

# ABILITY OF *CISTUS SALVIIFOLIUS* L. TO PHYTOSTABILIZE GOSSAN MINE WASTES AMENDED WITH ASH AND ORGANIC RESIDUES

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# Introduction

- The **São Domingos mine** is within the Iberian Pyrite Belt, one of the oldest mining districts in Europe, with one of the largest concentrations of polymetallic massive sulfide deposits.



- ***Cistus salvifolius* L.**, an autochthonous plant species well adapted to extreme environments and able to grow naturally in degraded environments may contribute to minimize the negative chemical impacts and improve the landscape quality.

This work studied the effectiveness of the phytostabilization with *C. salvifolius* of gossan mine wastes from the mine of São Domingos amended with organic/inorganic wastes.

# Materials & Methods



- The amendments used were
  - *Gossam* (as control)
  - biomass ash (**BA**, 2.5 g kg<sup>-1</sup> of *gossam*) from the Huelva thermoelectric power station (plant biomass);
  - mixture of organic residues (**OR**, 120 g kg<sup>-1</sup> of *gossam*) in a 1:1:1 ratio containing distillation bagasse from carob liqueur production; a mix of agricultural residues (substrate for strawberry cultivation with plant remains) and rock wool also used for strawberry cultivation
  - mixture of both (**BA+OR**, 2.5 + 120 g kg<sup>-1</sup> of *gossam*).
- Characterization of the amendments before the trial:

|                  | Al    | As   | Ca     | Cu  | Fe     | K     | Mg    | Mn   | Mo | Na   | Ni  | Pb    | V  | Zn  |
|------------------|-------|------|--------|-----|--------|-------|-------|------|----|------|-----|-------|----|-----|
| biomass ash      | 30900 | 30   | 159000 | 215 | 19800  | 25400 | 14700 | 2880 | 4  | 5500 | 111 | 95    | 83 | 253 |
| organic residues | 25780 | 7    | 134000 | 131 | 22333  | 9367  | 22167 | 1148 | 17 | 6800 | 33  | 11    | 62 | 259 |
| <i>gossam</i>    | 20867 | 9993 | 200    | 311 | 236333 | 3267  | 300   | 50   | 11 | 767  | 16  | 33367 | 65 | 111 |

CCME, 2020, Soil Quality Guidelines for the Protection of Environmental and Human Health

