ASSESSING PHYTOAVAILABILITY OF ELEMENTS AND IMMOBILISATION BY SOIL IMPROVER WITH SIMPLE LEACHING TESTS IN PHYTOTOXIC SOILS AND MINE RESIDUES

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Assessing phytoavailability of elements and immobilisation by soil improver with simple leaching tests in phytotoxic soils and mine residues

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Introduction: How to assess the immobilisation of phytotoxic elements by a soil improver?

Elemental contaminants in environmental matrices should be immobilized to reduce their detrimental effect. The immobilization is measured by availability tests (with specific complexing extractants like EDTA), by pore water analysis, by diffusive thin gradient devices, by laboratory or field plant growth and elemental content. The partition or speciation of the elements between the “immobilizing phases” is approached in most of the papers by sequential extraction or geomodelling.

In this paper a simple leaching test with deionized water is used to assess the immobilisation of the elements by modified bauxite residue, and the results are compared with aerial parts of plant concentrations.

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Introduction : pyritic mine residues, acid mine drainage

Oxydation of sulfides in contact with O_2 by mining activities generates sulfuric acid that dissolves (phyto)toxic elements (acid mine drainage)

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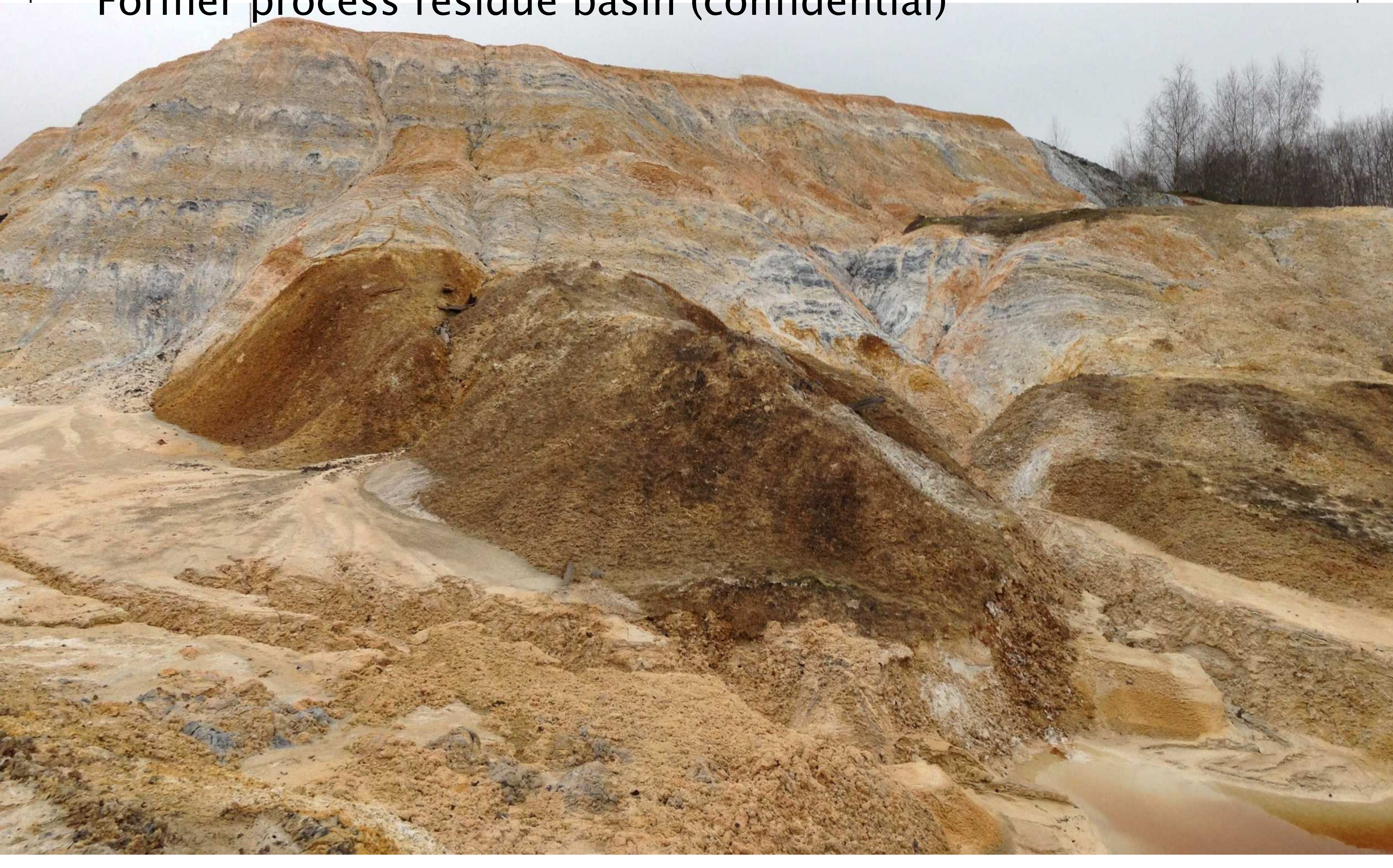
Saint Sébastien d'Aigrefeuille (Alès)

Former process residue basin (confidential)



Acid mine drainage (confidential)

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St Félix (Alès)

Materials and methods: soils and mine residues

Nine contaminated soil or mine residues, without vegetation, were used:

- excavated urban subsoil (Cr VI, Sb) (Marseille, Geze)
- heavily polluted soil from a former wood treatment facility (Cu, Zn, Cd) (Bordeaux, SME)
- bare pyritic mine tailings in sandstone (Pb, Zn) (Alès, SSAF)
- flotation tailing dumps (Zn, Pb, Mo, Cd) (Sardinia (I), Campo Pisano)
- mining residues and tailings, high As and Pb concentrations (Pb, Zn, As, Cu, Mo, Co, Cd) (Marseille, Escalette)
- marsh downstream of zone of mine tailings (Zn, Pb, Mo, Cd) (Sardinia (I), Sa Masa)
- bare or with poor adapted vegetation acid mine tailings (Zn, Pb, As, Cd, Mo, Cd, Co) (Montpellier, Saint Laurent le Minier)
- high lead and zinc concentrations (Zn, Pb, As) (Alès, St Félix)
- Sulfidic process residue with very high leaching copper (Cu, Pb) (RM3-1)
- control soil (forest clay soil on limestone=rendzina, Aix-en-Provence).

(As: 4 – 1300 mg/kg, Cd: 1 – 250; Cu: 1 – 10 000; Pb 10 – 20000; Zn 10 – 4000).

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Materials and methods: soil/mine residue treatment and leaching tests

Due to large iron and aluminum (hydr)oxide content, clay content, and alkalinity content, the soil improver “modified bauxite residue” (MBR) immobilizes elements (Hennebert *et al*. 2016). The phytotoxic elements are immobilised by addition of 0.1% to 30% of MBR, depending on the material.

Immobilisation is measured by a simple waste leaching test (EN 12457-2):

- 4 mm, 10 L deionised water/kg dry matter (test with 90 g DM)
- Agitation by roll-over 24 h
- 15 min decantation, Filtration 0.45 µm
- Acidification and ICP analysis

Hennebert P, Poizat L, Merdy P. 2016. Mine solid residue and mine water treatment at laboratory and pilot scale by modified bauxite residue with gypsum, an effective and cheap source of iron and alkalinity. Crete 2016. Proceedings 5th International Conference on Industrial and Hazardous Waste Management. Chania (Greece). 27-30/09/2016

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Materials and methods

Cultivation of plant in pot, lysimeter or field plot

Dactylis glomerata is grown in open air in 400 g pot of soil/mine residue laboratory material (dried at 40°C and crushed at 2 mm), amended with 0, 10% or 30% MBR, with NPK fertiliser at agronomic dose, with daily restrained irrigation and free leaching, from February to June 2016 at Aix-en-Provence.

The growth was very poor to poor, and after 2 months, compost (1%) has been added and *D. glomerata* re-seeded.

Dactylis glomerata is grown in open air lysimeters of 50 l with the mine residue of St Félix and MR3-1, since 2014 and 2015, with 1% compost for MR3-1, with NPK fertiliser at agronomic dose, with regular irrigation and free leaching. The growth with addition of MBR was flourishing.

A test plot of 30 m² has been installed at St Félix in 2014.

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Growth of *D. glomerata* in lysimeter: example of St Félix

Left: without MBR
Right: with MBR

78 days after sewing

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Growth of *D. glomerata* in plot: example of St Félix

Phytotoxicity : field trial 108 days after sewing (despite drought)

Phytotoxicity : field trial 458 days after sewing (summer)

Results
Growth of *D. glomerata* in pots: example of SSAF

Mine residue SSAF pH 3.5 : MR, MR+Fertiliser,, MR + 0.1% RBM + fertiliser, idem 0.3%, 1%, 3%, 10%, 30%

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Growth of *D. glomerata* in pots: example of RM3-1

