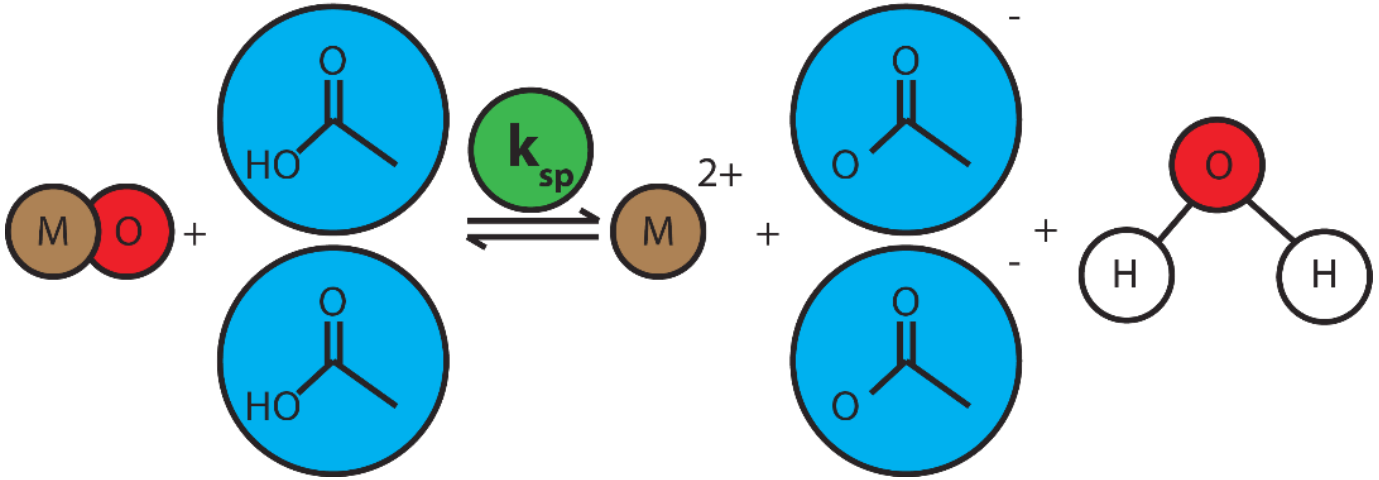
The University Of Sheffield.

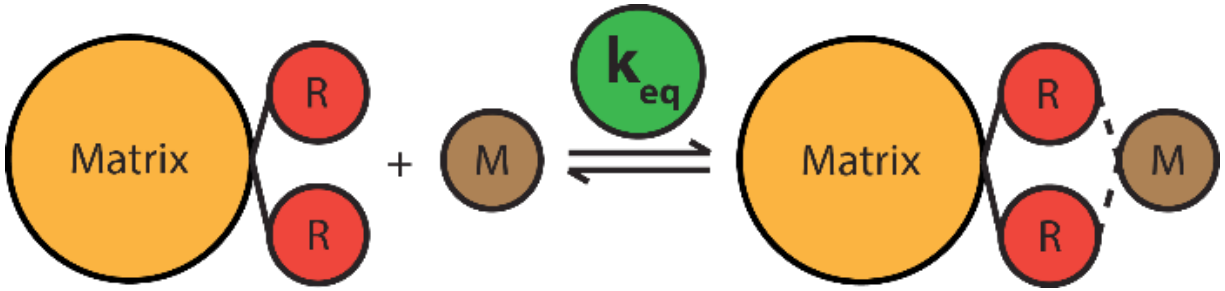
Grantham Centre for Sustainable Futures

SNUCER
Separations & Nuclear Chemical Engineering Research

Removal of Heavy Metals from Sewage Sludge



James Bezzina
Dr Mark D. Ogden &
Dr Robert Dawson

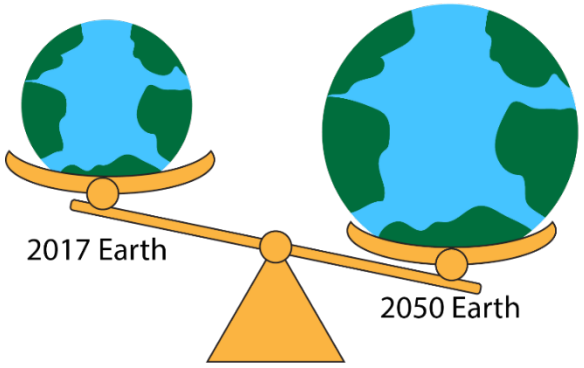


jpbezzina1@sheffield.ac.uk

@bezzinina

http://grantham.sheffield.ac.uk/scholars/bezzina/

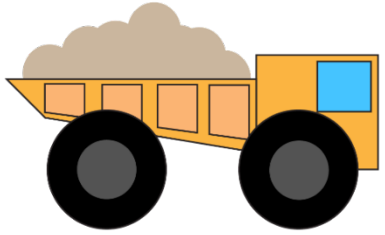
Why Sewage Sludge?



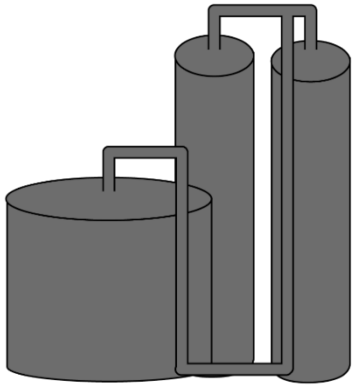
Global average consumption of:

- ~2750 kcal/person/day in 2005/2007
- >3000 kcal/person/day in 2050

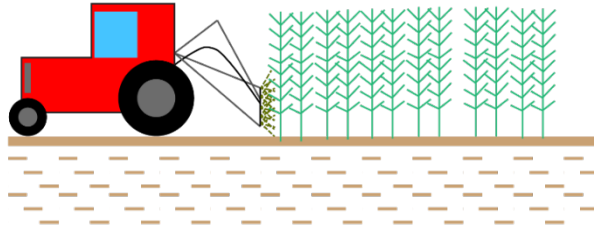
~50% increase in consumption!

