In situ Microbial Dissolution of Iron Mineral-Bearing Wastes for Metal Recovery

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Iron Mineral-Bearing Wastes

Acid Mine Drainage Sludges

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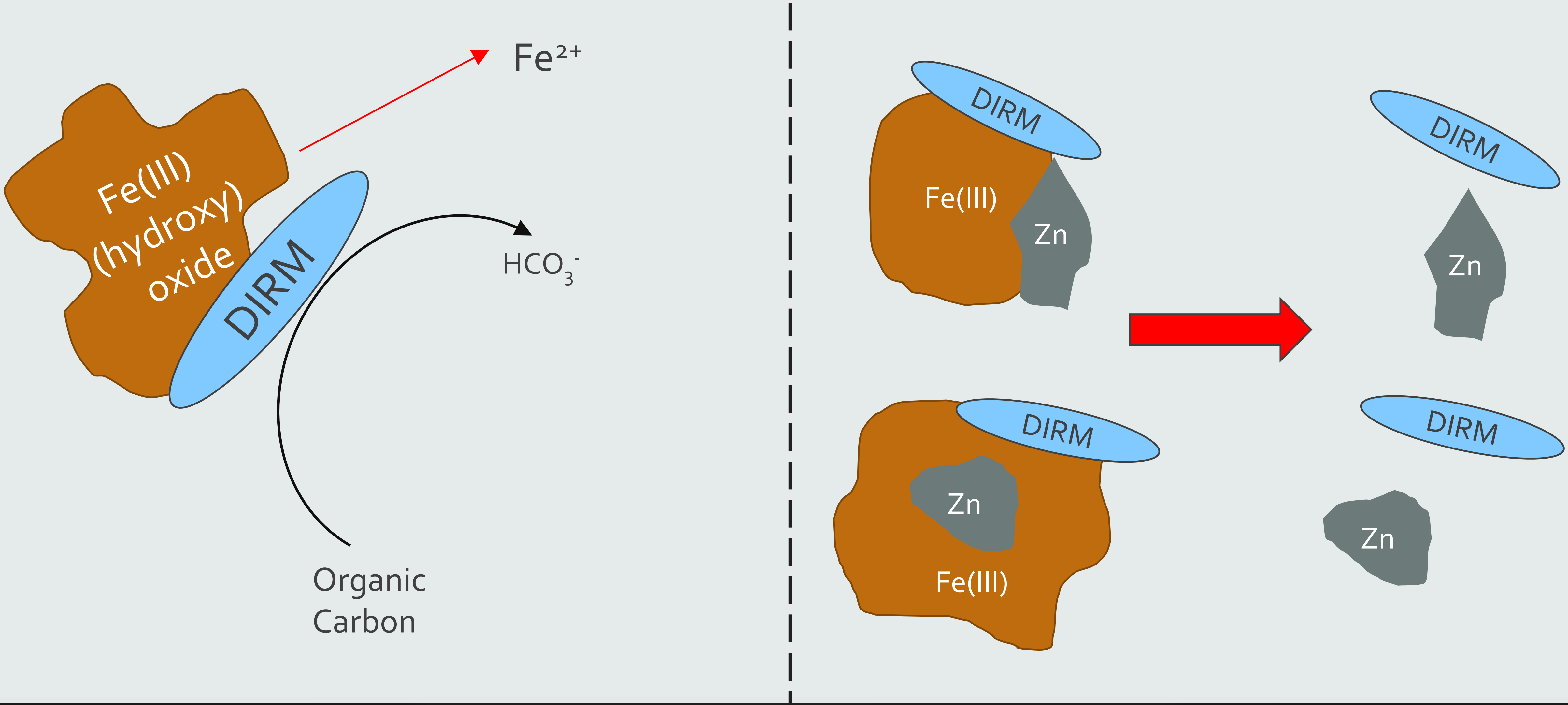
Active Mine Treatment Sludges

Red Mud

Dissimilative Iron-Reducing Microbes

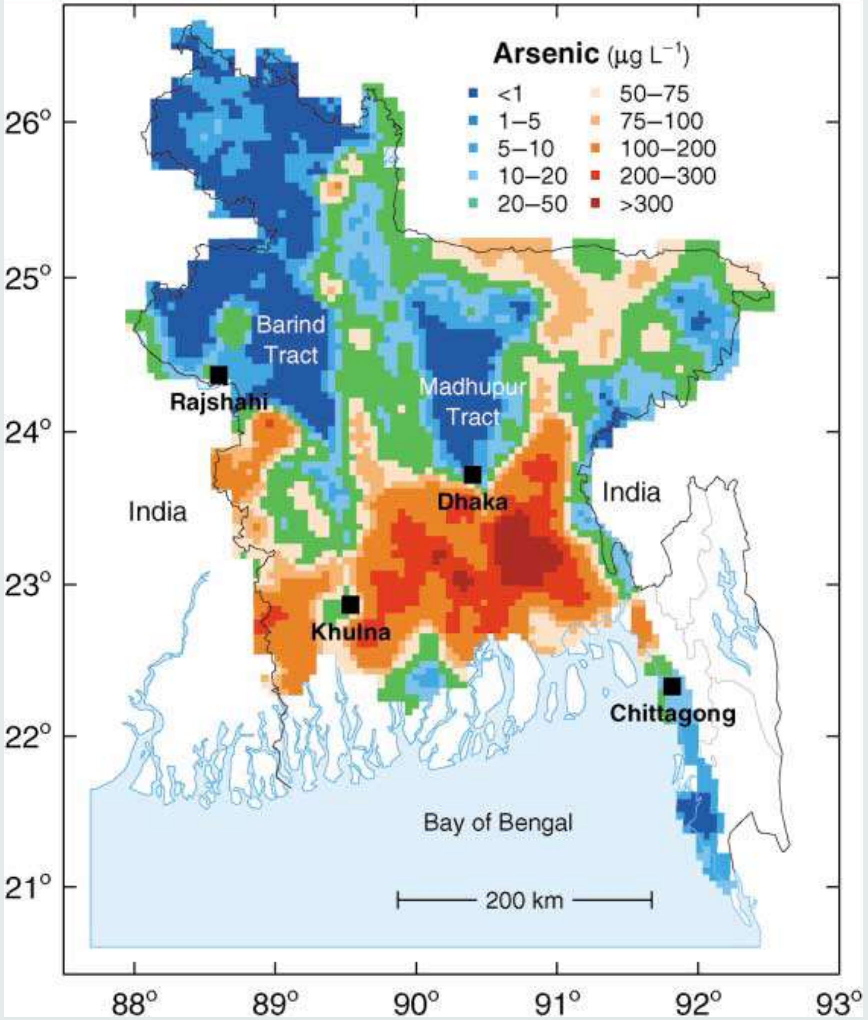


Natural Analogous Systems

- The most widely studied instance is the West Bengal Delta, Bangladesh. DIRM activity is believed to be causing the dissolution of iron (hydroxy)oxides and subsequent release of associated arsenic into the groundwater

- Other examples of DIRM facilitated arsenic release include: Silver Valley (USA), Mekong Delta (Vietnam/Cambodia), Terai (Nepal).

