CERESiS Final Event
CERTH, Thessaloniki 23/2/24
Project outcomes:
Phytoremediation

CERESiS

ContaminatEd land Remediation through Energy crops for Soil improvement to liquid biofuel Strategies

CERESiS WP2 partners:

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(*now at Net Zero Industry Innovation Centre, Teesside University)

NET ZERO INDUSTRY INNOVATION CENTRE

Teesside University

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CERESiS WP2 & phytoremediation strategy

Plant perennial grasses for phyto-stabilisation to:

- Maximise biomass yield (maximize energy production + income)
- Minimize contaminant uptake (minimise downstream issues)
- Maximise contaminant offtake (phyto-management during beneficial use of contaminated sites)

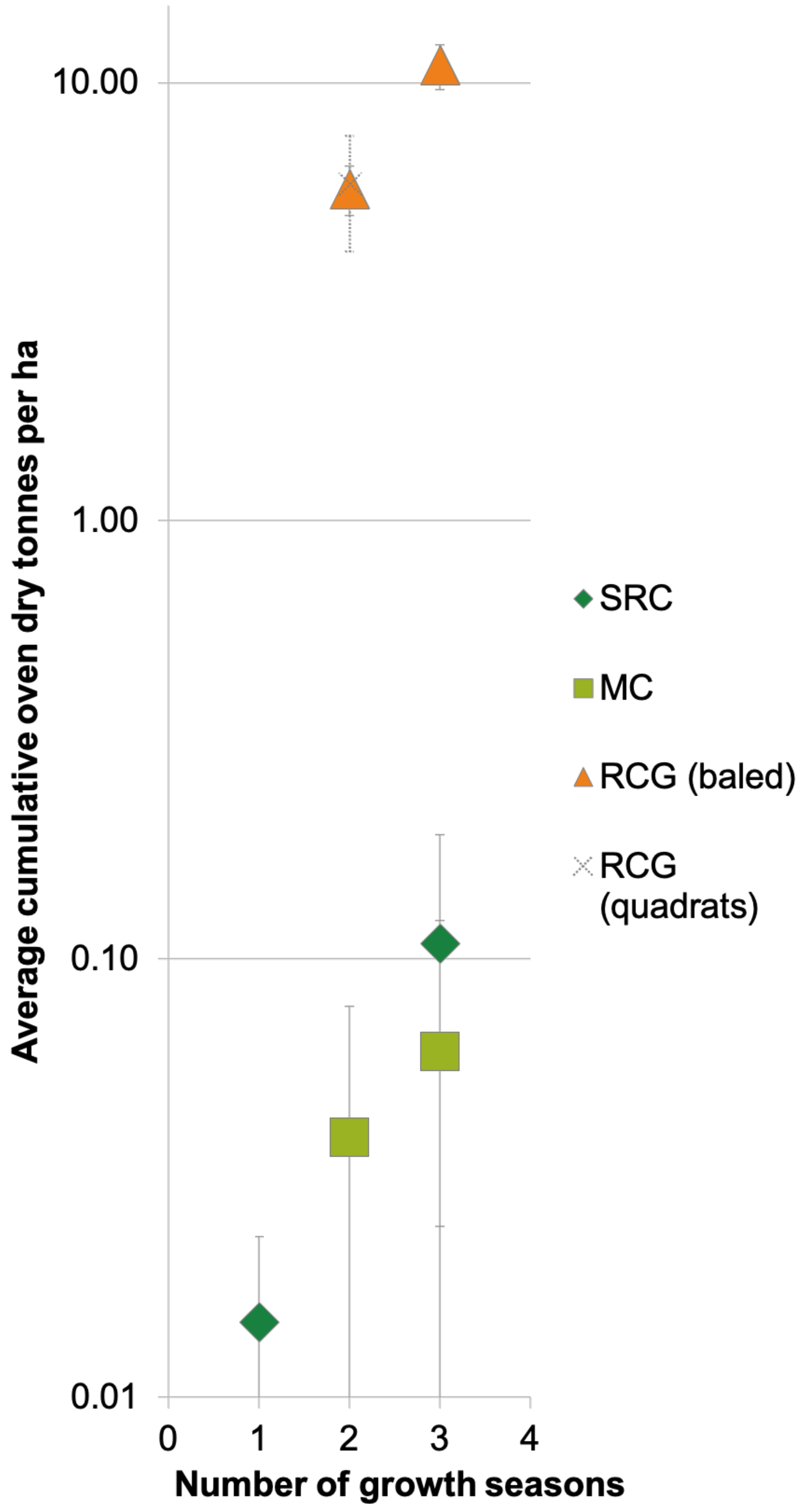
WP2 Energy crops & phytoremediation: Field trials (UK, IT, UKR BR)

Contaminated biomass

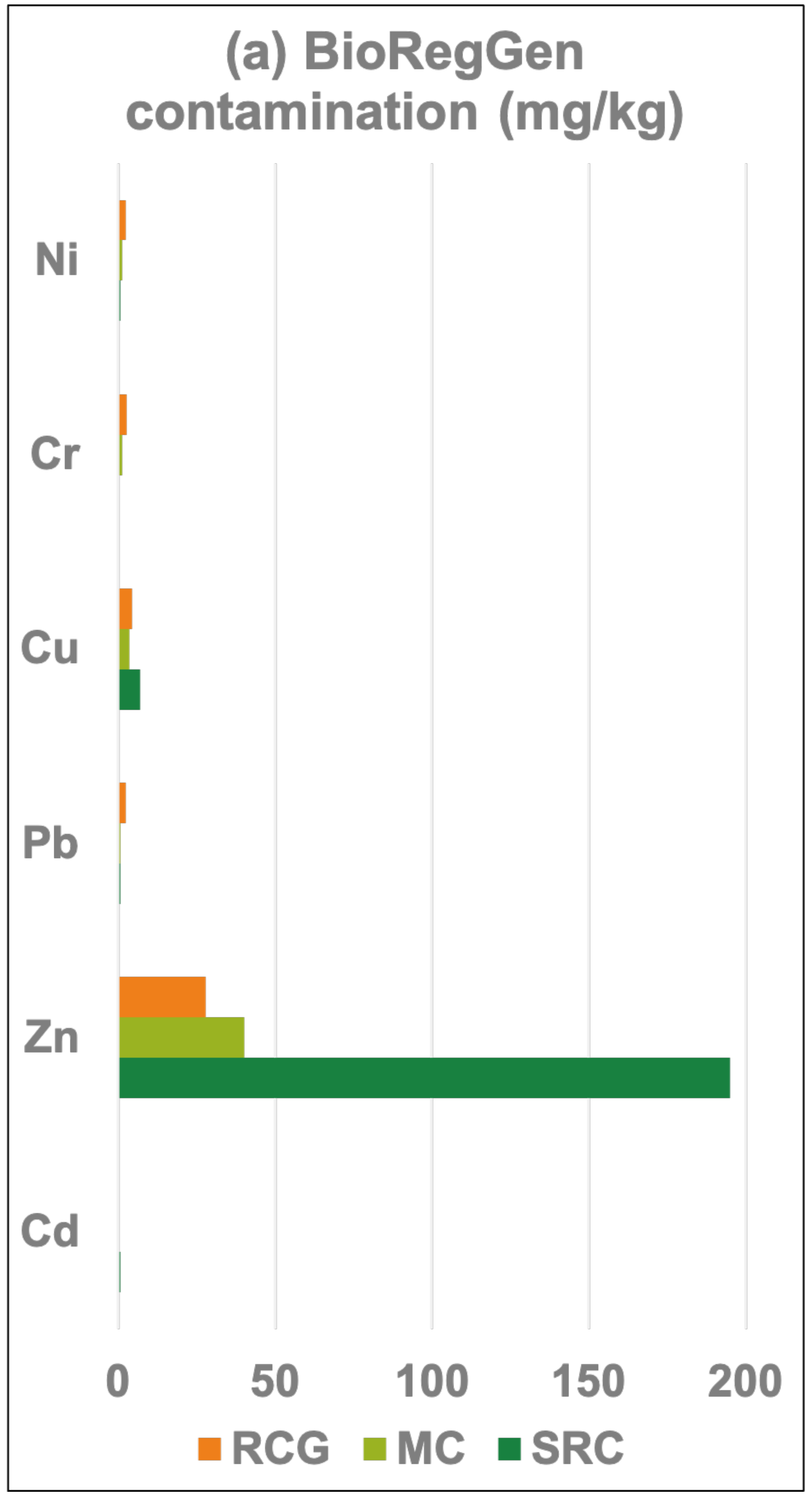
WP3 Technological: Fast pyrolysis, super-critical water gasification, clean-up & FT conversion