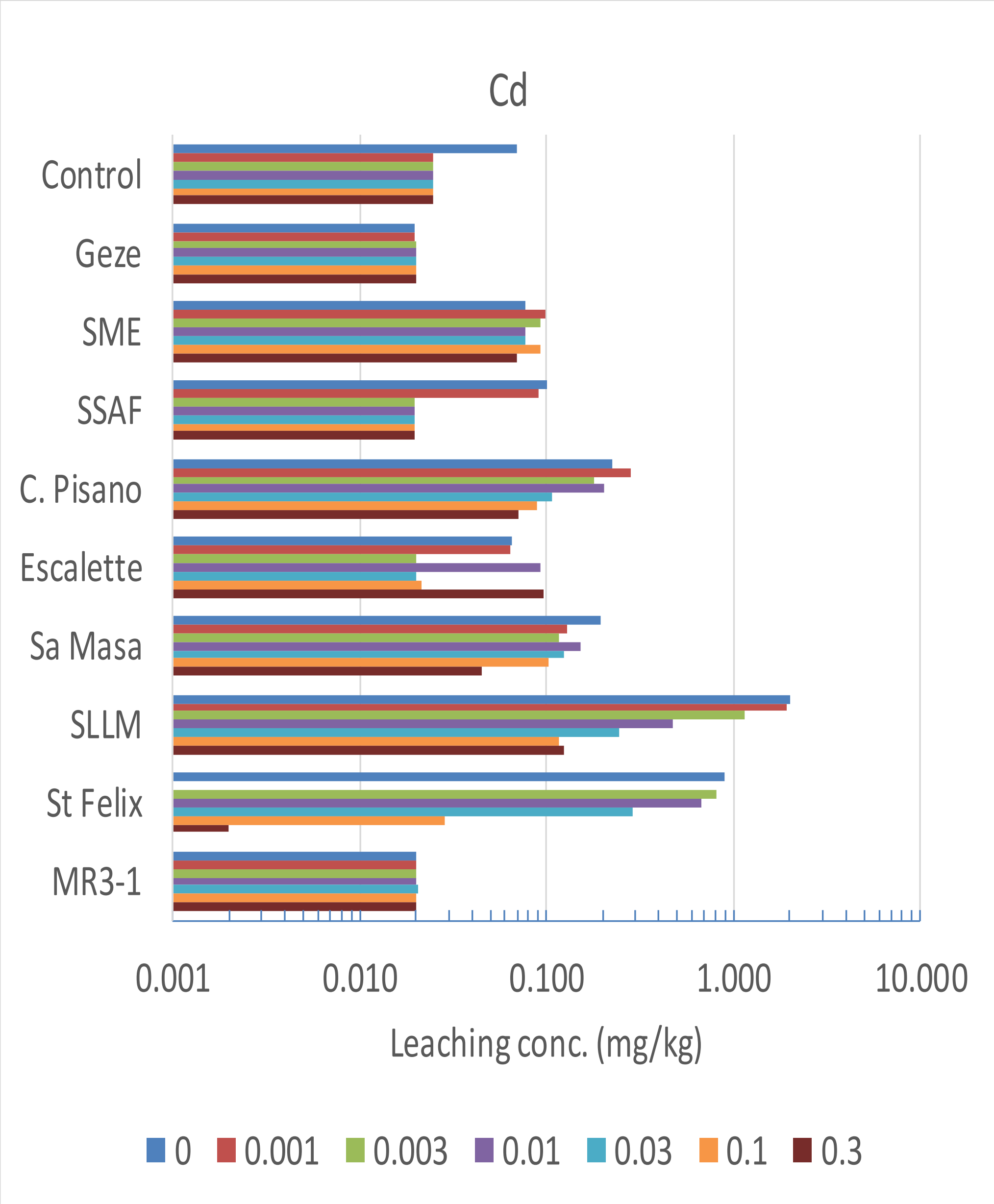
Growth of *D. glomerata* in lysimeter: example of RM3-1

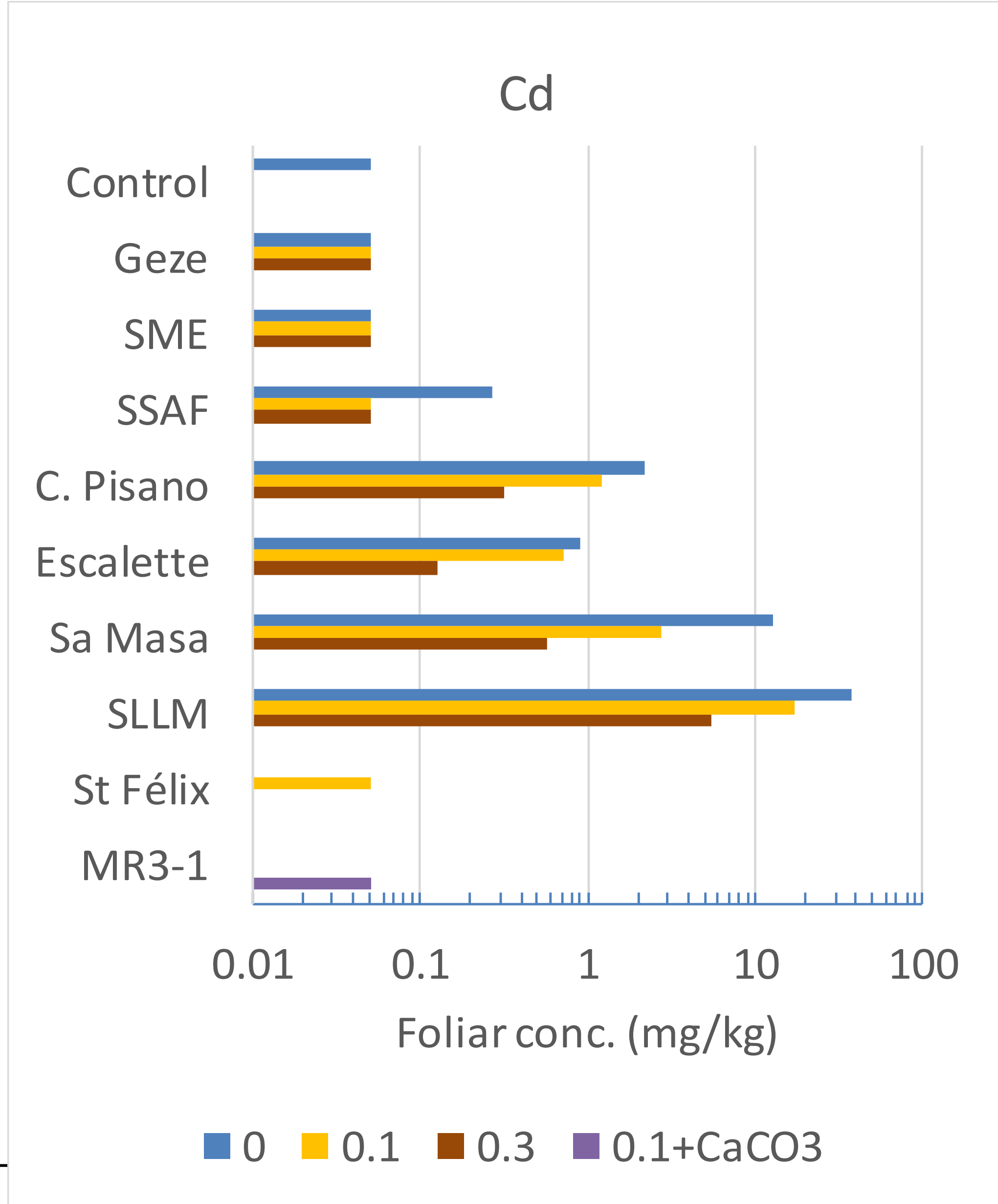
Growth of *D. glomerata* in pots: other soils/MR

- Left to right : Control, SLLM, SME, Escalette, Campo Pisano, Sa Masa, Geze
- Upper to lower row: 0%, 10% and 30% MBR