- Mercury has also been observed to be released upon Fe(III) bio-reduction (e.g French Guyana).



Source: Smedley & Kinniburgh, (2002)

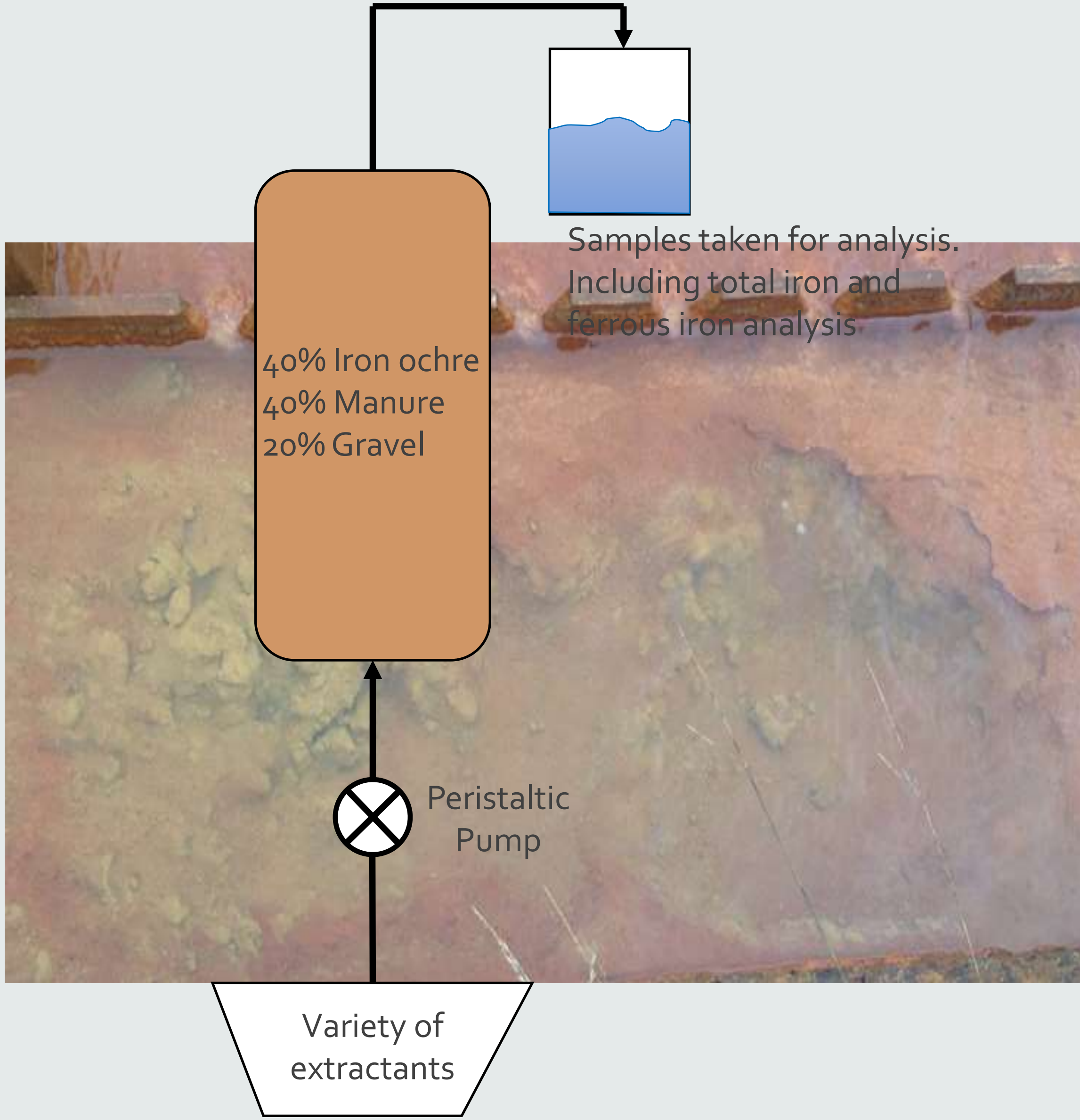
Preliminary Study

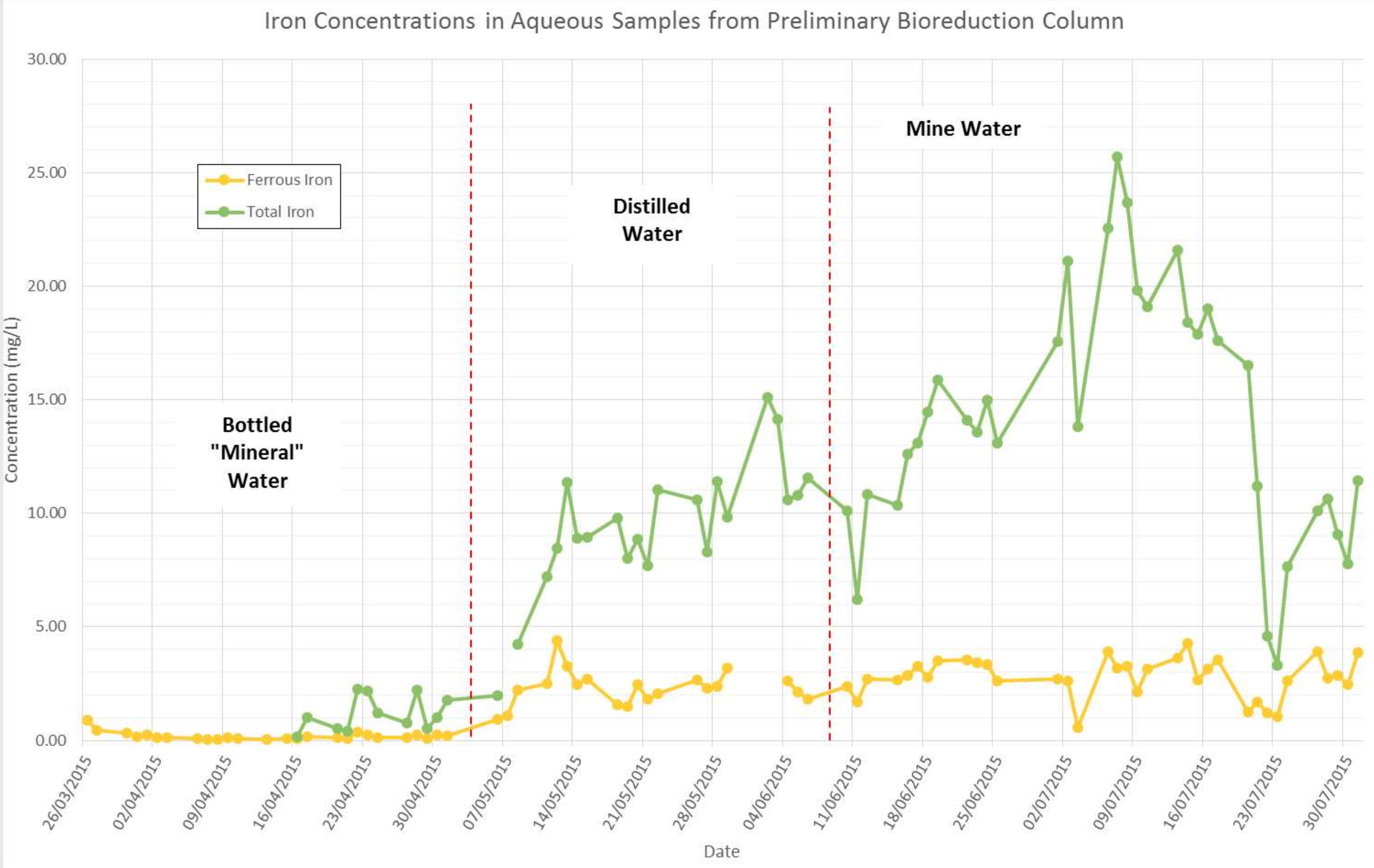
- Vertical flow column experiment utilising iron (hydroxy)oxide ochre with manure as an organic carbon source.