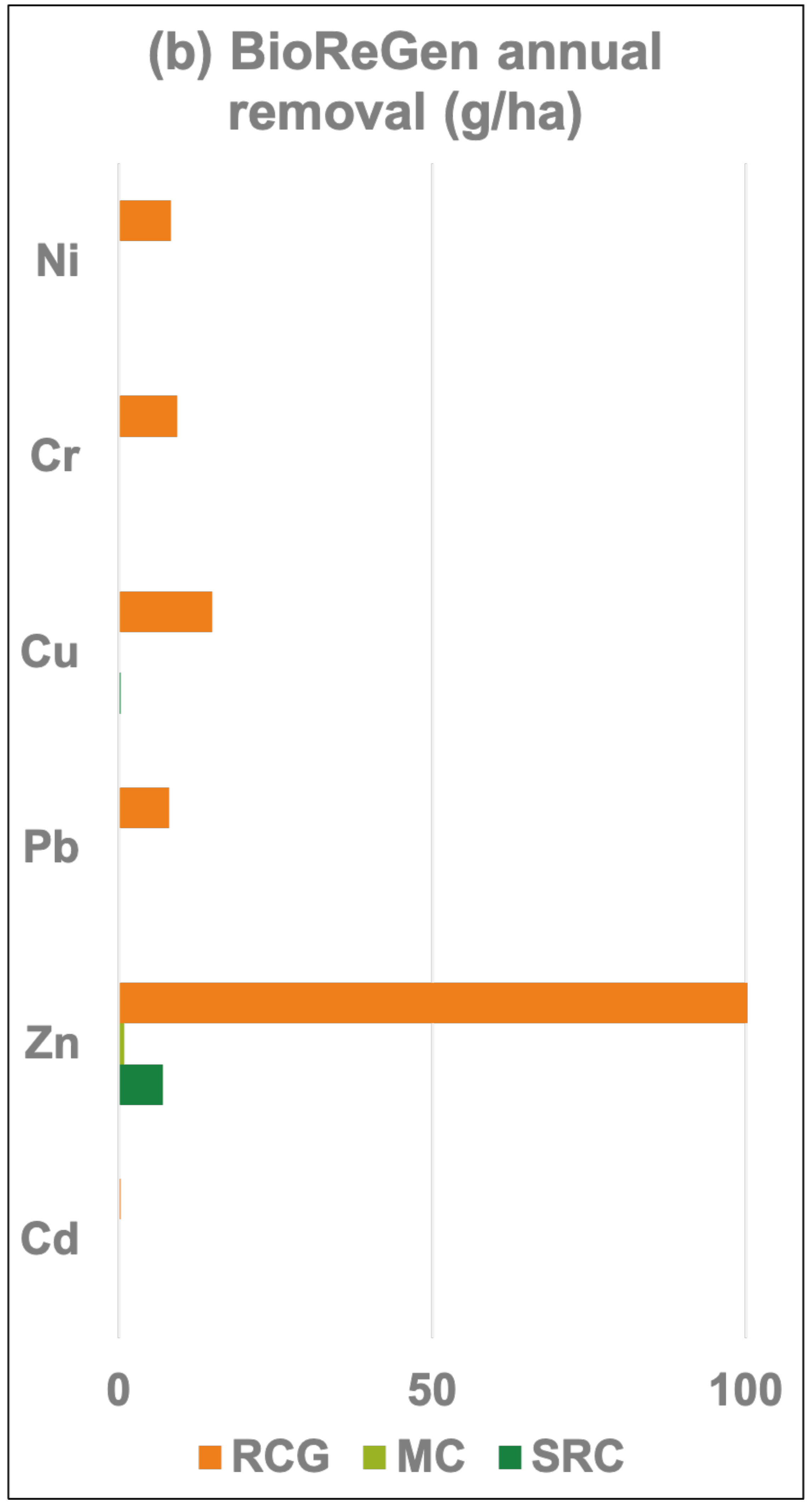
Decision support system

Finding the energy v. phytoremediation sweet spot?



Lord (2015) *Biomass & Bioenergy* 78, 110-25





Win, win win?

- ✓ Maximum energy (economic value)
- ✓ Minimum contamination (economic penalty)
- ✓ Plus phyto-management non-market benefits (environmental & social benefits, ecosystem services)

RCG: *Phalaris arundinacea*
MC: *Miscanthus giganteus*
SRC: *Salix* spp.

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CERESiS trial sites

University of Strathclyde Glasgow

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WP2: Energy & crop species

Phalaris arundinacea (reed canarygrass) - UK, IT, UKR

Miscanthus x giganteous - UK, UKR

Salix spp. (willow short-rotation coppice) - UK

Arundo donax (giant reed) – IT (ERSAF)

Panicum virgatum (switchgrass) – IT (ERSAF)

Corylus spp. (hazel prunings) - IT

Vitis spp. (vine prunings) - IT

Saccharum spp. (sugar cane & energy cane) - BR

Pennisetum purpureum Schum (Napier grass) - BR

P. purpureum cv. BRS Capiaçu (Capiaçu grass) - BR

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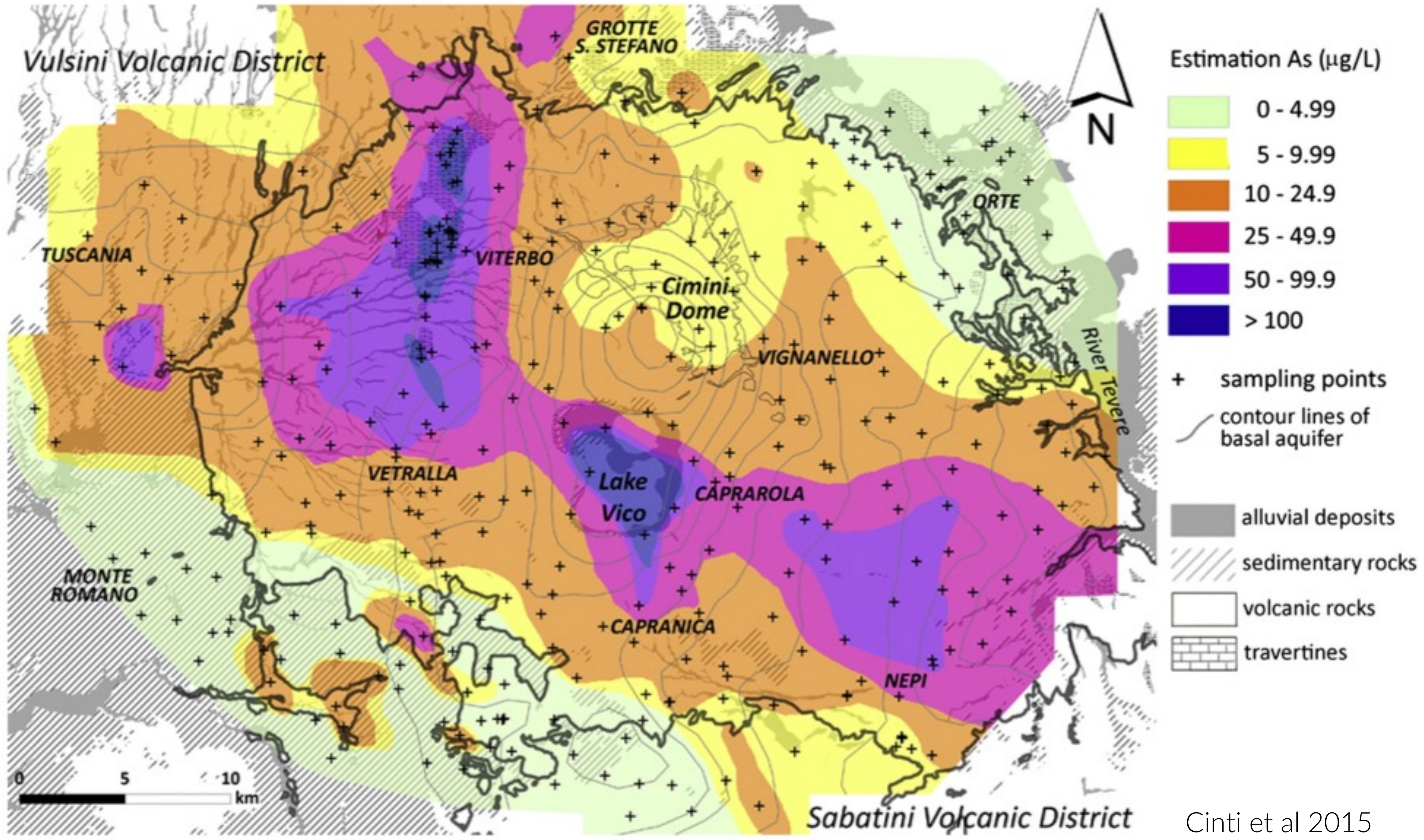
IT trial sites - geogenic As, Se (Be, V, Co, Tl, Pb)

As (mg/kg)	Soil	RCG
Experimental area	39	35
Biomass area 1	100	34
Biomass area 2	126	37



Cinti et al 2015

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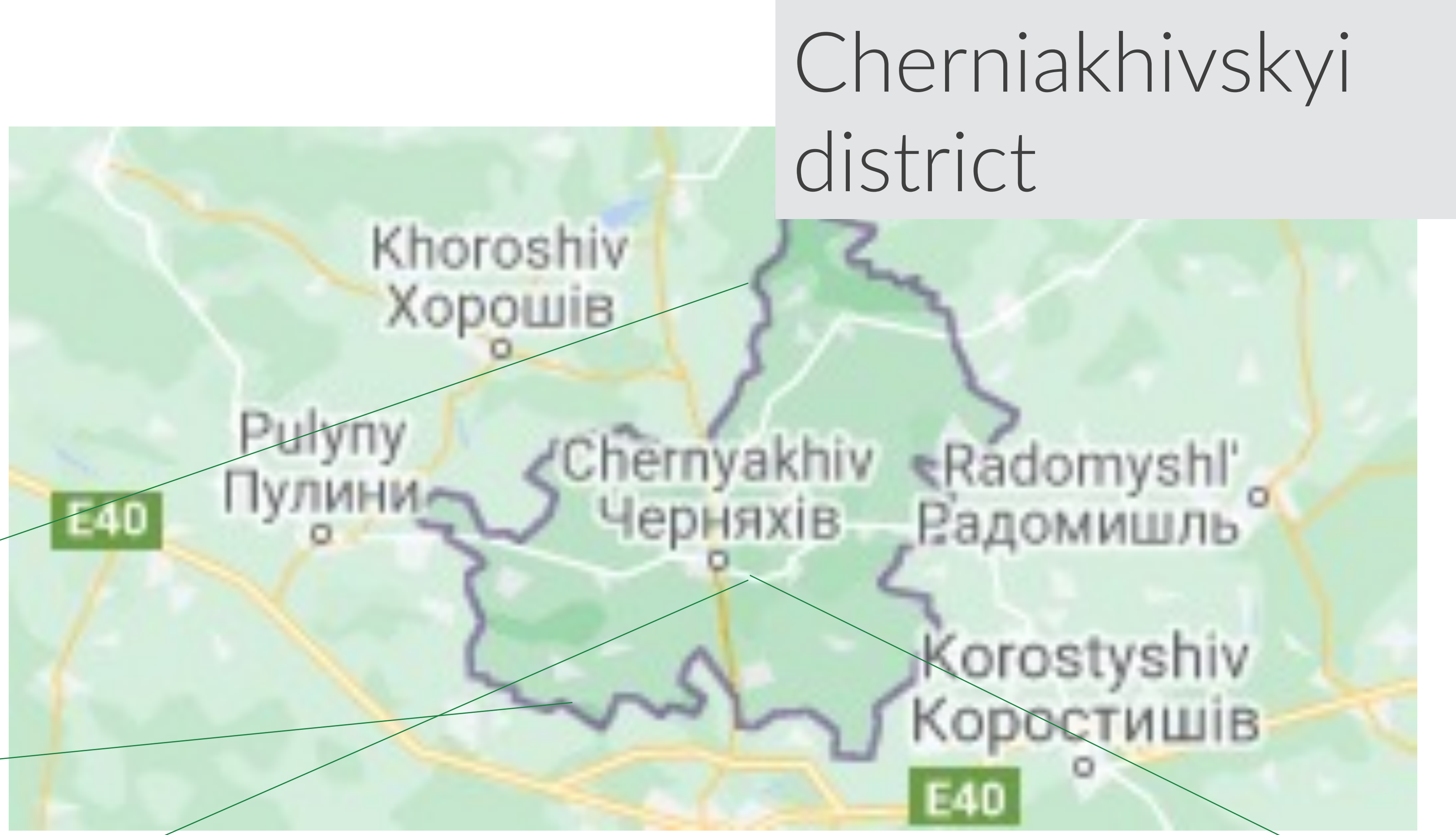
Ukrainian trial site – agri pesticides/fuel



