

8-20-2014

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>

 Part of the [Engineering Commons](#)

Recommended Citation

Alayne Street-Perrott, Siôn Brackenbury, Iain Robertson, Aoife Ryan, Robert Davison, and Heather De-Quincey, "Biochar for remediating contaminated soils: Outdoor experiments in Wales, UK" in "Biochar: Production, Characterization and Applications", Franco Berruti, Western University, London, Ontario, Canada Raffaella Ocone, Heriot-Watt University, Edinburgh, UK Ondrej Masek, University of Edinburgh, Edinburgh, UK Eds, ECI Symposium Series, (2017). <http://dc.engconfintl.org/biochar/47>

This Abstract and Presentation is brought to you for free and open access by the Proceedings at ECI Digital Archives. It has been accepted for inclusion in Biochar: Production, Characterization and Applications by an authorized administrator of ECI Digital Archives. For more information, please contact franco@bepress.com.

Authors

Alayne Street-Perrott, Si n Brackenbury, Iain Robertson, Aoife Ryan, Robert Davison, and Heather De-Quincey

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

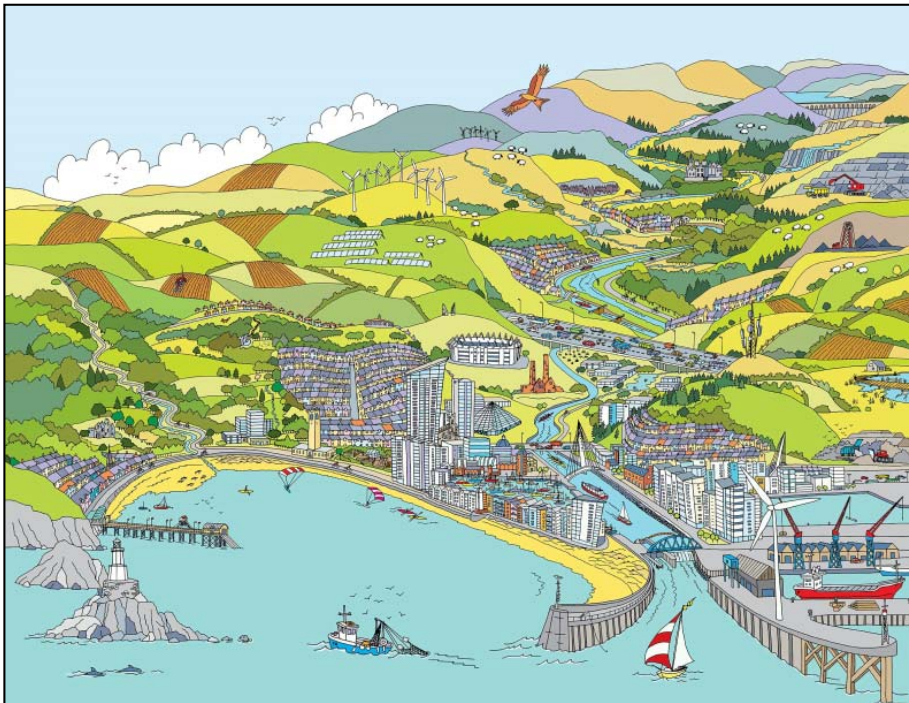
Aoife Ryan, Swansea University

Robert Davison, Swansea University

Heather De-Quincey, Swansea University



South Wales: a problem environment



- $\leq 1000\text{m}$ elevation
- $\leq 2500\text{mm}$ 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



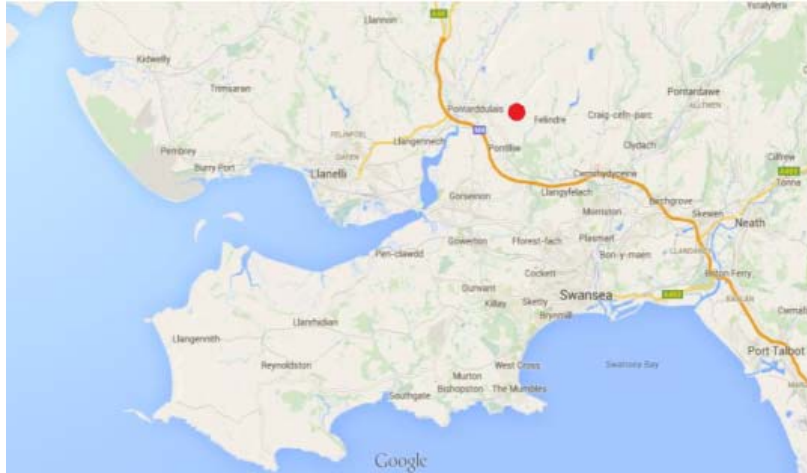
More data on posters and in Phil Harries's PhD thesis (2017)