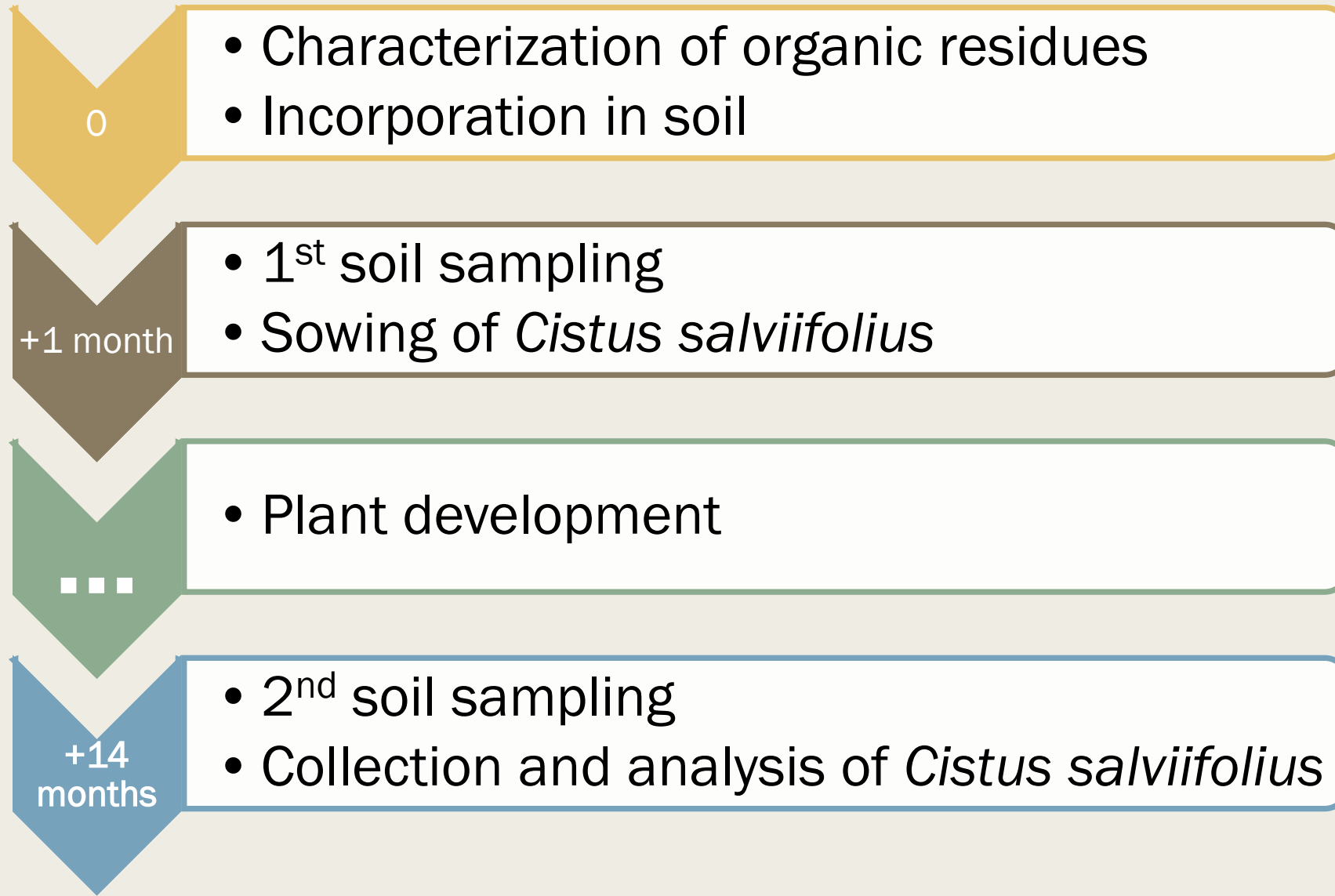
below:

above:

no data:

|                              | <i>gossam</i> | BA    | OR    |
|------------------------------|---------------|-------|-------|
| pH                           | 3.51          | 12.72 | 6.75  |
| CE (μS cm <sup>-1</sup> )    | 2.93          | ND    | 2.03  |
| C tot (g kg <sup>-1</sup> )  | ND            | 39    | ND    |
| Corg (g kg <sup>-1</sup> )   | 4             | ND    | 208   |
| N tot (mg kg <sup>-1</sup> ) | 0             | 0     | 14110 |
| C:N                          | 27            | ND    | 15    |
| P ext (mg kg <sup>-1</sup> ) | 17            | ND    | 2882  |
| K ext (mg kg <sup>-1</sup> ) | 459           | ND    | 4146  |