Fuel & organic pesticide spill: Petroleum products 690-2089 $mg.kg^{-1}$

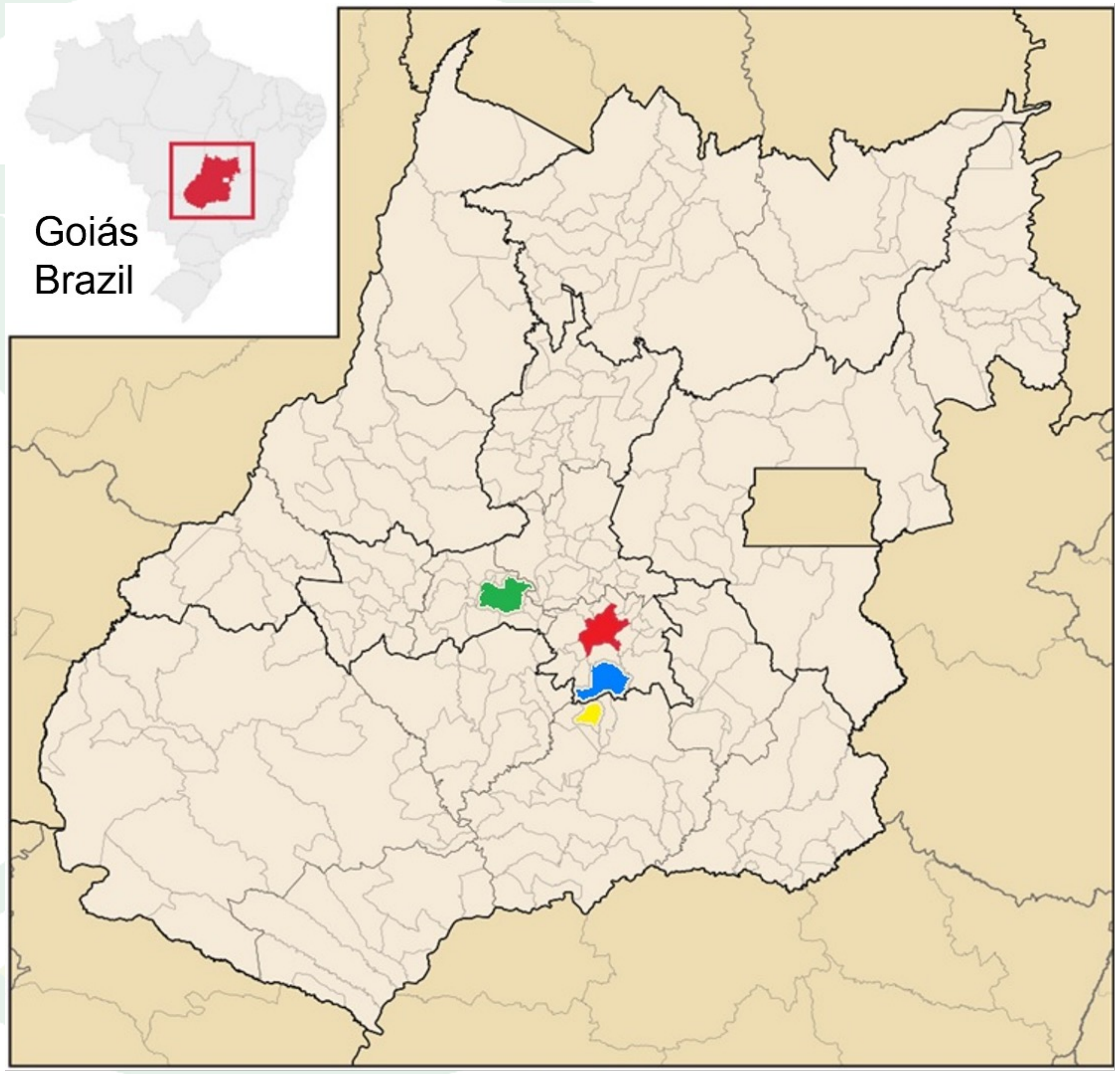
HCH isomers 0.245-0.280 $mg.kg^{-1}$,

161-172 $mg.kg^{-1}$ Sb (Sn, Cr, Co, Cd)

Phalaris 179-188 $\mu g.kg^{-1}$ Sb

Miscanthus 195-214 $\mu g.kg^{-1}$ Sb

Brazilian trial sites – Cr (Ni), agri & mining



BR1 | BR2 | BR4 | BR3

Cr^T 690 mg.kg^{-}

Explosives & Mines:
Cr^T 2000-3000 mg.kg^{-1}
Ni 1400-1900 mg.kg^{-1}

Brazilian field trial results (Field site BR1)




BR1	Cr Soil - T1	Cr Biomass - T1	Biomass Produtivity	Cr Extracted
Trat	mg/Kg	mg/Kg	t/ha	g/ha
Energy Cane	1935,3	19,9	3,2	64,2
Sugar Cane	911,7	26,4	1,3	33,6
Elephant Grass	995,0	27,3	11,3	307,5
Capiaçu Grass	1310,7	25,4	13,6	344,0
Weed	1078,3	22,0	4,0	88,0

So contaminant offtake is controlled by biomass yield?

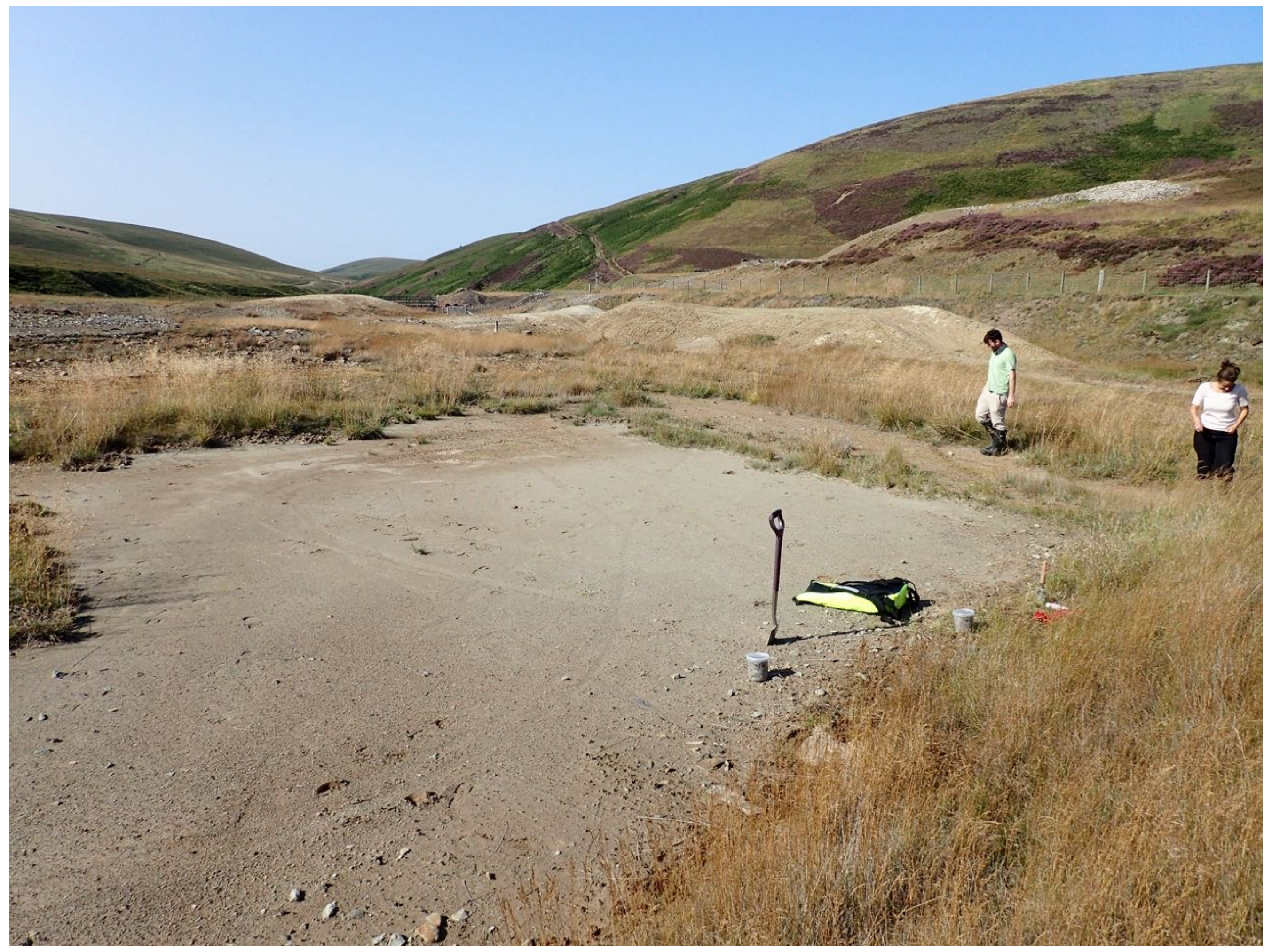
Energy-driven!