- Designed to investigate 2 primary aims:

  1. Can indigenous DIRM communities be enhanced with manure as an electron donor source

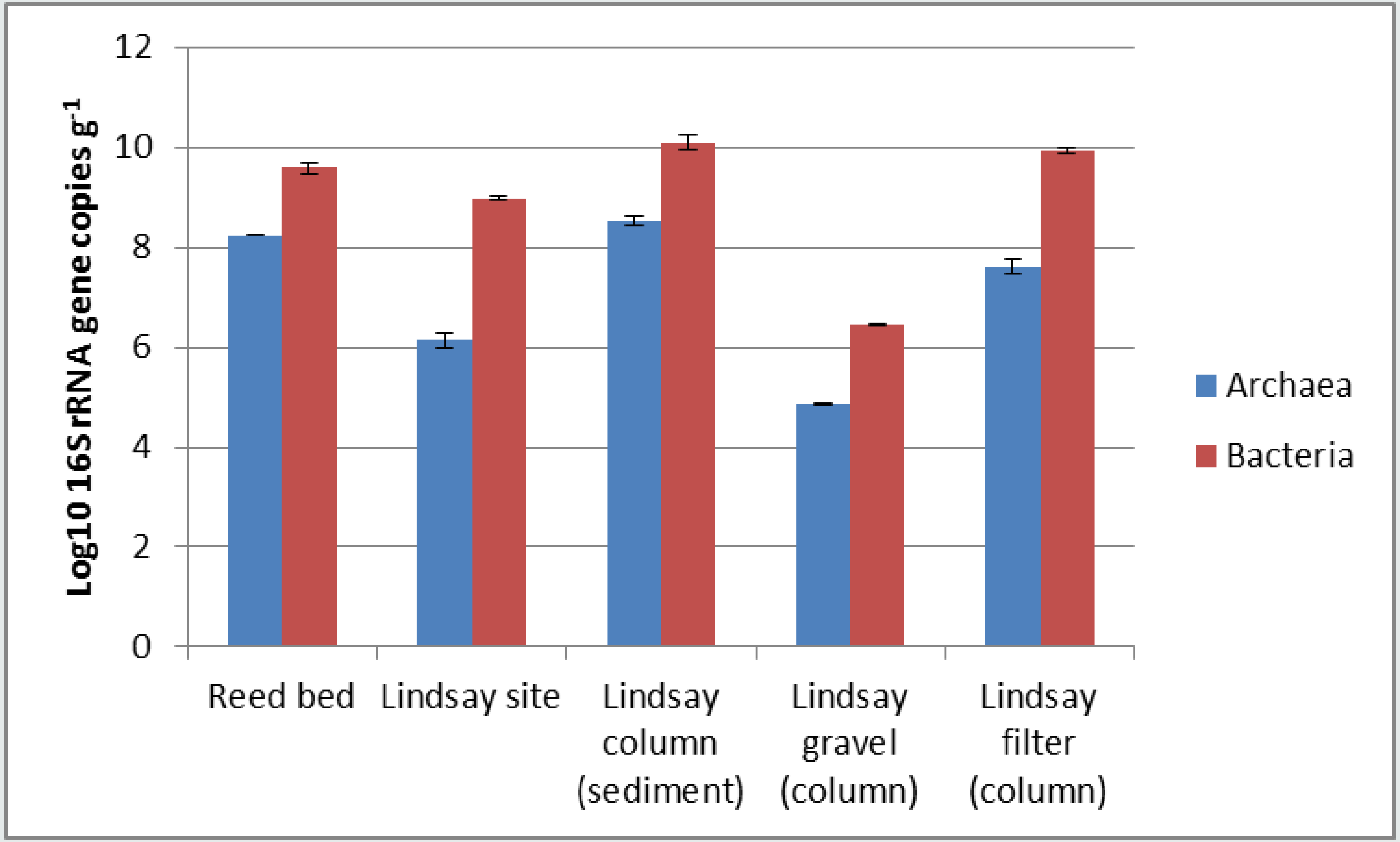
  2. Test the metal tolerance of and DIRM communities established