- **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



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

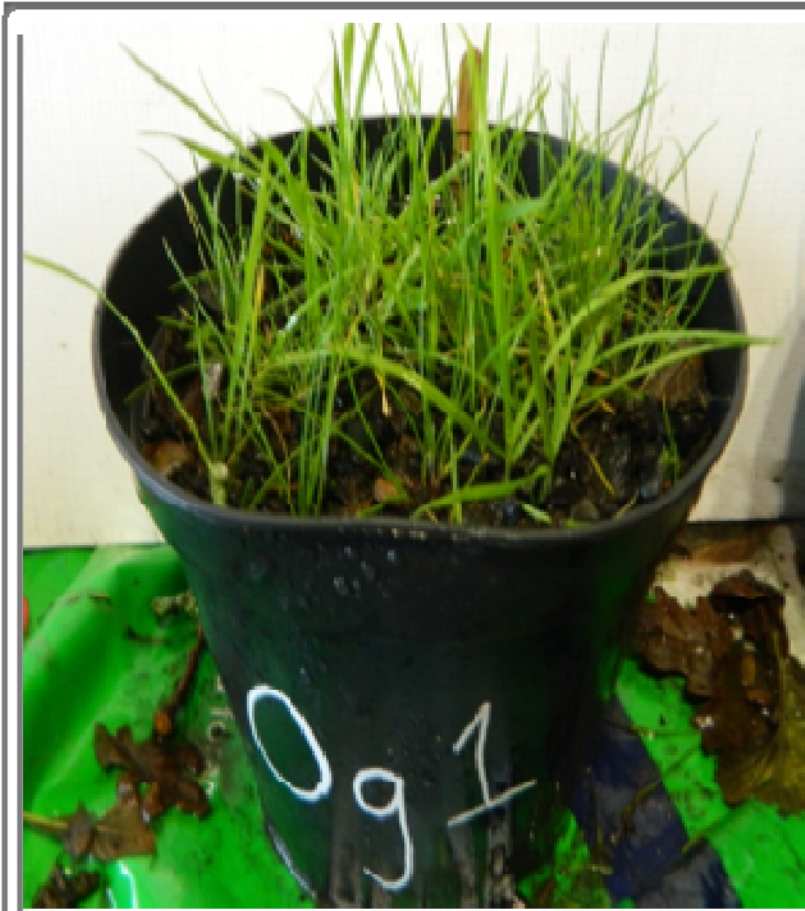


Colliery waste - outdoor pot trial



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

- $\geq 53,000$ ha in UK
- **Shades** out native vegetation
- **Acidifies soil** to \sim 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*



