Mobility and toxicity of heavy metal(loid)s arising from contaminated wood ash application to a pasture grassland soil.

Luke Beesley, L. Mollon, G.J. Norton,

Study aims & context:

-Examine the solubility of metal(loid)s from contaminated ash

-Conduct exploratory soil application trials to determine uptake and toxicity impacts of ash

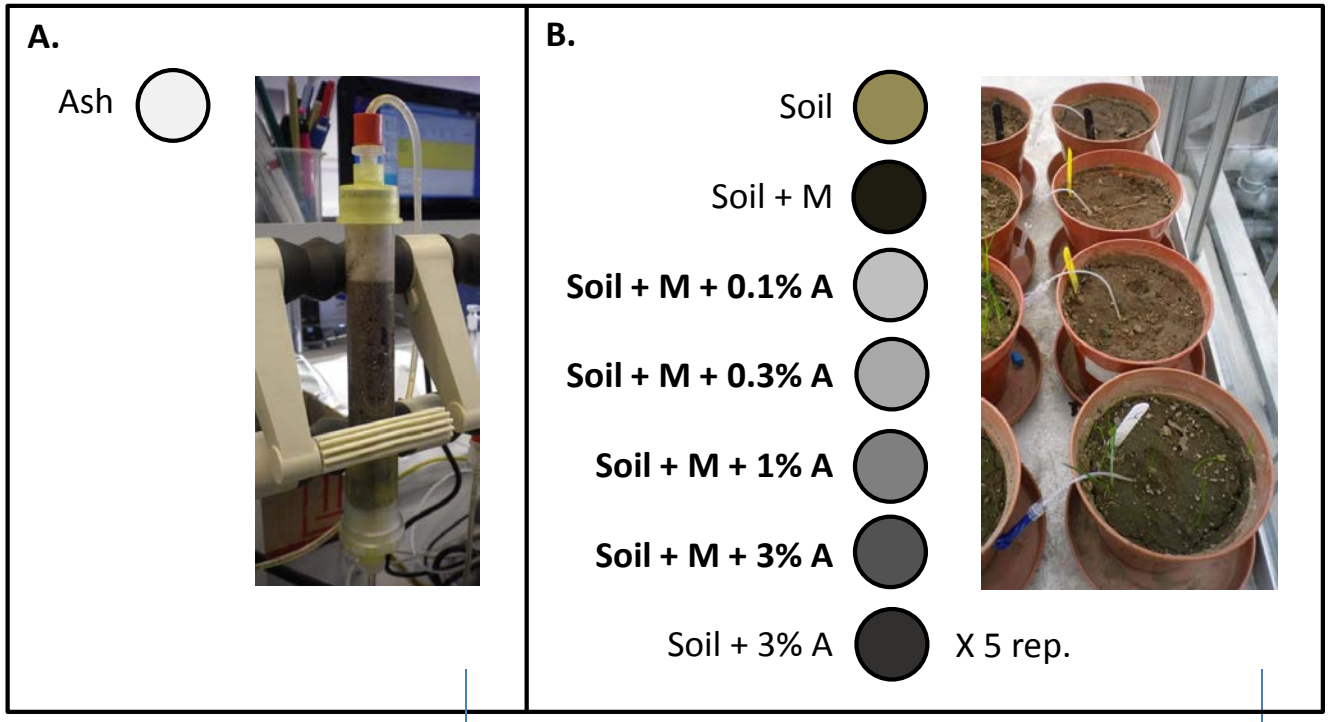
-Determine the influence of organic matter addition on metal(loid)s

-Wood ash derived from CCA treated sources

-Liming capability (rich in Ca, Mg etc)

