

RESUMEN MINETOX (Castellano)

La búsqueda de soluciones y alternativas para paliar los impactos de las actividades minero-industriales supone un reto a nivel mundial. La consecuencia principal derivada de la contaminación por residuos de minería es la presencia de elevadas concentraciones de elementos potencialmente tóxicos. Las alternativas de manejo y recuperación de estas zonas no son fáciles, ya que hay que conjugar aspectos científico-técnicos con la viabilidad económica y el impacto social de las propuestas. En este proyecto consideramos el biochar una enmienda adecuada para la remediación de residuos mineros, aunque su comportamiento dependerá de las características del propio biochar (en función del residuo orgánico a partir del que se fabrique), de la contaminación y las condiciones biogeoquímicas de los residuo.

Nuestra hipótesis de partida es que la toxicidad es un factor clave asociado a la contaminación por residuos mineros y que para evaluarla adecuadamente hay que ir más allá de conocer las concentraciones solubles o biodisponibles, siendo necesario analizar el efecto de éstos en los organismos expuestos. Por tanto, estos organismos podrían ser utilizados como bioindicadores de toxicidad, así como de los efectos que las estrategias de remediación tienen para reducirla. En este proyecto, LEITAT incorpora ensayos con invertebrados edáficos que presentan diferentes vías de exposición a los contaminantes presentes en los residuos mineros, lo que nos permitirá estimar el pool de metales disponibles en la fase sólida y acuosa de los residuos mineros antes y después de su tratamiento con diferentes enmiendas. La realización de estos ensayos en diferentes tipos de residuos y condiciones hidrológicas nos permitirá realizar evaluaciones de la eficacia de las enmiendas aplicadas en diferentes escenarios de exposición.

Los objetivos específicos que nos planteamos en este proyecto desde LEITAT son: i) Valorar en qué medida la adición de biochar procedente de residuos sólidos urbanos (RSU) y lodos de depuradora (EDAR) puede modificar la toxicidad de los residuos mineros enmendados (al inicio y al cabo de 6 meses del tratamiento) sometidos o no a hidromorfía, utilizando invertebrados edáficos como bioindicadores.

ABSTRACT MINETOX (English)

Mining activity results in the accumulation of waste scattered in the landscape. When trace elements contained in the wastes are mobilized, they can be transported in drainage waters increasing the risk of pollution of surrounding ecosystems. This pollution not only degrades the quality of soil, aquatic and atmospheric environment, but can also affect crop growth, causing serious problems to human health.