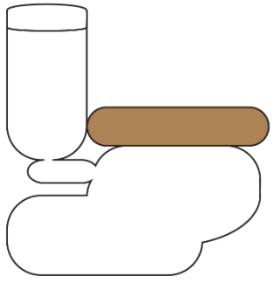


- Mostly phosphate rock
- Finite mineral
- Predicted reserves max 130 years



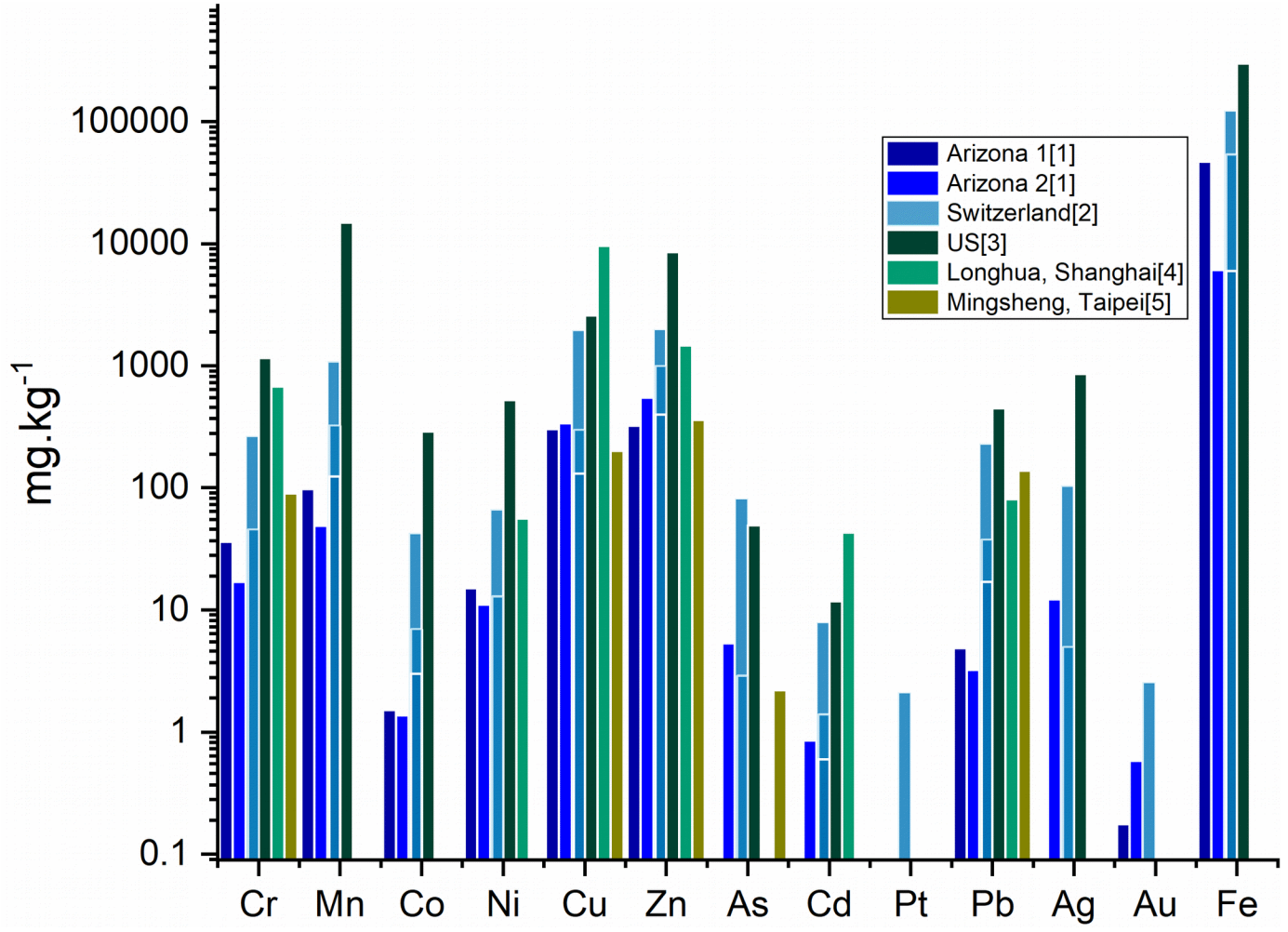
- ~80% NH_3 Harber-Bosch
- 1.1592×10^{13} MJ in 2013!