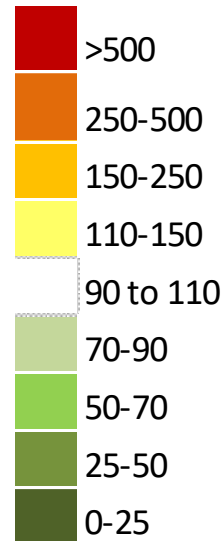
# Materials & Methods



# Results: soil

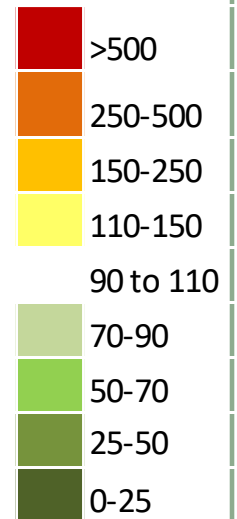


|    | Control | BA     | OR      | BA+OR   |
|----|---------|--------|---------|---------|
| Al | 112,90  | 25,68  | 203,58  | 134,97  |
| As | 130,77  | 7,64   | 28,72   | 31,60   |
| Ca | 83,07   | 71,49  | 116,20  | 212,79  |
| Cu | 118,07  | 140,74 | 93,10   | 93,10   |
| Fe | 96,44   | 23,13  | 165,65  | 113,97  |
| K  | 143,80  | 15,47  | 57,83   | 81,96   |
| Mg | 55,78   | 161,21 | 6,98    | 5,83    |
| Mn | 100,00  | 20,78  | 151,88  | 126,84  |
| Mo | 55,56   | 55,56  | 55,56   | 45,45   |
| Na | 714,18  | 47,33  | 215,24  | 122,38  |
| Ni | 101,89  | 65,06  | 66,67   | 27,55   |
| Pb | 490,00  | 231,34 | 6800,00 | 6800,00 |
| V  | 98,73   | 98,73  | 98,73   | 98,73   |
| Zn | 201,89  | 28,90  | 183,78  | 130,91  |