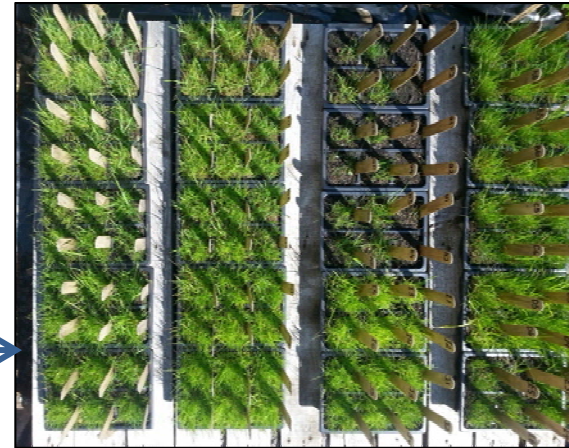
Rhododendron pot trial



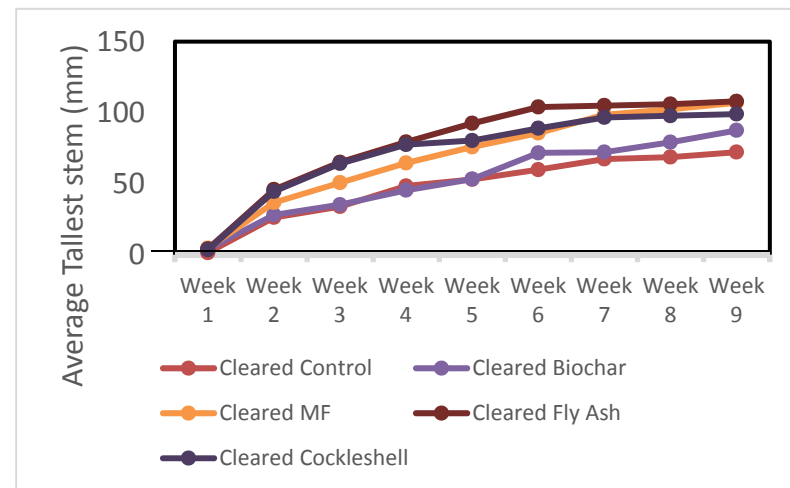
Week 6

← No seed

With seed →



- **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



Map data ©2016 Google Imagery



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

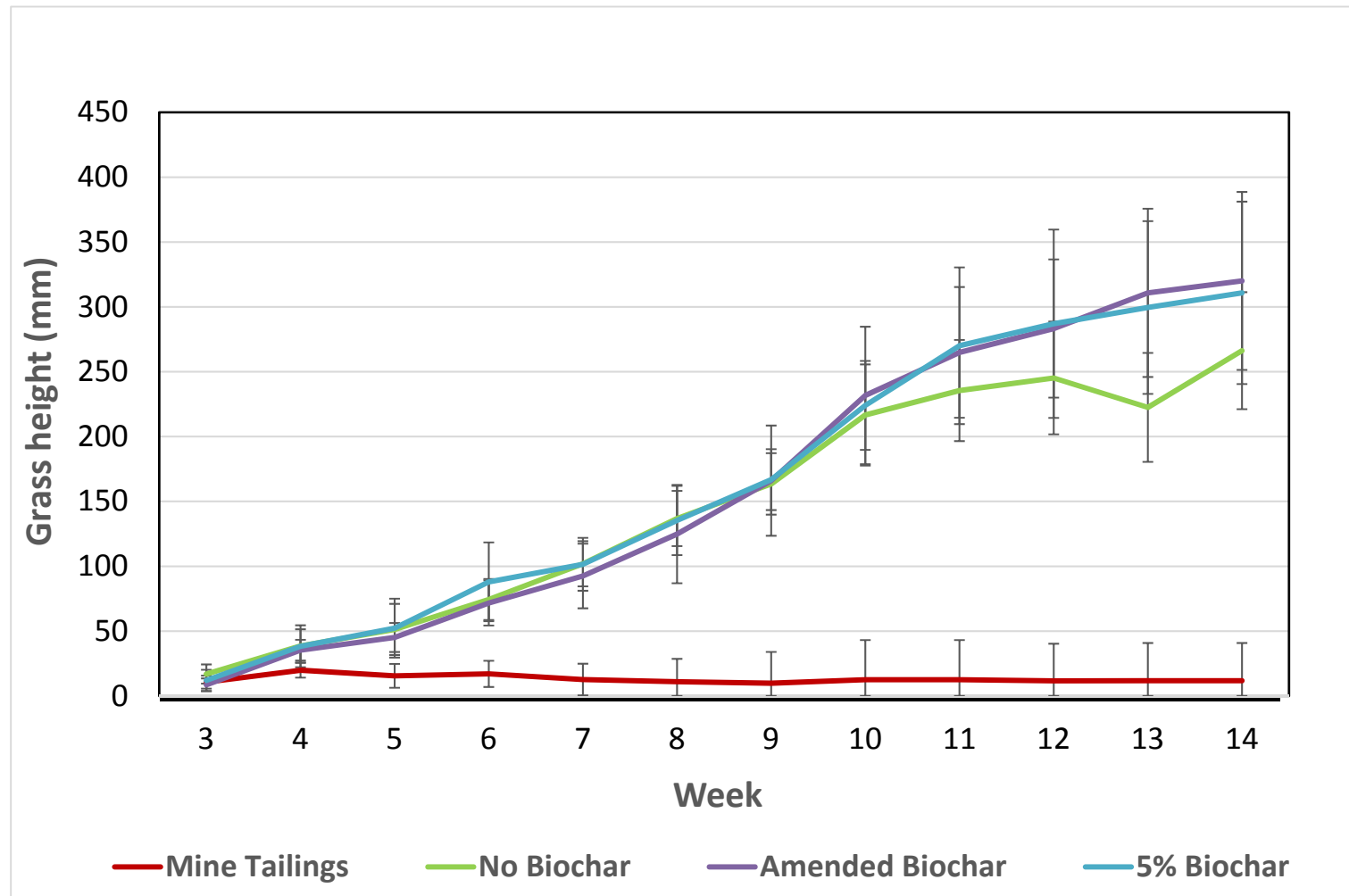
Frongoch Pb/Zn mine, Ceredigion



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

WEEK 14



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?**



ATKINS



Salix