"Elephant grass" a.k.a. Uganda grass or Napier grass (*Pennisetum purpureum*)

UK trial sites: Pb-Zn mines

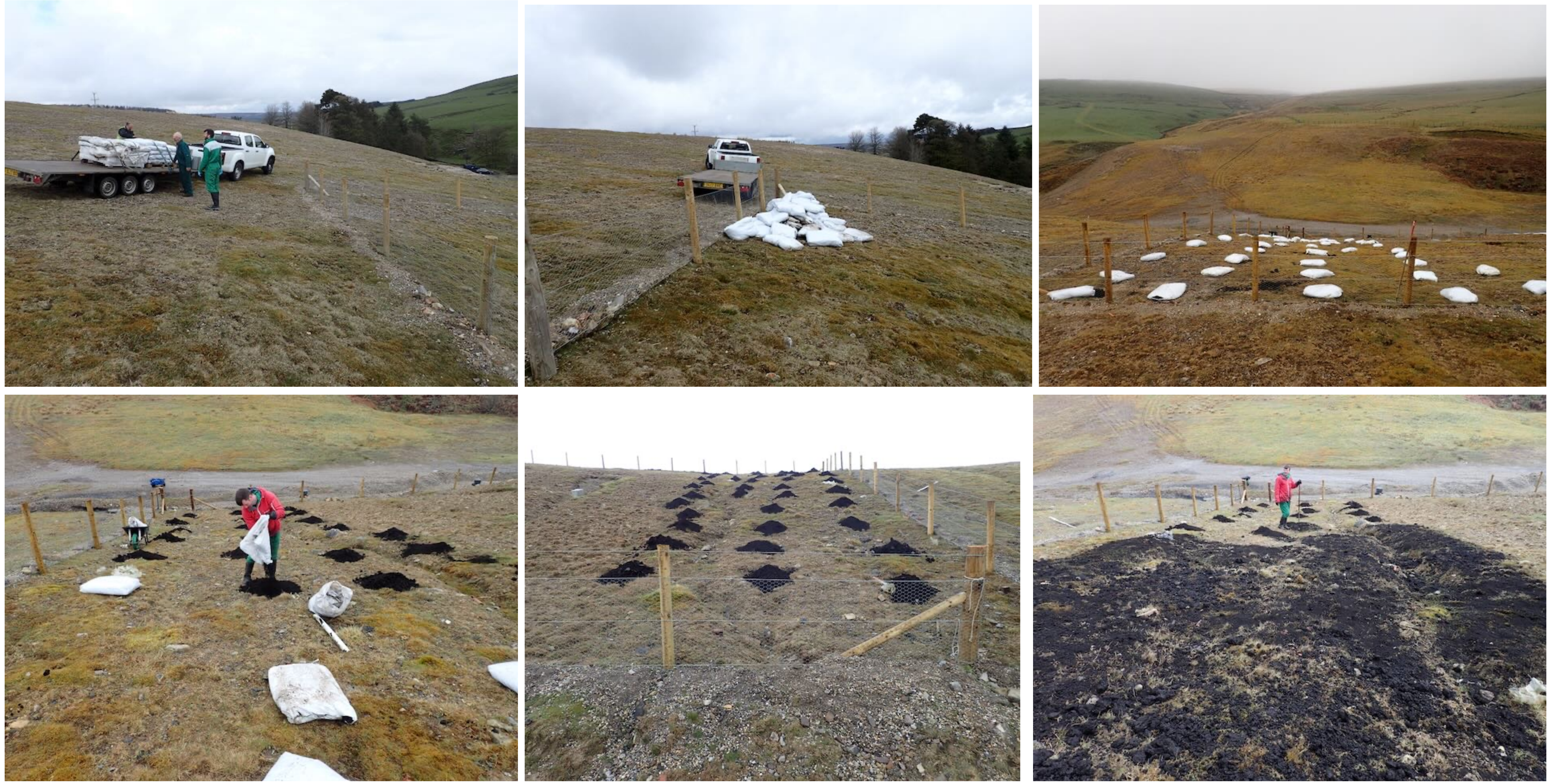
UK#1(3): Pb 1.4%, Zn 0.2 % (Cu, Cd)

UK#1(5) Pb 0.9 %, Zn 0.5% (Cu, Cd)



UK#2 Pb 8-9%, Zn 0.7-5 % (Cd, Cu, Hg)

Compost blankets (no-till planting) to reduce dispersion…



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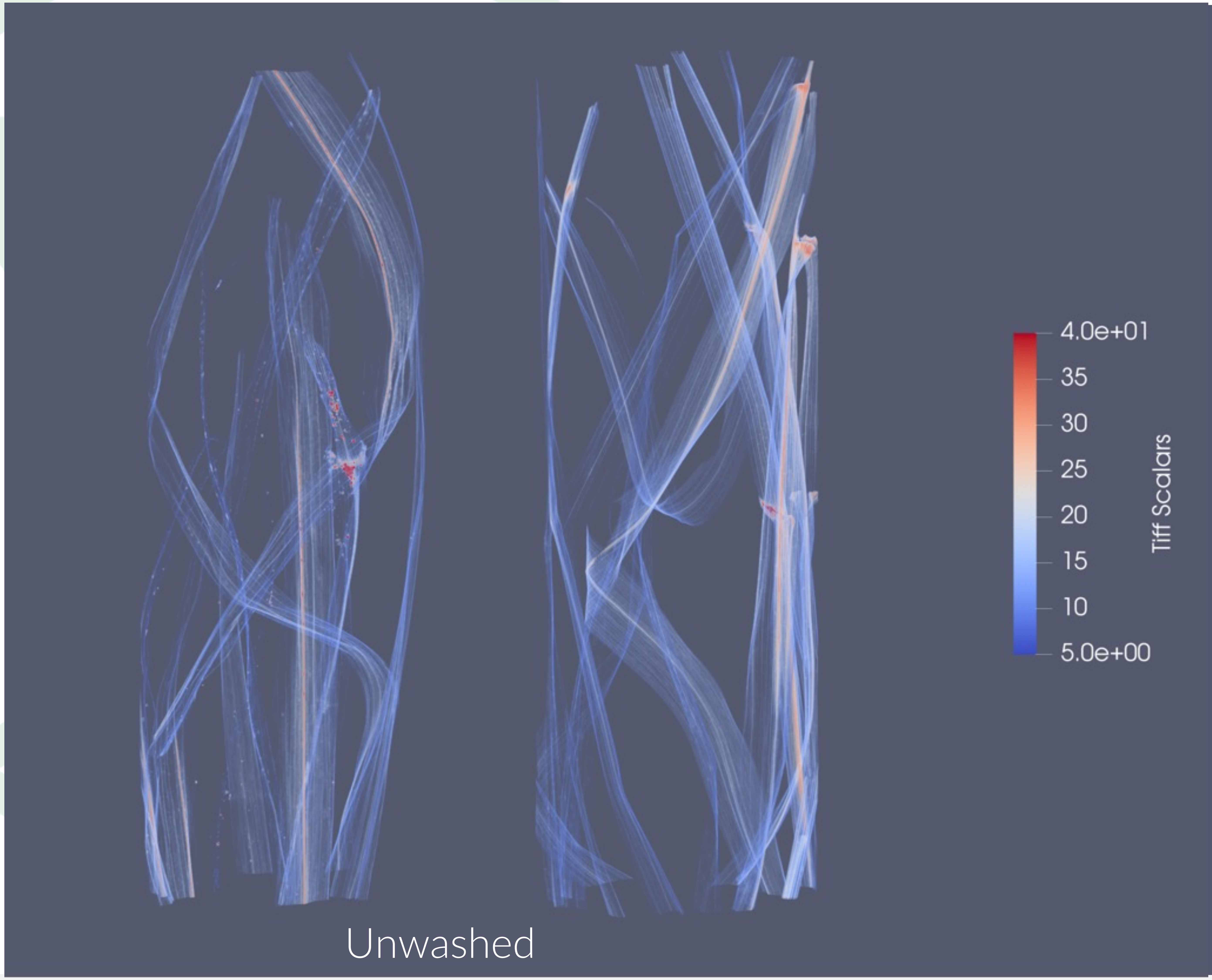
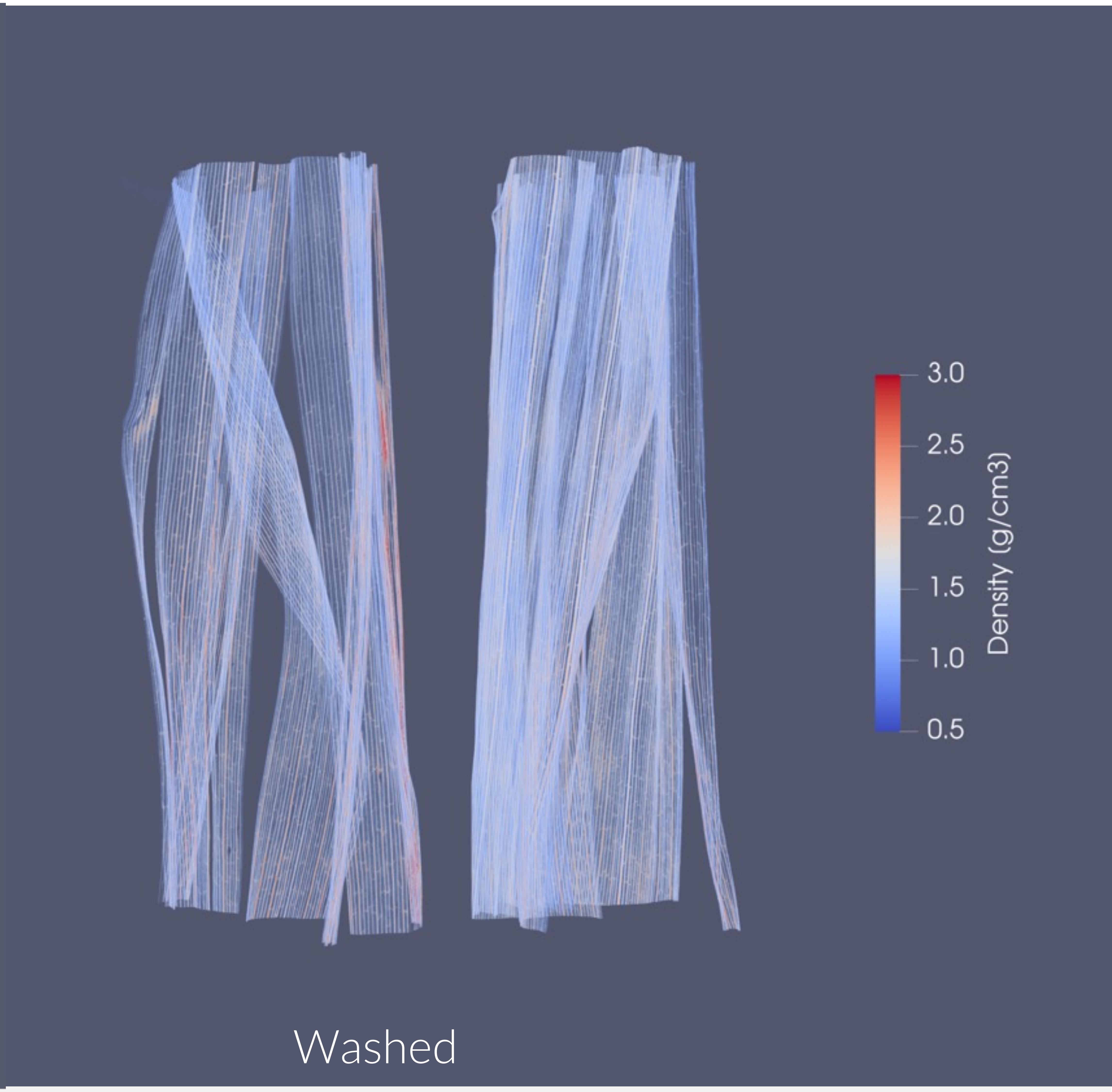
UK trial site #1(3): initial results

- Successful establishment (on challenging site)
- Mechanical stabilisation by root network
- Variable PTE concentrations in washed biomass (different amendments*)
- Visible soil dust cross-contamination during sampling!