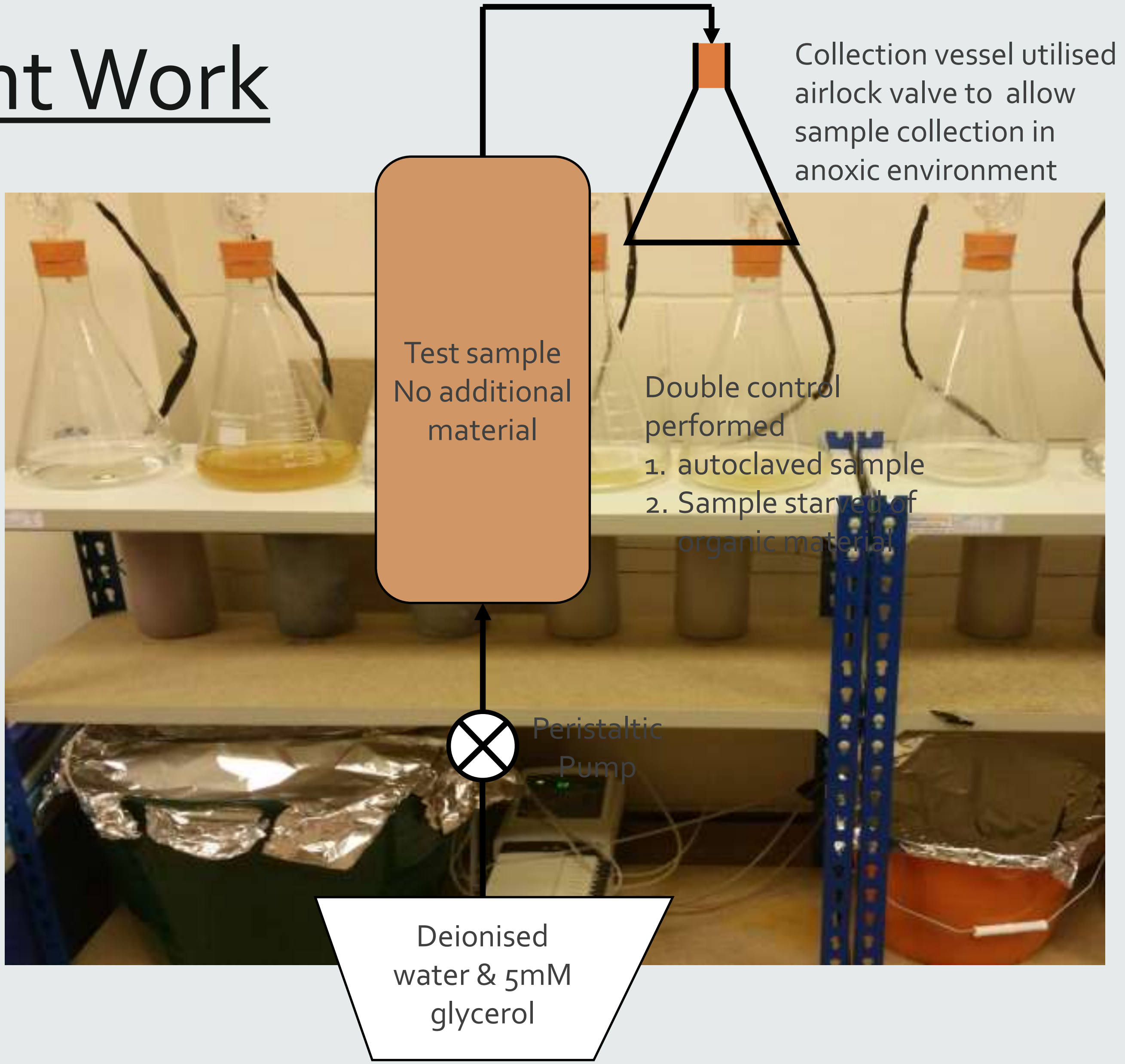
Iron Concentrations in Aqueous Samples from Preliminary Bioreduction Column
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Concentration (mg/L)
Ferrous Iron
Total Iron
Bottled "Mineral" Water
Distilled Water
Mine Water
26/03/2015
02/04/2015
09/04/2015
16/04/2015
23/04/2015
30/04/2015
07/05/2015
14/05/2015
21/05/2015
28/05/2015
04/06/2015
11/06/2015
18/06/2015
25/06/2015
02/07/2015
09/07/2015
16/07/2015
23/07/2015
30/07/2015
Date

