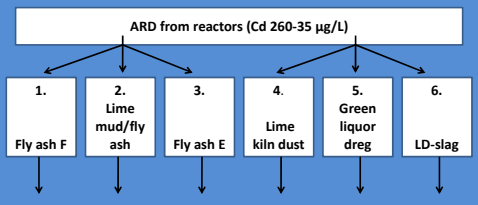
- 2008
  - F1: Iron and aluminum prec.
  - F2, F3, F5: Iron and aluminum low degree of prec. (low pH)
  - F4, F6: Iron and aluminum low degree of prec., pH too low for iron(II)hydrolysis
- 2009
  - F1: Iron and aluminum prec.
  - F2, F3, F5: Still low degree of Fe and Al prec.
  - F4, F6: Iron and aluminum prec., pH high enough for Fe(II)hydrolysis (pH>8). Blue-green precipitates (probably $FeCO_3$ (green rust))

Pb, mass-reduction (in %) compared to loading



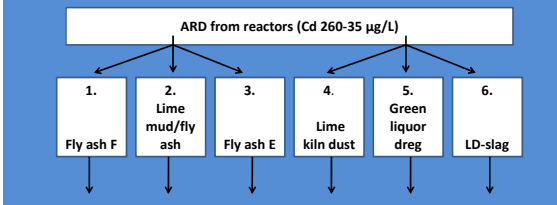
2008	89 %	46 %	32 %	54 %	25 %	42 %
2009	87 %	17 %	45 %	80 %	20 %	81 %

Cd, mass-reduction (in %) compared to loading



2008	97 %	7 %	17 %	54 %	8 %	19 %
2009	75 %	7 %	12 %	80 %	8 %	83 %

Cd, mass-reduction (in %) compared to loading



2008
2009

The main purpose with the first filter section is however to neutralize the acid and increse pH, not necessarily decrease trace elements!

Discussion

- Filters 2, 3 and 5 low acid neutralizing effect
- Iron and aluminum precipitates seem to passivate neutralizing surfaces (especially for carbonate materials)
- Horse manure added to filters 2 and 3 in summer 2010
  - pH increased to above 5.5

Conclusions

- Carbonated fly ash and mixture fresh fly ash/lime mud act as carbonate materials
- Hydroxide materials were superior to carbonate materials in the present experimental setup
- As the filters are designed today, only hydroxide materials work sufficiently, some modifications are though suggested

Conclusions, cont.

- Filters with carbonate materials
  - Addition of reducing material, analogous to an ALD
  - Aeration of ARD prior to filter
- Filters with hydroxide materials
  - Mixing of material with e.g. wood chips for better flow
  - Precipitation of aluminum cannot be avoided, iron(II) can however maintain in solution up to pH 8

Thanks for Your Attention!

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