Biochar for remediating contaminated soils: Outdoor experiments in Wales, UK

Alayne Street-Perrott
*Swansea University, United Kingdom*

Siôn Brackenbury
*Commons Vision Ltd, United Kingdom*

Iain Robertson
*Swansea University, United Kingdom*

Aoife Ryan
*Swansea University, United Kingdom*

Robert Davison
*Swansea University, United Kingdom*

See next page for additional authors

Follow this and additional works at: [http://dc.engconfintl.org/biochar](http://dc.engconfintl.org/biochar)

Part of the Engineering Commons

Recommended Citation
Authors
Alayne Street-Perrott, Siôn Brackenbury, Iain Robertson, Aoife Ryan, Robert Davison, and Heather De-Quincey

This abstract and presentation is available at ECI Digital Archives: http://dc.engconfintl.org/biochar/47
BIOCHAR FOR REMEDIATING CONTAMINATED SOILS: OUTDOOR EXPERIMENTS IN WALES, UK

Alayne Street-Perrott, Swansea University
f.a.street-perrott@swansea.ac.uk
Siôn Brackenbury, Commons Vision Ltd
Iain Robertson, Swansea University
Aoife Ryan, Swansea University
Robert Davison, Swansea University
Heather De-Quincey, Swansea University
South Wales: a problem environment

- ≤ 1000m elevation
- ≤ 2500mm rainfall
- Acid rain (high H\(^+\) flux)
- Shallow, poor soils (mainly acid)
- Long industrial history (coal mining, steel, non-ferrous metals)
- Swansea: “Copperopolis”
- Highest background levels of heavy metals in UK soils
- Invasive plants: Japanese knotweed, *Rhododendron ponticum*
Outline

• **Collaboration** with commercial producer of sustainable, accredited biochars (Commons Vision Ltd, Swansea)

• **Experiments** on biochar applications for revegetating damaged and/or contaminated land

• **Case studies:**
  – Colliery waste: Cwm Dulais, Swansea, South Wales
  – Soils damaged by invasive rhododendron (ditto)
  – Metal-mine tailings: Frongoch Pb/Zn mine, mid-Wales

• **Future plans:** scaling up!
Commons Vision’s mobile, pilot-scale, fast pyrolysis-gasification unit

- **Originally designed** by Black is Green Pty, Australia for remote rural sites – no bio-oil or aqueous fractions produced
- **Adapted** for use in Welsh climate (!)
- **Top-fed, upright, rotary kiln**, optimized for biochar (~30s residence time; 500-750°C; 64-86%C; O:C 0.03-0.32; BET(N₂) 1 - 455m²/g)
- **Hot biochar** augered out from base and quenched with water or mineral amendments
- **Syngas and particulates combusted** at 800-1100°C in thermal oxidiser (low emissions)
- **High-grade chars** made from local coniferous woodchip accredited by BBF and Welsh Government for application to soils

More data on posters and in Phil Harries’s PhD thesis (2017)
Colliery waste, Cwm Dulais, north side

Graig Merthyr colliery, 1973

Today
Environmental problems, Cwm Dulais colliery waste

- High annual rainfall (~1200mm)
- Low overall species diversity
- Natural regeneration very slow
- pH 4.5 – 7.7
- Low organic-matter content
- Cu, As contamination of spoil
- PAHs also present
- Cementation and compaction
- Surface runoff and gullying
Different application rates of rhododendron biochar and bracken compost
Colliery waste - pot trial results

**Best growth:** 5% v/v biochar and 25% v/v compost

**Worst growth:** spoil only (control)
Field plots – amended and unamended biochars

Best growth:
10% v/v biochar
25% v/v bracken compost

Worst growth:
Control (coal spoil only)
Key findings on colliery waste:

• Biochar compost significantly increased grass height and biomass in both trials

• In pot trial, biochar compost reduced heavy-metal concentrations in grass, notably Cu, compared with control pots. This may reflect dilution by increased organic-matter production, since total uptake per pot did not change

• In pot trial, biochar compost increased infiltration, and reduced cementation and compaction

• In plot trial, biochar compost increased grass palatability to grazers, which may be attributable to increased water-soluble carbohydrates
Invasive rhododendron: Cwm Dulais S side

46ha of mature invasive rhododendron
Invasive rhododendron ravages soils

- ≥ 53,000ha in UK
- **Shades** out native vegetation
- **Acidifies soil** to ~pH3.5 – 4.2, eliminating soil mixing by earthworms
- **Destroys** native seedbank
- **Poisons soil** with allelopathic compounds, e.g. grayanotoxins
- Roots support specialized **ericoid mycorrhizal fungi** that efficiently capture nutrients
- **Accumulates heavy metals** (notably Pb) and As, especially in wood. These are released by burning cleared biomass
- Acts as a **host for Japanese Larch Disease** (*Phytophthora ramorum*)
- **Cleared areas** only support mosses and a few native plants, e.g. *Digitalis*
Rhododendron pot trial

- **4 different soils:** control (grassland), dense rhododendron, cleared rhododendron, burnt rhododendron
- **No seed (left) or added acid-grassland seed mix (right)**
- **No added compost**
- **5 treatments:**
  - Untreated control or
  - 5%v/v unamended biochar or
  - 5%v/v biochar plus 3 alternative amendments (mycorrhizal inoculant, biomass ash or cockleshell)

**Results:** 5%v/v rhododendron biochar with added mineral nutrients performed best
Rhododendron hydroseeding trial
HydraCX™ plus 0.25t/ha amended biochar
Results of the hydroseeding trial:

- All control plots performed poorly (<0.5g/m² grass dry weight)
- Native seedbank and earthworms are eliminated by rhododendron invasion: seeding is essential
- HydraCX™ with amended conifer-wood biochar was most successful treatment: greatest stem height, coverage and above-ground biomass
- Earthworms were most abundant in HydraCX™ with amended biochar and HydraCX™-only treatments
Frongoch Pb/Zn mine, Ceredigion

Frongoch after £1.15M EU-funded hard-engineering remediation project!
Pot trial with PAS100 greenwaste/foodwaste compost plus amended conifer biochar

See poster!
Adding excessive mineral amendments (here, cockleshell) to biochar reduces grass biodiversity.
General conclusions:

• Amended biochars produced better results than unamended biochars in almost every case

• Optimum application rate 5% v/v (but expensive!) Benefits still present at 2.0% v/v in pot trials

• Organic-matter addition essential where soil organic content is low.

• Hydroseeding is the most cost-effective/efficient application method, adding amended biochar and selected seeds to commercial hydroseeding products
Where next? Biochar for land remediation
Acknowledgements

Thank you for your attention. Questions?