Revisiting the Role of pH Modifier and Process Water Ions in Platreef Cu-Ni-PGM Ore Flotation: *What's the Matter with Choosing a pH Modifier?*

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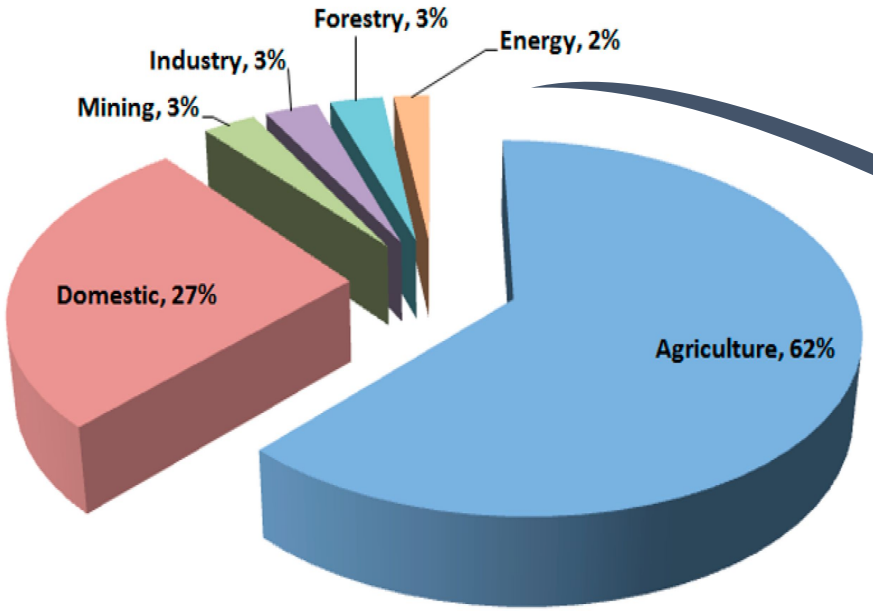
South African Mining Industry on Water: Challenges & Opportunities



This then brings us here!

- Water scarcity
- Legal compliance
- Environmental protection
- Mine closure requirements
- Production penalties
- Socio – political pressure

- Reduction of freshwater consumption
- The removal of contaminants from mine water seepages and effluent
- Highly water efficient processing plants.
- Supporting the establishment of **"closed water concentrators"** in the minerals processing industry.

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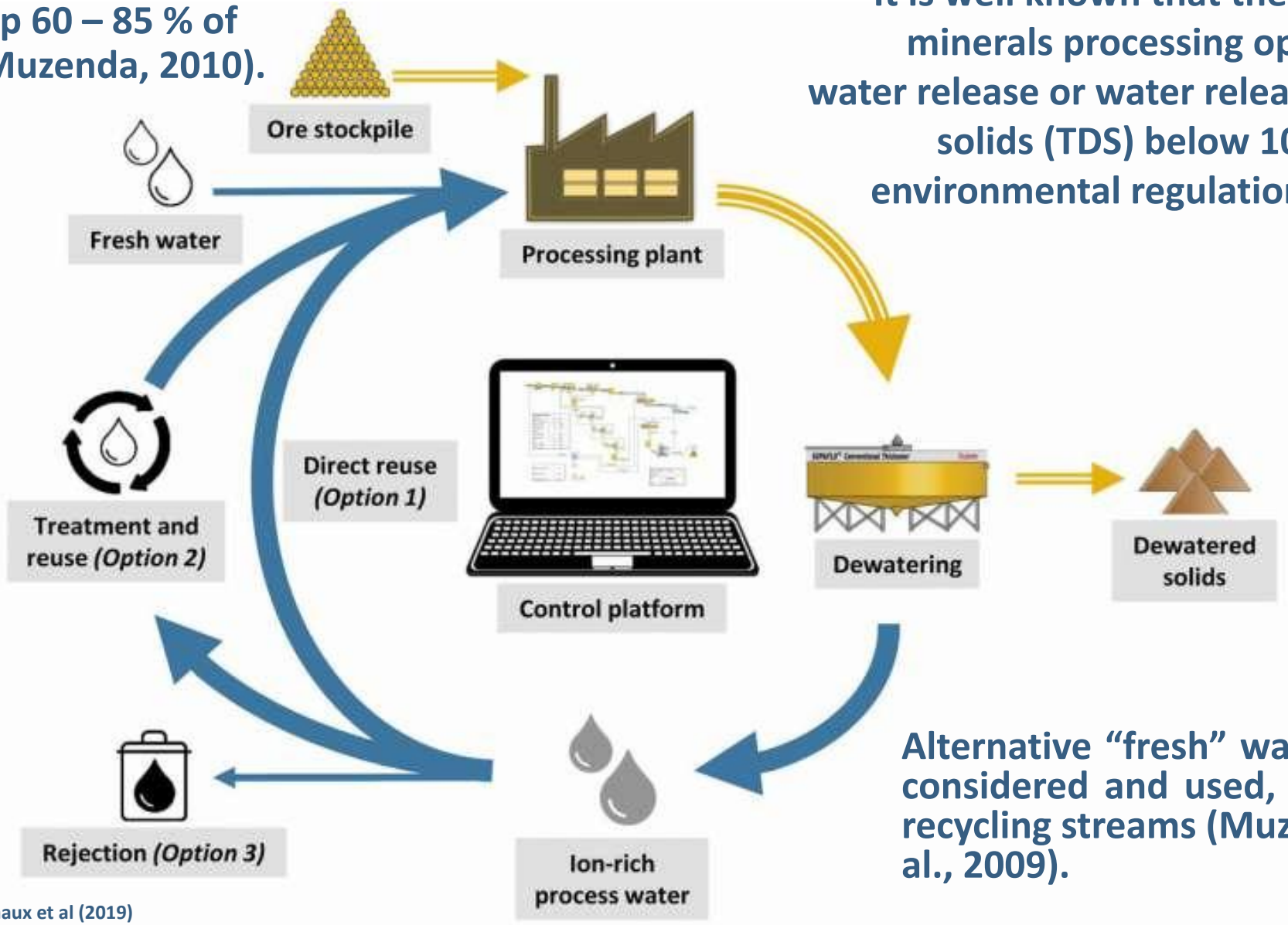
The Closed Water Circuit in Minerals Processing

Water makes up 60 – 85 % of pulp volume (Muzenda, 2010).

