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Development of passive bioneutralization technology

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What is passive bioneutralization

- Technology must meet definition of “passive”
- Must be capable of treating acidic mine water with pH lower than 4.5, i.e. extend the range of passive sulphate reduction technology downwards
- Suitable as pretreatment ahead of sulphate reduction or as stand-alone technology for acidity and metal removal
- Strictly biological process – no use of neutralizing chemicals

Background to bioneutralization

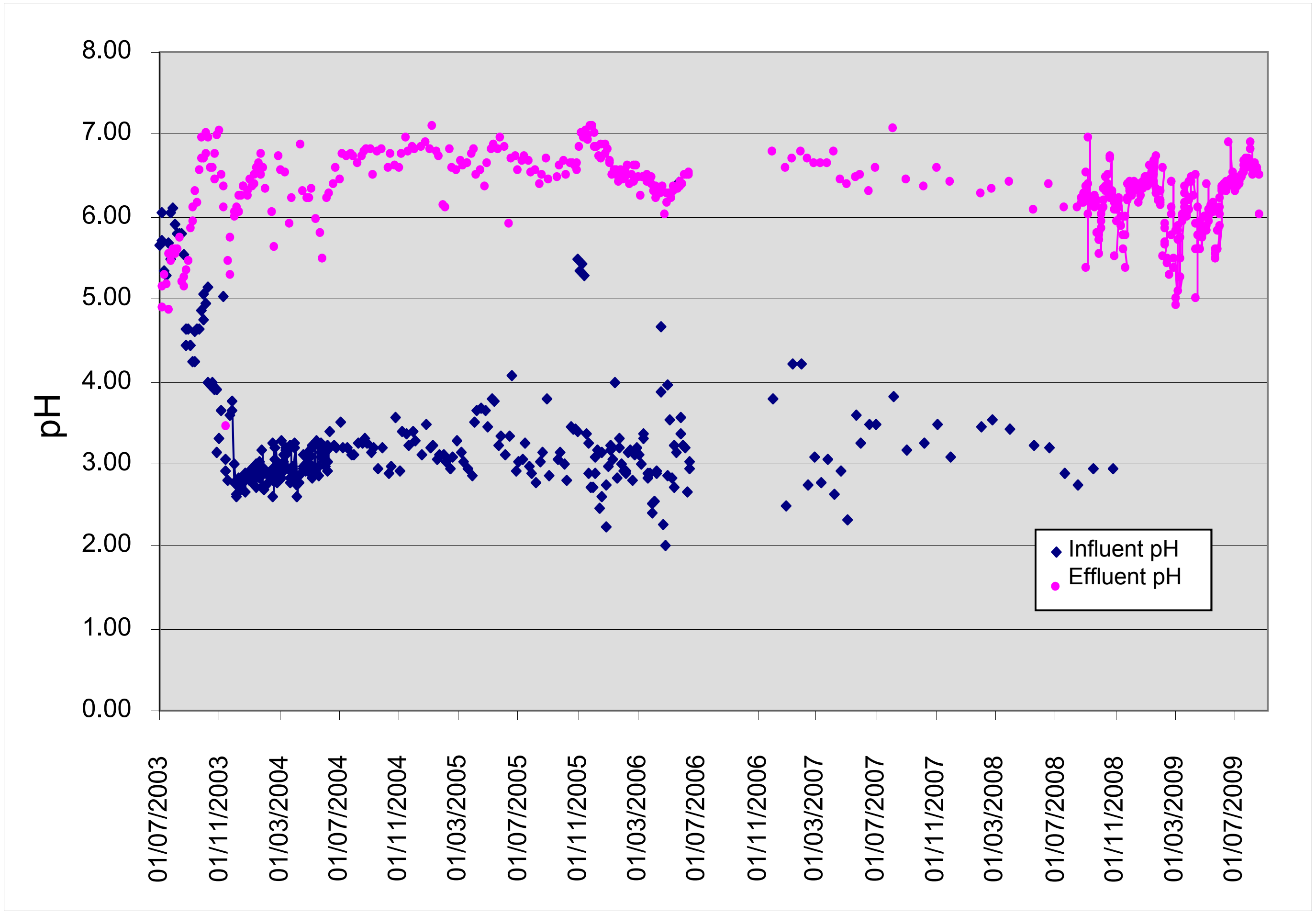
- Standard sulphate reducing systems require pH > 4.5
- For mine effluents with pH < 4.5, some form of pretreatment is required
- PHD commenced research in 2003 to develop biological system as redox-reducing reactor upstream of ALD
- Discovered that redox reduction and bioneutralization could be effected in single stage DPBR with right biota
- Technology has been developed:
  - Sustainably treat water with pH<3
  - Also treat water with metals >1000mg/l