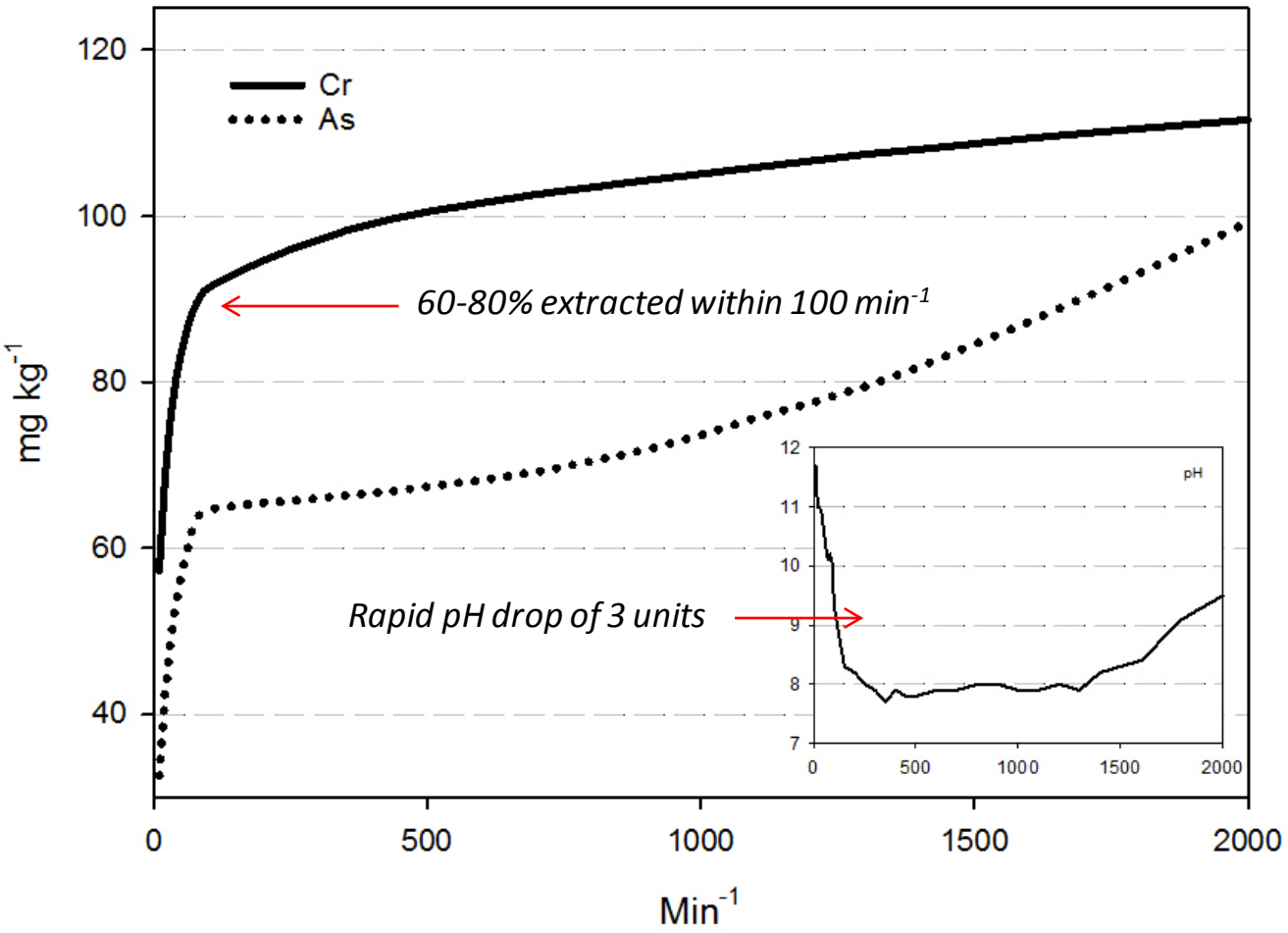
-Metal(loid) concentrations 10000 mg kg^{-1}

Overview of experimental set-up:



Figures based on Mollon et al; in-press

Outcomes of the column procedure:

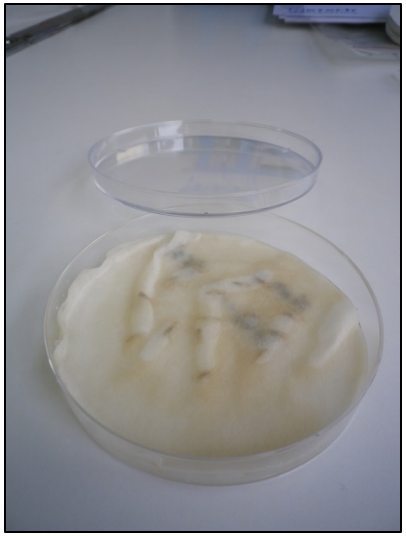


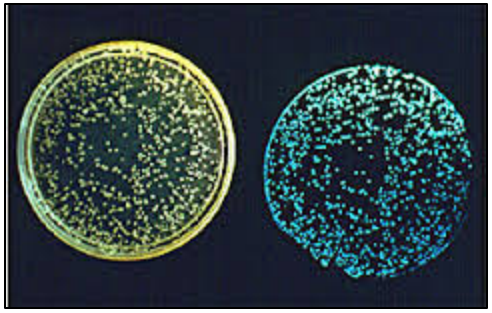
Materials & methods (pot test):