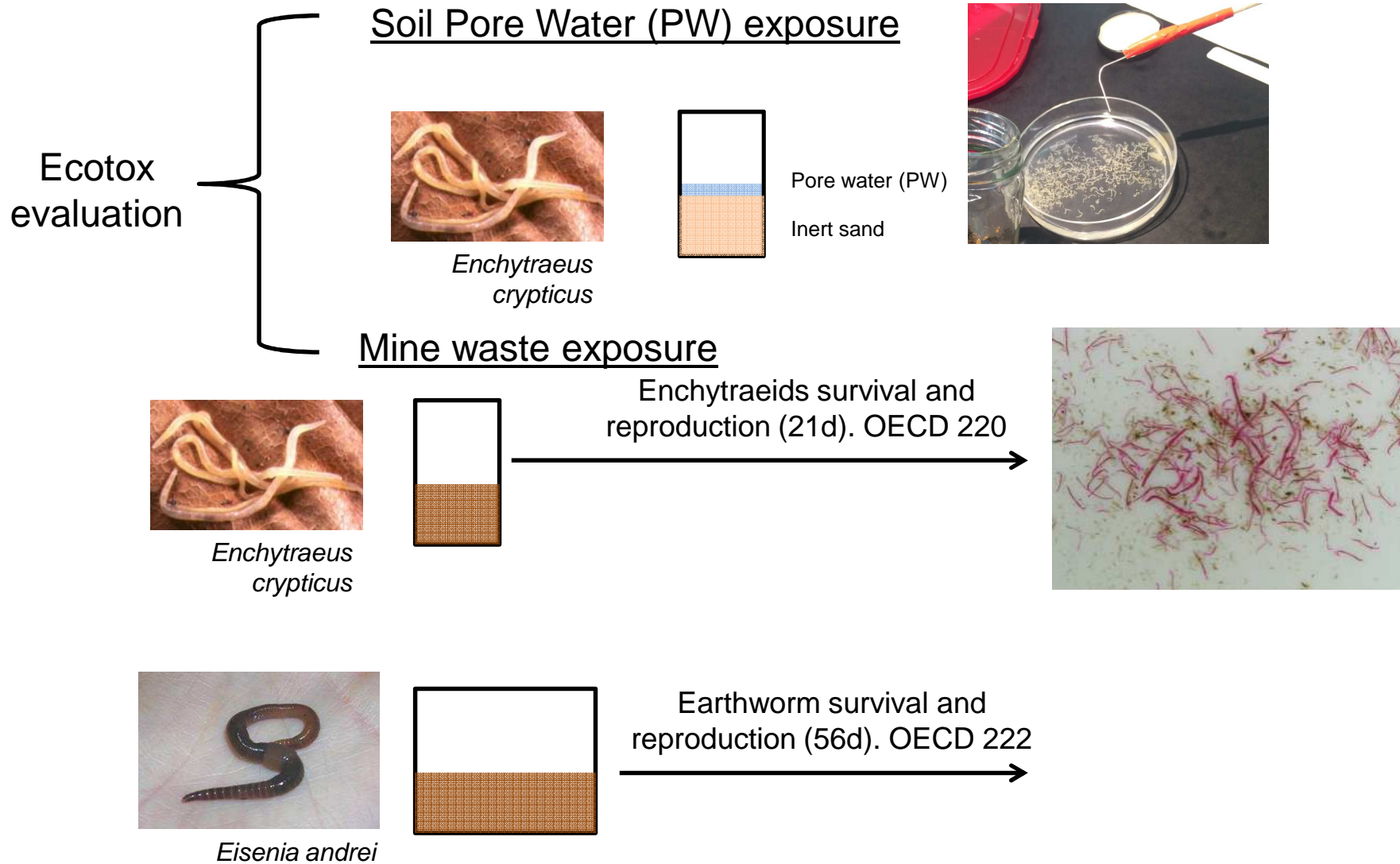
Remediation of soils contaminated with trace elements is mainly based either on the extraction or on the stabilization of the contaminants. Stabilization is based on the use of amendments to accelerate the processes of sorption, precipitation, and complexation that naturally take place in soils to reduce mobility and bioavailability of trace elements. Biochars are biological residues combusted under low oxygen conditions, resulting in a porous, low density carbon rich media. The use of biochar is inexpensive and sustainable because the substrates are waste products and their incorporation uses simple low energy mechanical mixing techniques.

In this project, we apply two types of biochars (from municipal solid wastes and from sewage sludge from a waste water treatment plant) as amendments capable of immobilizing trace elements whilst also providing a medium suitable for the re-vegetation of mining waste. The overarching aim of this project is to evaluate the toxicity of two different types of mining

wastes using a battery of bioassays. The bioassays will be selected in order to take into account the pathways along which organisms will be exposed to pollutants in wastes. Firstly, we will assess the toxic effect on enchytraeids who will be exposed to the fraction of pollutants dissolved in the soil pore water. Secondly, the uptake of pollutants adsorbed to solid particles and the toxic effect of the mining wastes (bulk) will be tested in enchytraeids and earthworms.

The toxicity data obtained from these bioassays will be compared with the physicochemical properties characterized in each treatment to assess the effectiveness of the different biochars in remediating mining wastes.

LEITAT experimental setup





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Proyecto: MINETOX
(Retos de Investigación 2013)

Application of bioassays with *Enchytraeus crypticus* to evaluate the effect of biochar in metal bioavailability

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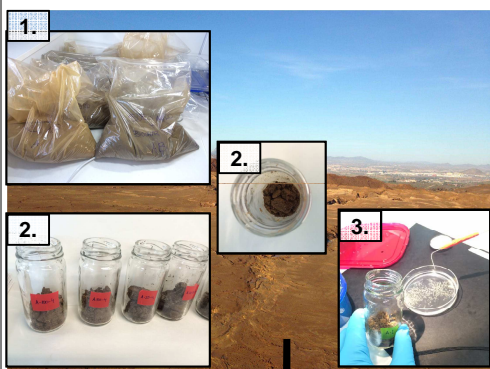
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OBJECTIVE

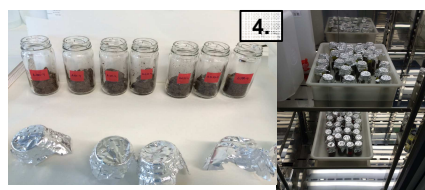
Mining activity results in the accumulation of waste scattered in the landscape. When contaminants contained in these wastes are mobilized, the risk of pollution of surrounding areas increases, degrading soil quality and causing serious problems to human health. **Biochar** is a stable carbon-rich by-product synthesized through pyrolysis/carbonization of plant- and animal-based biomass. Some studies demonstrated that biochar has potential for the reduction of a variety of organic and inorganic contaminants present in soils (Beesley et al., 2011). Sorption mechanisms for metal-contaminated soils by biochar could be dependent on the type of soils and the cations present in both soils and biochar, and thus implications for metal remediation in contaminated soils could vary.