- 28% of the N
- 44% of the P

Heavy Metals

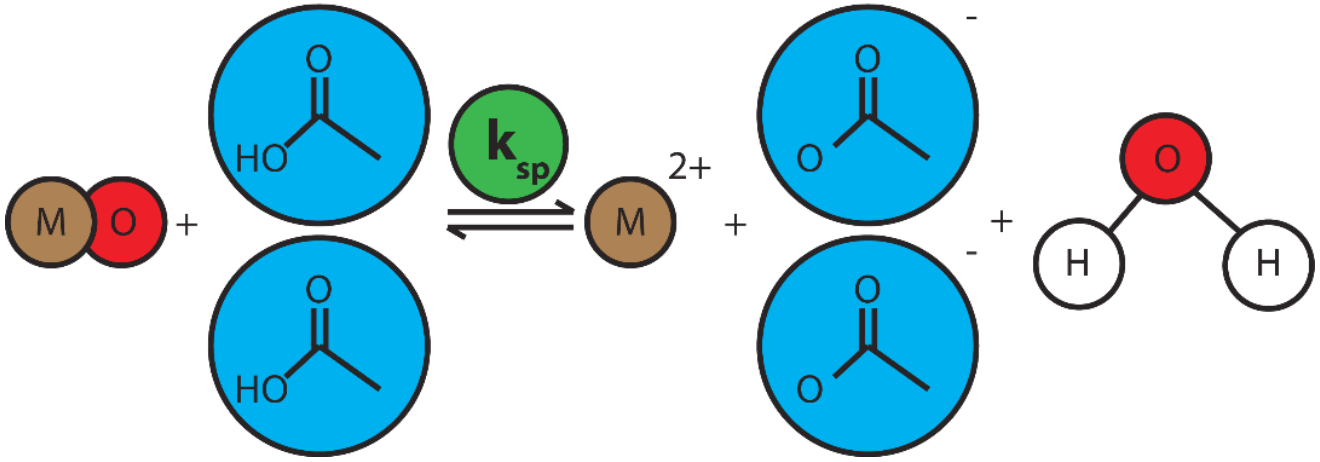


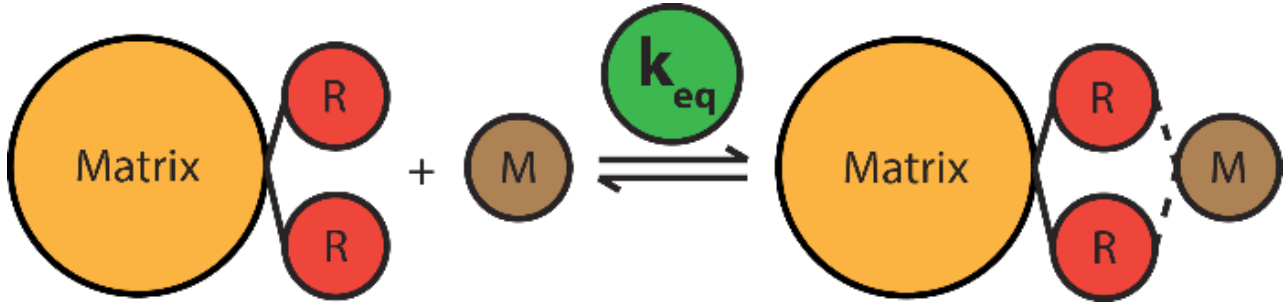
[1] Westerhoff *et al.* 2015
[2] Vriens *et al.*, 2017
[3] Stevens, 2009
[4] Liu *et al.*, 2010
[5] Hsiau and Lo, 1998

SNUCER
Separations & Nuclear Chemical Engineering Research

Hydrometallurgy

- Weak acid leaching
- Stabilise metals at higher pH
- Cheap, waste materials

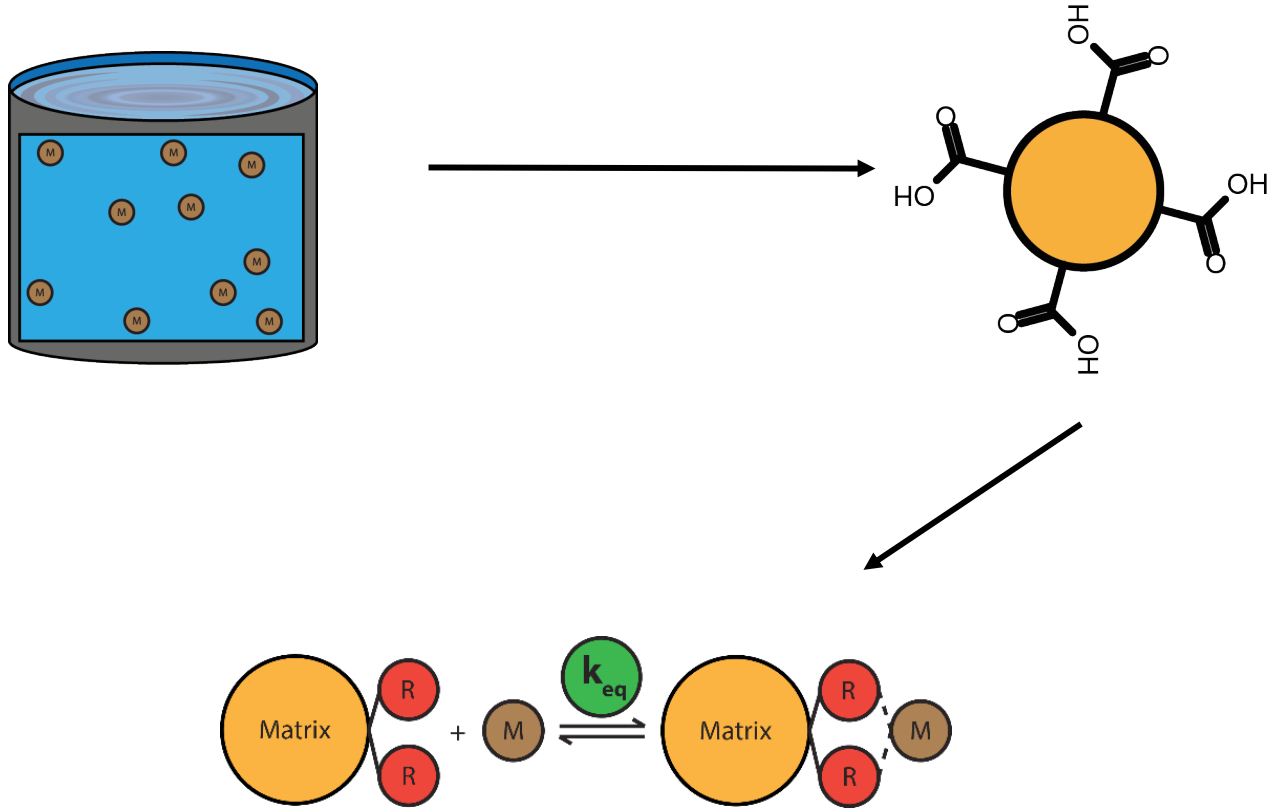




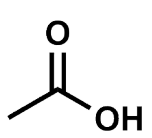
- No filtration
- Ion exchange is unknown in weak acid media