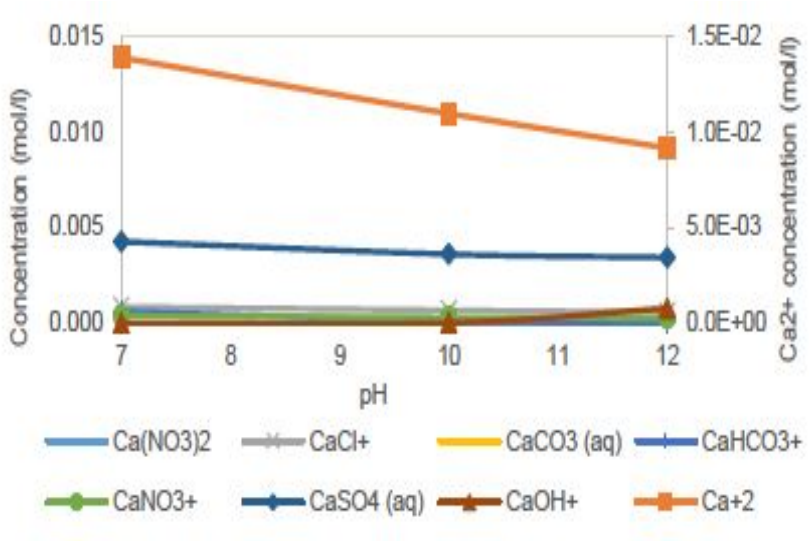


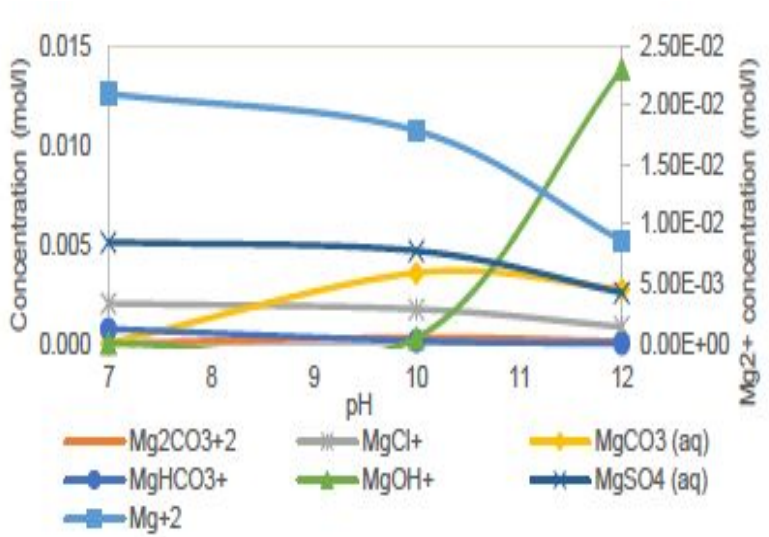
"It is well known that there are now mining and minerals processing operations in which zero water release or water release with total dissolved solids (TDS) below 1000 ppm is required by environmental regulation." (Levay et. al., 2001)

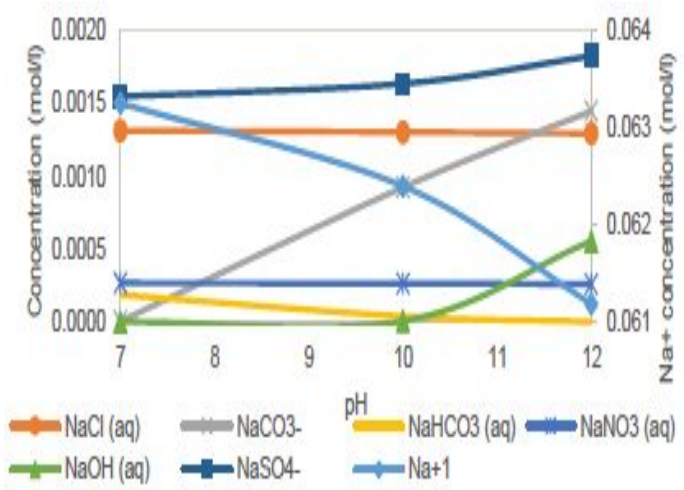
Alternative "fresh" water sources are being considered and used, eg. ground, grey and recycling streams (Muzenda, 2010, Slatter et al., 2009).

Michaux et al (2019)

MinteQ Speciation of Synthetic Plant Water (TDS = 1023 mg/L, *I* = 0.0241 mol/L)







pH>9 shows a rise in [$CaOH^+$]

pH>9 shows a rise in [MgOH+], $MgCO_3$(aq)

Oxyhydroxo species on the rise beyond pH 9

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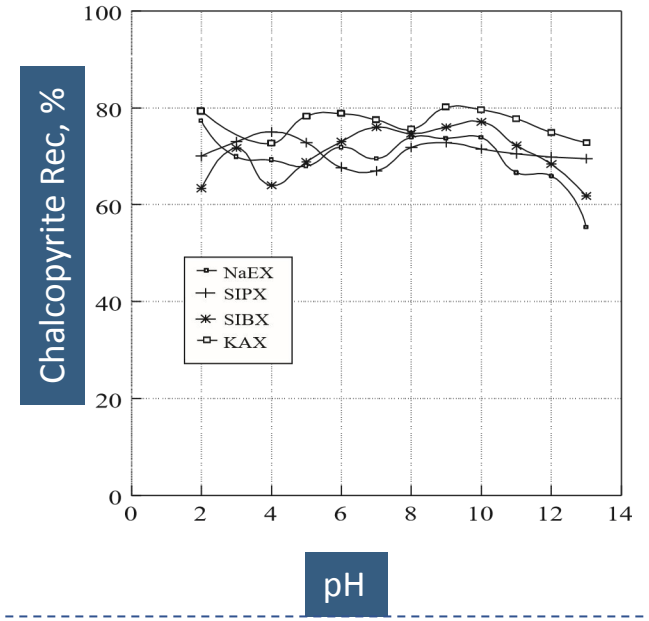
Manono et al (2018a)

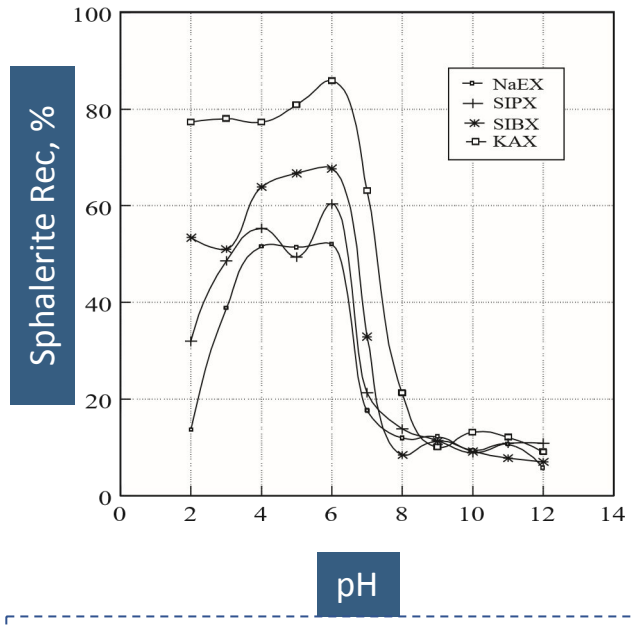
Pulp pH on Mineral Flotation – Insights from Ġoktepe (2001)