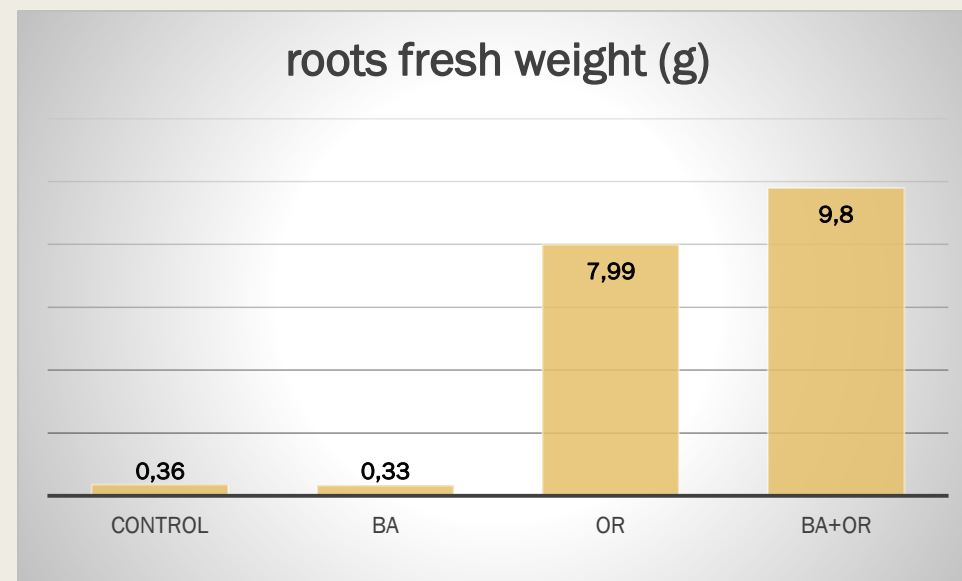
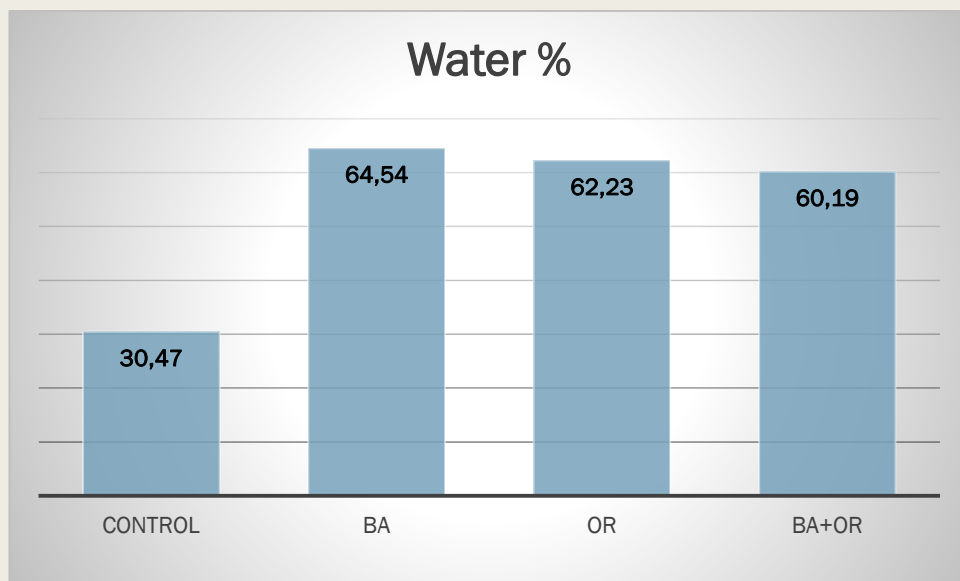
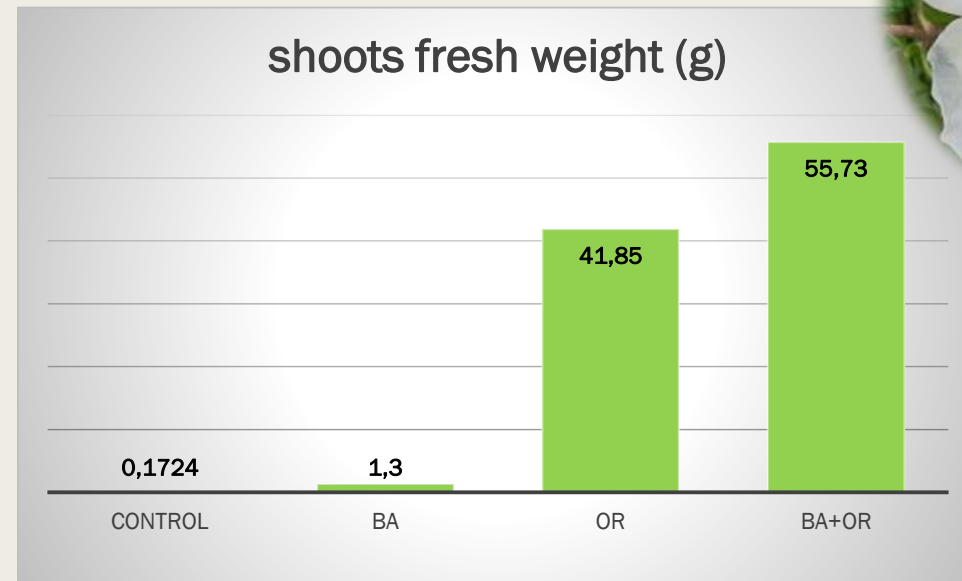
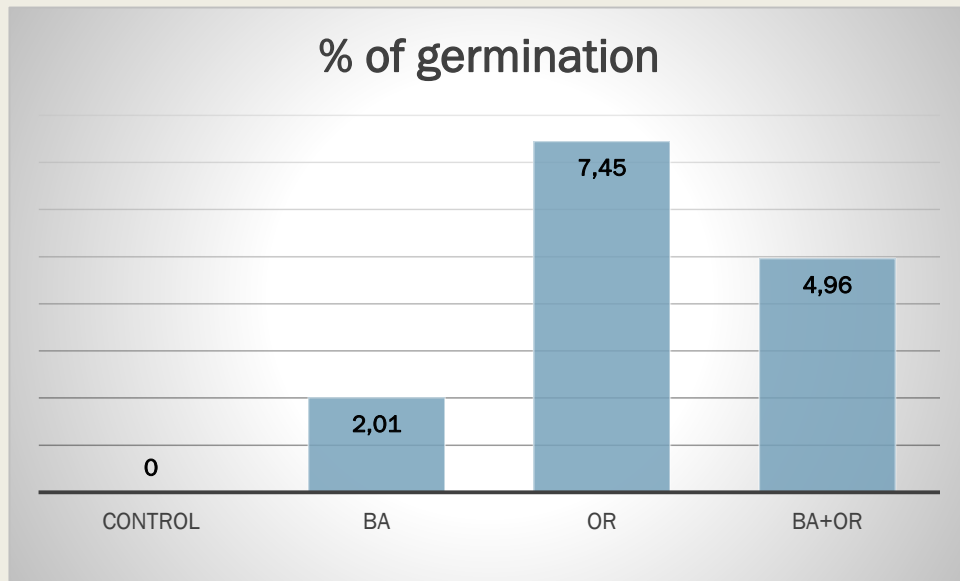


Variation (in %) of general characteristics and concentration of elements in the available fraction of the soils/amendments between the first sampling at 1 month incubation and the second sampling at the end of the assay.

