# MOBILITY AND TOXICITY OF HEAVY METAL(LOID)S ARISING FROM CONTAMINATED WOOD ASH APPLICATION TO A PASTURE GRASSLAND SOIL

**Luke Beesley[1], L. Mollon[2], G.J. Norton[2], L. Trakal[3], E. Moreno-Jimenez[4], R.L. Hough[1]**

*[1]The James Hutton Institute, Aberdeen, UK; [2]University of Aberdeen, Aberdeen, UK; [3]Czech University of Life Sciences, Prague, Czech-Republic; [4]Universdad Autonoma de Madrid, Spain*

*luke.beesley@hutton.ac.uk*

**Keywords:** Heavy metal toxicity, pore water, bioavailability, wood ash, arsenic, chromium

## Introduction

Wood which has been treated with weatherproof protectants, paints and preservatives can contain high amounts of heavy metal(loid)s and, once combusted, the resultant ash can be entrained with those meta(loid)s. One way to dispose of wood ash is by application to land, which has a number of benefits (liming effects, nutrient provision etc) and potential concerns associated (heavy metal(loid) leaching, toxicity etc).
The following study examines the fate of the metal(loid)s Cr, Cu, As and Zn from wood ash generated from mixed source waste wood to determine, when added to soil, the effect on 1) bioavailability of the metal(loids) in soil, and 2) whether co-application with manure could mitigate phyto-toxicity.

## Methods

Soil, ash and manure was obtained from an upland farm located in North-East Scotland (UK). Soil had an organic carbon (OC) content of ~7% and nitrogen (N) contents of ~0.6% (data not shown). Manure was partially humified cattle excreta collected on the farm. Ash was sampled from a 75kw biomass boiler which provides heat for farm buildings, powered by farm-derived mixed waste wood. Total metal(loid) concentrations of ash, measured by aqua-regia digestion, were c. 10000 mg $kg^{-1}$ As, Cr and Cu and c. 5000 mg $kg^{-1}$ Zn (data not shown).

Various volumes of ash (0.1-3%) were mixed into soil with or without manure in replicated pots, where rye grass (*Lolium perenne*) seeds were then sown. Controls without manure or ash were included. A controlled moisture and temperature regime was implemented for 9 weeks whilst soil pore water was collected by rhizon samplers (Eijkelkamp Agrisearch equipment, Netherlands).

After 9 weeks pore water samples were analysed for chemical parameters including metal(loid) concentrations by ICP-MS and a sub-sample subject to a genetically modified luminescent bacteria *Escherichia coli* HB101 pUCD607 for toxicity determination (following Tiensing et al. 2001). Ryegrass was harvested and dry mass was determined before samples were digested and analysed for metal(loids) by ICP-MS.

## Results

Concentrations of As, Cu and Cr were elevated in pore water (up to ~100 fold) and ryegrass tissue (up to approx. ~10 fold) after ash applications compared to soils receiving no ash. Pore water concentrations of As and Cu significantly correlated with ryegrass uptake, indicating that these elements were the most bioavailable of those tested; Cr was predominantly influenced by manure and not ash addition whilst no treatments impacted on Zn.


*This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.*

None of the pore water collected from the soil with manure and the four concentrations of ash differed significantly from the soil and manure treatment in terms of percentage luminescence, however the pore water collected form the pots that contained soil and ash without manure had a significantly lower percentage luminescence compared to the pore water sampled from the soil and manure treatment (figure 1). Thus pre-manuring soils effectively buffered some phyto-toxicity effects by regulating pH regardless of ash application volume (circumneutral).

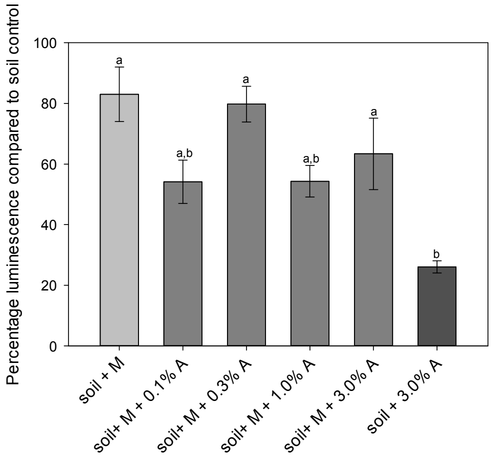


**Figure 1.** Bacterial biosensor toxicity tests of pore water for the different treatments (+M = with manure; + A = with ash). Bar represent the average of the replicates and the bar is the s.e.m (n=5). Means that share the same letter are not significantly different.

## Conclusion

There are potential environmental pollution issues associated with the application of metal(loid) contaminated wood ash to land related with leaching of contaminants out of soil and phyto-toxicity. The particular ash used in this study had high concentrations of As, Cu, Cr and Zn, so the immediate concern is that soil metal loadings will dramatically increase with high or repeat doses of ash application. Pre-manuring soil before adding ash can buffer pH and reduce the solubility of metals in from the alkaline ash, minimizing potential toxicity effects.

## References

Tiensing, T.; Preston, S.; Strachan, N.; Paton, G.I. (2001). Soil solution extraction techniques for microbial ecotoxicity testing: a comparative evaluation. *J. Environ Monit., 27*, 91–96.


*This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.*