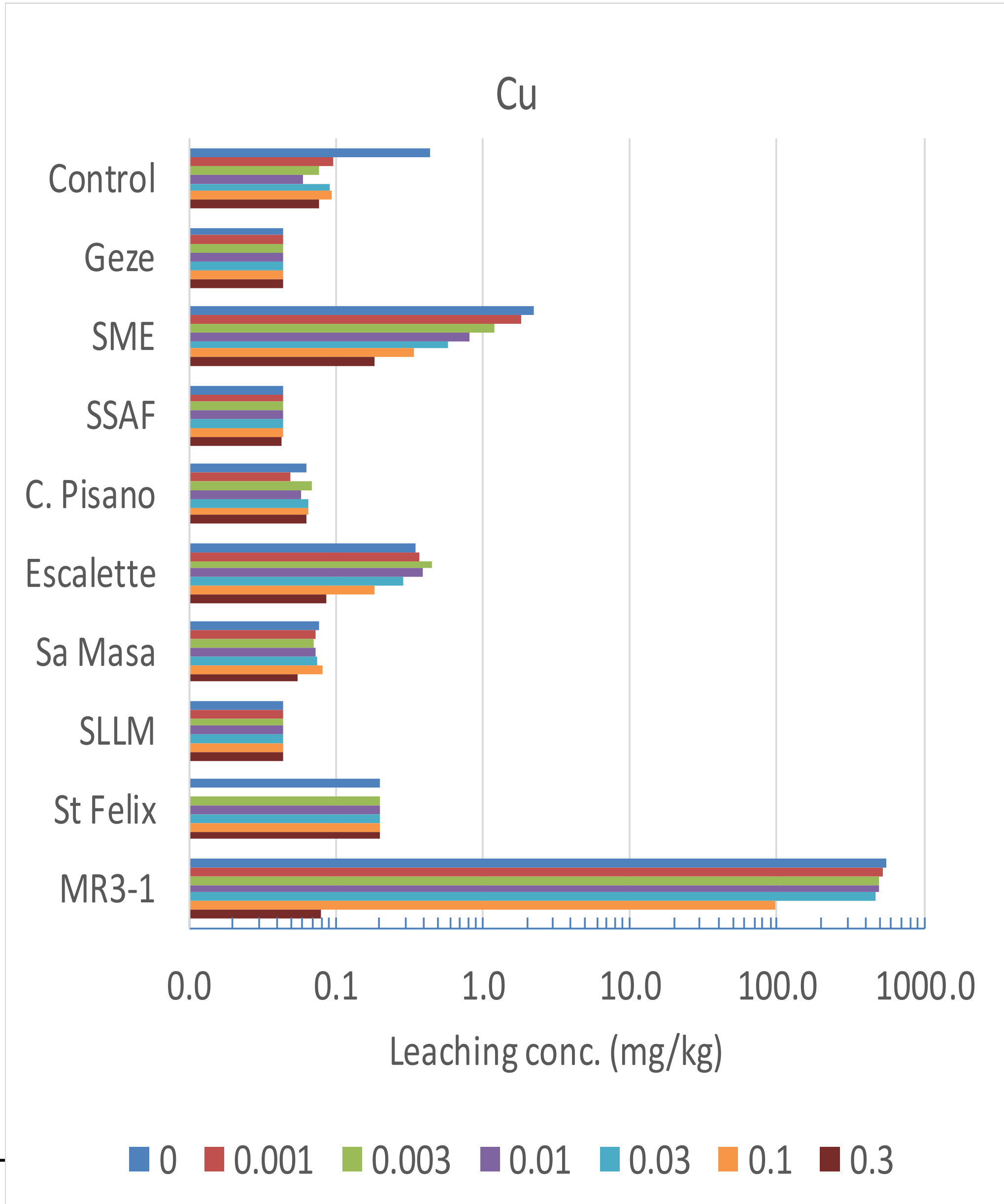
Results

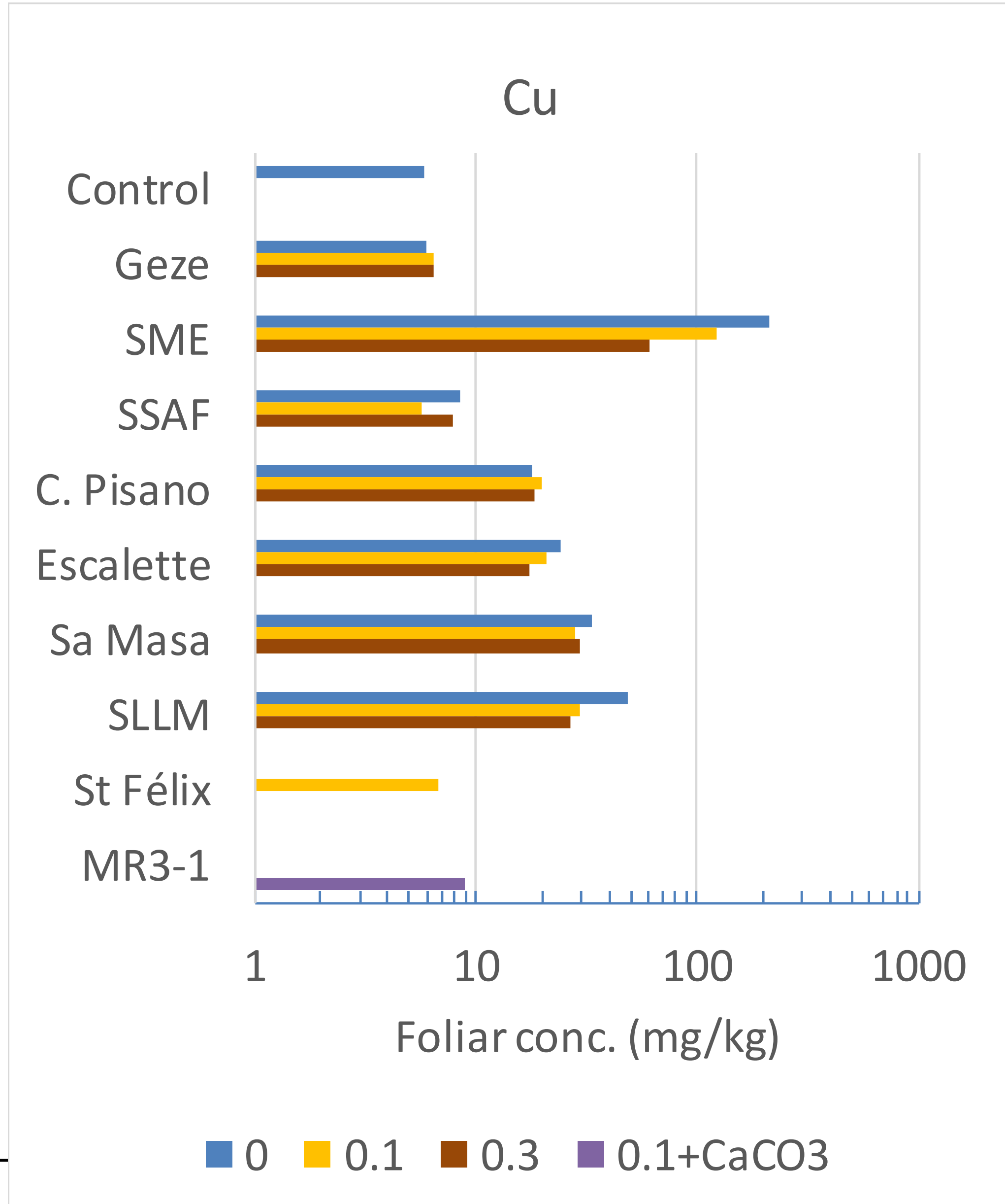
Leaching concentrations / Foliar concentrations: Cd



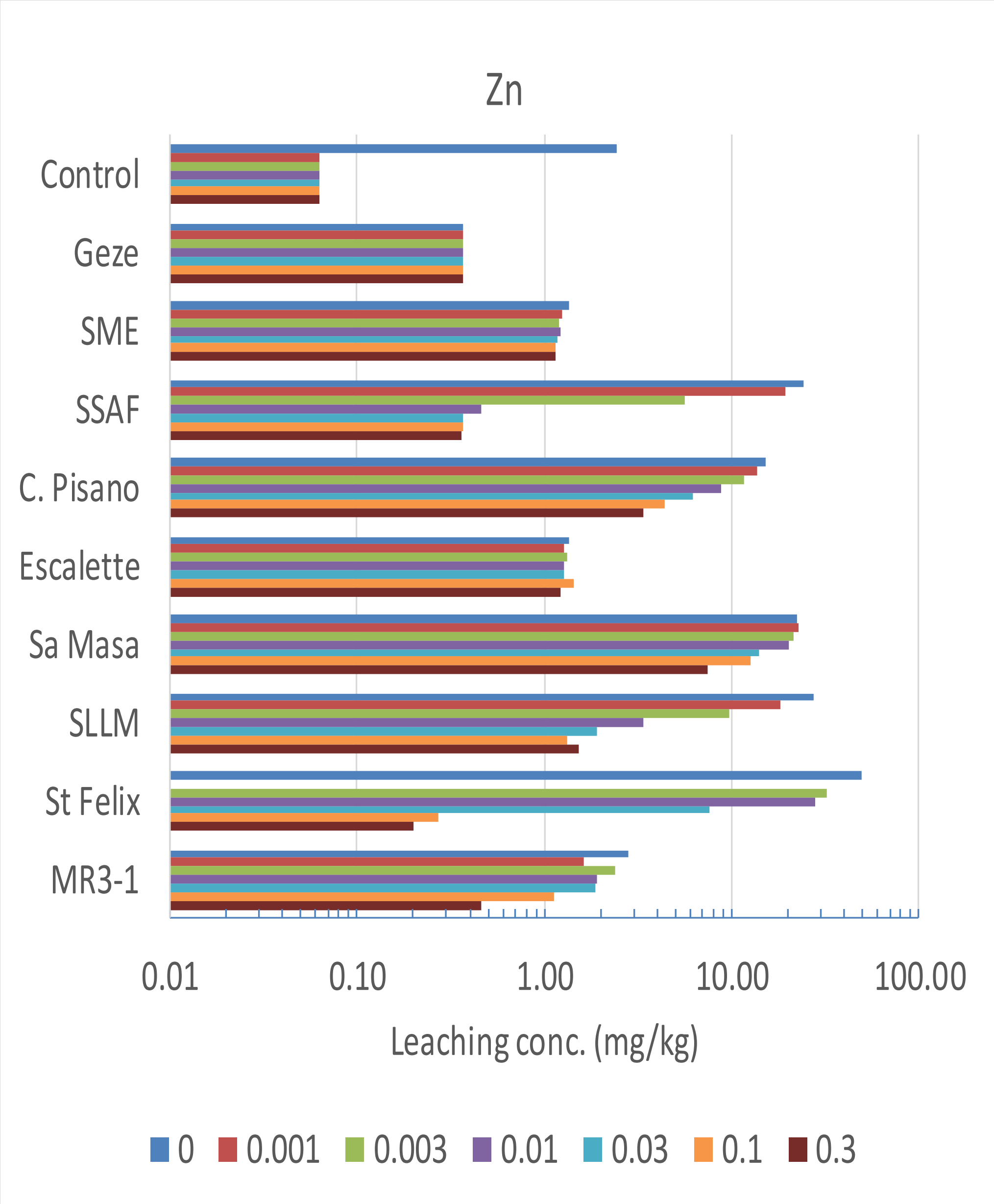


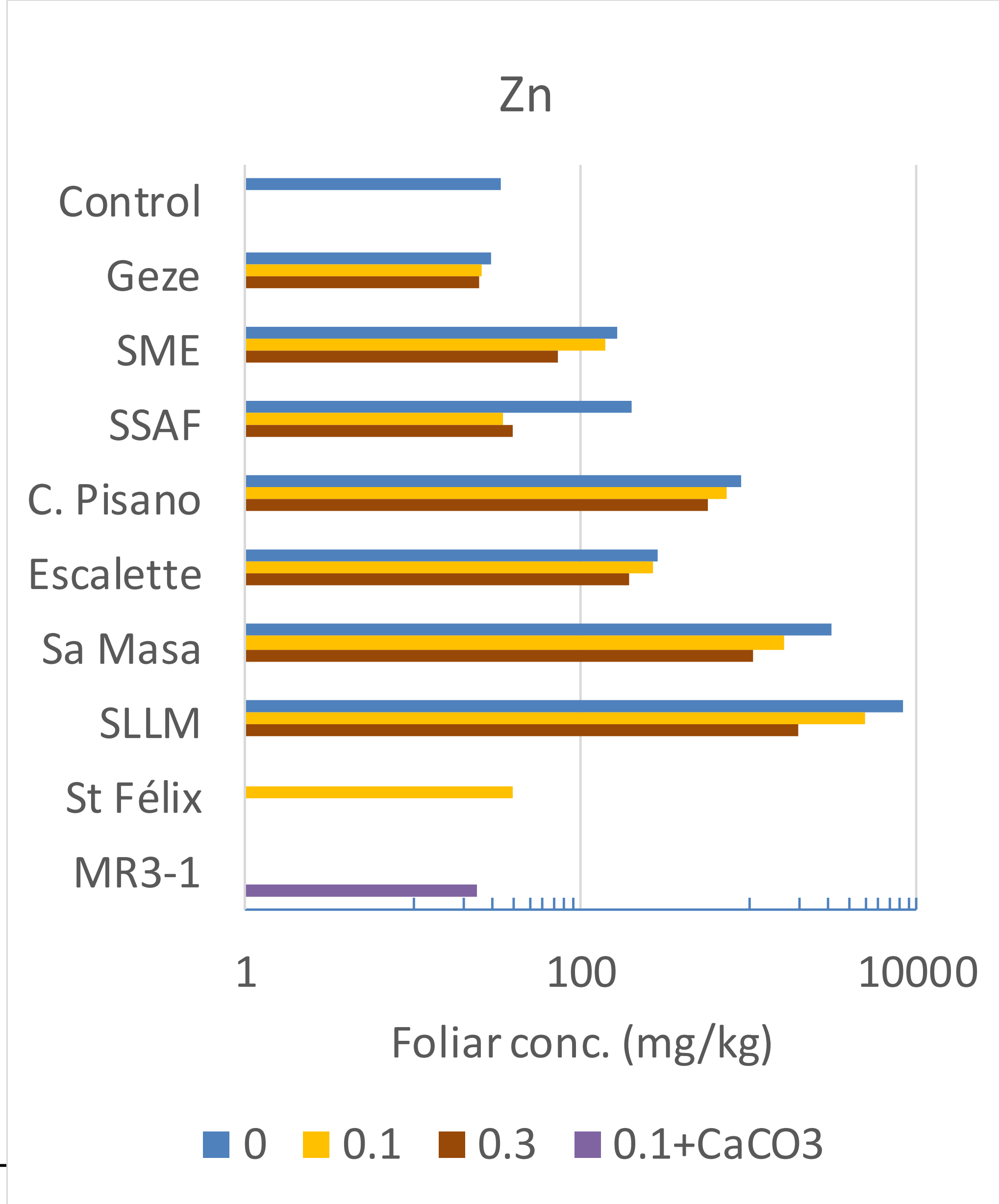
Leaching concentrations / Foliar concentrations: Cu