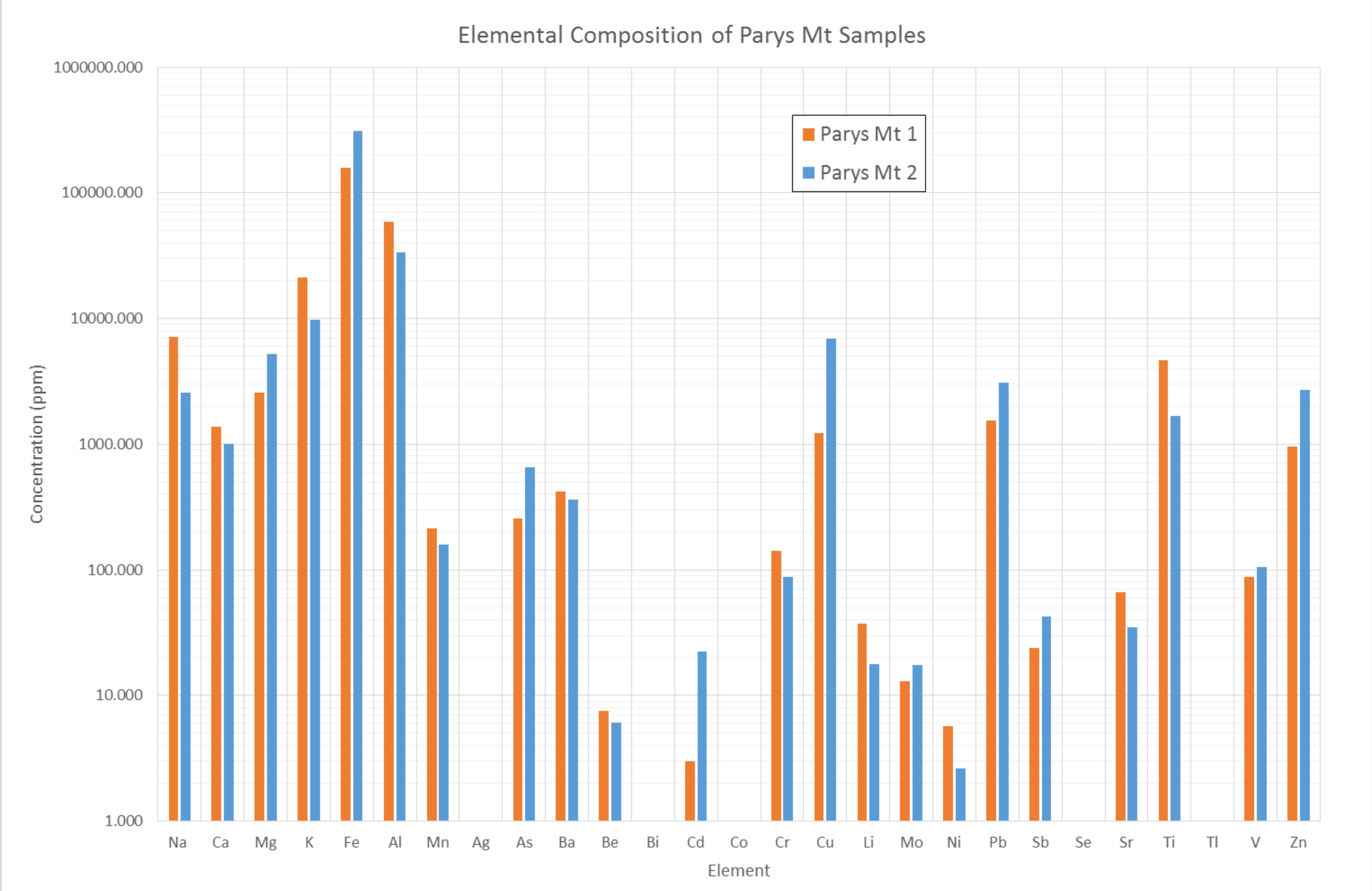
Microbial Analysis -qPCR

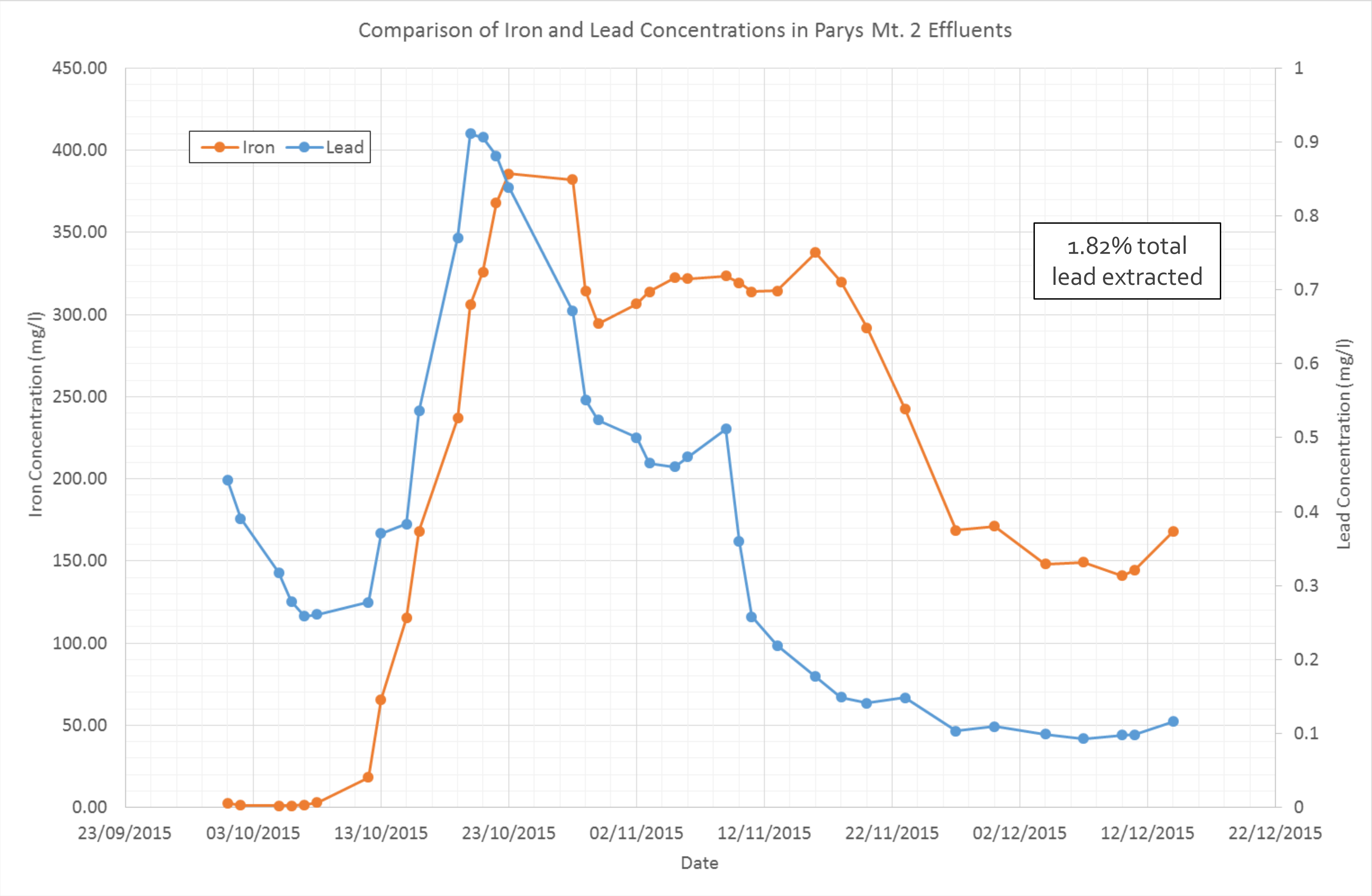


Subsequent Work

- Column experiments refined with findings from the preliminary study
- Investigated whether glycerol (as a soluble organic carbon source) proved as effective as manure
- Investigated whether indigenous DIRM communities were present, and could be enhanced, within a range of wastes.




Elemental Composition of Parys Mt Samples
1000000.000
100000.000
10000.000
1000.000
100.000
10.000
1.000
Concentration (ppm)
Parys Mt 1
Parys Mt 2
Na
Ca
Mg
K
Fe
Al
Mn
Ag
As
Ba
Be
Bi
Cd
Co
Cr
Cu
Li
Mo
Ni
Pb
Sb
Se
Sr
Ti
Tl
V
Zn
Element



Comparison of Iron and Lead Concentrations in Parys Mt. 2 Effluents
Iron
Lead
1.82% total lead extracted
Iron Concentration (mg/l)
Lead Concentration (mg/l)
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
23/09/2015
03/10/2015
13/10/2015
23/10/2015
02/11/2015
12/11/2015
22/11/2015
02/12/2015
12/12/2015
22/12/2015
Date

Conclusions

- Evidence strongly suggests DIRM are present within some anthropogenic iron (hydroxy)oxide wastes
- Indigenous DIRM communities can be enhanced with the introduction of an organic carbon source to act as an electron donor
- DIRM have shown a high tolerance to elevated metal contents
- Evidence of the potential to extract metals associated with iron (hydroxy)oxides