PHD Column Laboratory

Key aspects of early research

- Tried numerous approaches before isolating bacterial cultures capable of bioneutralization
- Undertook long-term studies coupled with depth profile studies & microbial ecology
- Developed basic descriptive model
- Believe that there is a complex consortium of bacteria involved in bioneutralization:
  - Population 1 – remove oxygen and reduce redox to -250 to -350 mV with high H^+
  - Population 2 – anaerobic degradation of LC to simple charge-neutral carbon compounds
  - Population 3 – sulphate reduction
  - All 3 groups in closely-linked feedback
- Bioneutralization happening in first 300 mm of reactor
- Long-term performance validated – viable technology for simple acidic waters

Bio-neutralization studies - results



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Bio-neutralization studies - results

- Have developed and operated a technology that can achieve the following:
  - Operate as a shallow DBPR with 2-3 day retention
  - Increase pH from <3 to >6.5 & produce water with net alkalinity of 400 - 500 mg/l
  - Reduce redox potential to < -300mV
  - Pre-treat water for use in DPBR
  - Metal accumulation >1kg/m^3
  - Sulphate removal up to 1000 mg/l
  - Bacterial cultures can be successfully seeded into new reactors

Treating highly acidic waters

- Whereas a standard sulphate reducing system will produce 1.05 mol alkalinity per mol sulphate reduced, the DPBR produces 1.5 mol.
- DPBR technology can consistently produce 3500 mMol/m^3/day alkalinity (as $CaCO_3$)
- Technology packages being developed to use DPBR as high rate alkalinity producing system for neutralization and metal removal