Ion Exchange

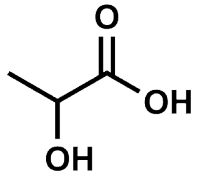
- Small, functionalised polymer beads
- Ion exchange kinetics are fast
- The effect of complexing materials (such as the weak acids) is not well understood with respect to IX material
- Working backwards approach



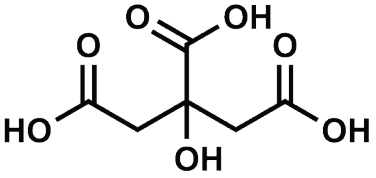
Resin Screening



Acetate



Lactate



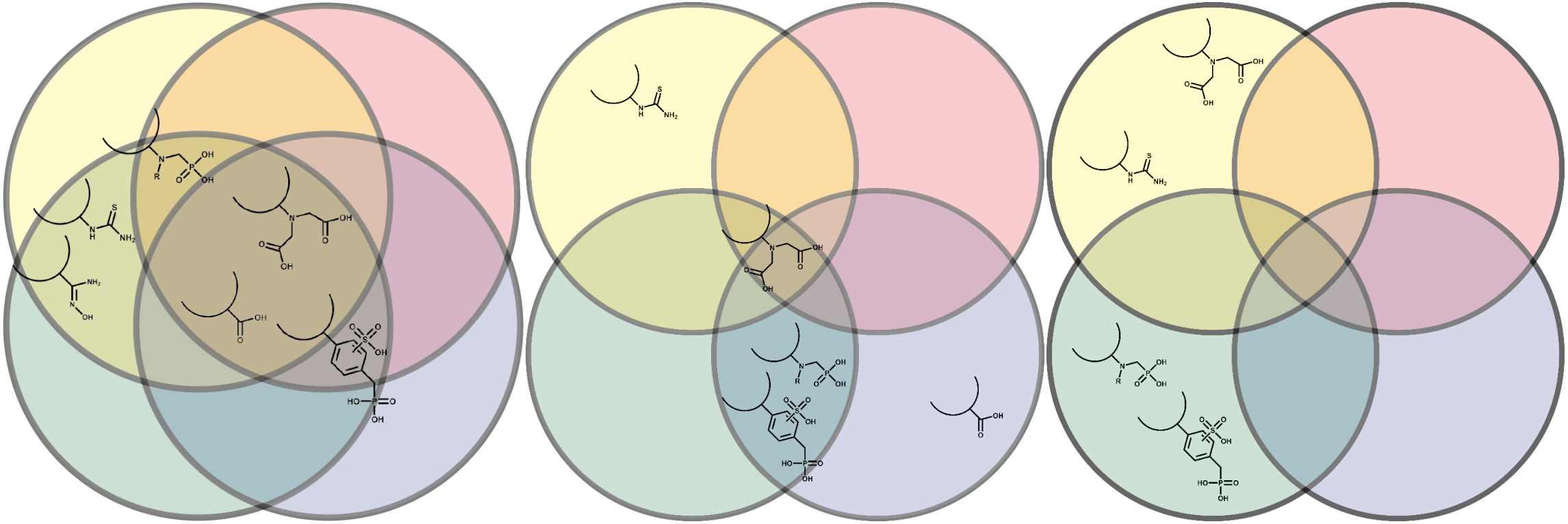
Citrate

Cu

Fe

Pb

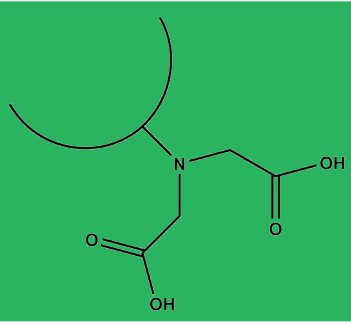
Zn

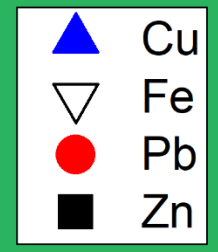


SNUCER Separations & Nuclear Chemical Engineering Research

J. P. Bezzina, et al., Water Research, 2019

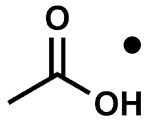
Extraction by MTS9301

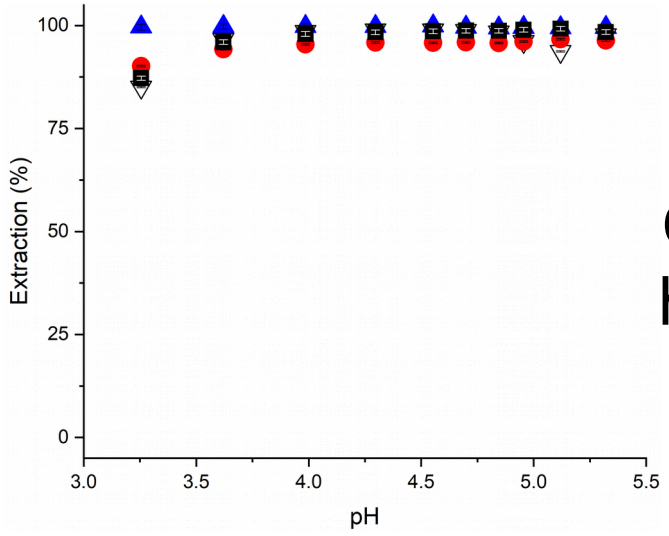




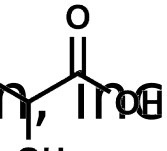
- High affinity for all metals, increasing with pH
- High affinity for Pb and Zn, increasing with pH