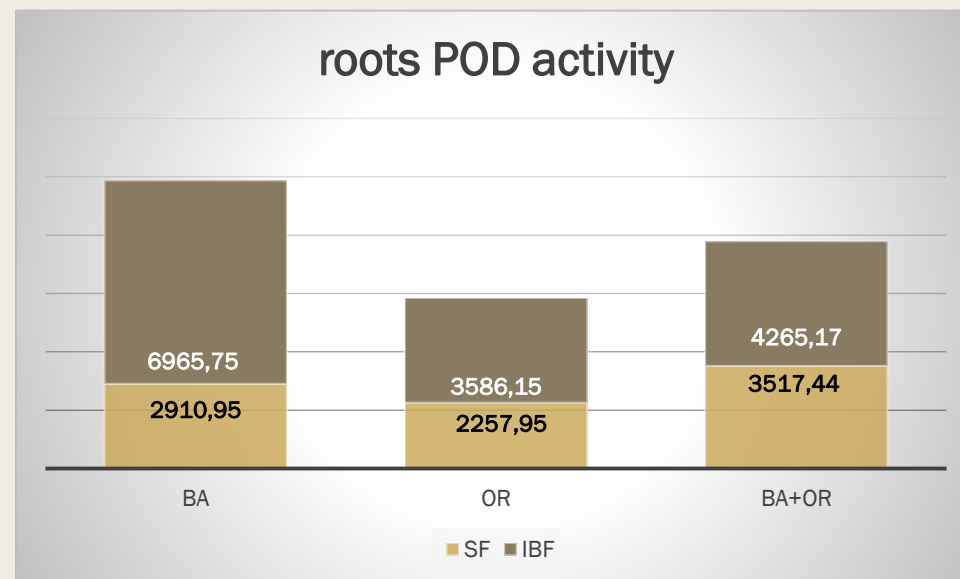
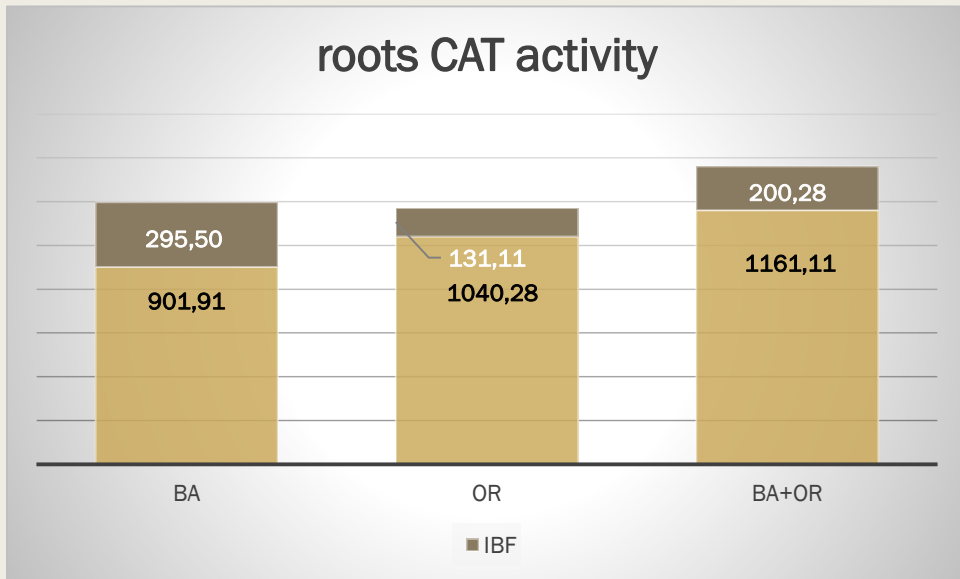
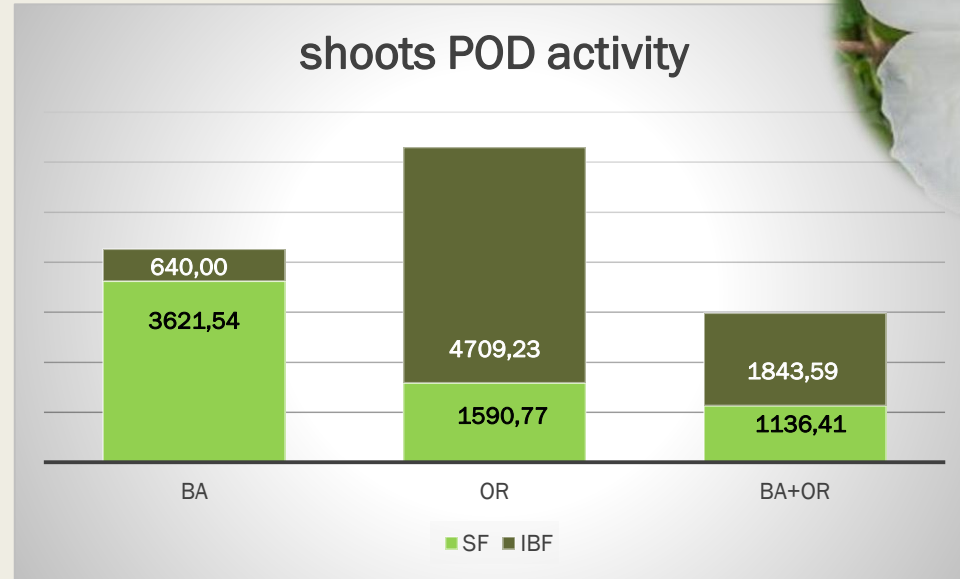
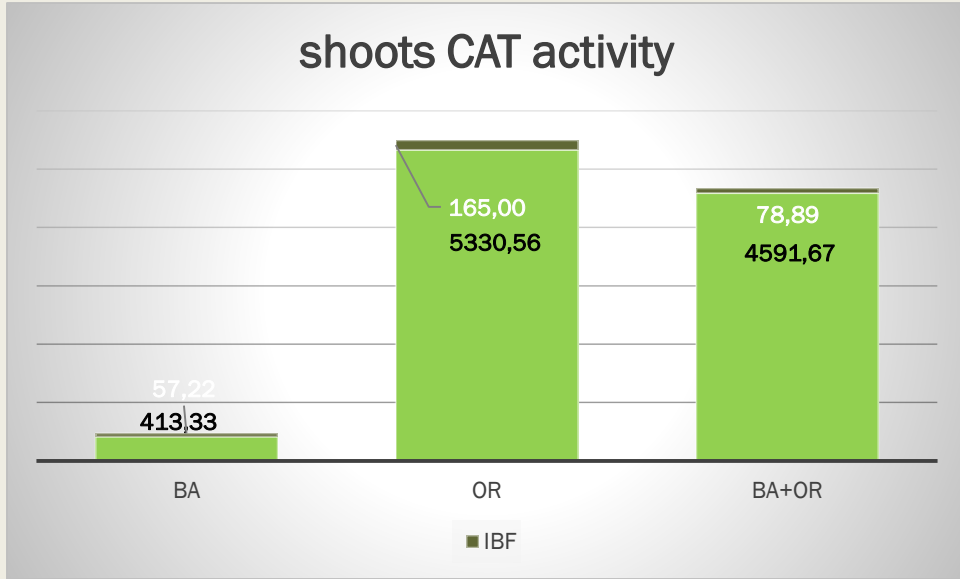
|                               | Control | BA  | OR  | BA+OR |
|-------------------------------|---------|-----|-----|-------|
| pH                            | 107     | 95  | 111 | 116   |
| CE ( $\mu\text{S cm}^{-1}$ )  | 84      | 48  | 76  | 36    |
| Corg ( $\text{g kg}^{-1}$ )   | 134     | 141 | 416 | 104   |
| N tot ( $\text{mg kg}^{-1}$ ) | 154     | 133 | 454 | 148   |
| C:N                           | 426     | 31  | 92  | 70    |
| P ext ( $\text{mg kg}^{-1}$ ) | 100     | 1   | 626 | 170   |
| K ext ( $\text{mg kg}^{-1}$ ) | 86      | 31  | 83  | 40    |