NEW CHALLENGE IN EARLY 2006

TREAT HIGHLY ACIDIC WATER WITH VERY HIGH METAL ACIDITY - LANDAU

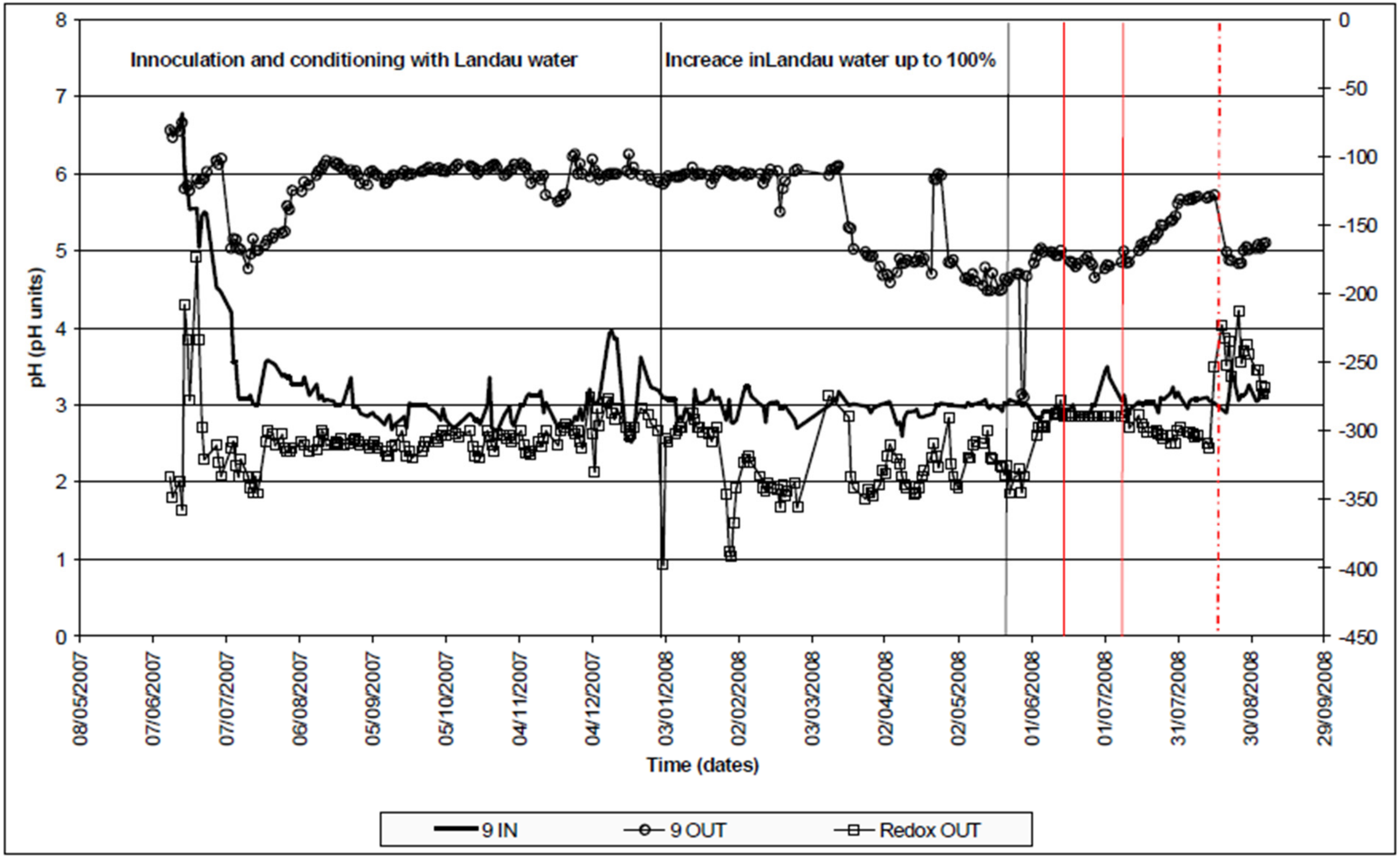
Treating high acid & metal waters

- High metals present as high metal acidity in addition to proton acidity (pH<3; Fe 800-1200 mg/l; Al 100-150 mg/l; Mn 80-120 mg/l)
- Formation of metal hydroxides and sulphides consumes alkalinity
- Metal precipitates have hydraulic and thermodynamic/physical effects on bacterial consortia
- Requires specific design approaches to deal with metal acidity
- May require acceptance of lower efficiency as pretreatment to DPBR