HCl and NaOH

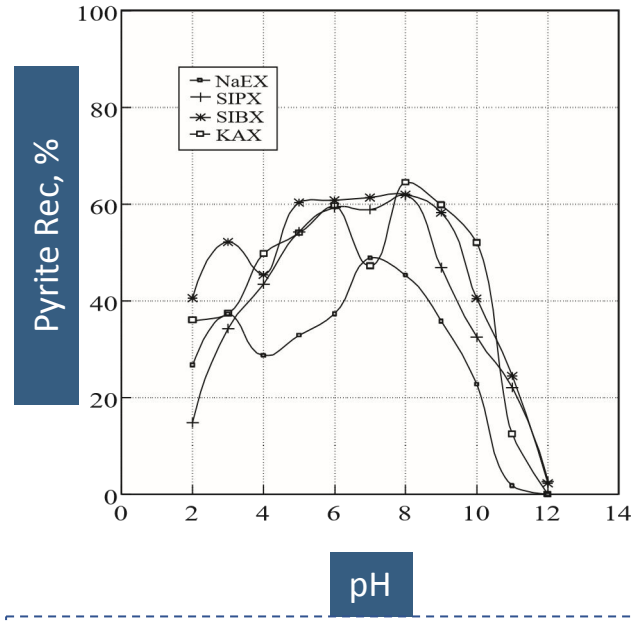
Increasing C chain length increased mineral recoveries



pH had little to no impact on chalcopyrite recoveries



Sphalerite recoveries on a max at pH 6, beyond neutrality, a significant drop is seen



Pyrite recoveries drop significantly at pH>8

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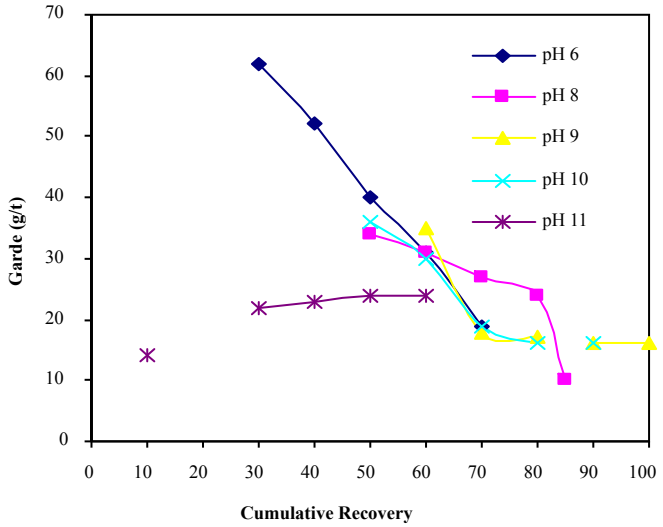
Pulp pH on Mineral Flotation – Insights from Muzenda et al.(2011)

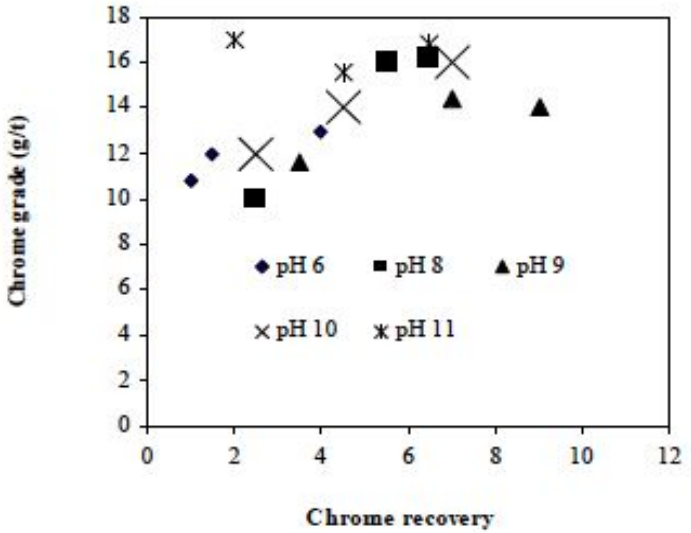
Using H_2SO_4 and $Ca(OH)_2$

PGMs Grade-Recovery



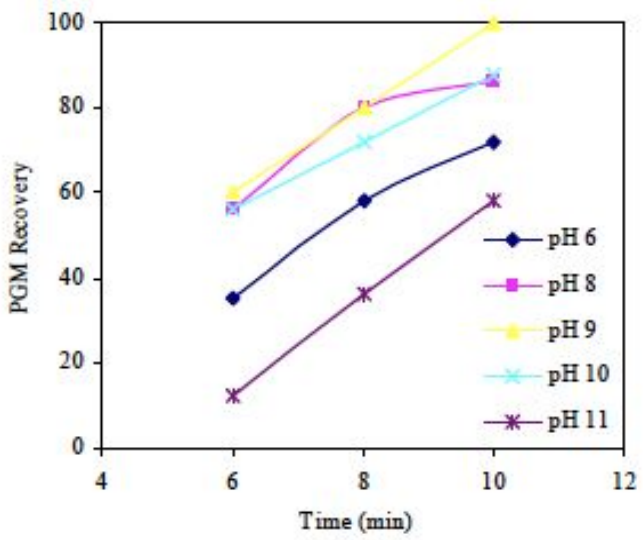
Alkaline pH>8 but pH<11 good for PGM recoveries at the expense of PGM grade