# Results: plants



# Results: plants

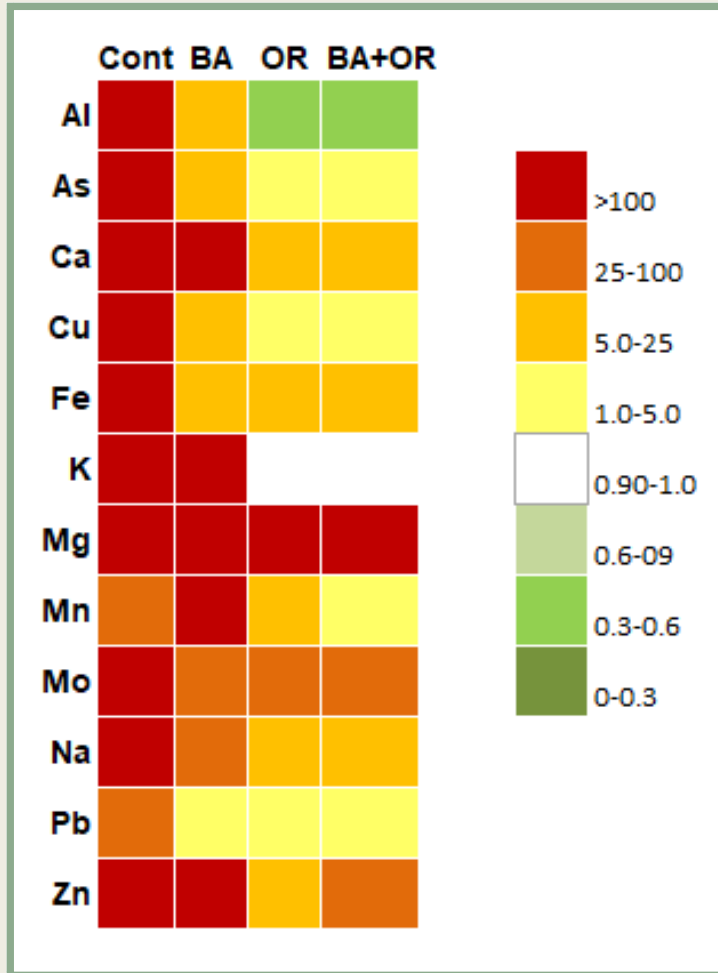


Enzyme activities in  $\mu\text{mol H}_2\text{O}_2 \text{ min}^{-1} \text{ g}^{-1} \text{ FW}$

# Results: soil/plant interaction



Coefficient of bioaccumulation of elements in plants in all treatments.



| Element | BA   | OR  | BA+OR |
|---------|------|-----|-------|
| Al      | 7    | 5   | 4     |
| As      | 1    | 0   | 0     |
| Ca      | 210  | 85  | 79    |
| Cu      | 10   | 2   | 2     |
| Fe      | 1    | 1   | 1     |
| K       | 137  | 148 | 134   |
| Mg      | 135  | 105 | 103   |
| Mn      | 1076 | 160 | 57    |
| Mo      | 23   | 50  | 33    |
| Na      | 10   | 7   | 7     |
| Pb      | 0    | 0   | 0     |
| Zn      | 32   | 27  | 13    |

Percentage of element accumulation in shoots in treatments in relation to the control (*gossam*).





# Conclusion

The application of amendments, especially containing **organic matter** (mixture or single application), together with the phytostabilization allowed the improvement of the plant-soil system.

We observed:

- a better plant cover
- improvement of chemical characteristics of the mine wastes: decrease of the majority of PHE in the available fraction, increase of fertility and water-holding capacity
- ... and a speed up of the the environmental rehabilitation.

# Acknowledgments

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