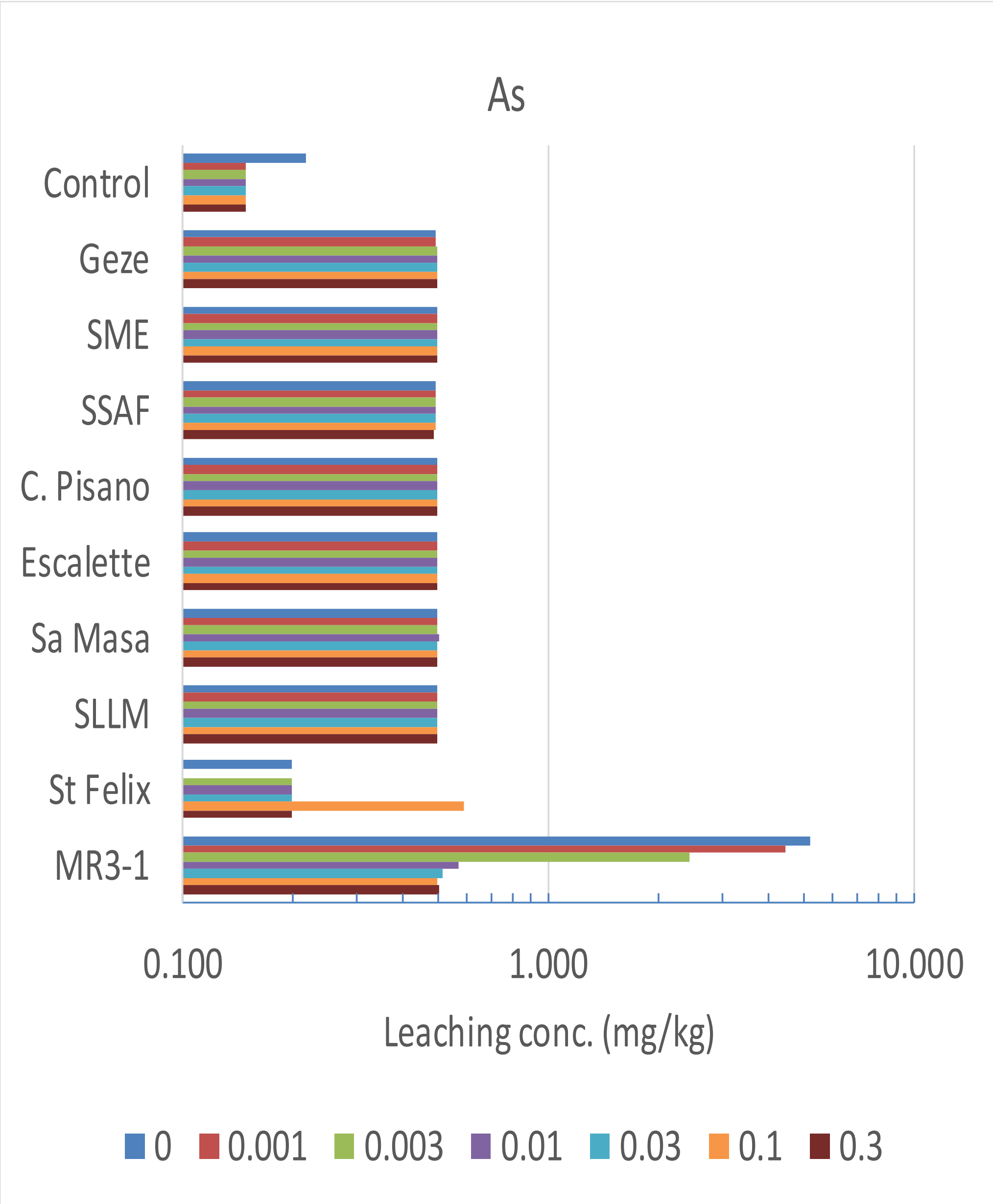


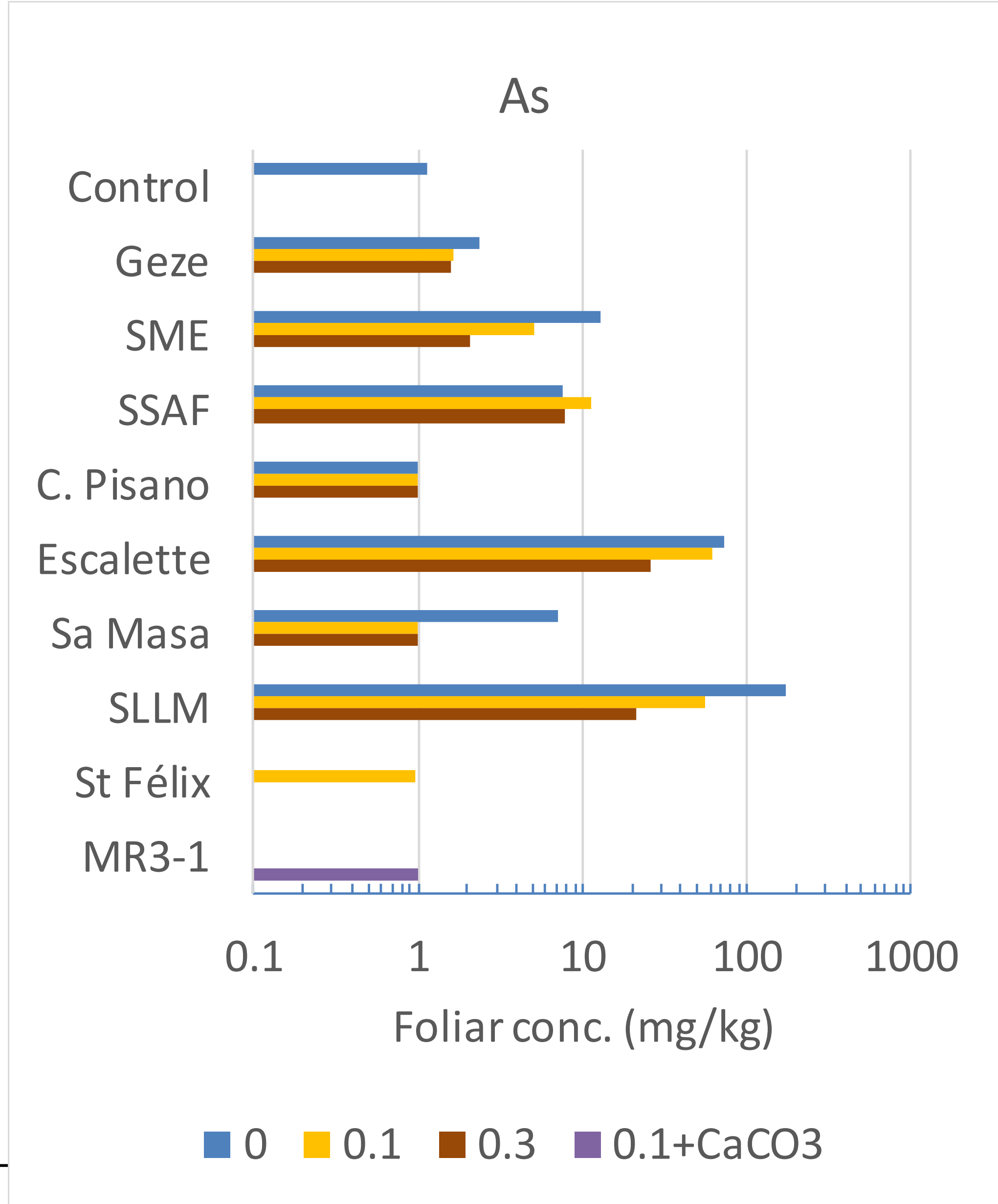
Leaching concentrations / Foliar concentrations: Zn