*from B. Nunn (2022) PhD thesis, Nunn et al. (2023) J. Env. Man. 345, 118809

X-ray computed tomography showing $PbCO_3$ surficial contamination on *Phalaris arundinacea*





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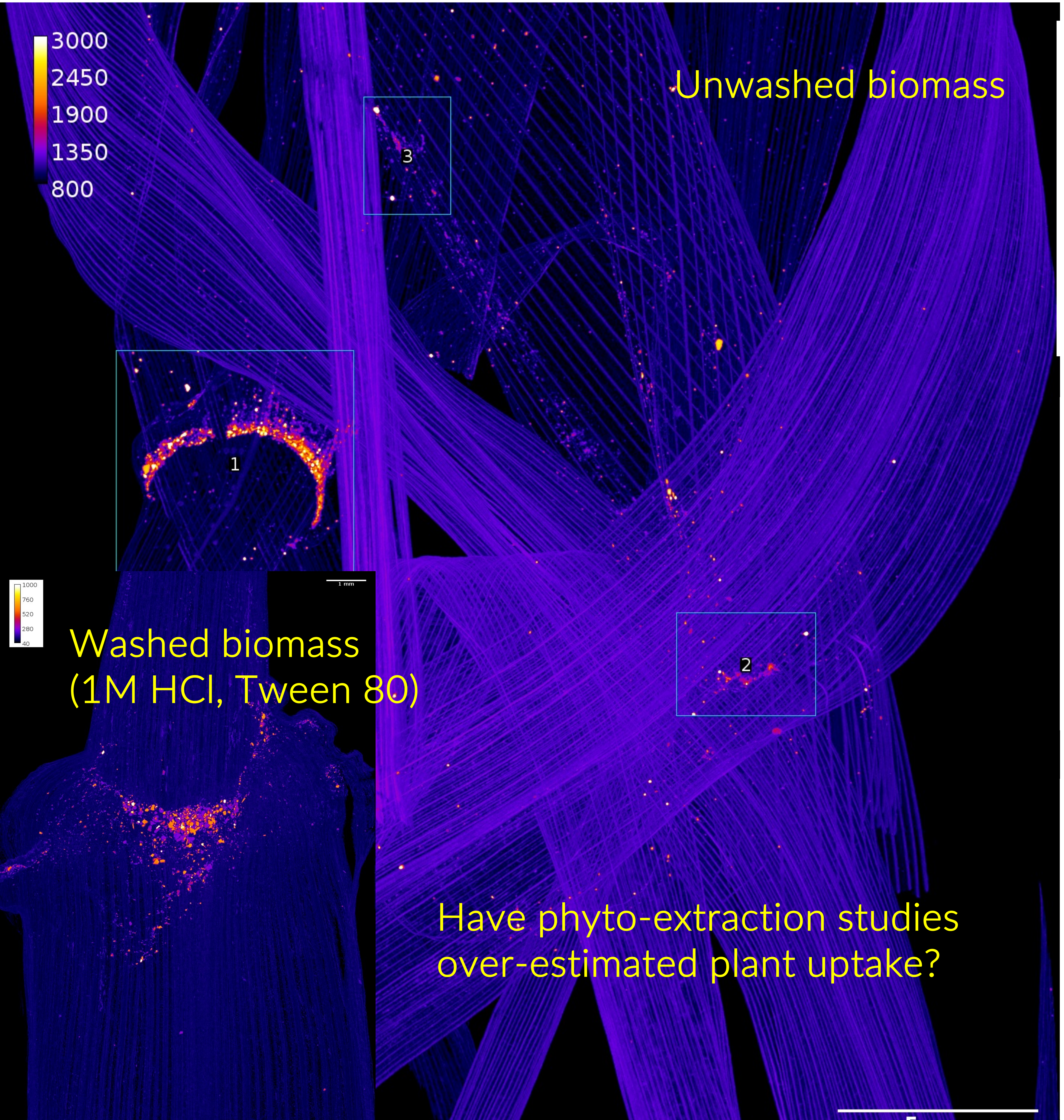
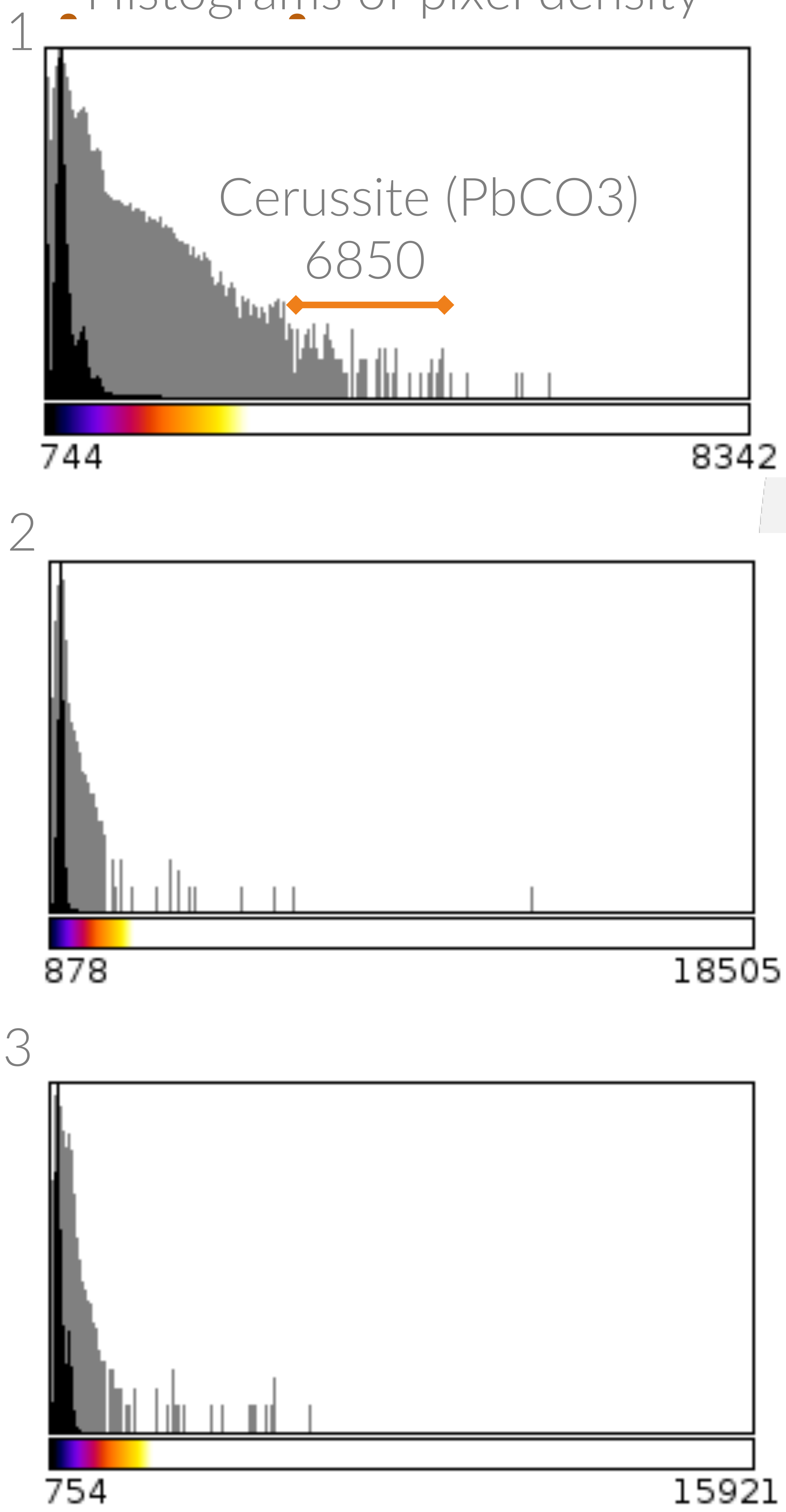