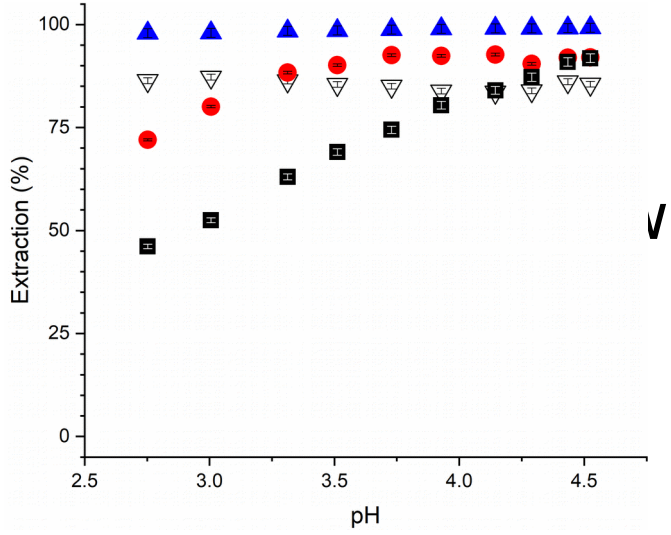
Acetate





Lactate



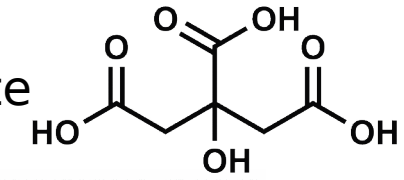


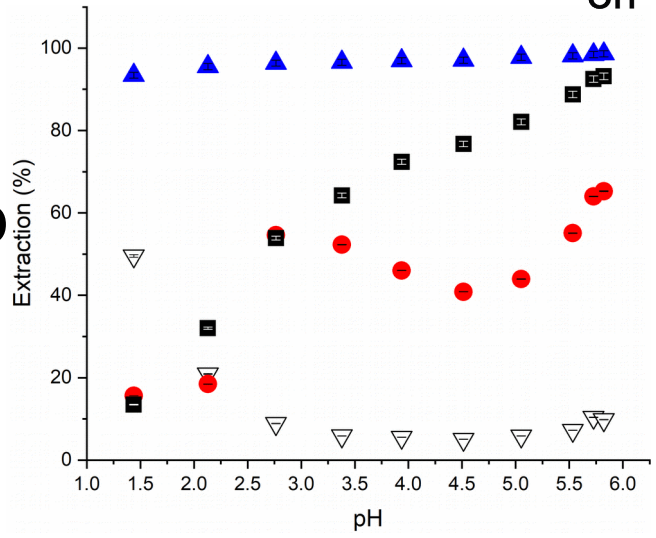
Cu, Zn

hange

with p

Citrate



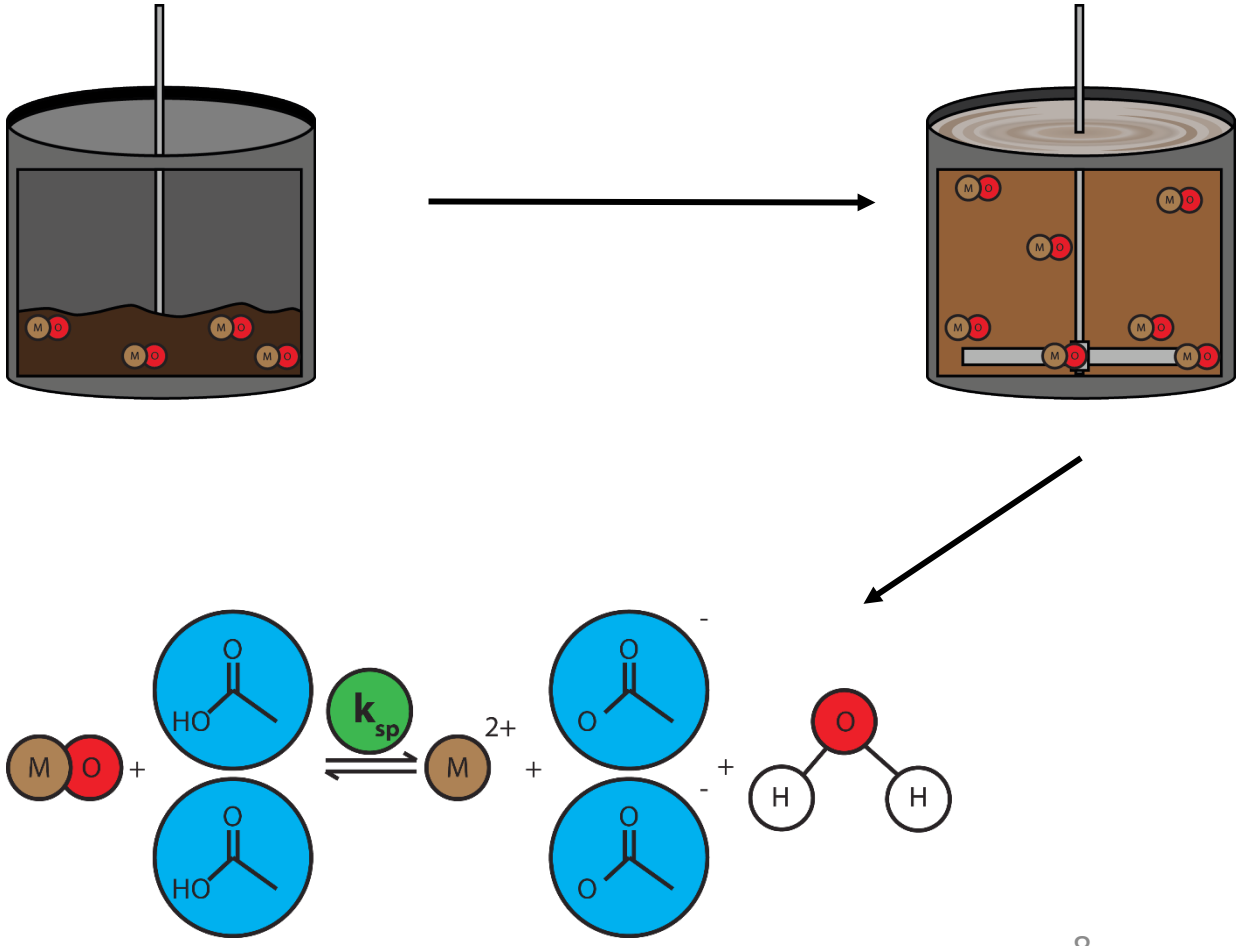


SNUCER Separations & Nuclear Chemical Engineering Research

J. P. Bezzina, et al., Water Research, 2019

Leach the Metals from Sludge

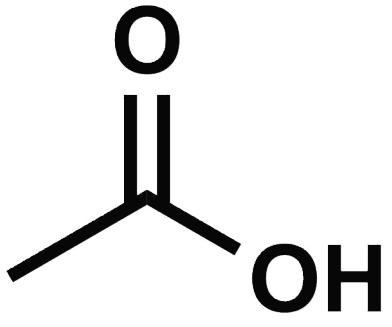
- Lower acidity required to stabilise metals due to complexation