1) Pore water collected by rhizon sampler (picture), measured by ICP-MS for metals

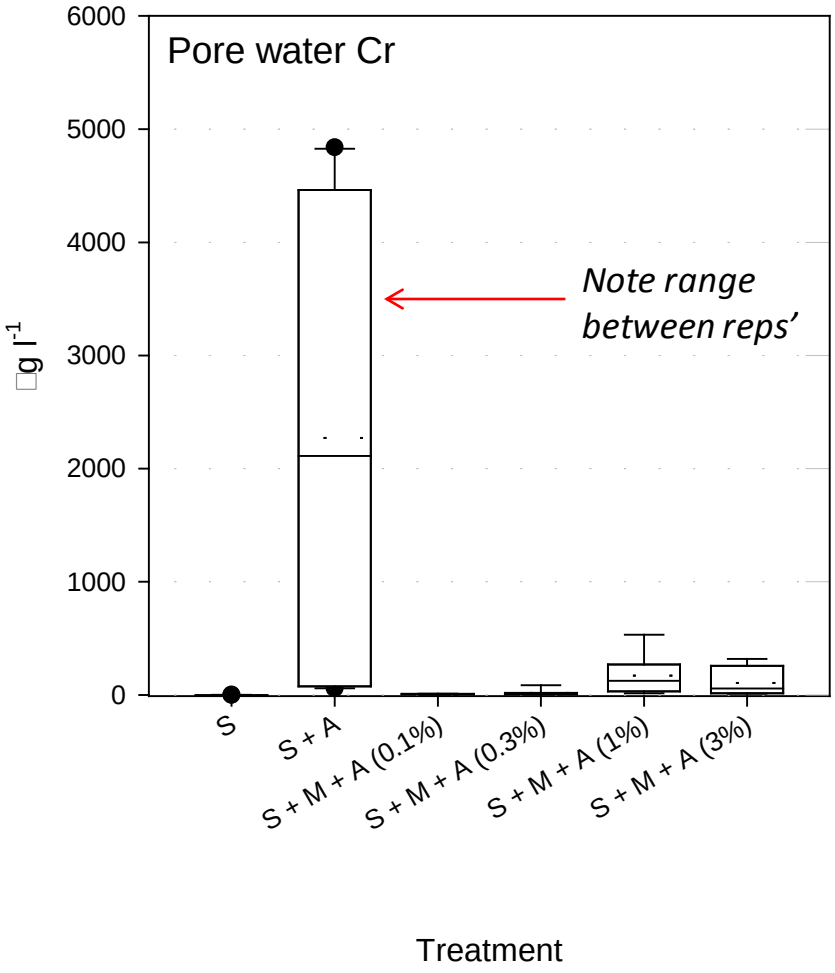
2) Ryegrass germinated and harvested after 9 weeks, mass, digested and ICP-MS for metals

3) Toxicity bio-assays performed on pore water as 'bioavailable' fraction of metals (E.coli HB101 pUCD607)





Results; As and Cr:

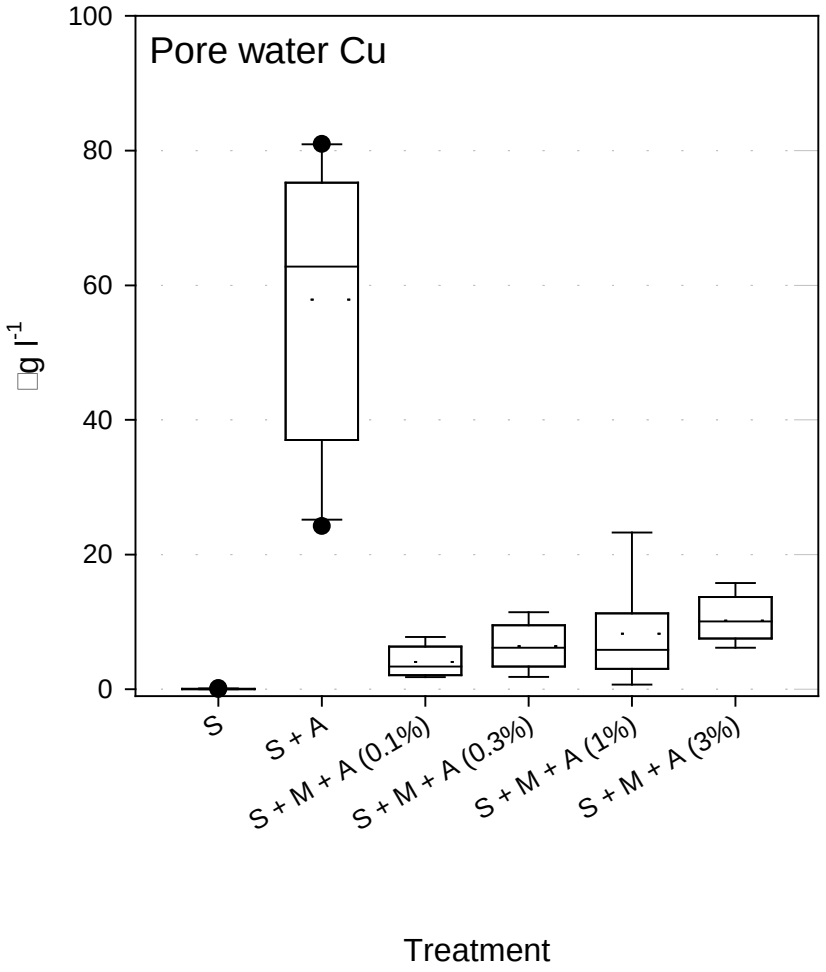


-Cr(VI) strongly soluble

-As bound to organic matter

Fraction	As	Cr
'Exch'	<1	<1
'Org'	67	6.5
'Residual'	32	90

Results; Cu and Zn:



-Cu bound to organic matter (~40%)

-Zn not influenced by any treatment

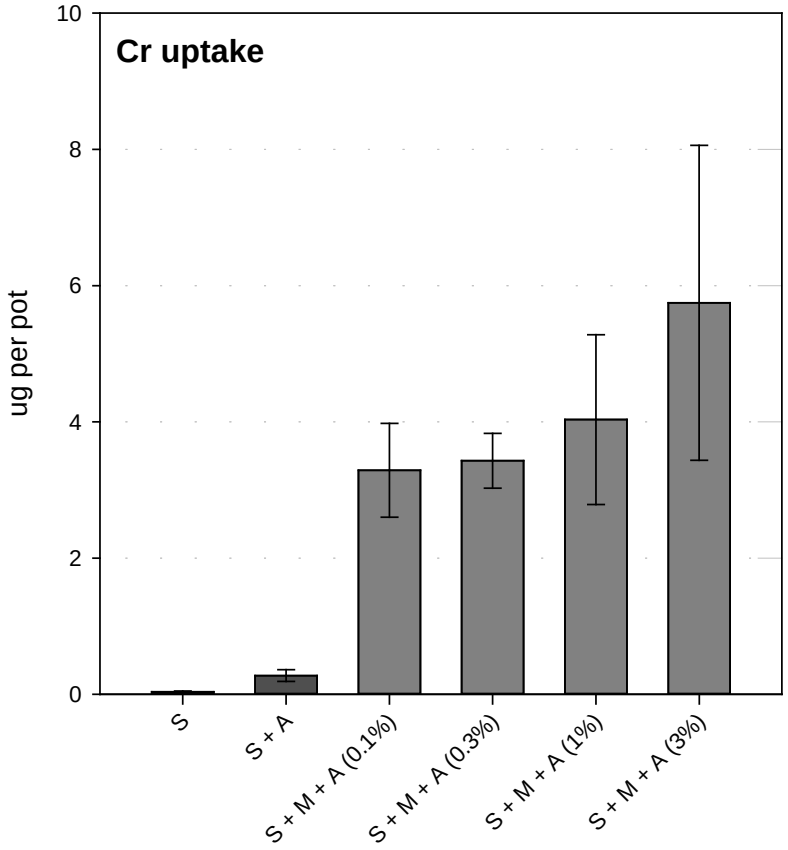
Arsenic, cadmium, copper, lead and zinc concentration (μg l^{-1}) in the pore water of several field trials.