Chrome Grade-Recovery



Alkaline pH>8 results in increases in chrome grades and recoveries

PGM Flotation Kinetics



Alkaline pH=11 resulted in lowest PGM flotation kinetics

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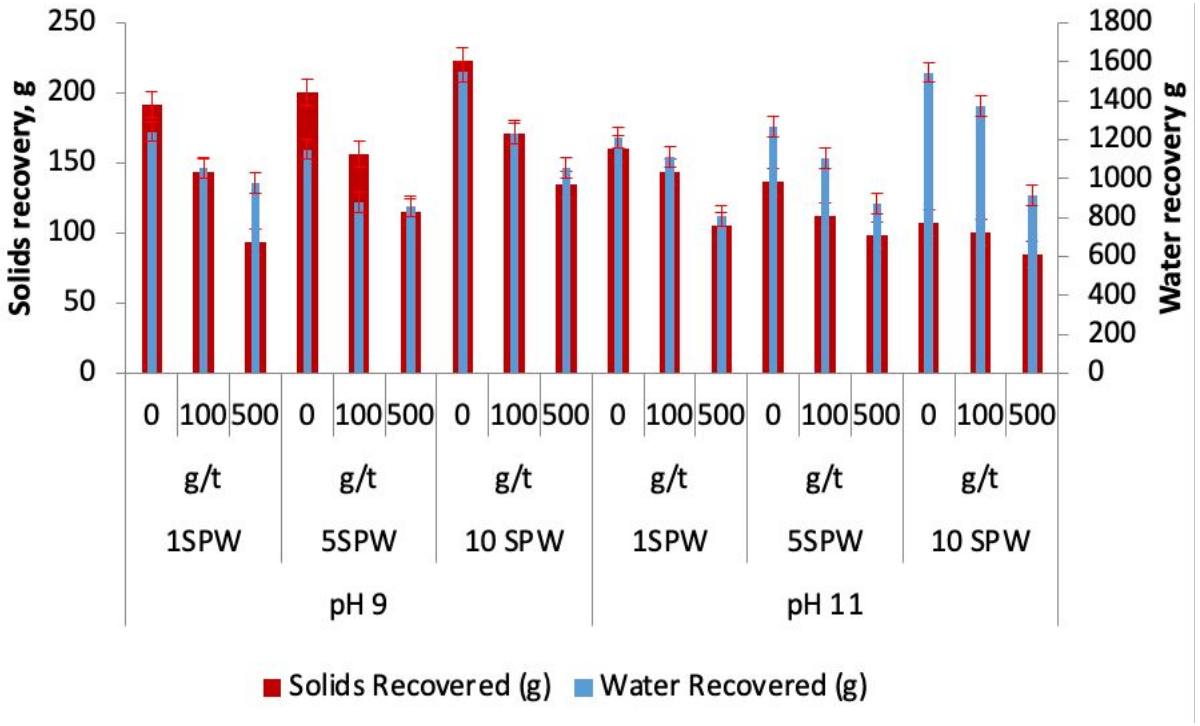
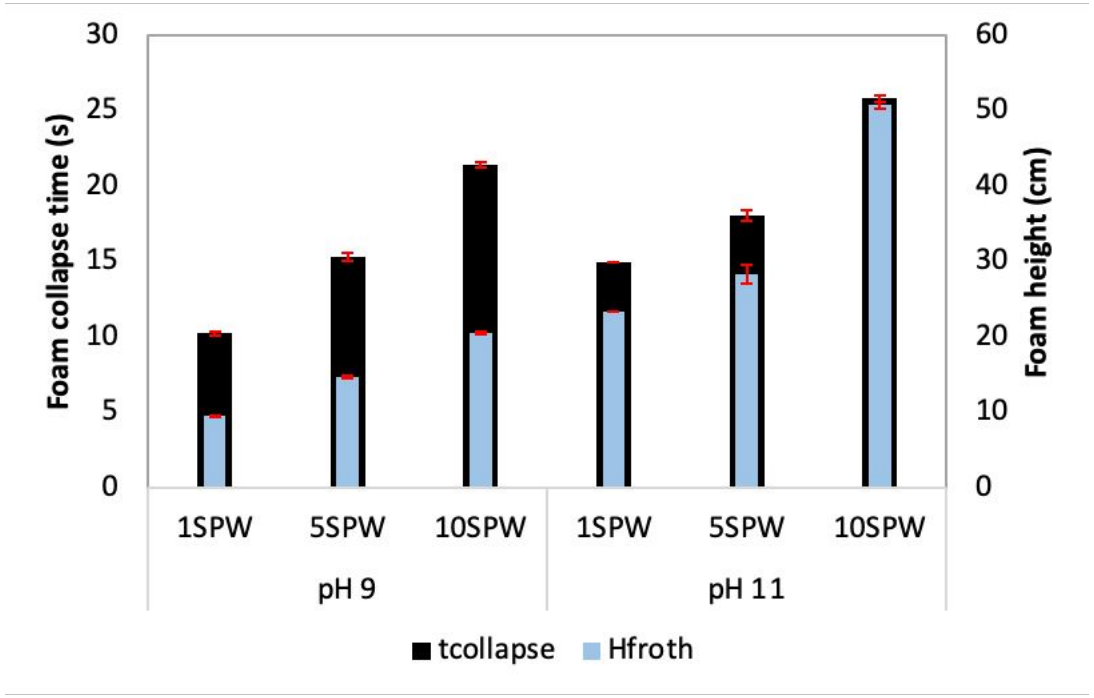
Pulp pH on Mineral Flotation – Insights from Manono et al.(2024)

NaOH





pH 11 resulted in a decrease in solids recoveries while increases in IS increased solids and water recoveries

Froth stability measurements enhanced in increasing IS and pH

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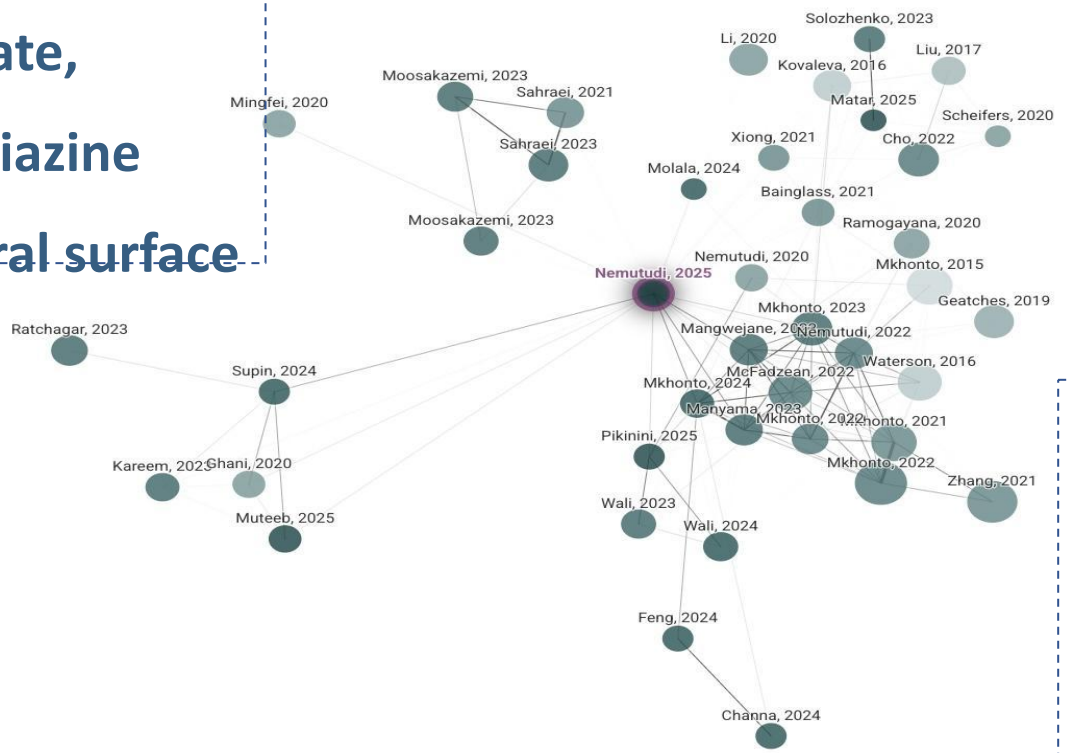
pH on Collector Adsorption and $PtAs_2$ Floatability - Nematudi et al. (2025)