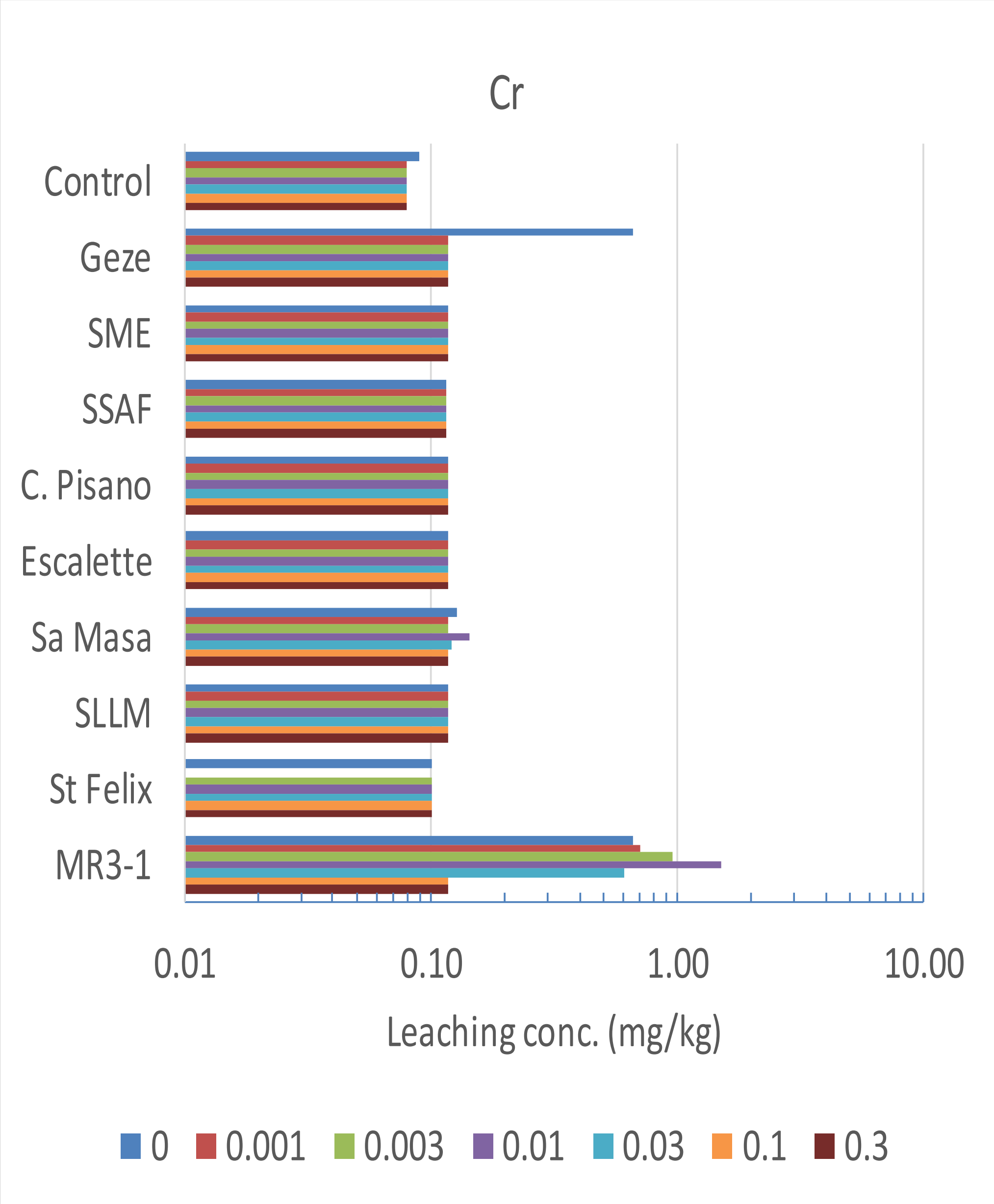


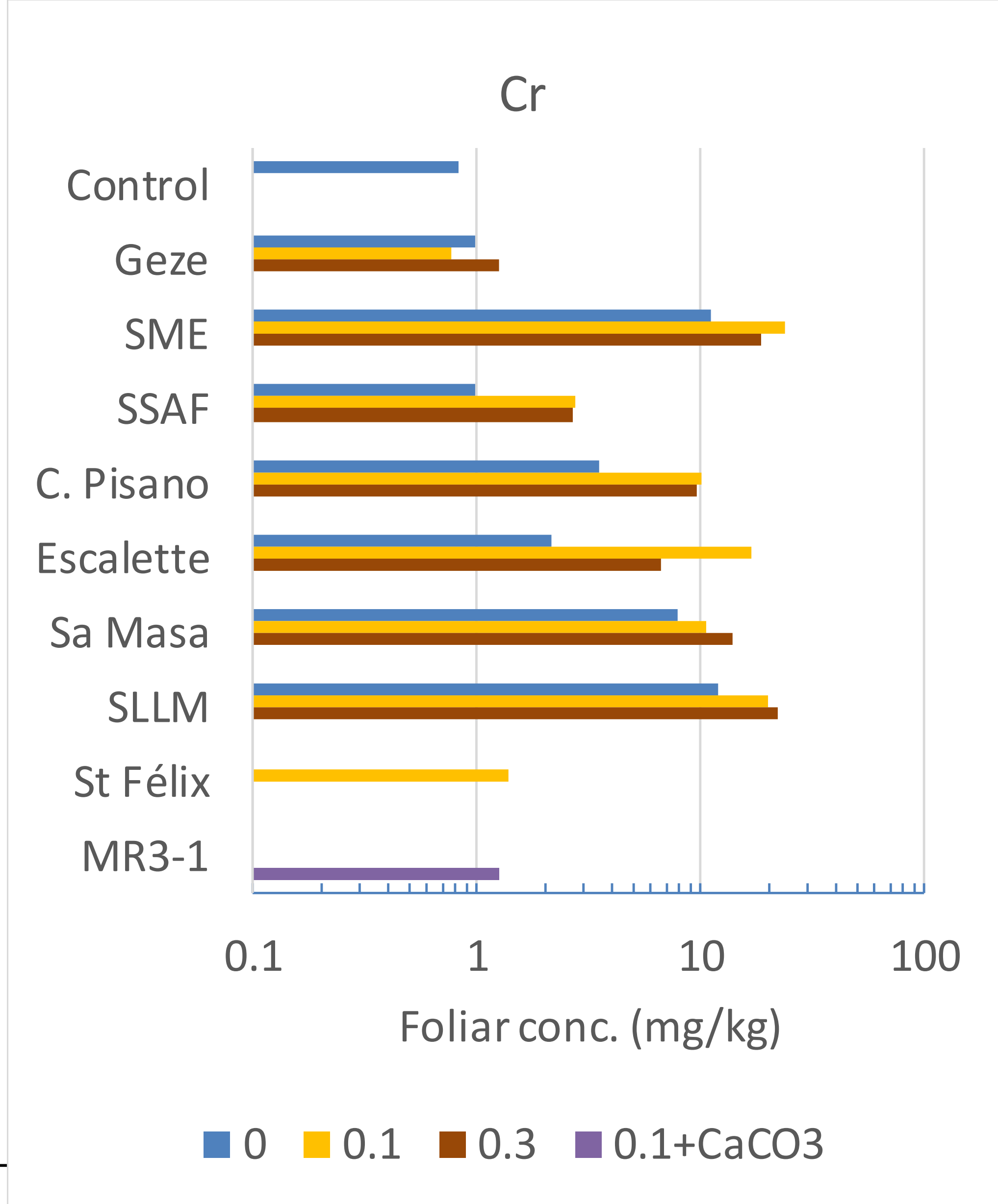
Leaching concentrations / Foliar concentrations: As