Histograms of pixel density



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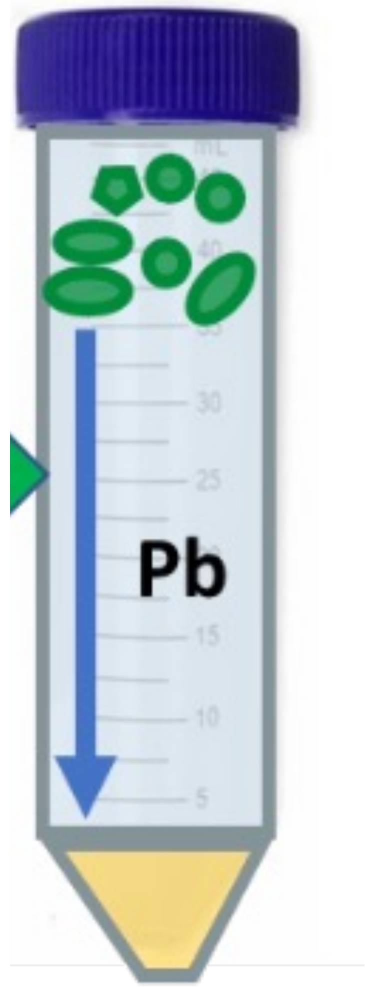
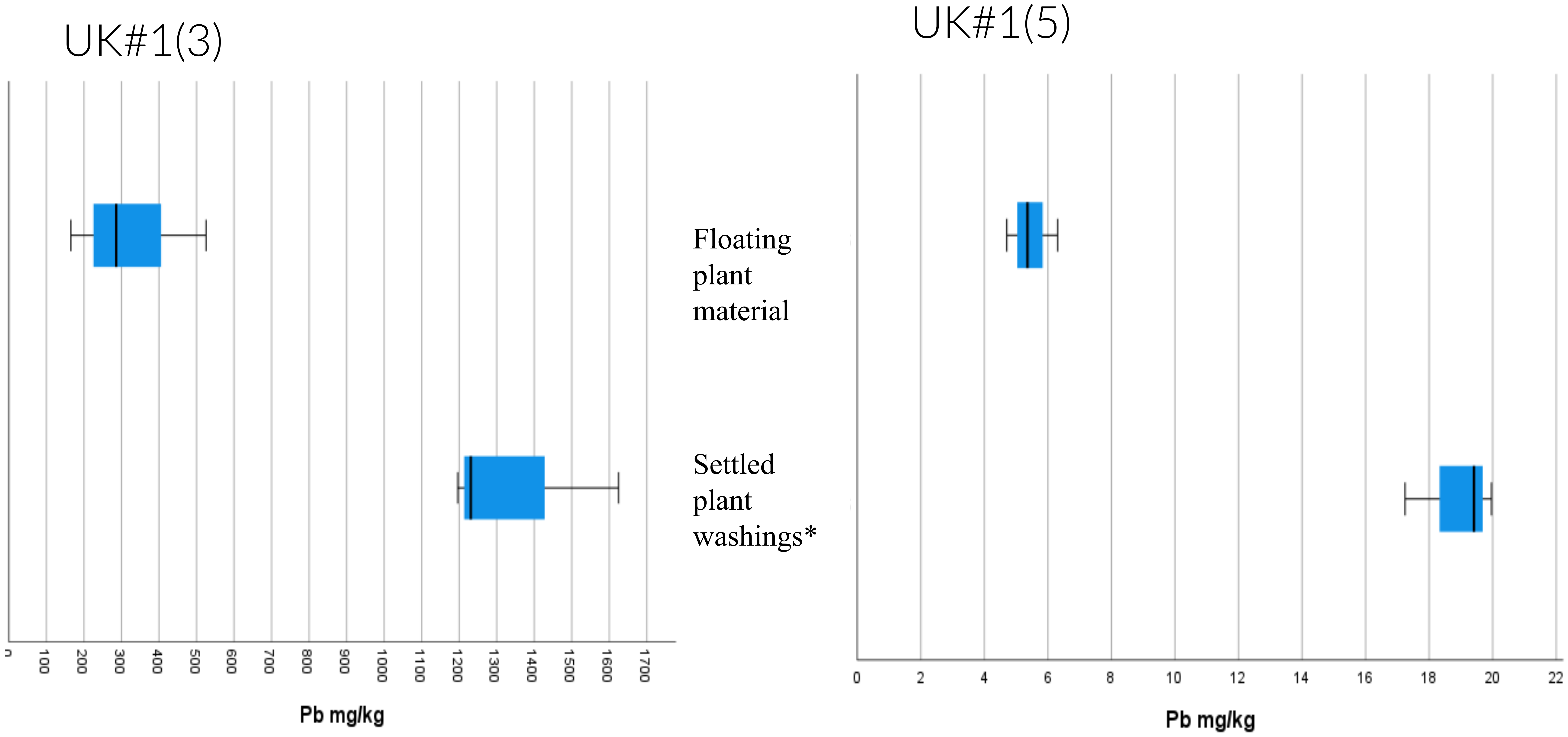
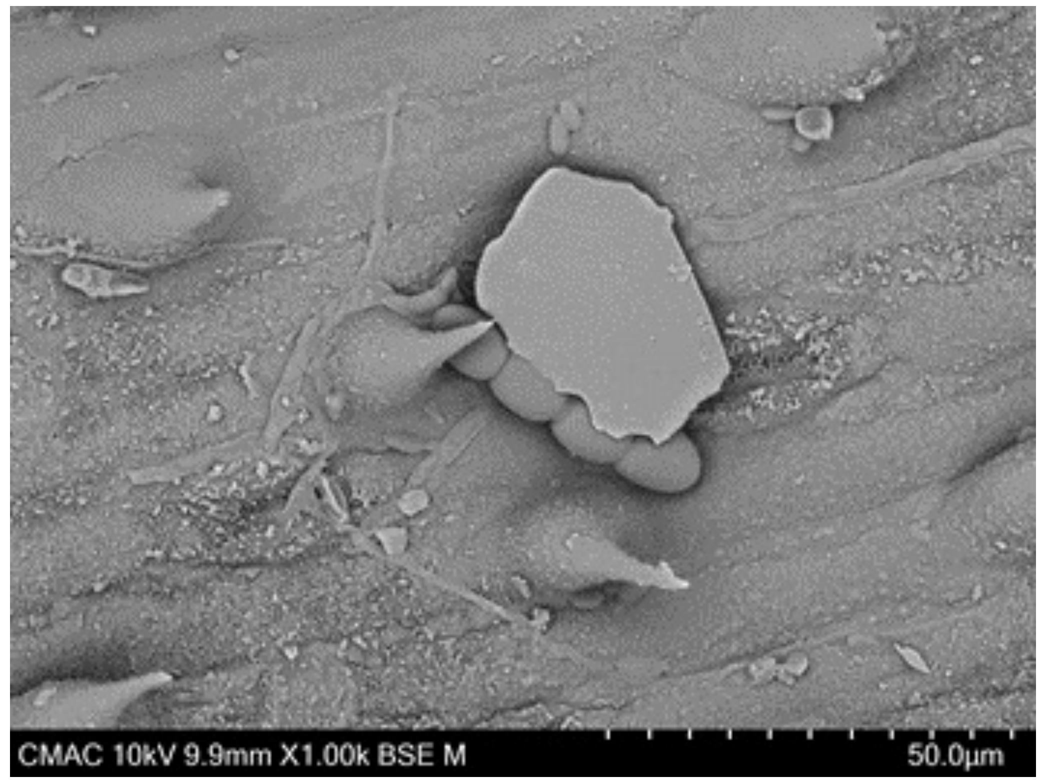
Contaminated ground biomass washing experiment *Phalaris arundinacea*





1000 x UK#1(3) washed



*After1-minute wash in 1M HCl **and** 2% Tween 80 (n = 3).

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UK#2 trial site : biomass analysis

Soil:
Pb 8-9%, Zn 0.7-5 % (Cd, Cu, Hg)

Unwashed biomass ($mg.kg^{-1}$) :

	Y1	Y2 ★
Cd	8.7	11
Zn	1485	1679
Pb	8223	3917
Cu	62	23

c. 1 % total metals in Y1 dry biomass!

(highest levels reported worldwide in an energy crop species?)

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UK CERESiS trial biomass yields (t/ha)