- Environmentally safe acids
- Less cost in the neutralisation of the effluent
- Leaching kinetics are slow

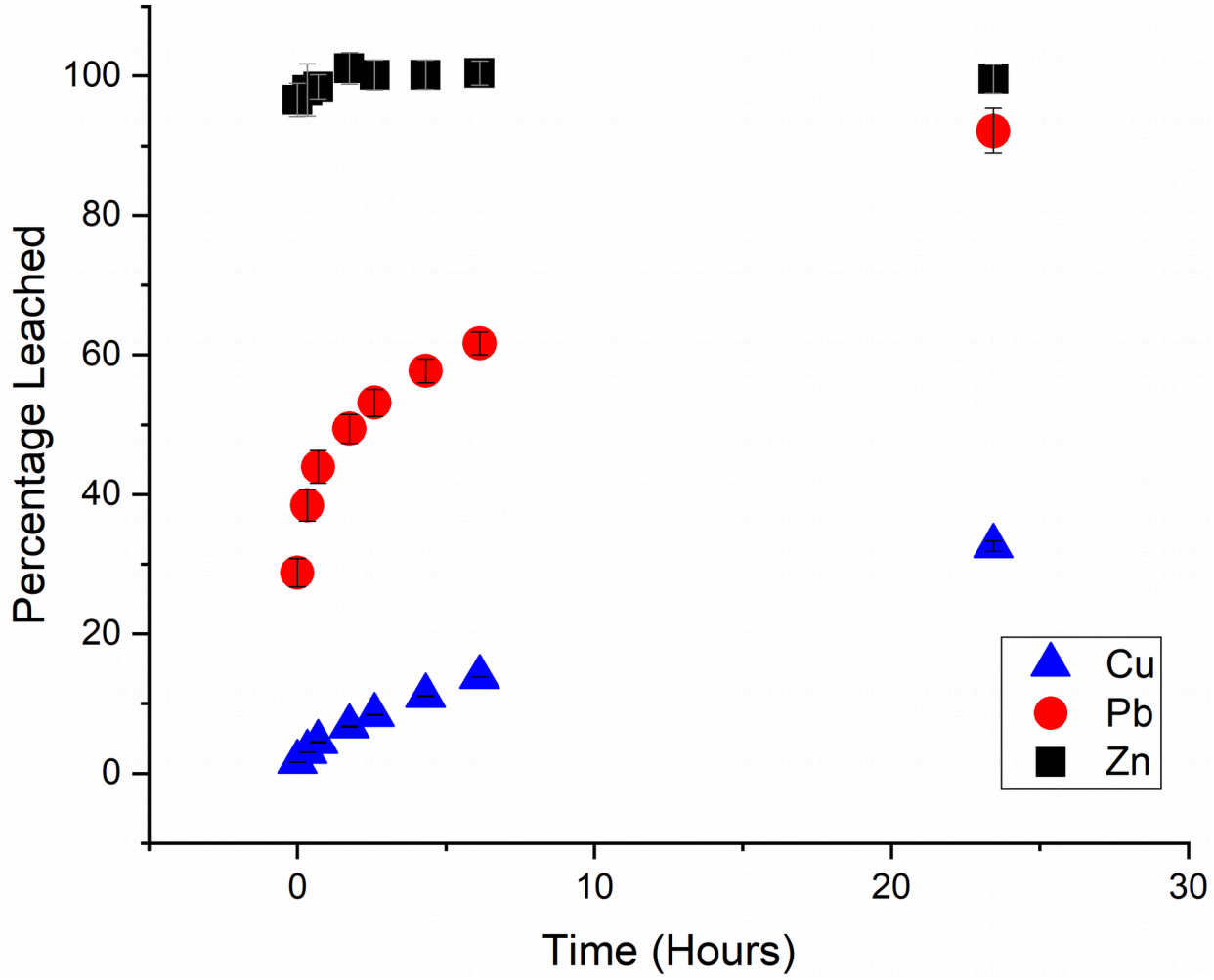


SNUCER
Separations & Nuclear Chemical Engineering Research

Acetic Acid Leaches

- Simulant sludge used for experiments
- Extremely fast leaching of zinc
- Slow leaching of lead and copper
- Oxidants or reductants can be added depending on speciation