HCl and NaOH

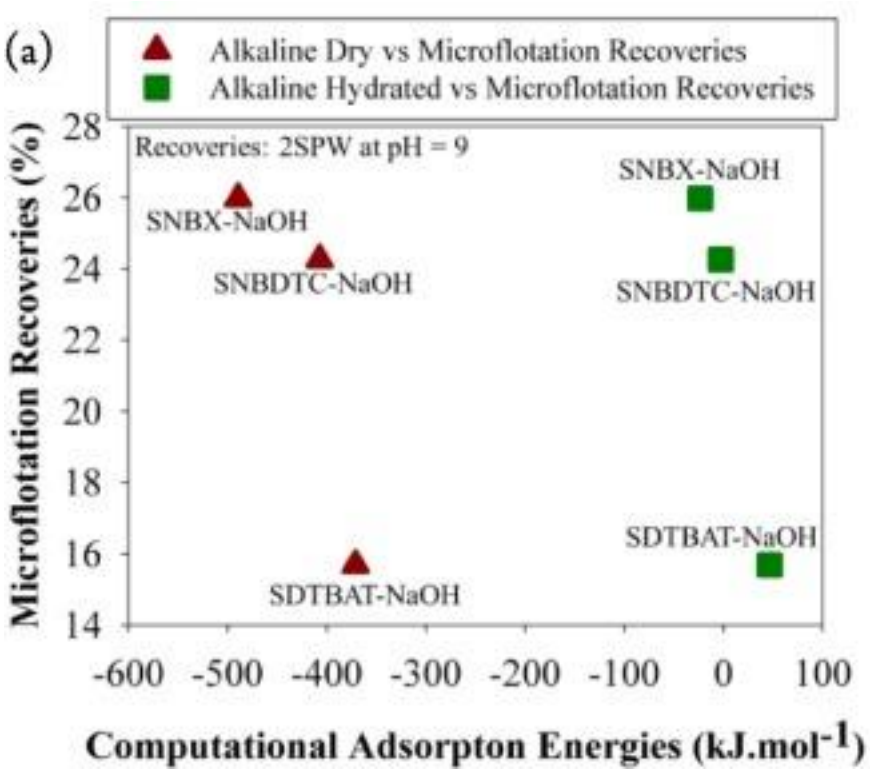
pH effect on adsorption and performance of xanthate, dithiocarbamate and s-triazine collectors on sperrylite mineral surface

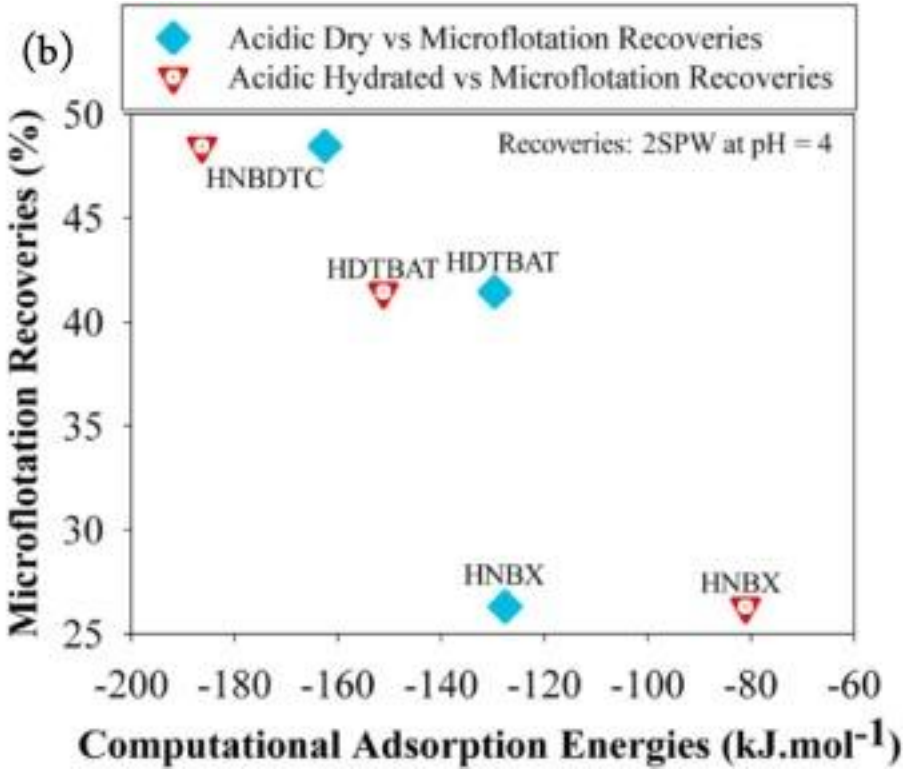


Xanthate, DTC and S-triazine adsorption stronger under acidic condition. Alkaline conditions resulted in poor collector adsorption and low recoveries.

pH on Collector Adsorption and $PtAs_2$ Floatability - Nematudi et al. (2025)