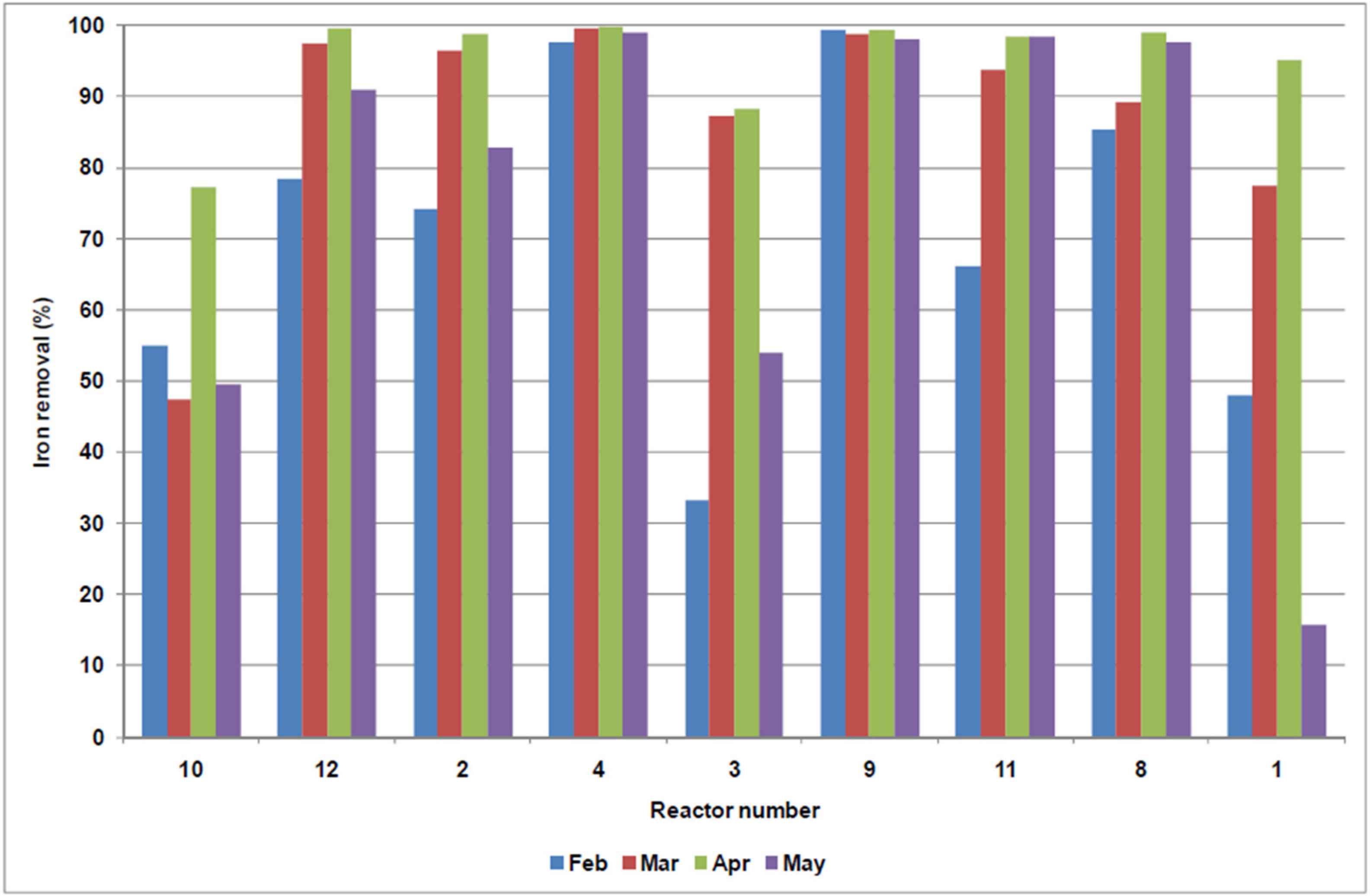
History of Landau bioneutralization

- **Phase 1:** Upflow DPBRs achieved 30% blend of Landau water then failed – post mortem showed metal fouling
- **Phase 2:** Various components:
  - Bench scale studies to remove maximum metals before bioneutralisation with alkali addition (result = oxidation + settling)
  - Sacrificial downflow metal removal columns – slowly acclimatised to Landau
  - In-situ metal backflushing (result = 89% Fe recovery & 21% Al recovery)
- Had developed good understanding of these reactors by mid-2008 and response to various upsets such as draining of reactor and low temperatures and response to various remediation strategies (retention time, pH, blending, etc.)