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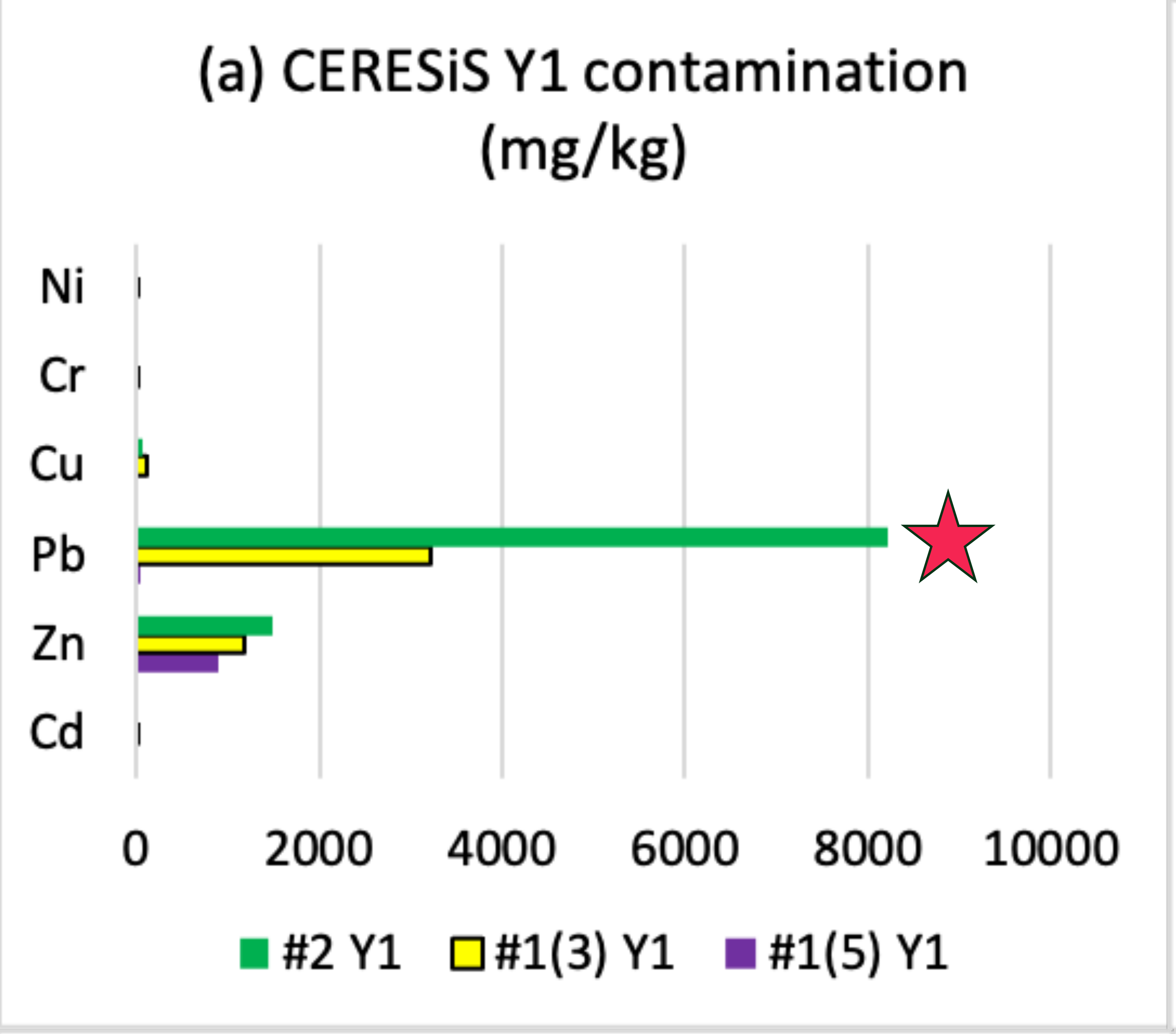
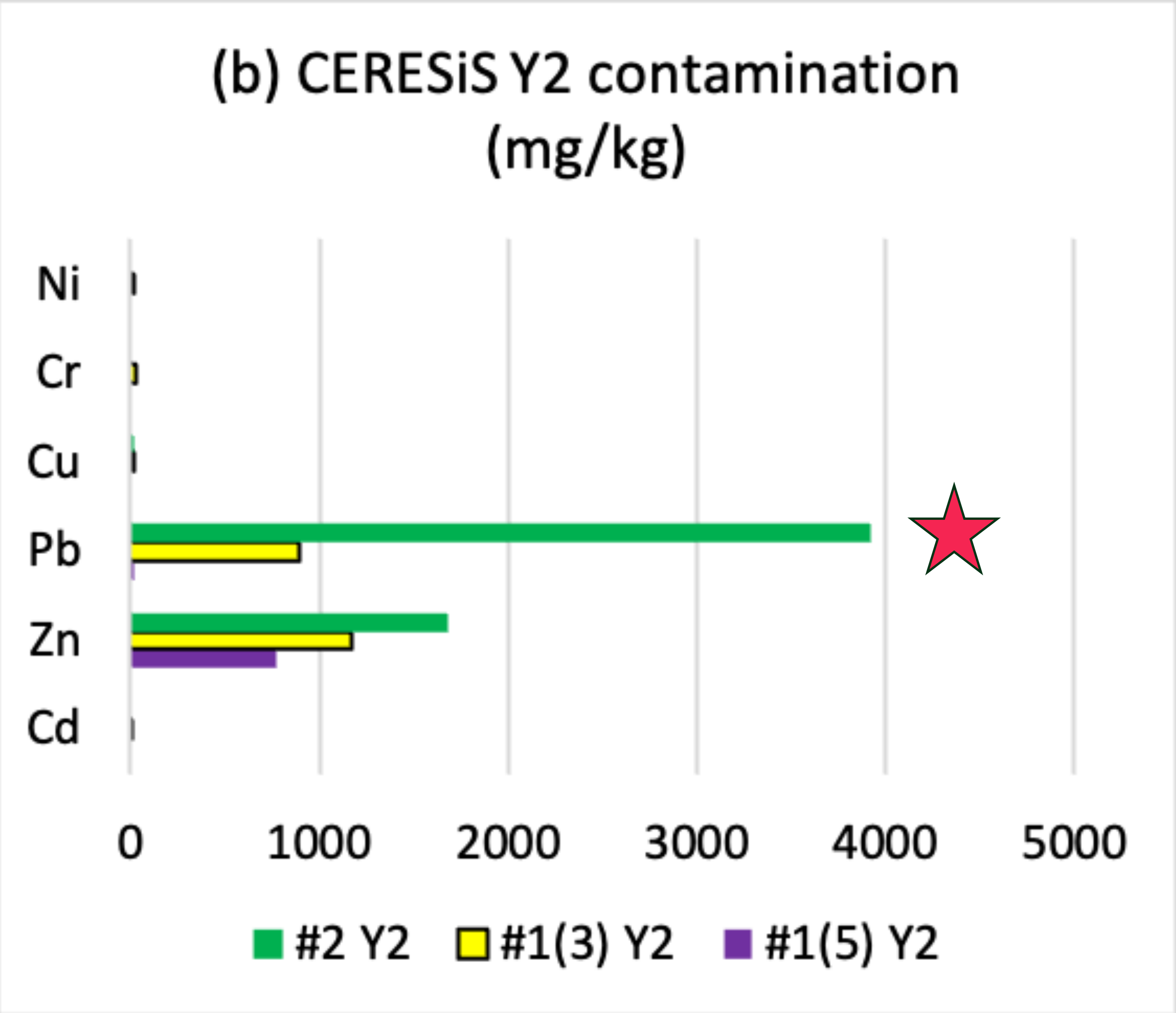
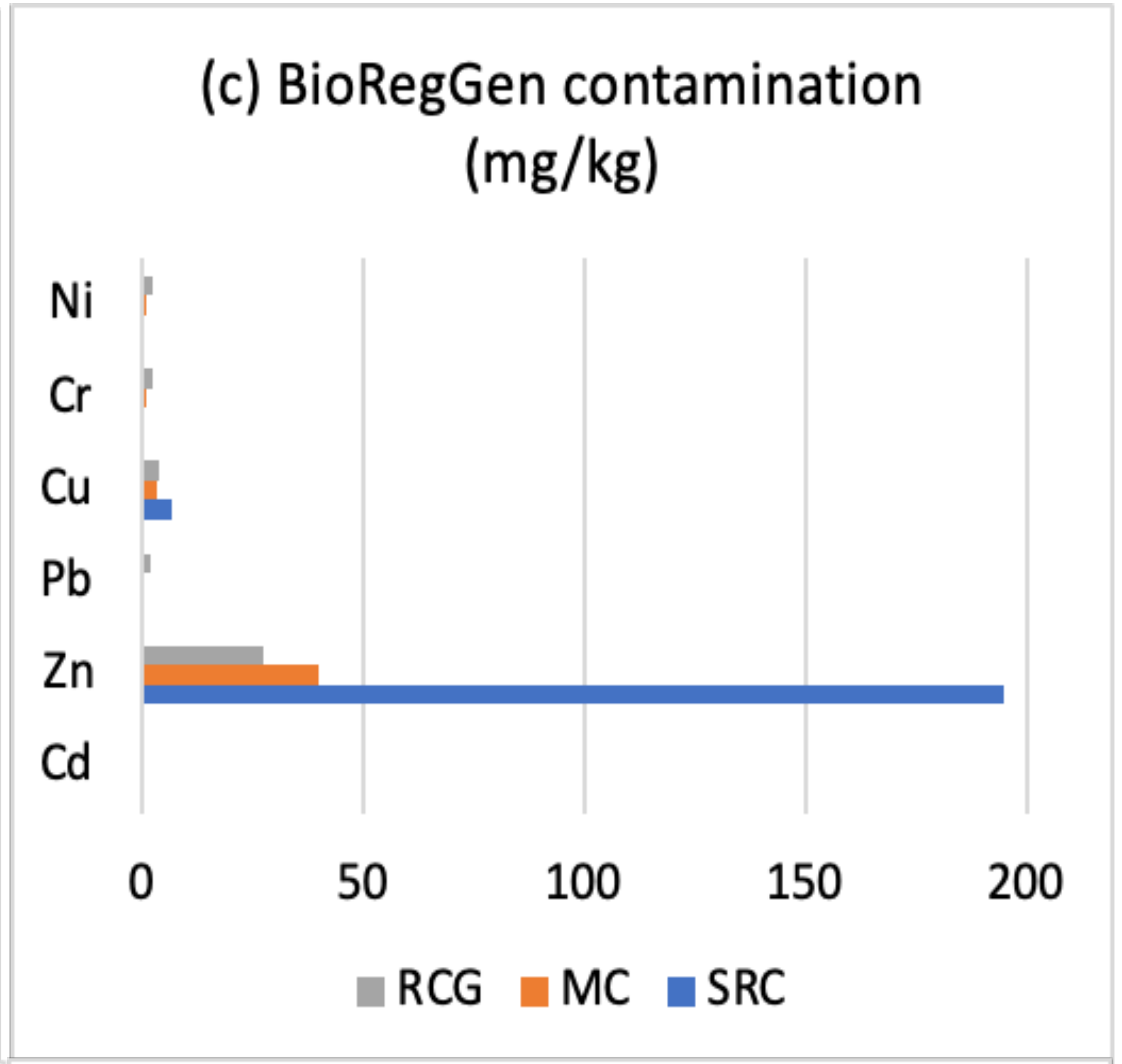
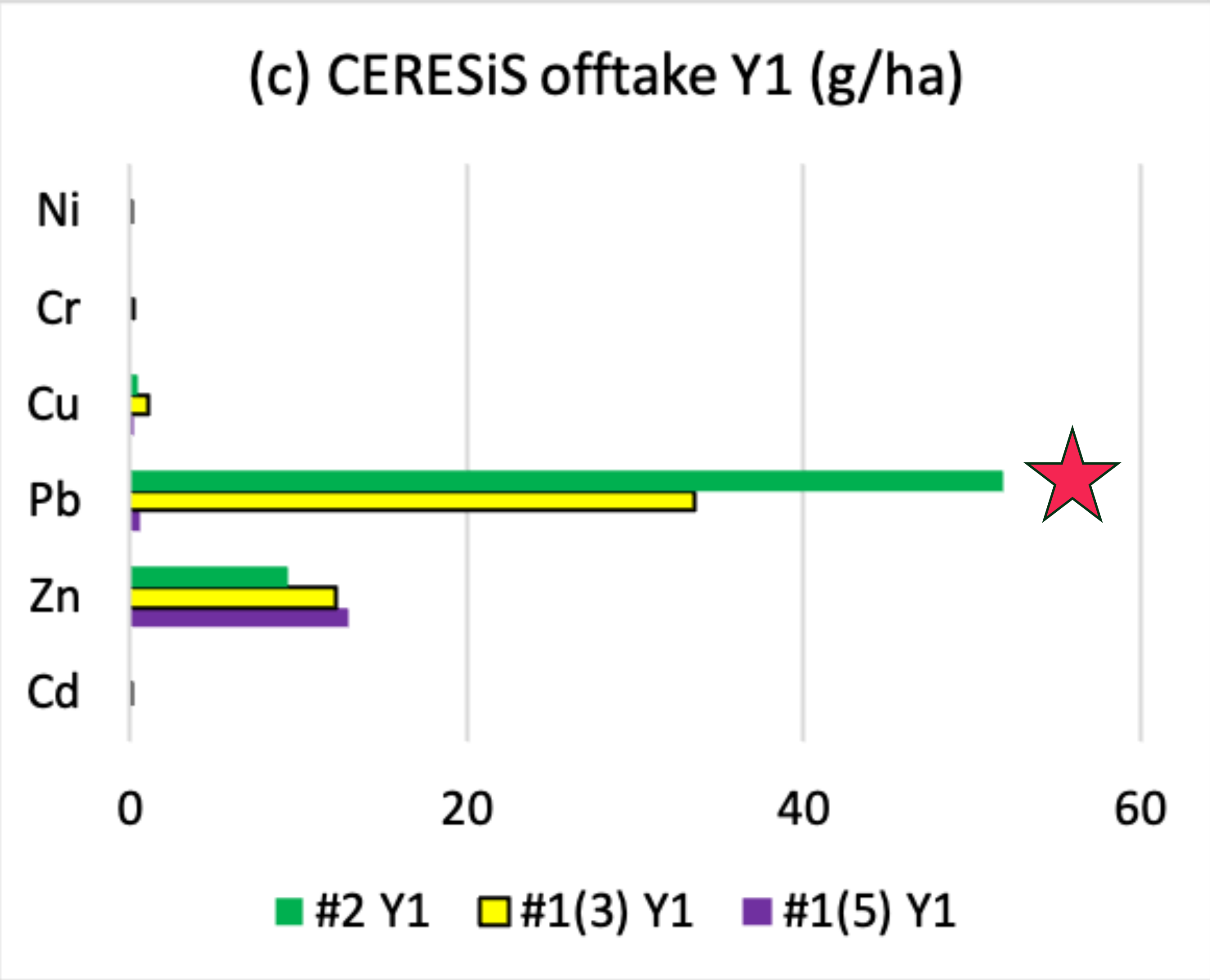
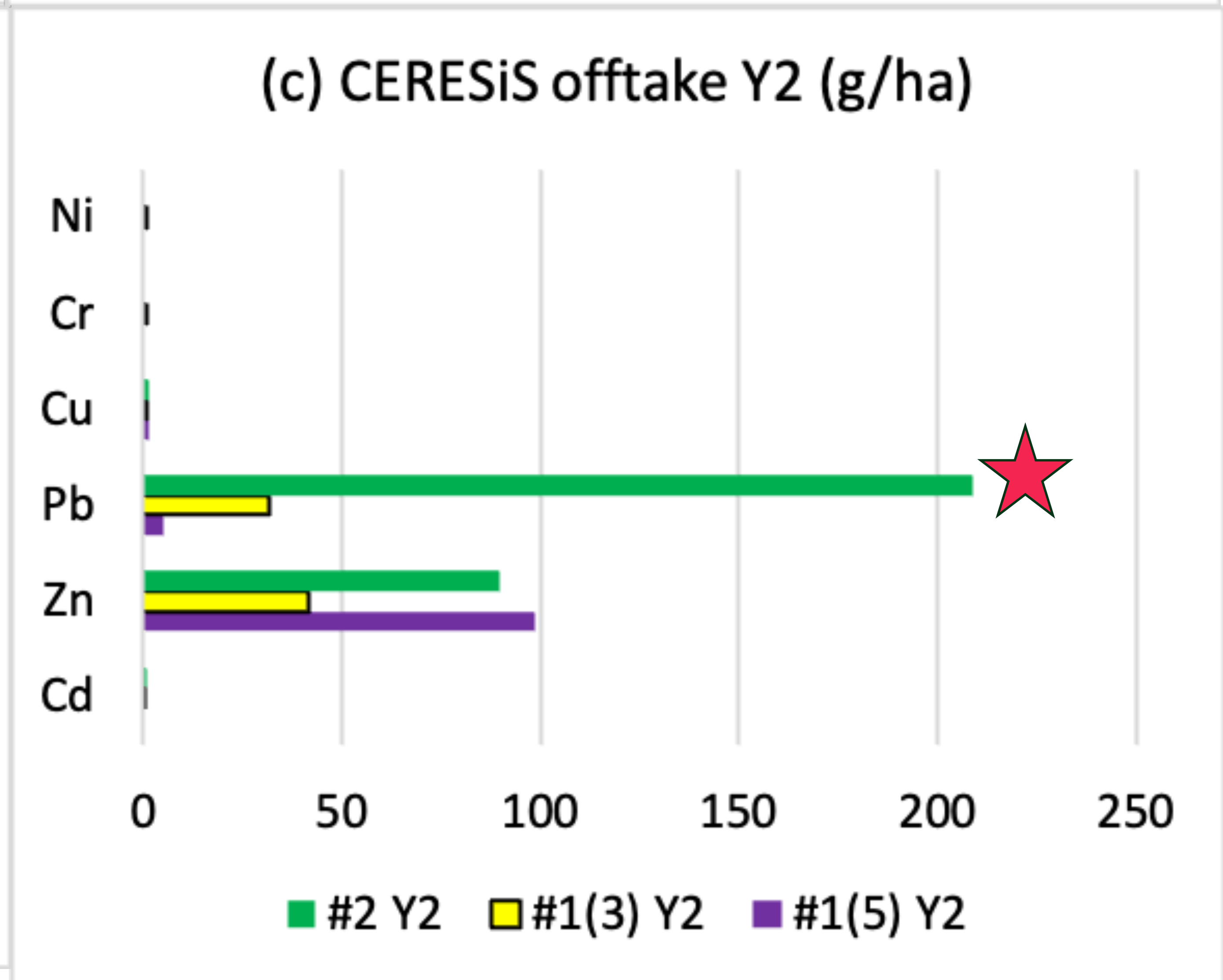
UK CERESiS trial biomass contamination levels (mg/kg) & contaminant offtake (g/ha/a)