HCl and NaOH





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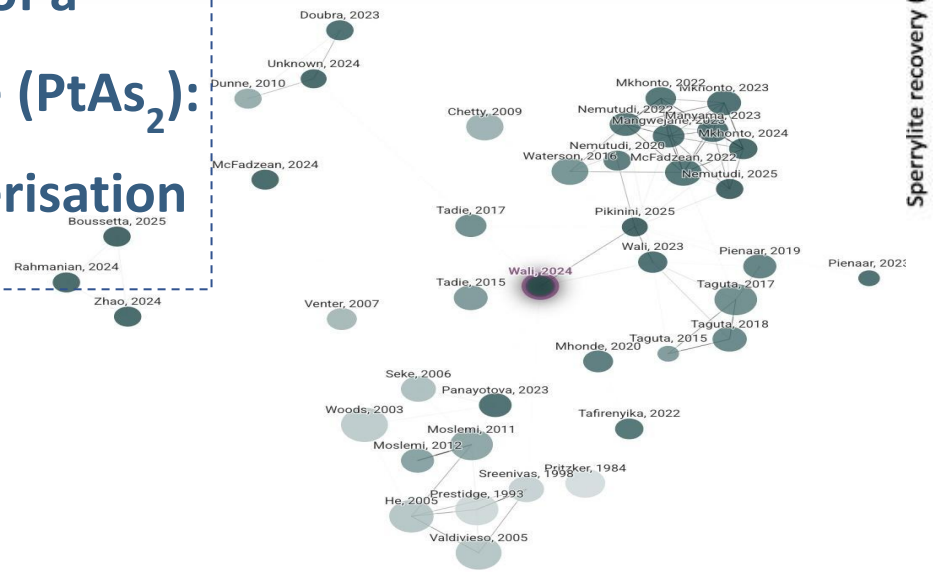
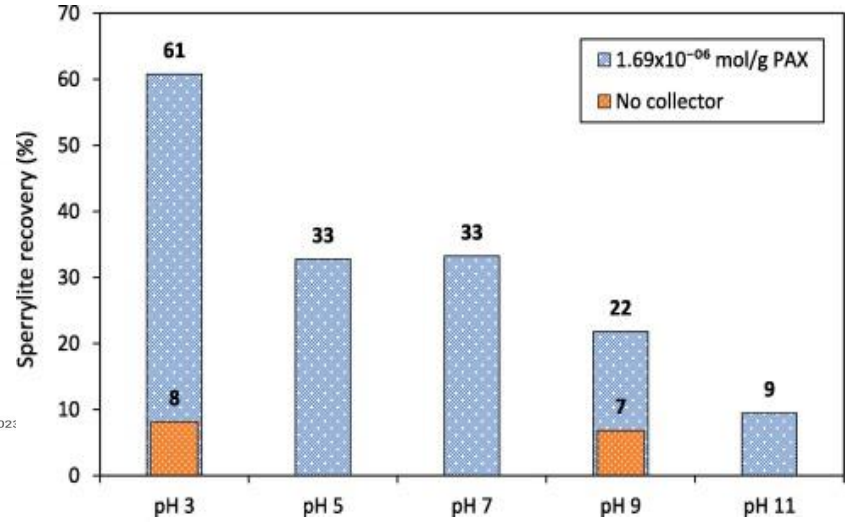
pH on Collector Adsorption and $PtAs_2$ Floatability – Wali et al.(2024)

HCl and NaOH

An investigation into the effect of Eh and pH on the adsorption of a xanthate collector on sperrylite ($PtAs_2$): A surface and solution characterisation study





PAX adsorption and floatability of sperrylite is better in acidic pH. Poor collector adsorption at pH 9 may be due to preferential OH^- adsorption.

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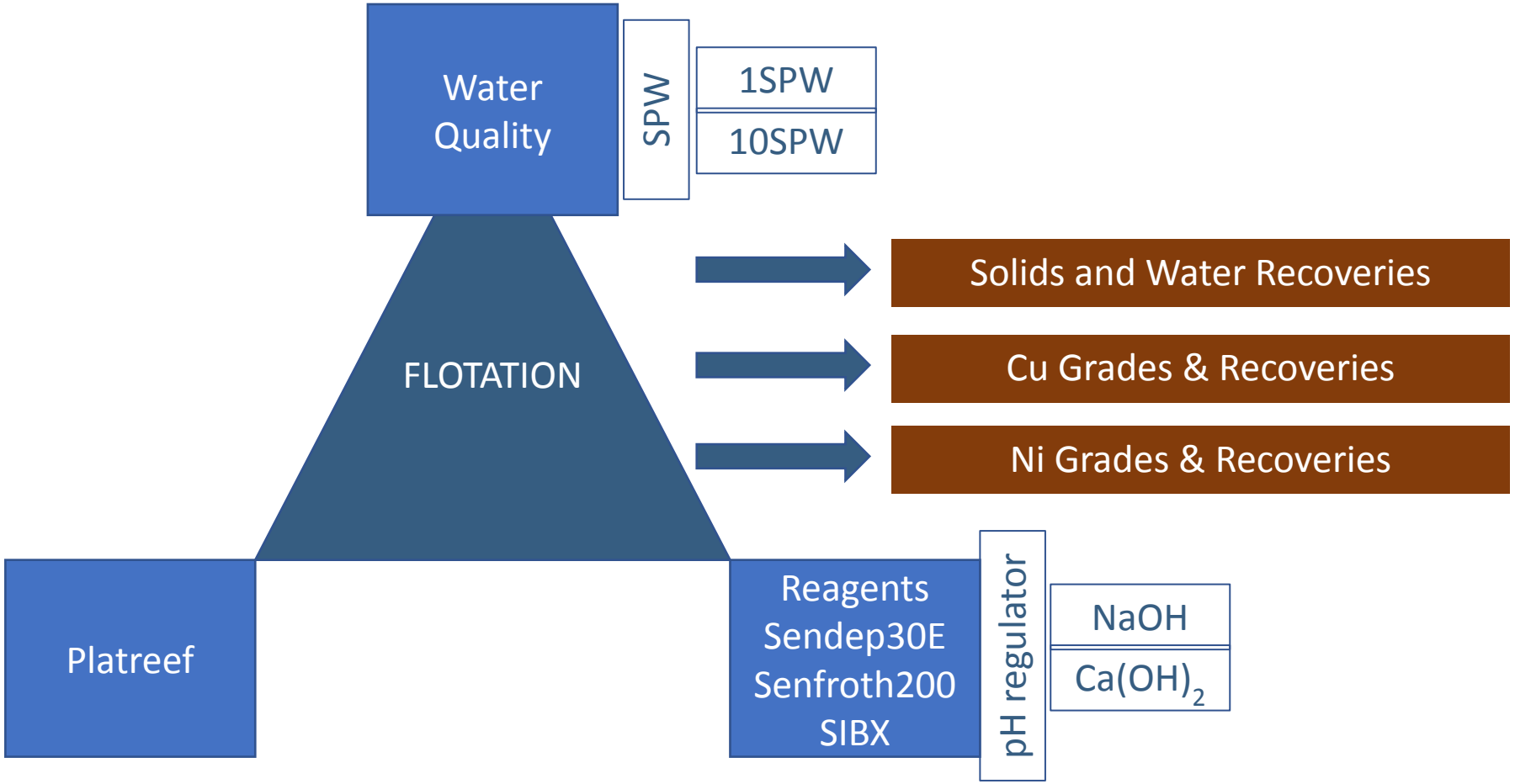
Experimental Design Approach to the Current Work



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UCT Synthetic Plant Water (SPW)

"The ionic concentrations were based on the typical values found at one selected concentrator. Because of the nature of the gangue minerals it would be expected that similar type water was being used at other concentrators." Wiese et al. (2005)

Based on an actual Cu-Ni-PGM Concentrator in early 2000's

Water Type	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	Cl^{-} (mg/L)	SO_4^{2-} (mg/L)	NO_3^{-} (mg/L)	CO_3^{2-} (mg/L)	TDS mg/L	I [M]
SPW	80	70	153	287	240	176	17	1023	0.0242

Multiplying concentration 10-fold, *increase by the same magnitude*

Water Type	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	Cl^{-} (mg/L)	SO_4^{2-} (mg/L)	NO_3^{-} (mg/L)	CO_3^{2-} (mg/L)	TDS mg/L	I [M]
10SPW	800	700	1530	2870	2400	1760	170	10230	0.242