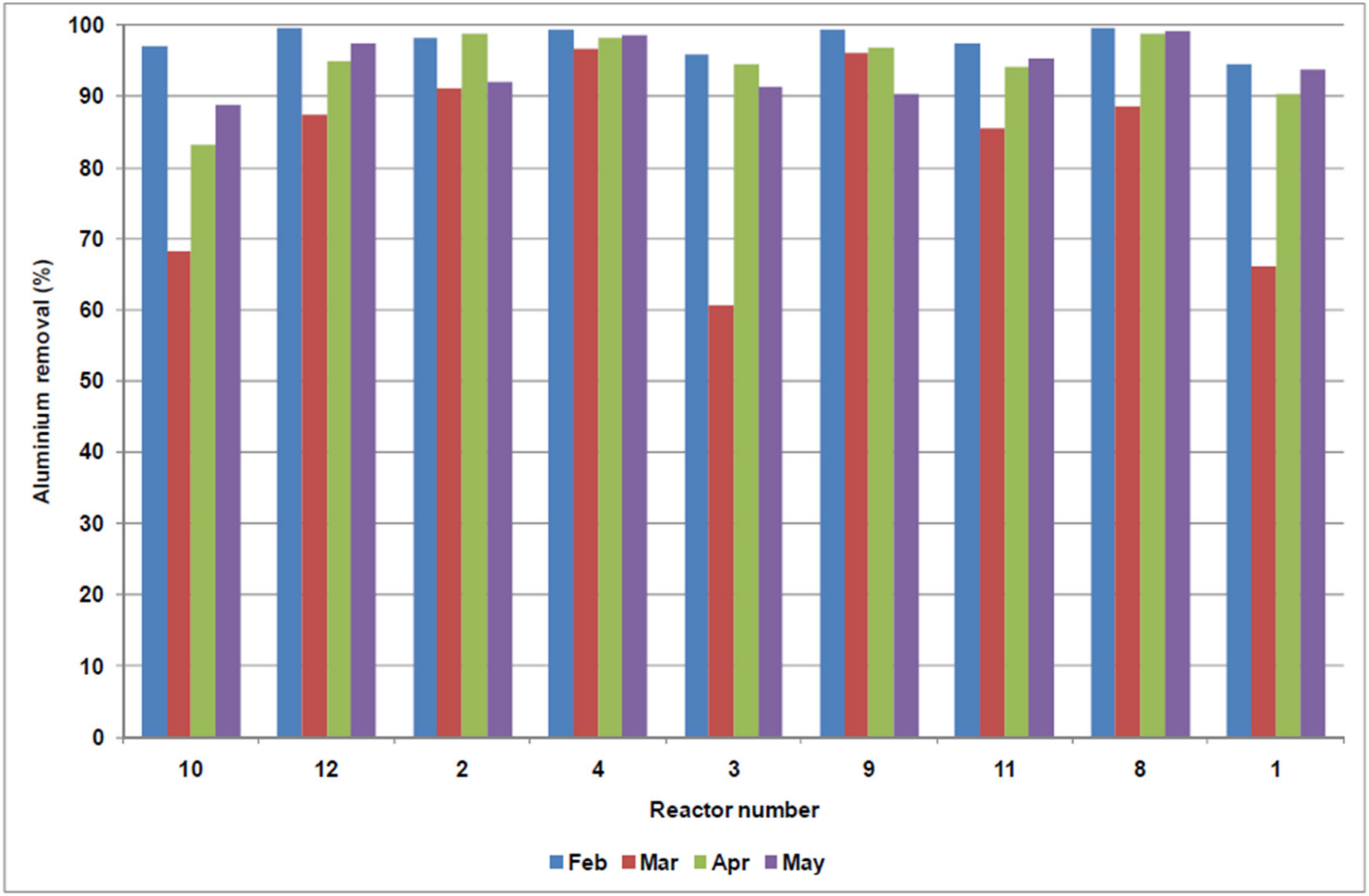
Typical bioneutralization column results



Iron removal efficiency



Aluminium removal efficiency



History of Landau bioneutralization - 2

- **<u>Phase 3:</u>** Prepared detailed proposal in October 2008 to take research to next logical step:
  - combine pre-treatment metal removal reactor with bioneutralisation DPBR
  - integrate metal removal, SOBR & DPBR
  - further refine and optimise metal removal strategies
  - post-mortem studies (microbial & mineralogical) on metal removal reactor
- DECISION: revert to care & maintenance programme with no active research component – this is still the current status.

Current Status

- Bioneutralisation reactors have been operating around 30 months on 100% Landau water producing pH>5 and around 90% metals removal
- Have set up and evaluated integrated bioneutralization with DPBR since Jan 2010
- Need to address issues relating to removal of metals from reactor and optimisation of process operating conditions
- Research programme in dead end – continued care and maintenance programme will not advance the technology

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Conclusions

- Robust bioneutralization technology has been developed for treating mine water with pH down to 2.5 and total metals in range of <200 mg/l.
- Such reactors have been operating continuously in lab-scale for 8 years and incorporate key elements of DPBR technology
- Treatment of acidic water with very high levels of metals is more problematic but has been shown to be capable of raising pH above 4.5 required for standard DPBR
- Research programme on acidic high-metal water is currently stalled due to lack of funding and reactors are in care & maintenance mode

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