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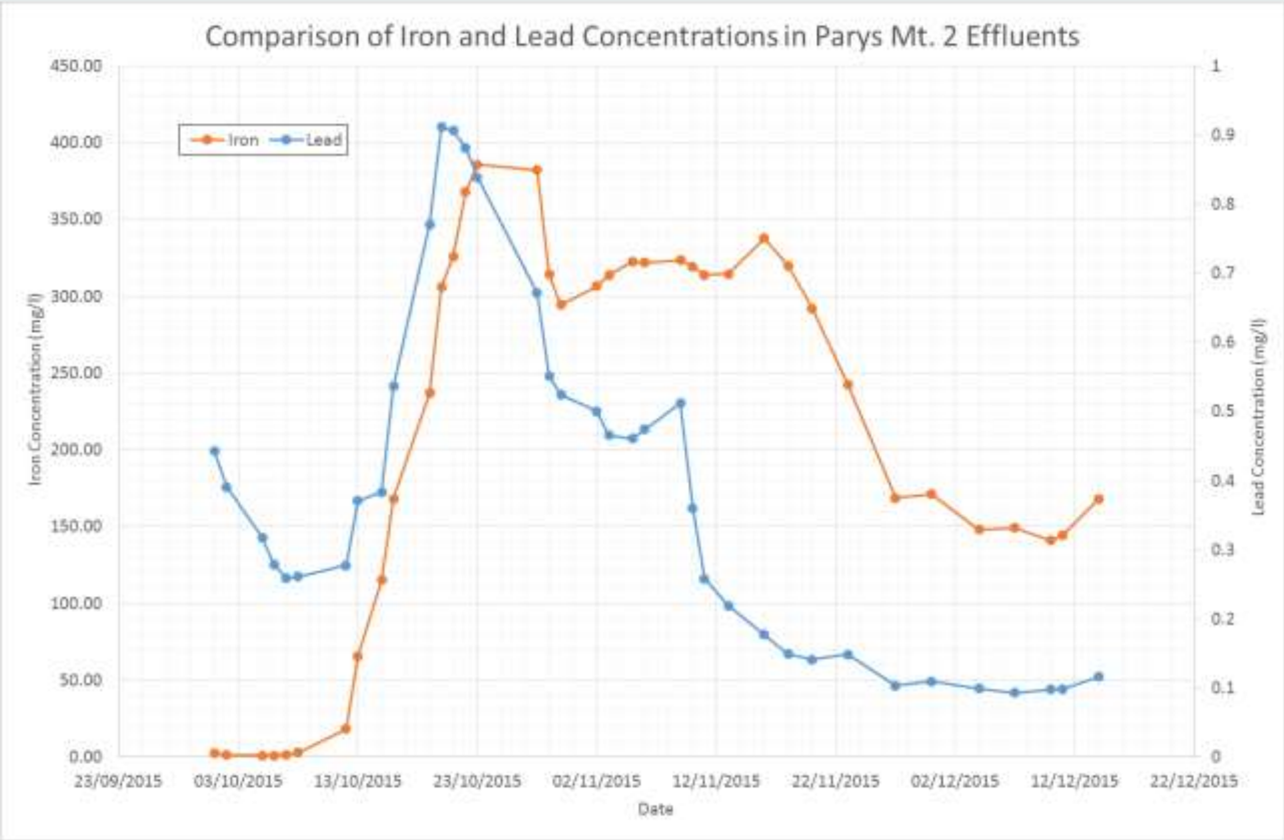
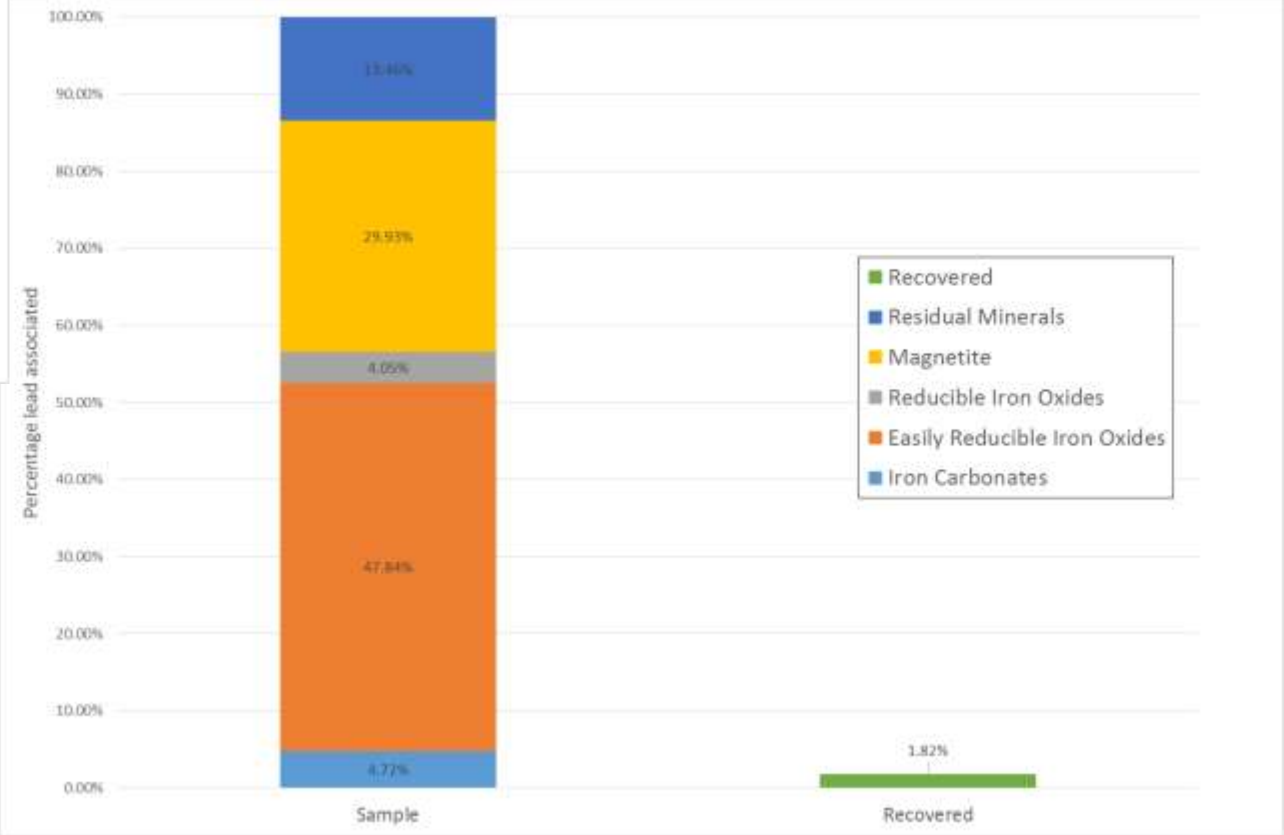
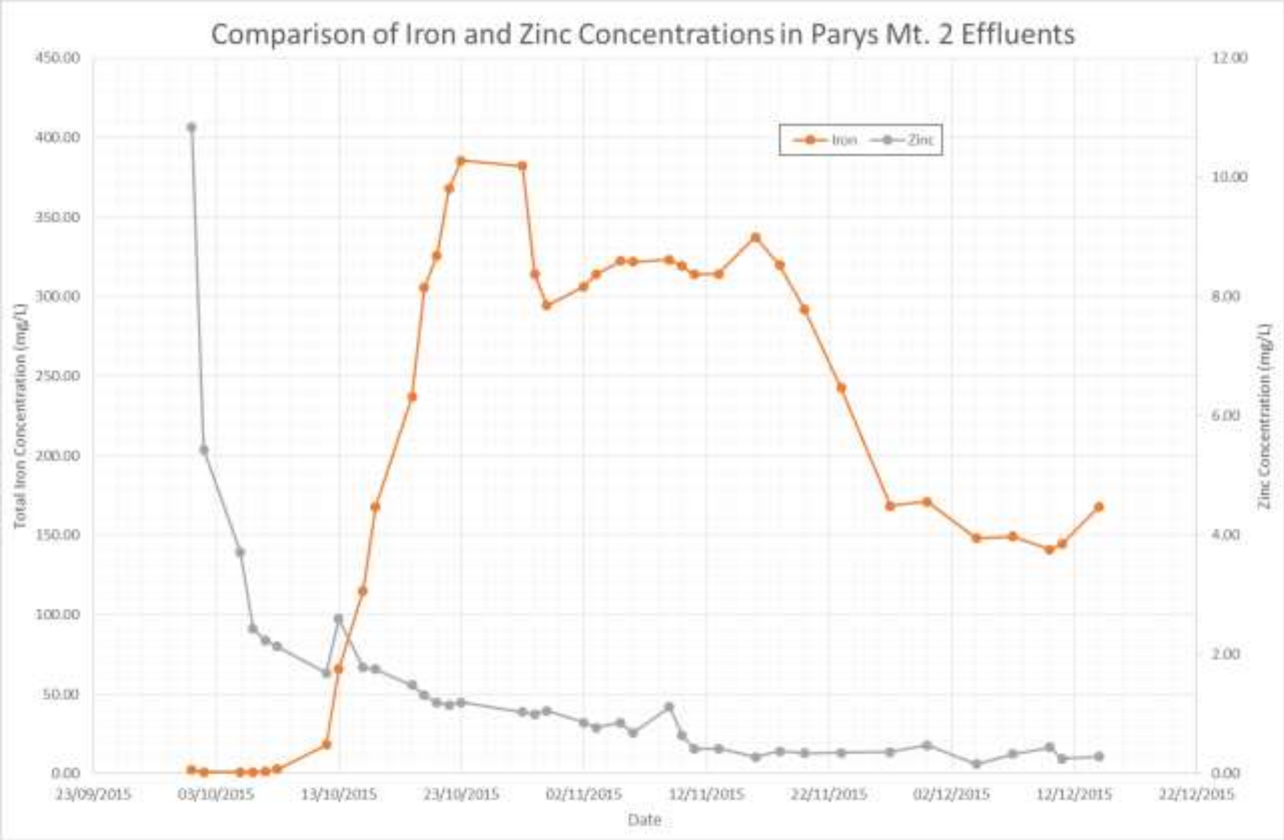
EPSRC Engineering and Physical Sciences Research Council