SNUCER
Separations & Nuclear Chemical Engineering Research

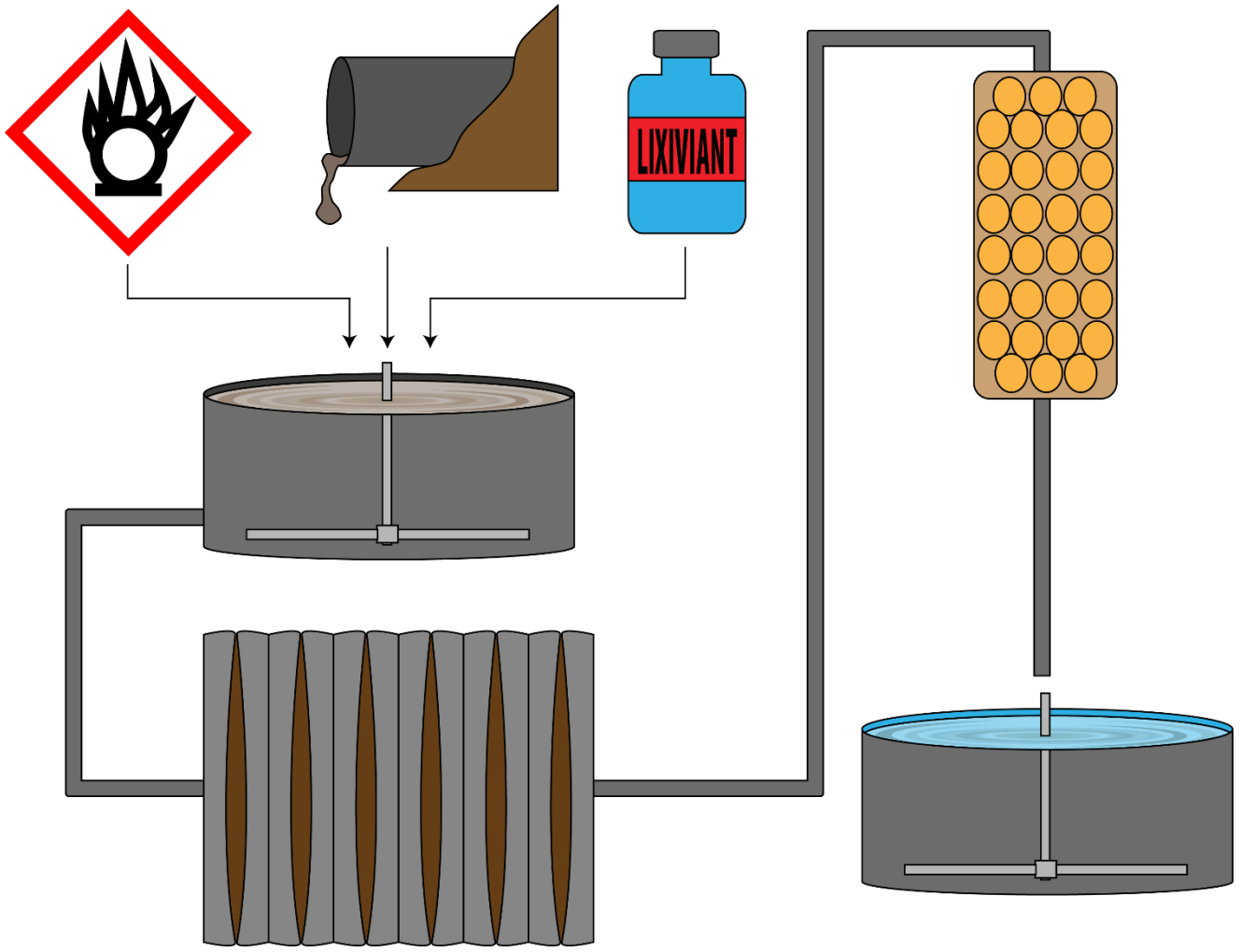
Mineral Refinery Overview

Leaching Process

- Lixiviant
- Mineral
- Oxidant/Reductant

Filtration

- Subject to blinding with organic matter
- Leaves a dewatered sludge



Ion Exchange

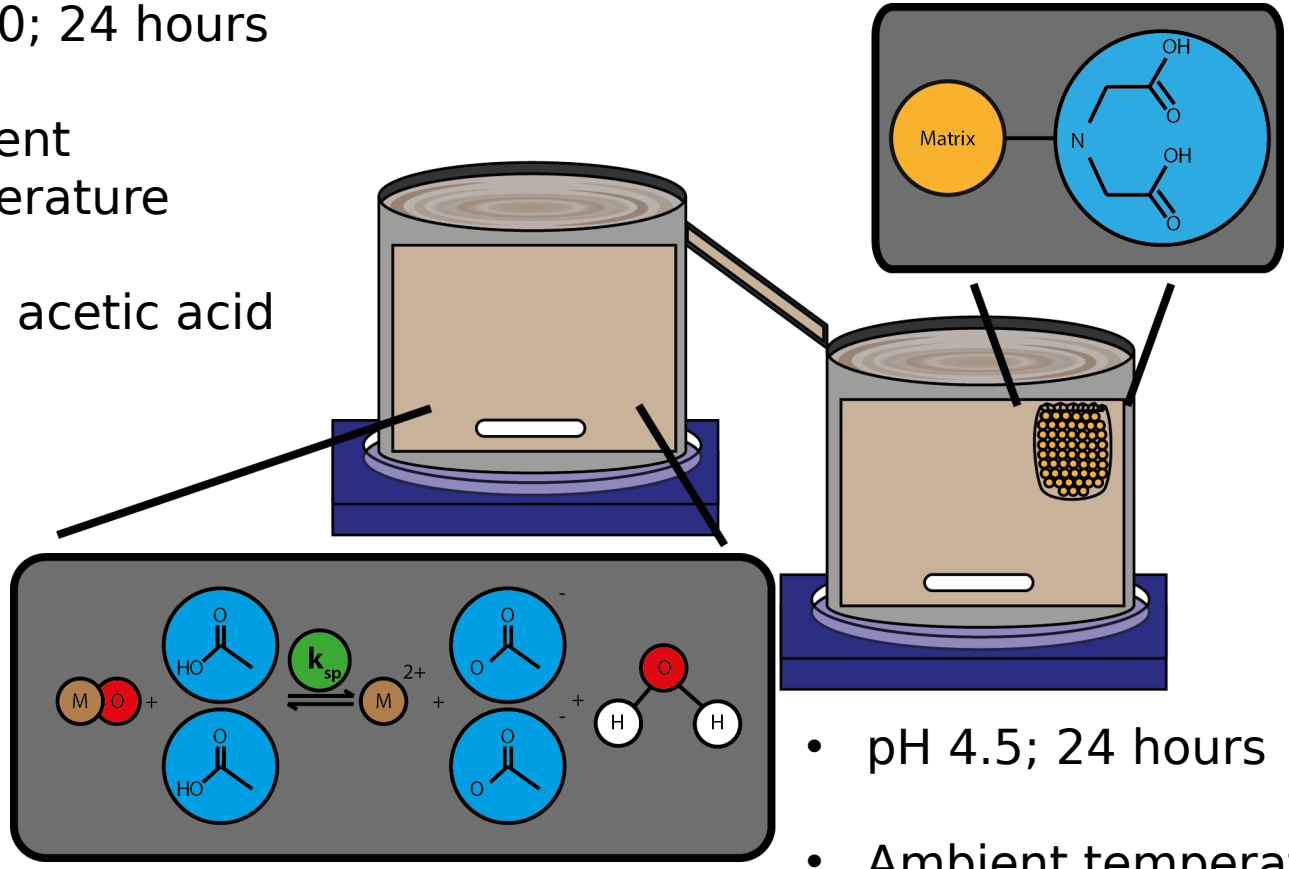
- Metals stabilised on resin surface
- Generates the “clean” liquid

Elution and Precipitation