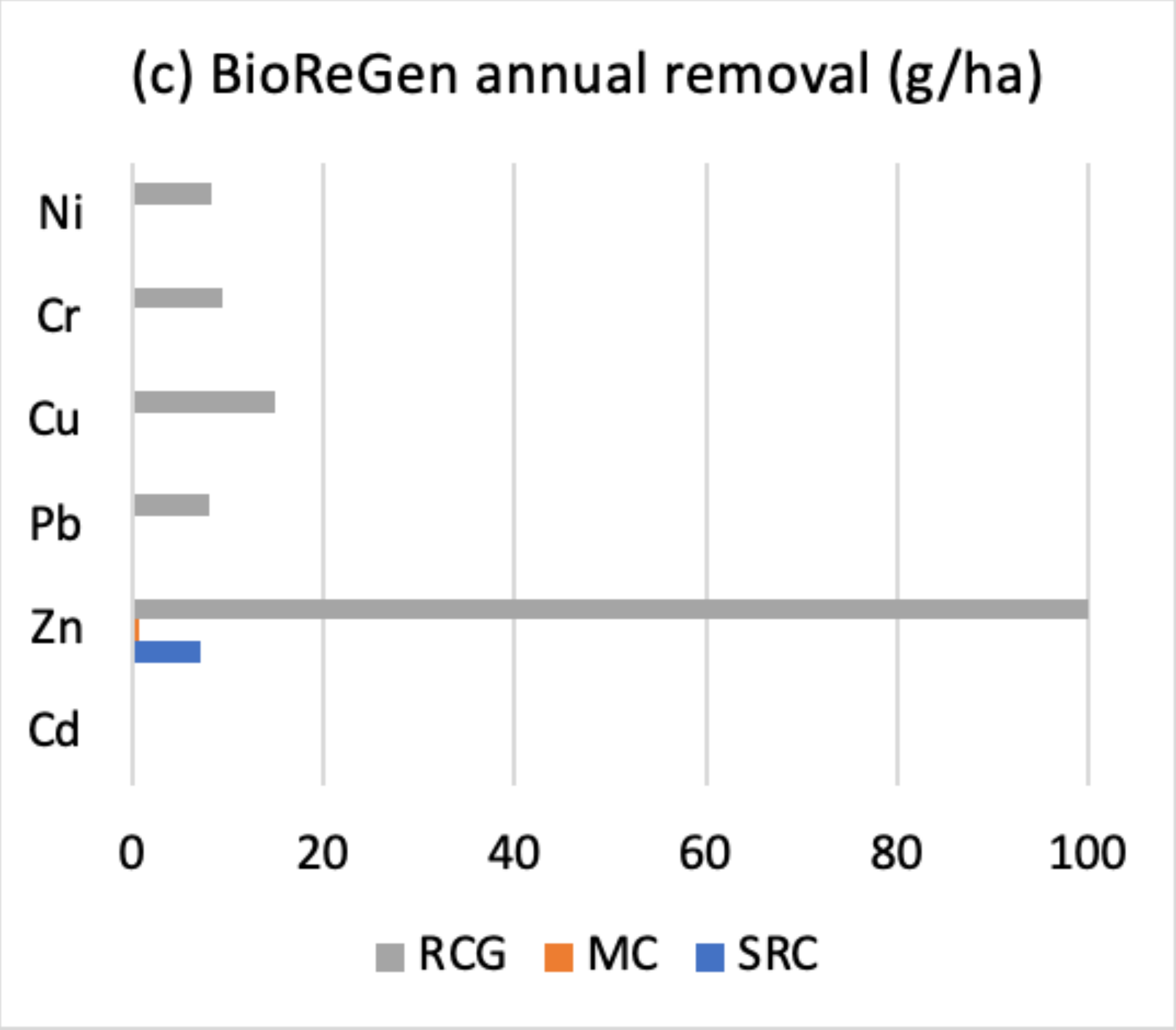












So contaminant offtake is controlled by soil contamination

But also limits yield

And at least partly surficial, so not extracted!

So is it phyto-removal not phyto-remediation?

Wider benefits, so phyto-management!

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What do we know as CERESiS ends?

- *Phalaris* is a viable (high biomass/low contaminant uptake) energy crop species in England, Scotland, Italy and Ukraine (may need irrigation to establish)
- Generally low uptake (phyto-excluder), hence low levels of As, Sb and Cr in geogenic & anthropogenic contaminated soils in IT & UKR. Likewise Cr, Ni in *Pennisetum* in Brazil.
- BUT higher levels of cross-contamination from surficial dust (wind-blown or rain splatter) on unvegetated, highly metal-contaminated UK Pb-Zn mine sites (will reduce by stabilisation & revegetation?).
- => Biomass contamination (and yield) reflects soil contaminants & levels!
- Challenging to valorise by washing (even when surface particulates)
- Source of low ILUC biomass on marginal lands (e.g. for RED II revision & sustainable biofuels) & good phyto-management (but not phyto-remediation)

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