Wiese *et al.* (2005), Manono *et al.* (2018b)

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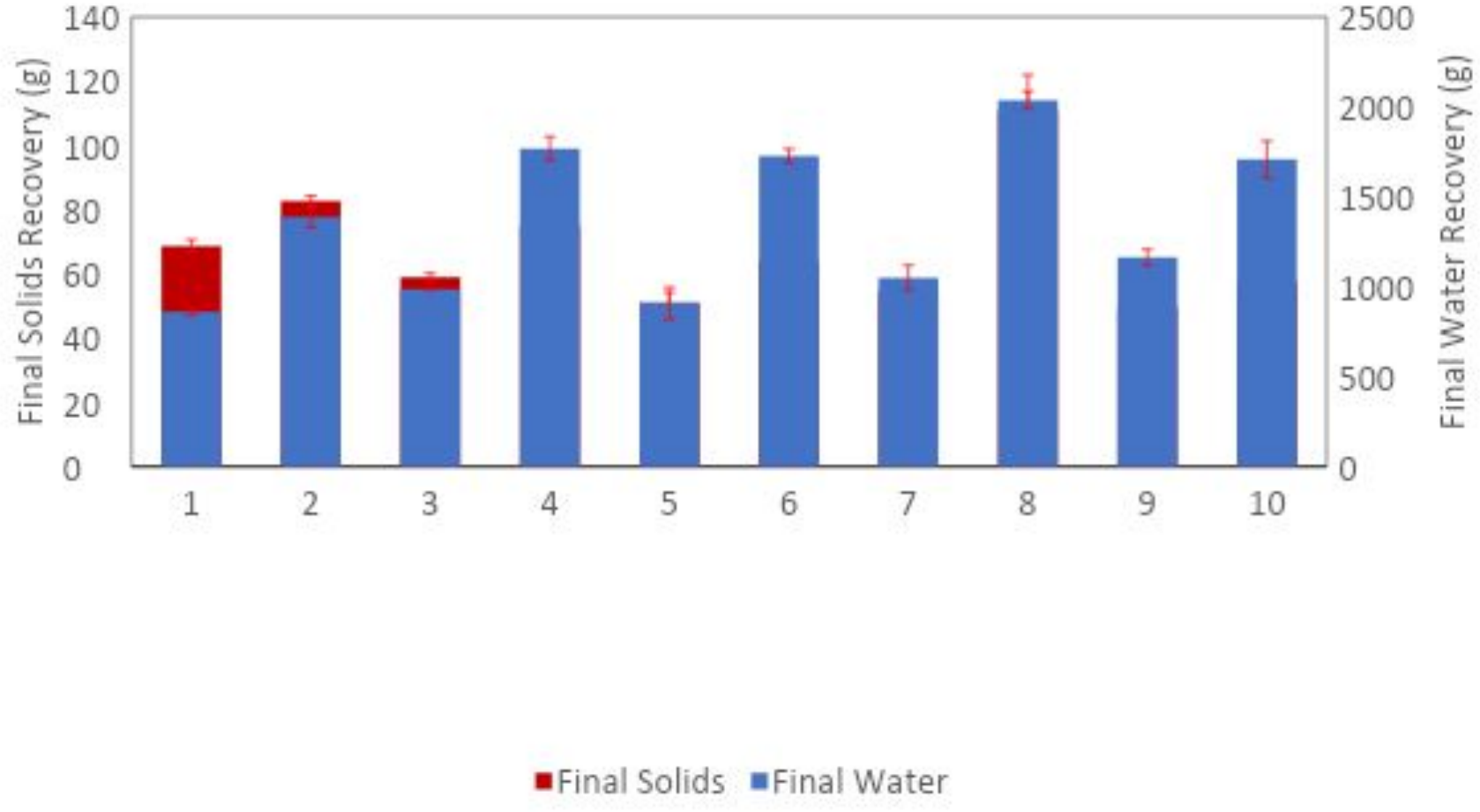
An Interplay between IS-pH-Regulator on Solids and Water Recoveries



Increasing IS increased Solids and Water Recoveries

Increasing pH decreased Solids Recoveries and Increased Water Recoveries

More solids reductions in $Ca(OH)_2$ than in NaCl. Increases in Water<NaOH

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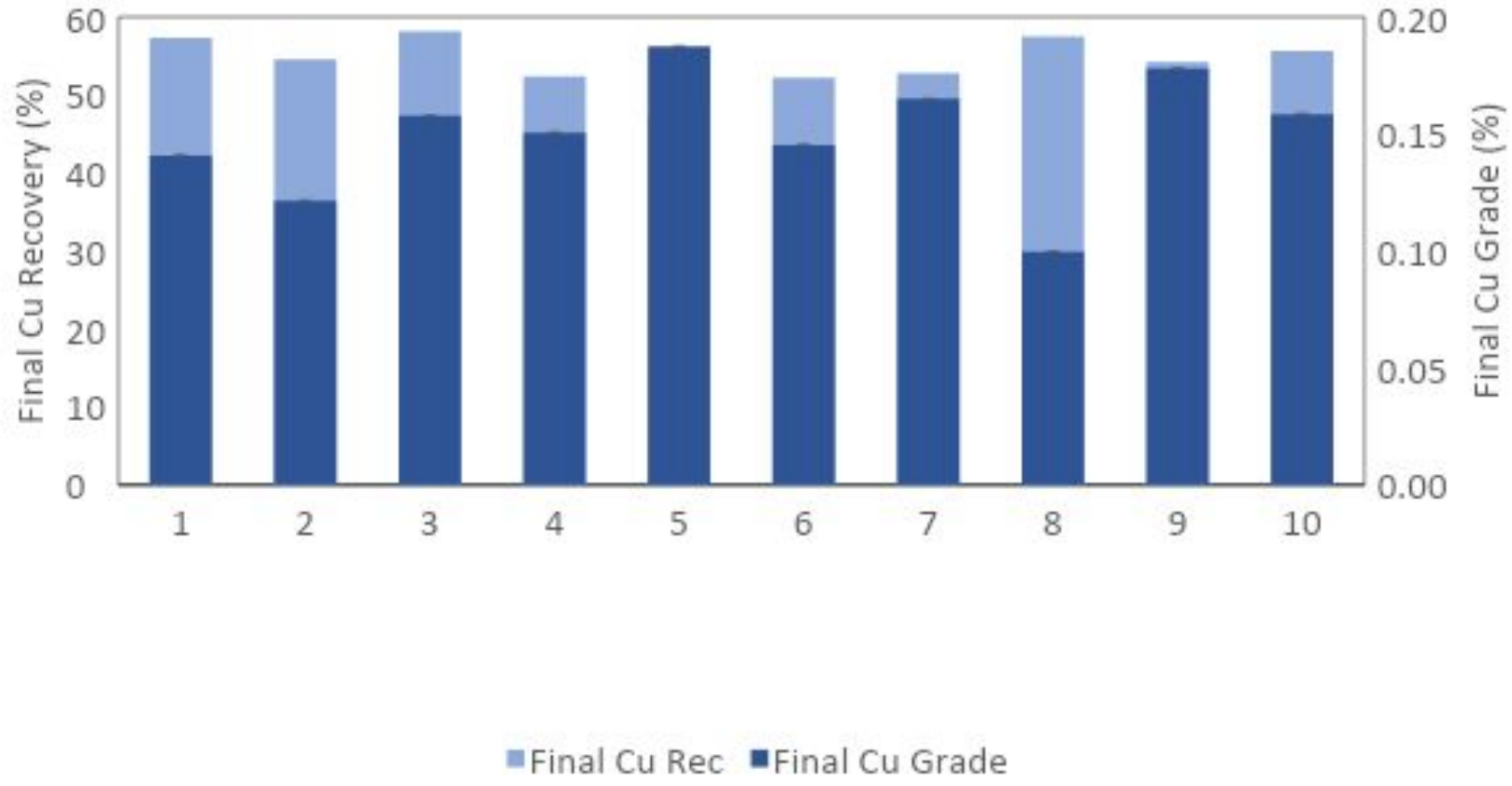
An Interplay between IS-pH-Regulator on Copper Grades & Recoveries