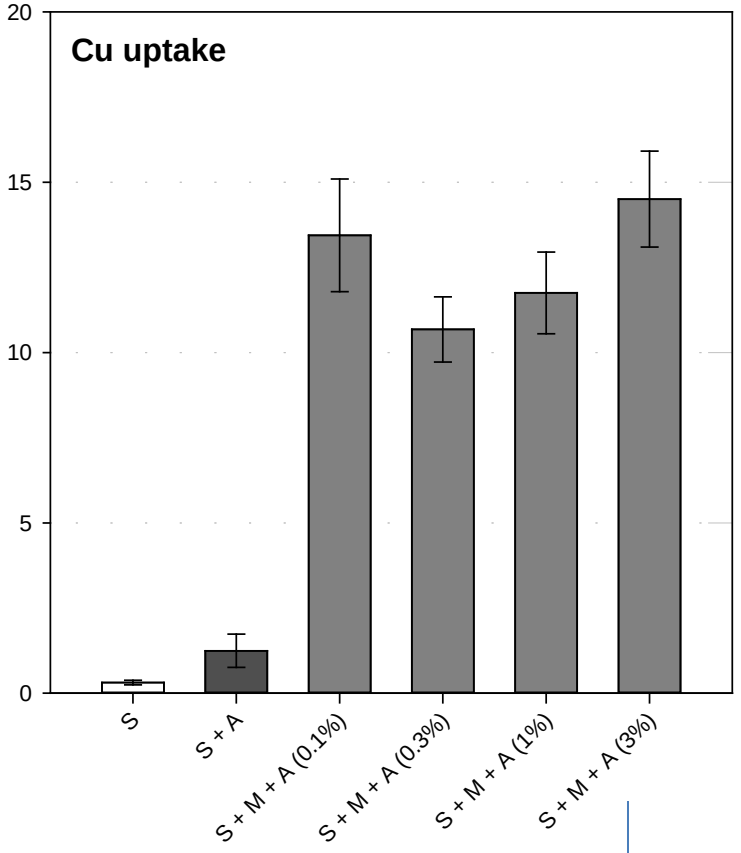
Site & location	As	Cd	Cu μg l^{-1}	Pb	Zn
United Kingdom					
Byrom Street, Liverpool	1–3		2–10	n.d.–21	n.d.–360
Quaker Meeting House, St Helens	2–83	n.d.–2	4–55	1–22	6–93
Merton Bank, St Helens	15–52	n.d.	25–47	13–495	67–205
Kidsgrove, Staffordshire	1–2	20–6120	n.d.–0.71	n.d.–8	63–6470
Thornton Hough, Cheshire	2–110	n.d.–2	16–104	n.d.–9	22–449
Prescot, Merseyside	1–108	5–1400	49–1190	2–72	72–3749
Spain					
Mina Mónica, Madrid	2–2901	1–17	n.d.–48	n.d.–2	147–871
Pinares de la Fuente del Collado, Madrid	n.d.	n.d.–2	15–45	n.d.	71–111
La Unión, Murcia	n.d.	n.d.–3000	1400–27900	n.d.	36000–927000

n.d., not detected.

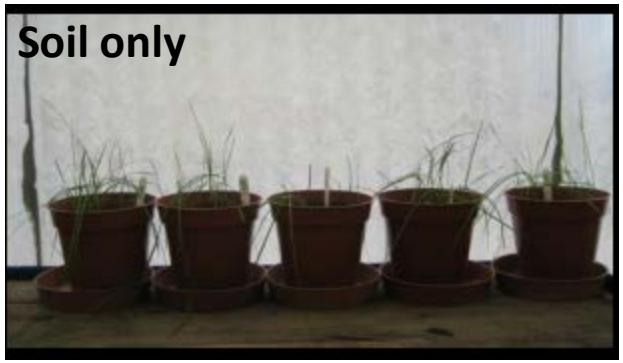
Values from contaminated industrial and mine areas in Europe; from Moreno-Jimenez et al, 2011

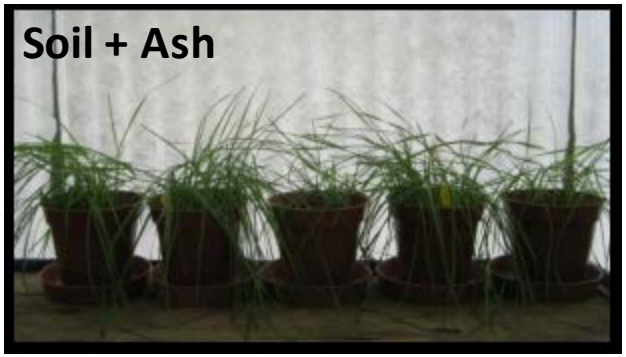
Results; ryegrass uptake:





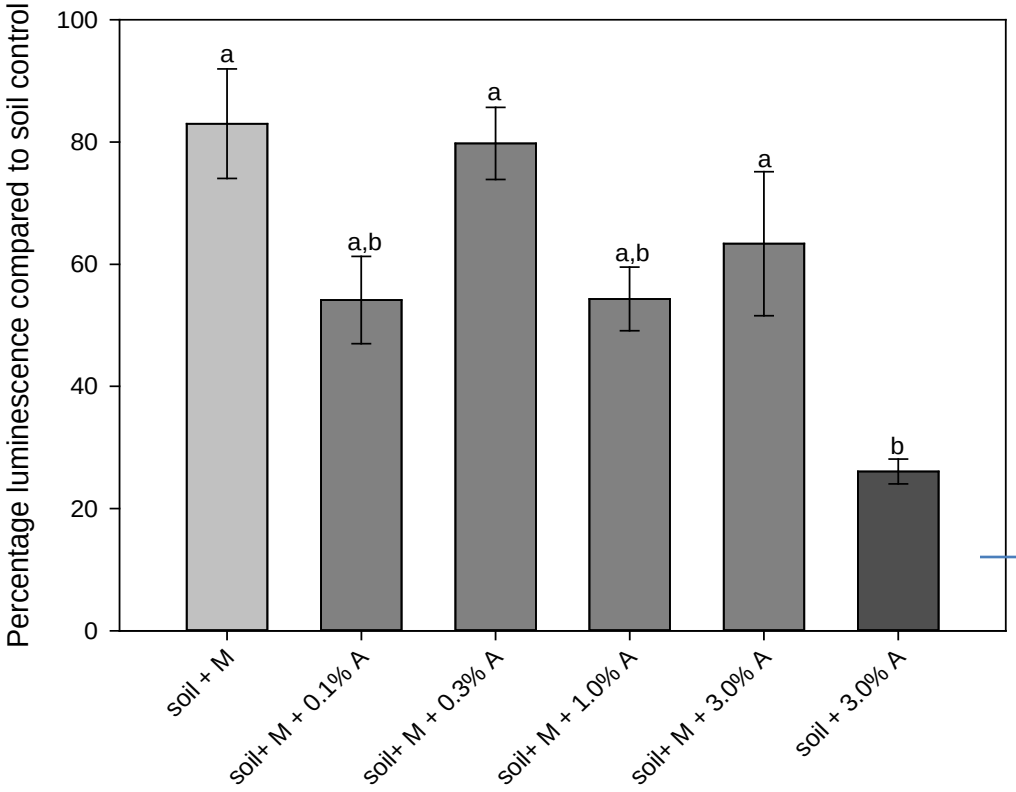
Metal(loid) conc' x biomass

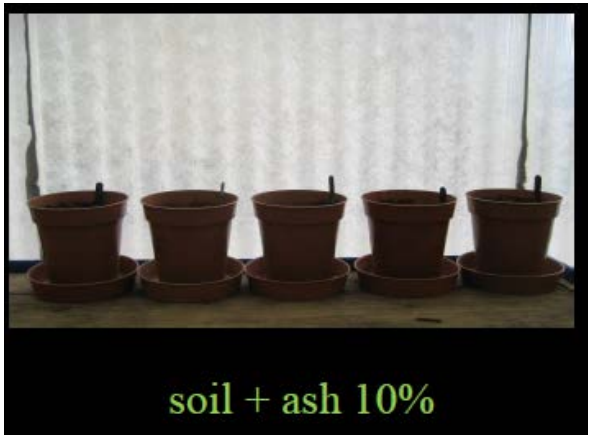

Soil only


Soil + Ash


Soil + Manure + Ash

Results; toxicity assays:





Phyto-toxicity limit

Discussion points:

-Arsenic and Cr were readily water-soluble and could be rapidly leached from soil with metal(loid) bearing ash applied

-Manure co-addition resulted in increased organic matter-bound As and Cu, and reduced uptake of Cu to ryegrass

-Toxicity testing confirmed the beneficial effects of manure at mitigating metal[loid] toxicity from ash in this soil; too much ash is toxic

Conclusions:

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Mollon et al; in-press "…it can be concluded that the application of heavy metal(loid) rich ashes to soils should be avoided unless there is evidential proof that soils and added amendments have the capacity to render metal(loid)s immobile, bio-unavailable and non phyto-toxic"