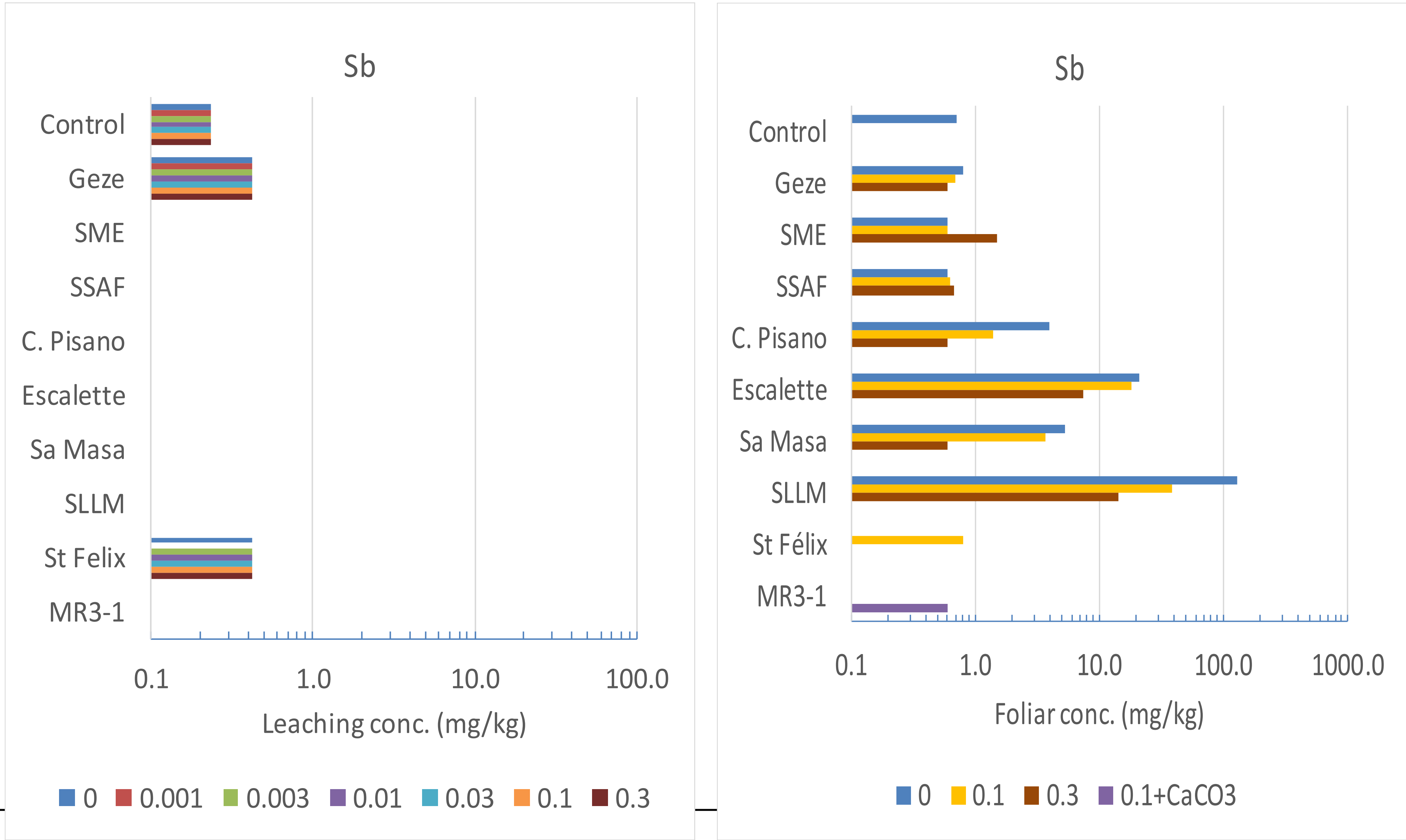


Leaching concentrations / Foliar concentrations: Cr

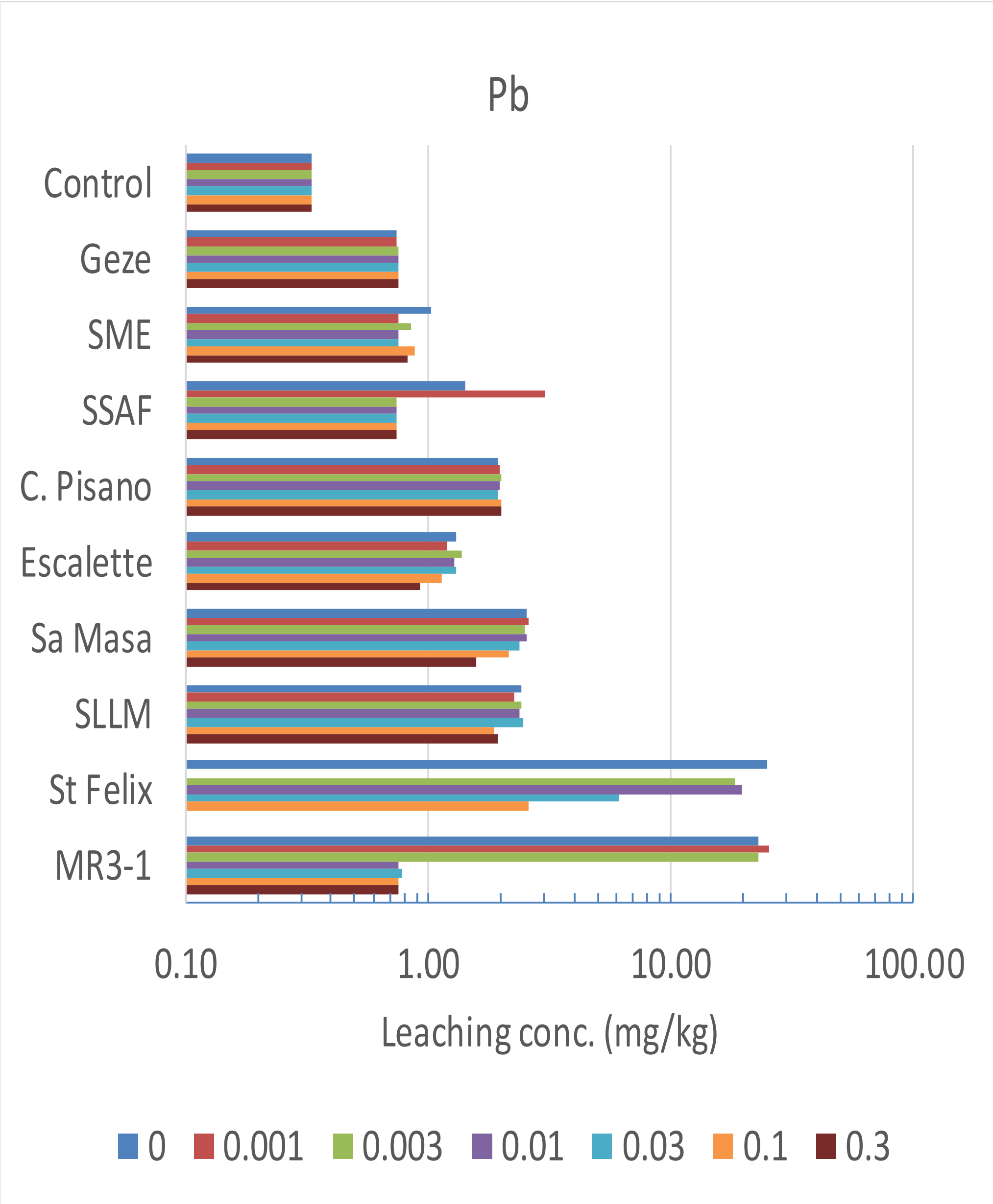


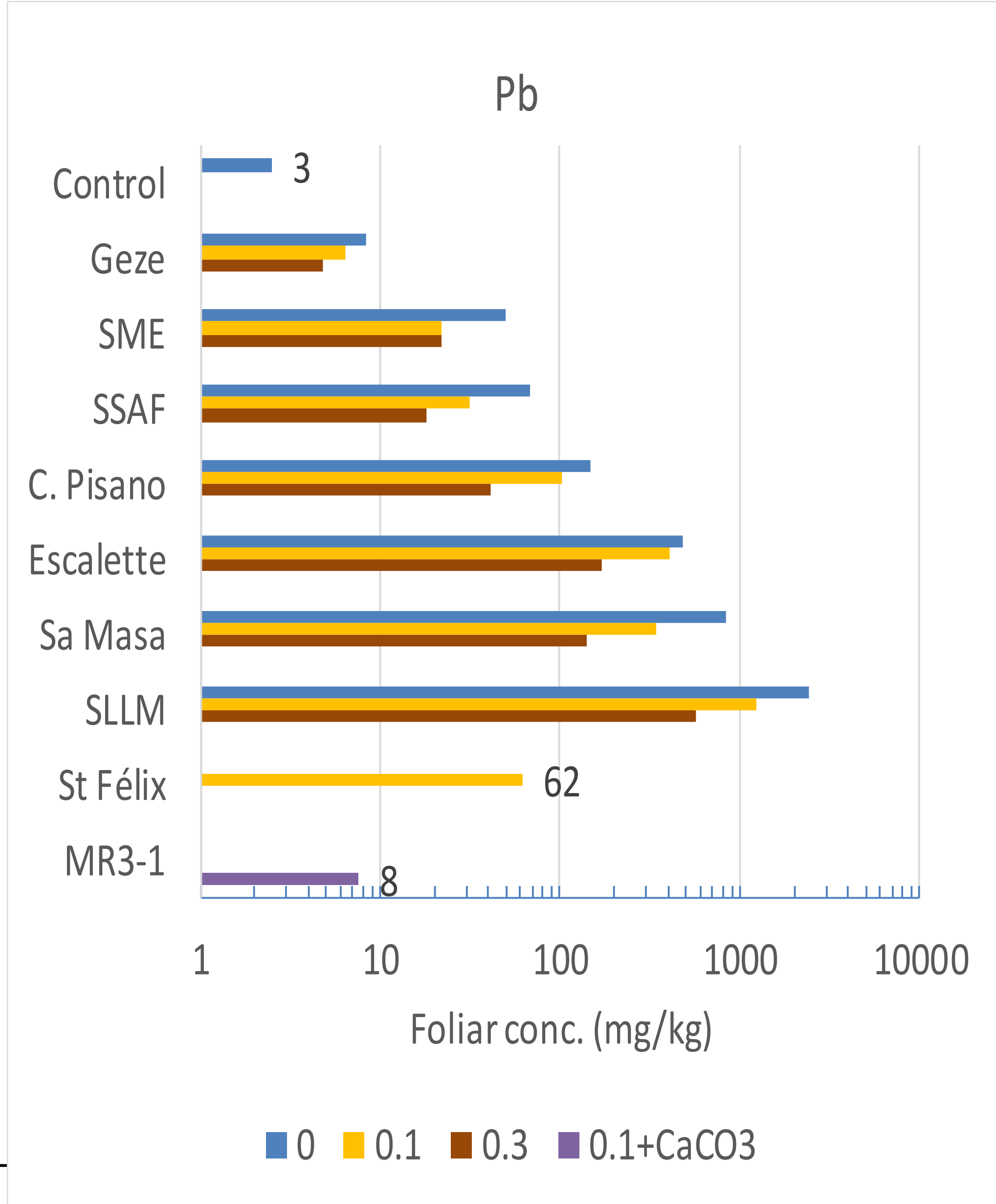


Leaching concentrations / Foliar concentrations: Sb