Increasing IS decreases the grade

Increasing pH increases the grade of the concentrate even the more in $Ca(OH)_2$

Use of $Ca(OH)_2$ is detrimental to recoveries but beneficial for grades

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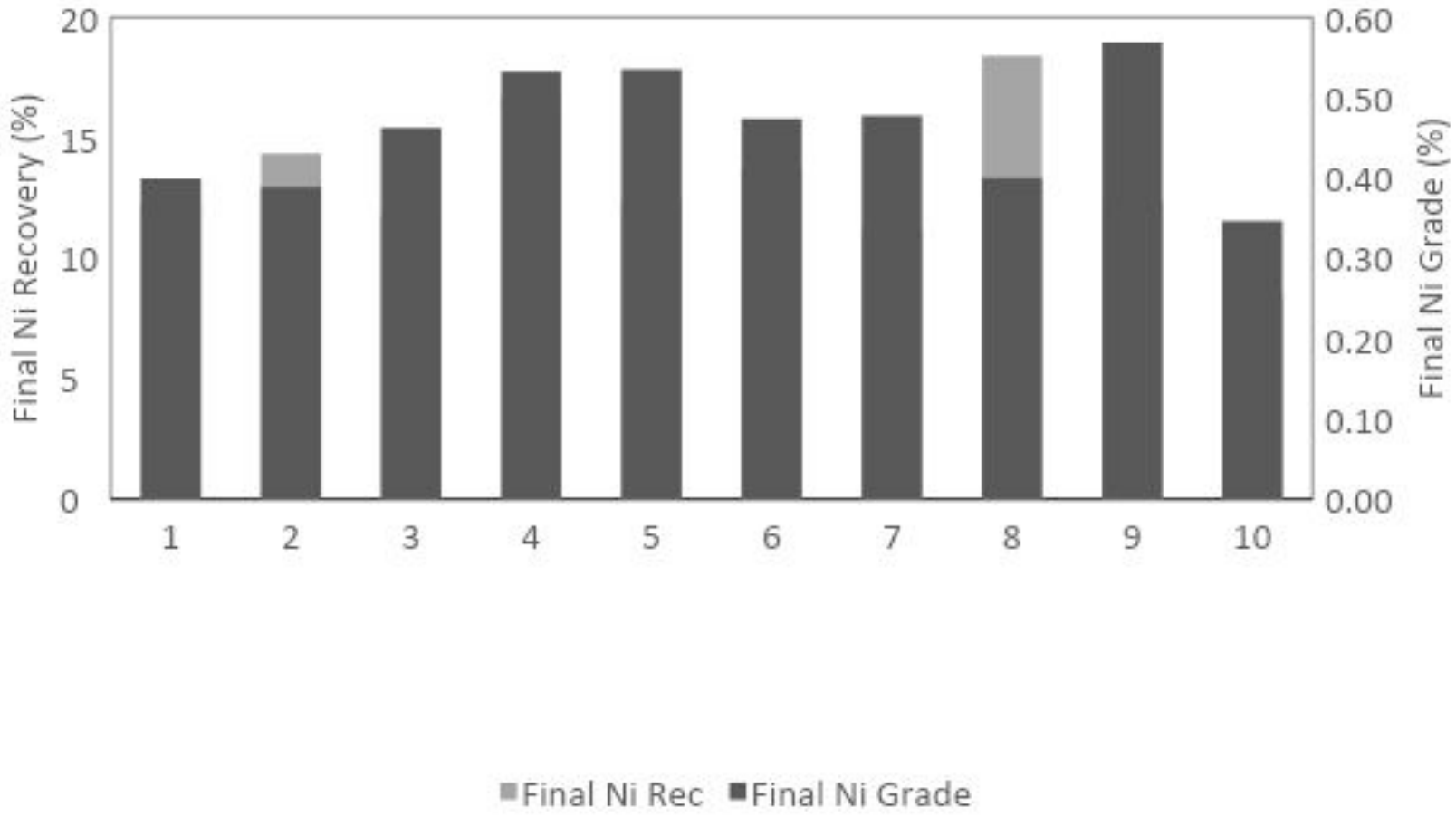
An Interplay between IS-pH-Regulator on Nickel Grades and Recoveries



Increasing IS results in increases in Ni Recoveries at the natural pH

NaOH favours higher recoveries compared to $Ca(OH)_2$

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Conclusions

pH modifiers are not chemically neutral. Beyond pH control, they act as electrolyte sources that shape pulp chemistry, froth behaviour, and selectivity.

NaOH and $Ca(OH)_2$ deliver distinct flotation outcomes. NaOH (Na^+) enhances froth stability and mass pull, while $Ca(OH)_2$ (Ca^{2+}) suppresses froth but improves concentrate grades.

Ionic strength amplifies these effects. High-IS water promotes froth stability and entrainment; At highly alkaline pH, Ca^{2+}-rich systems counteract this through froth destabilisation and gangue depression.

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Industry Takeaway

Recovery–grade trade-offs are modifier-dependent. NaOH favours throughput and recovery; lime favours selectivity and cleaner concentrates.

Reagent choice must align with water circuit chemistry. In closed-loop or high-salinity operations, the additive effects of ions from both process water and pH modifiers become decisive.

Operational implication: pH modifier selection should be integrated into **water–reagent management strategies**, not treated as a routine pH adjustment.

Industry takeaway: Optimising flotation in recycled water circuits requires balancing **chemical speciation, froth stability, and downstream concentrate quality.**

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