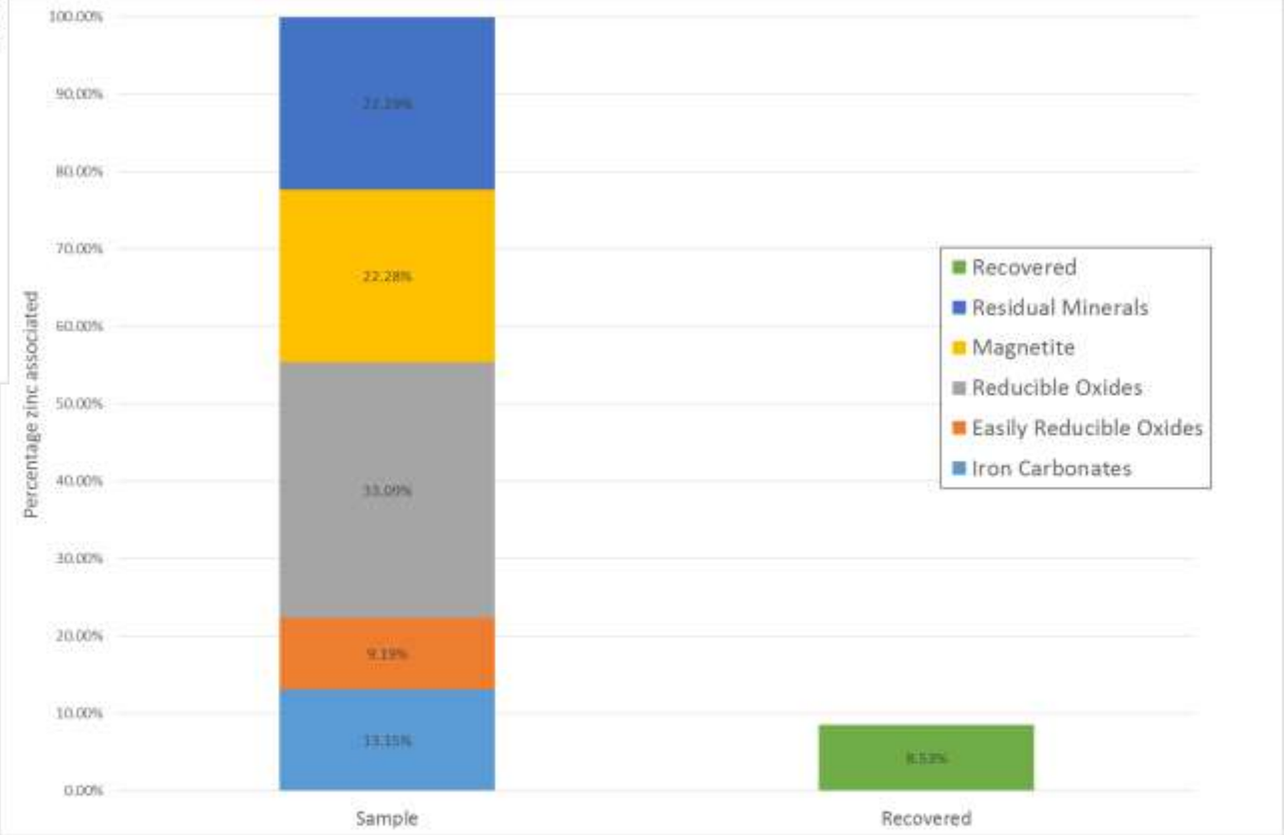
Thank you for your attention

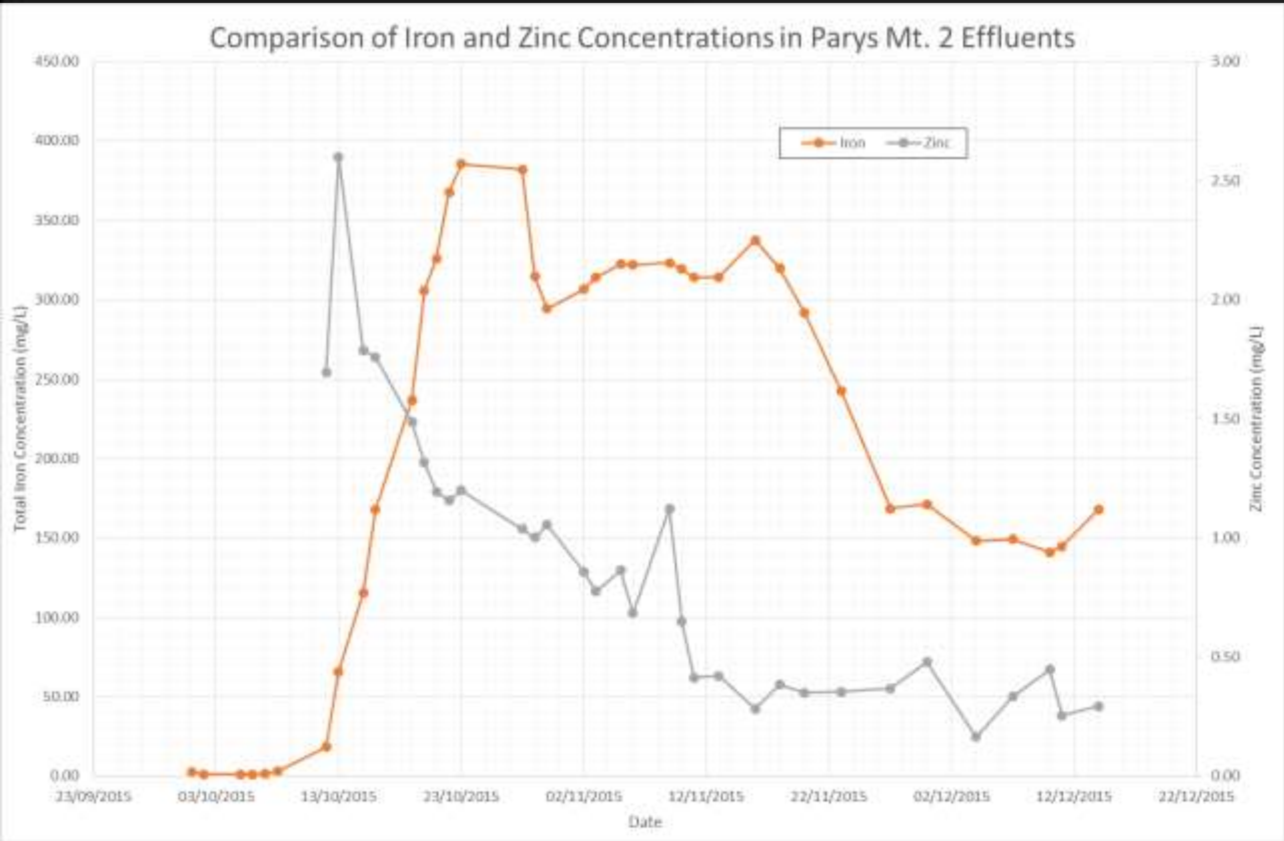
Questions welcome

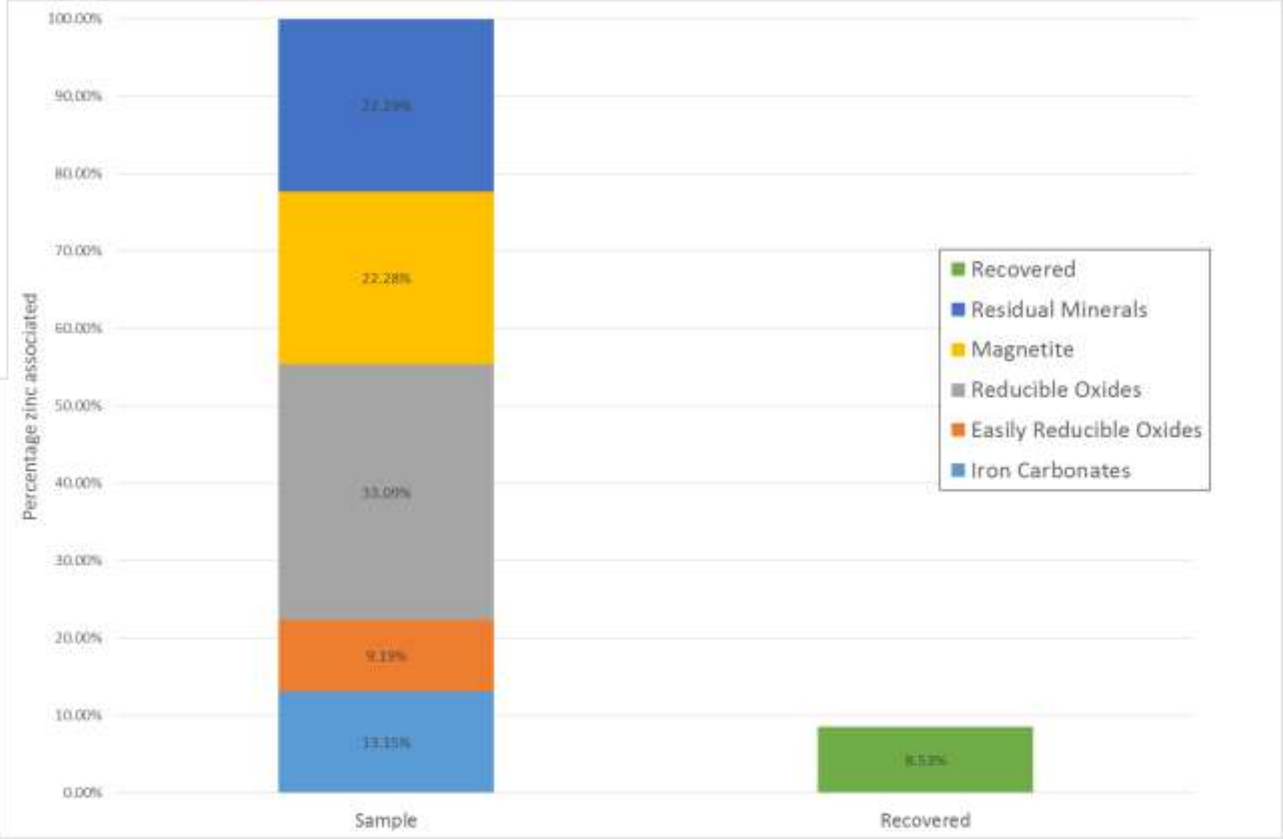

Comparison of Iron and Lead Concentrations in Parys Mt. 2 Effluents
Iron
Lead
Iron Concentration (mg/l)
Lead Concentration (mg/l)
Date
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
23/09/2015
03/10/2015
13/10/2015
23/10/2015
02/11/2015
12/11/2015
22/11/2015
02/12/2015
12/12/2015
22/12/2015


Percentage lead associated
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
29.93%
4.06%
47.84%
4.77%
1.82%
Sample
Recovered
Recovered
Residual Minerals
Magnetite
Reducible Iron Oxides
Easily Reducible Iron Oxides
Iron Carbonates


Comparison of Iron and Zinc Concentrations in Parys Mt. 2 Effluents
Iron
Zinc
Total Iron Concentration (mg/L)
Zinc Concentration (mg/L)
Date
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
23/09/2015
03/10/2015
13/10/2015
23/10/2015
02/11/2015
12/11/2015
22/11/2015
02/12/2015
12/12/2015
22/12/2015


Percentage zinc associated
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
22.28%
Sample
Recovered
Recovered
Residual Minerals
Magnetite
Reducible Oxides
Easily Reducible Oxides
Iron Carbonates


Comparison of Iron and Zinc Concentrations in Parys Mt. 2 Effluents
Iron
Zinc
Total Iron Concentration (mg/L)
Zinc Concentration (mg/L)
Date
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
3.00
2.50
2.00
1.50
1.00
0.50
0.00
23/09/2015
03/10/2015
13/10/2015
23/10/2015
02/11/2015
12/11/2015
22/11/2015
02/12/2015
12/12/2015
22/12/2015


Percentage zinc associated
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
22.28%
33.09%
13.15%
Sample
Recovered
Recovered
Residual Minerals
Magnetite
Reducible Oxides
Easily Reducible Oxides
Iron Carbonates