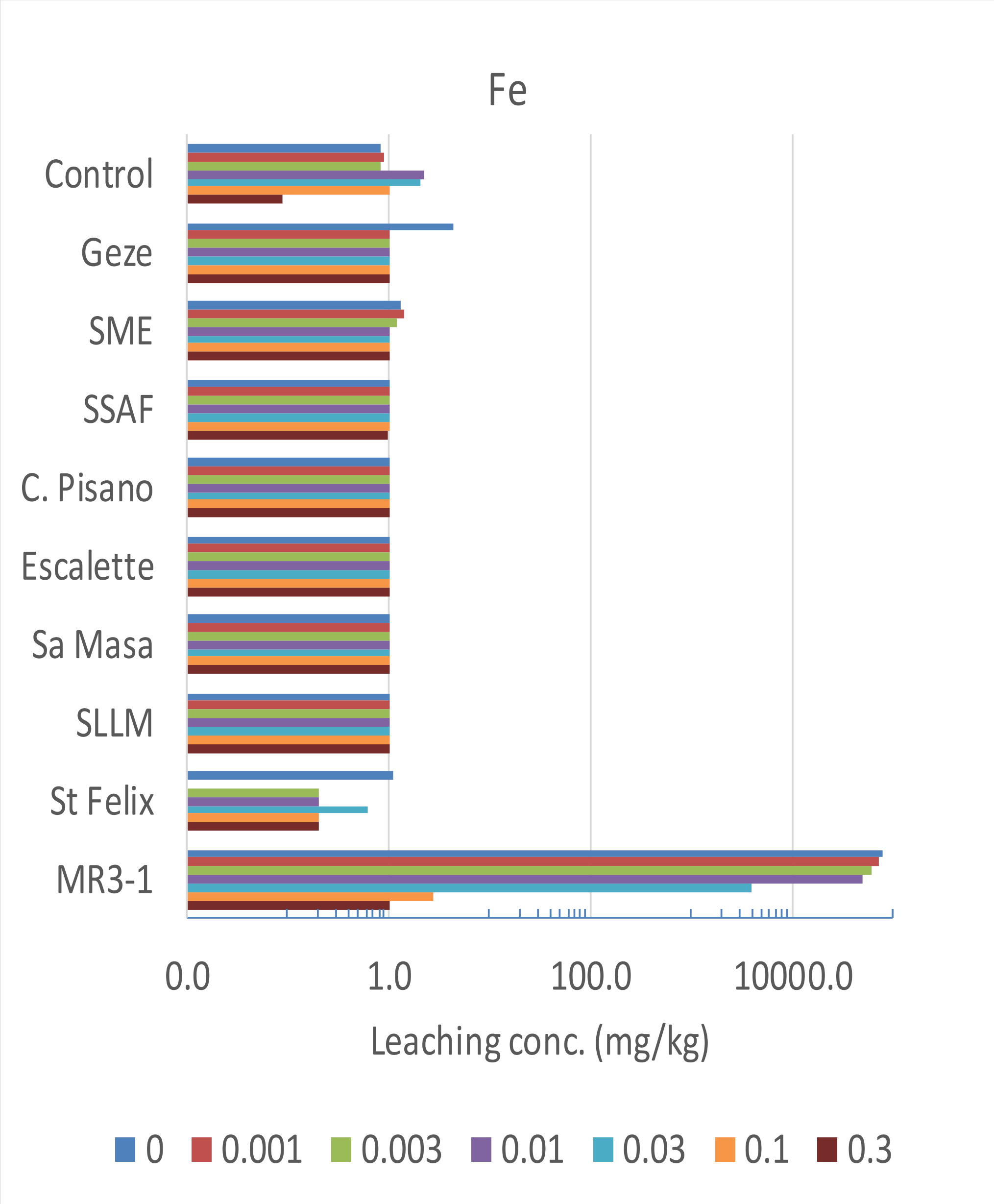


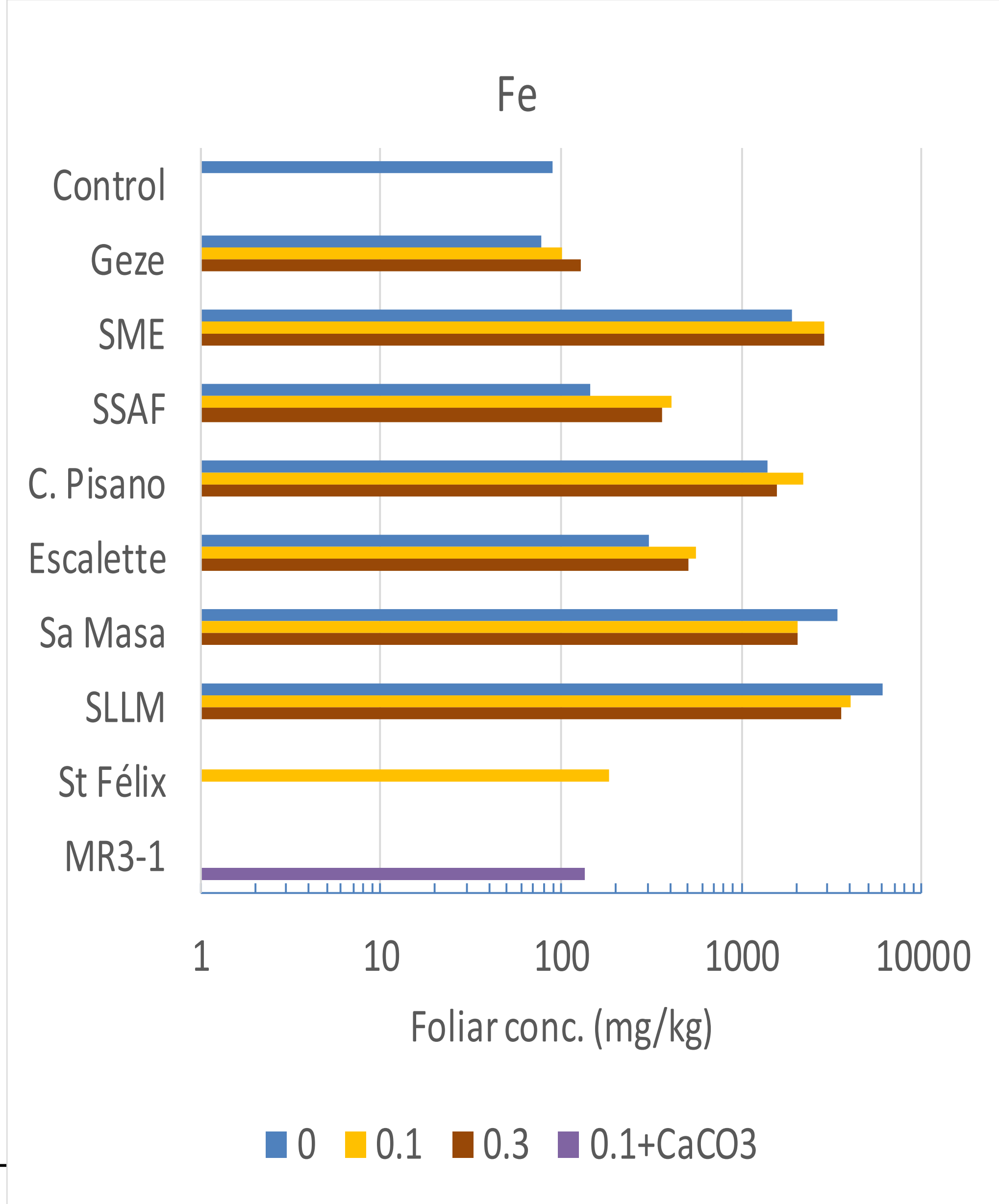
Leaching concentrations / Foliar concentrations: Pb



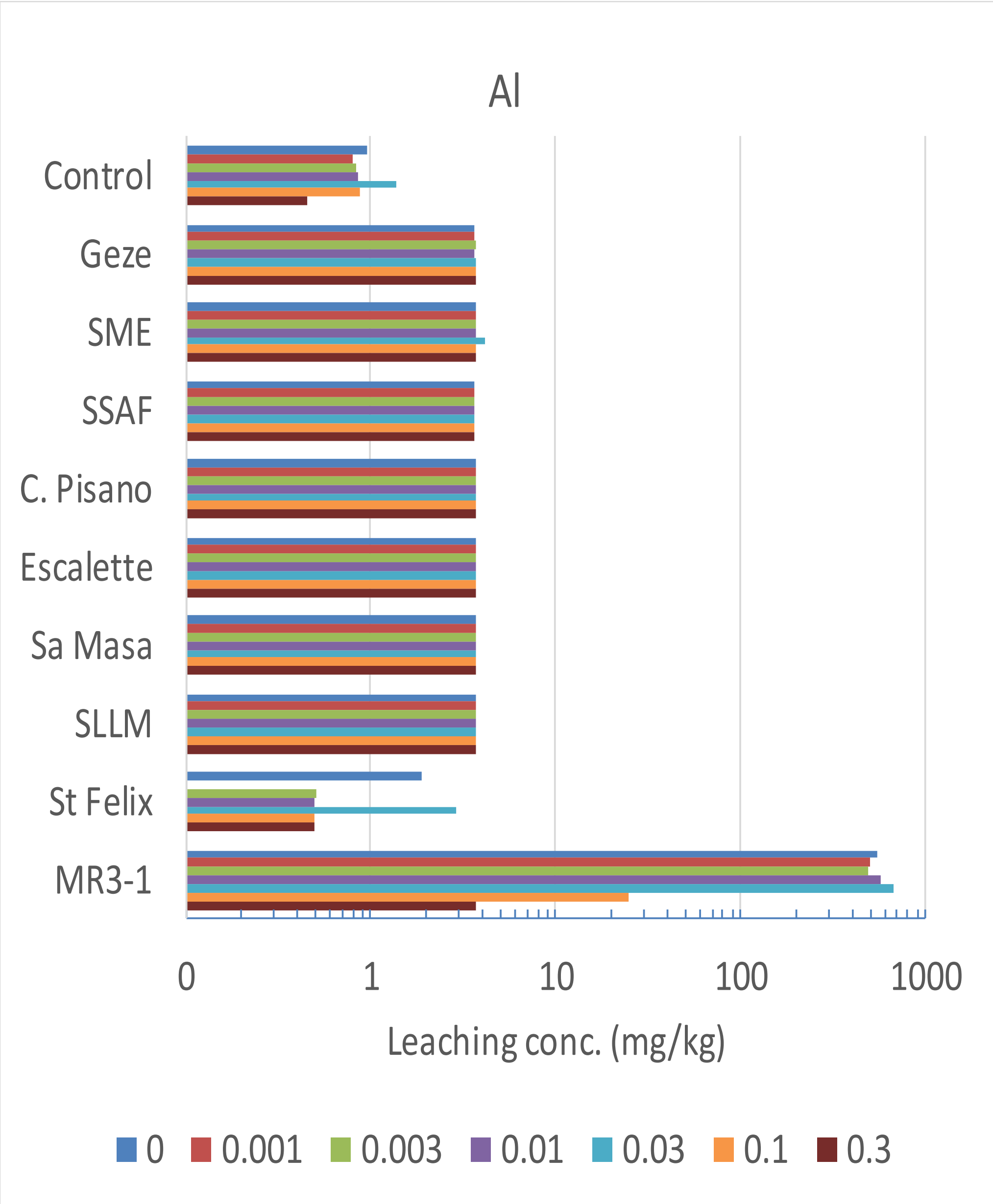


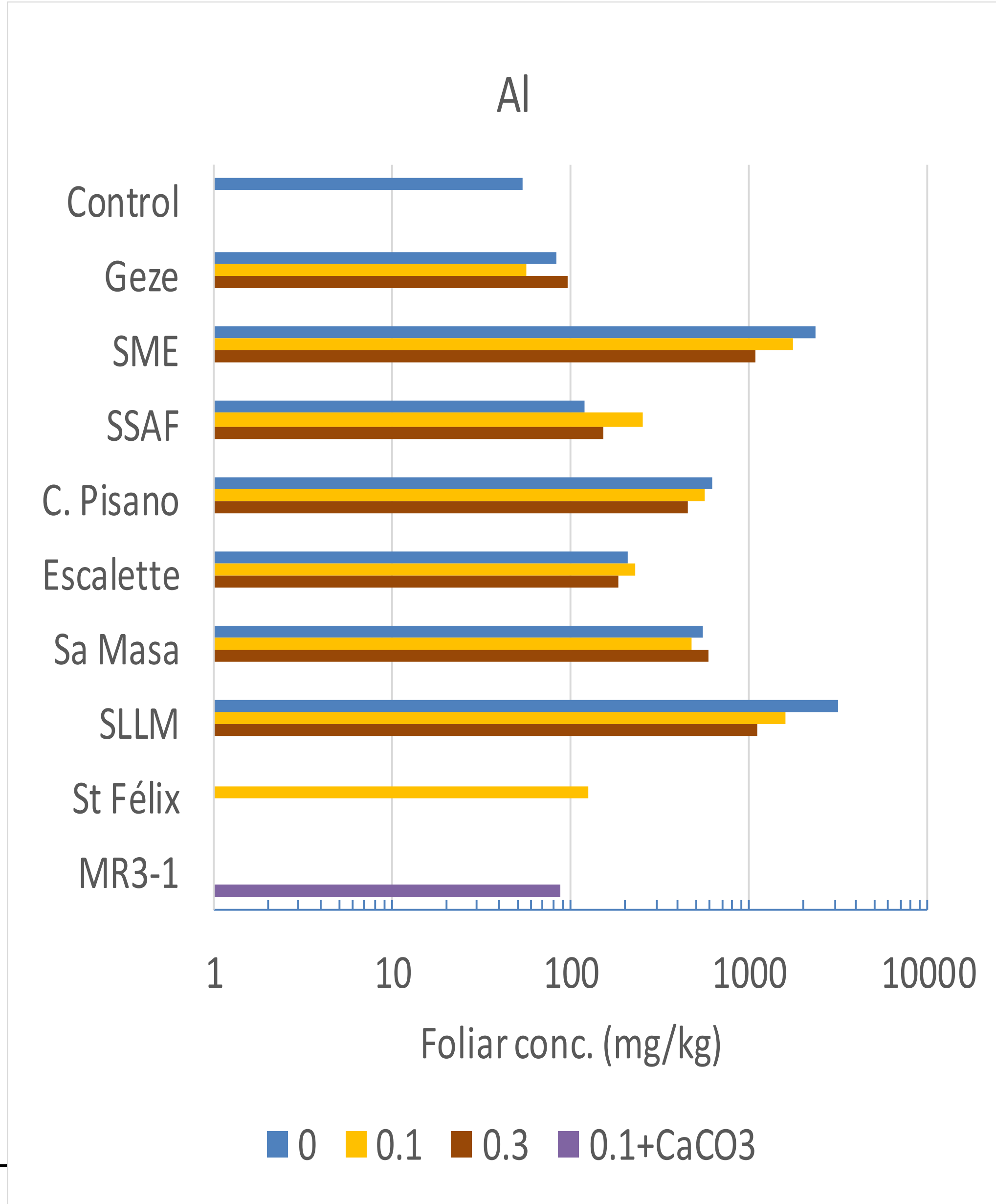
Leaching concentrations / Foliar concentrations: Fe