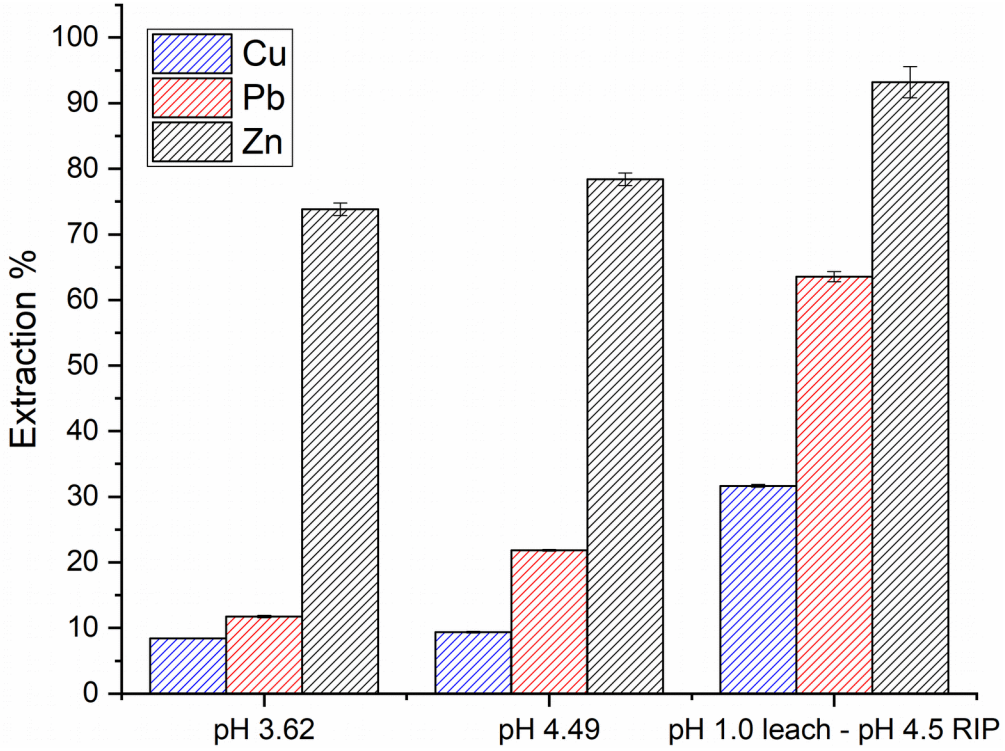
SNUCER
Separations & Nuclear Chemical Engineering Research

Resin-In-Pulp

- pH 1.0; 24 hours
- Ambient temperature
- 0.5 M acetic acid



- pH 4.5; 24 hours
- Ambient temperat
- 2:100 resin:slurry



SNUCER
Separations & Nuclear Chemical Engineering Research

Thank you!

The University Of Sheffield.

Grantham Centre for Sustainable Futures

SNUCER
Separations & Nuclear Chemical Engineering Research