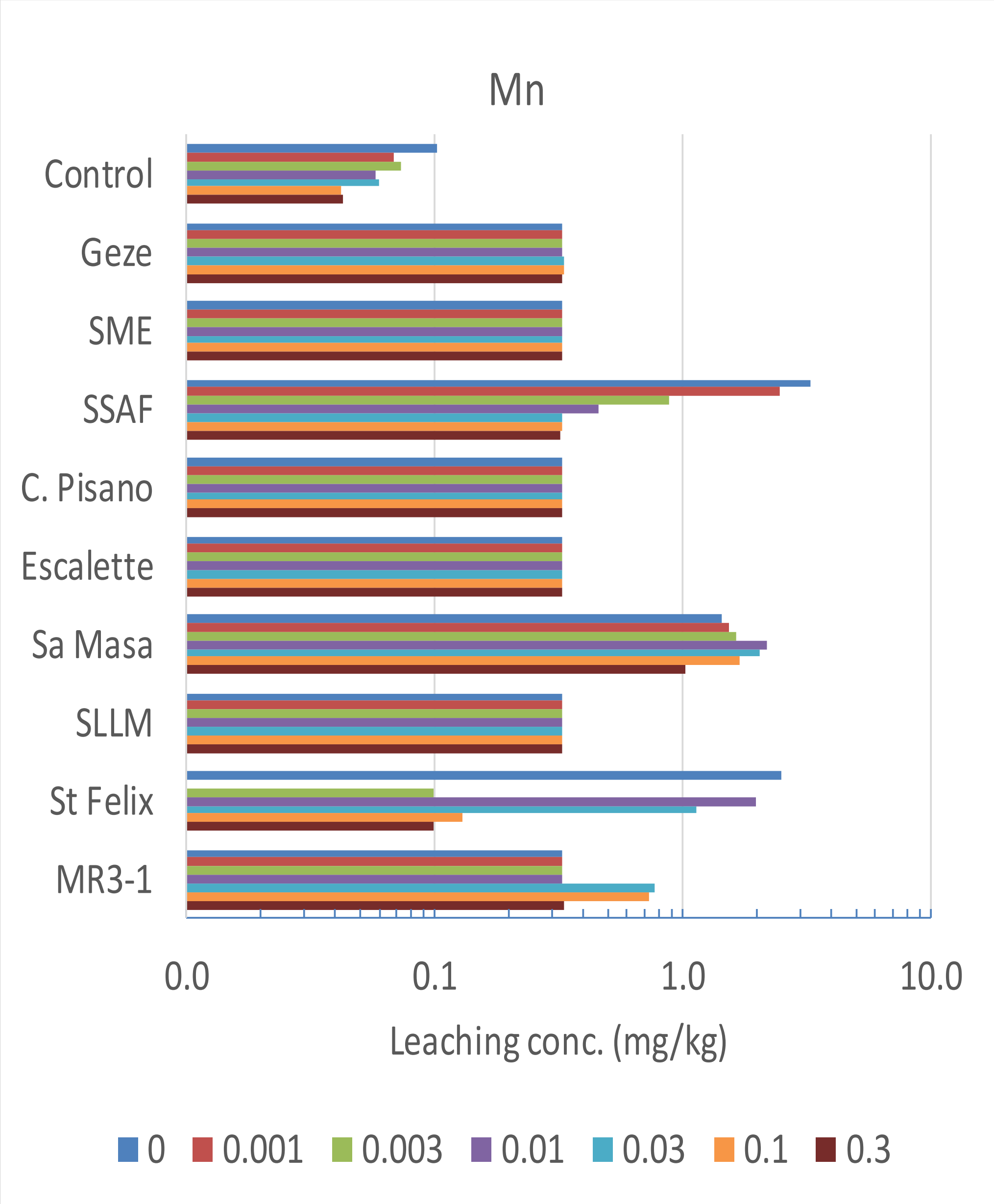


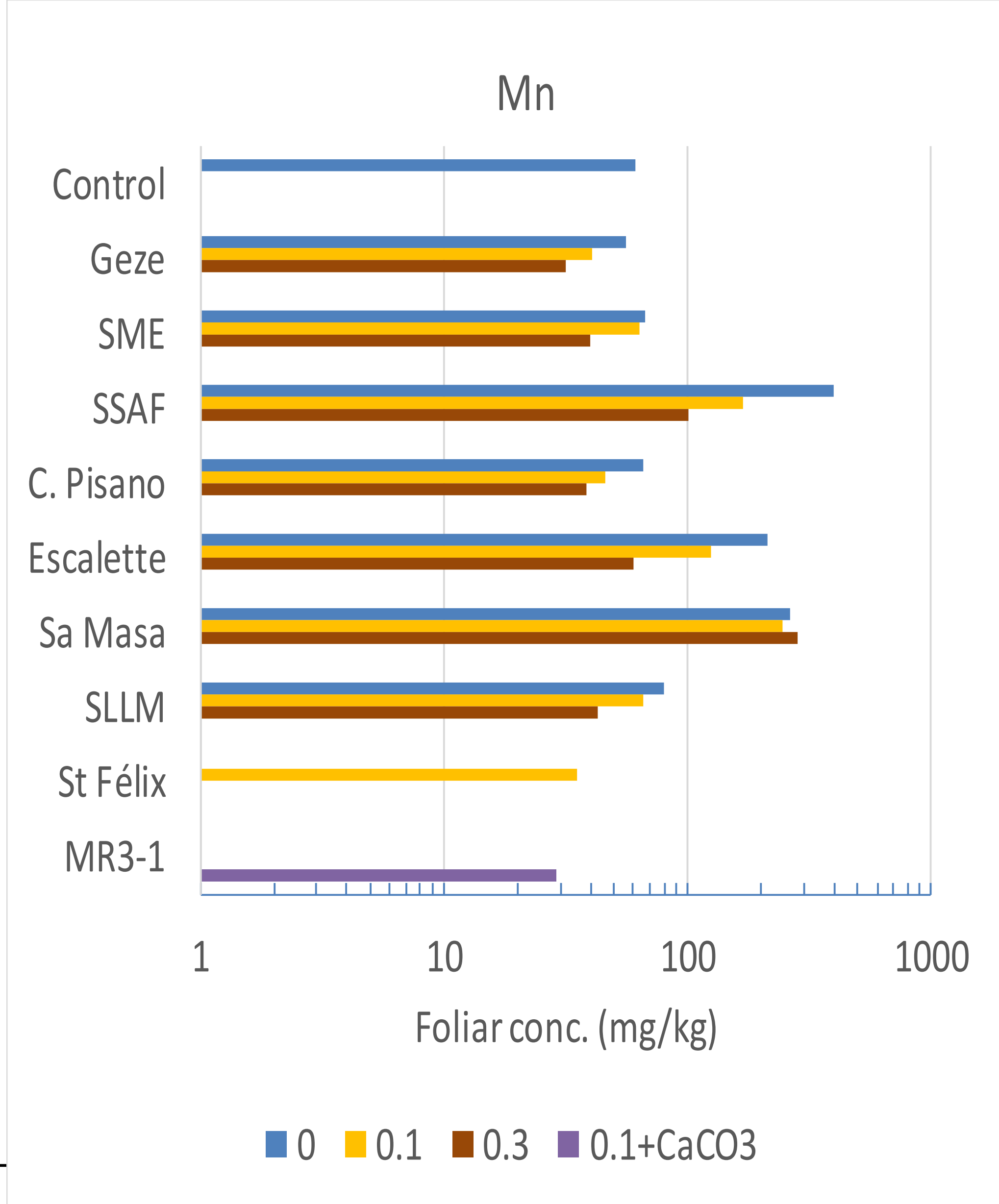
Leaching concentrations / Foliar concentrations: Al





Leaching concentrations / Foliar concentrations: Mn





Conclusions

Modified bauxite residue addition reduces the leaching concentration (10 liter deionised water/kg DM) of all elements, up to concentration of the control soil, or to the limit of quantification, depending on the amount added.

In pots, growth is poor (frequent death of plants for pots without MBR) to moderate (for 0.3 parts of MBR). Foliar concentrations are reduced with the MBR addition.

In lysimeters and plot, growth is flourishing foliar and concentrations are reduced up to the control concentration for all elements, excepted for lead (3 mg/kg for control, 62 mg/kg for St Félix and 8 mg/kg for MR3-1).

The simple leaching concentrations (with deionised water) can be used to test soil improvers, with the exception of lead.

The elements are immobilised primarily by iron and aluminum (hydr)oxides (speciation not shown). Without acidity input or reductive conditions, immobilisation should be stable.

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Plant growth on MBR landfill

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Thank you…