The main objective of this study is to establish the effect of biochar in metal availability and toxicity of two different types mine wastes by means of the ecotoxicological characterization of the treatments.

MATERIALS & METHODS



Survival and reproduction studied



1. An acid mine waste (A) and a basic one (B) were amended with two different types of biochars: one from pruning remains (BRU) and the other from waste water treatment plant (BED). Physicochemical properties are shown in Table 1.

	Mine waste		Biochar	
	A	B	BED	BRU
pH	4.69 ± 0.13	7.43 ± 0.15	8.2 ± 0.12	9.8 ± 0.4
EC (dS m ⁻¹)	5.32 ± 0.27	2.69 ± 0.17	0.18 ± 0.03	0.52 ± 0.04
CaCO ₃ (g kg ⁻¹)	nd	6.33 ± 0.44	7.07 ± 0.31	8.45 ± 0.24
CEC (cmol _c kg ⁻¹)	6.43 ± 0.44	4.61 ± 0.37	25.4 ± 0.6	37.5 ± 1.1
Sand (g kg ⁻¹)	72.1 ± 2.4	88.0 ± 1.4	nd	nd
Silt (g kg ⁻¹)	20.7 ± 1.96	9.80 ± 1.34	nd	nd
Clay (g kg ⁻¹)	7.17 ± 0.59	2.17 ± 0.15	nd	nd
Cu (mg kg ⁻¹)	203 ± 19	88.5 ± 6.9	435 ± 14	39.5 ± 3.0
Zn (mg kg ⁻¹)	13956 ± 406	11784 ± 404	1043 ± 64	58.1 ± 5.5
Cd (mg kg ⁻¹)	16.7 ± 0.4	30.9 ± 2.2	2.08 ± 0.32	0.12 ± 0.03
As (mg kg ⁻¹)	975 ± 56	611 ± 27	5.83 ± 0.60	2.87 ± 0.23
Pb (mg kg ⁻¹)	16758 ± 291	7354 ± 210	126 ± 7	7.50 ± 0.52

Table 1. Characteristic of the mine wastes and biochars used in this study (EC=electrical conductivity; nd=no data).

2. The six different treatments (A, A-BED, A-BRU, B, B-BED and B-BRU) were mixed with the natural soil LUFA 2.2 to obtain concentrations of 100, 50, 25, 12.5, 6.25, 3.13 % (w/w) of waste, moist to reach 50% of their maximum water holding capacity and left 5 days for equilibration.

3. The effect on the survival and reproduction of *Enchytraeus crypticus* (OECD 220, 2004) were used to evaluate the toxicity of amended and unamended mine wastes.

4. LC₅₀ (ratio of waste causing 50% of effect on survival in respect to the control) and EC₅₀ (ratio of waste causing 50% of effect on reproduction) values were calculated by using the logistic model according to Haanstra et al. (1985) and expressed on the basis of the ratio waste concentrations. All analyses were conducted in SPSS 17.0.

Survival and reproduction in control soils (LUFA) met the validity of the test (OECD 220, 2004).

No effect on survival and reproduction of enchytraeids was observed when expose to waste B, B-BED and B-BRU (Figure 2 and 4).

The application of biochar from waste water treatment plant (BED) was the most effective treatment in reducing effect on survival in waste A (Figure 1). In waste A, an LC₅₀ of 29% (a ratio of 29% of soil reduced survival at 50% in respect to control) was observed, this value was increased to 89% in waste A-BED (Table 2).

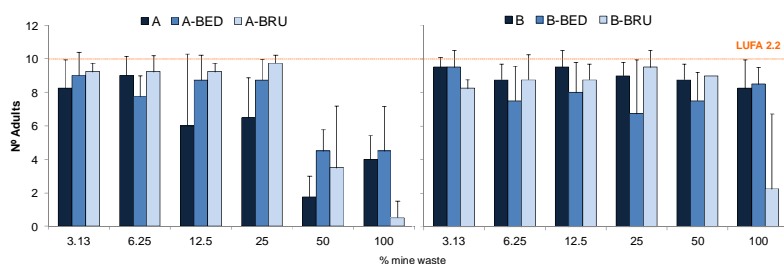


Figure 1. Effect on survival in waste A, A-BED and A-BRU

Figure 2. Effect on survival in waste B, B-BED and B-BRU

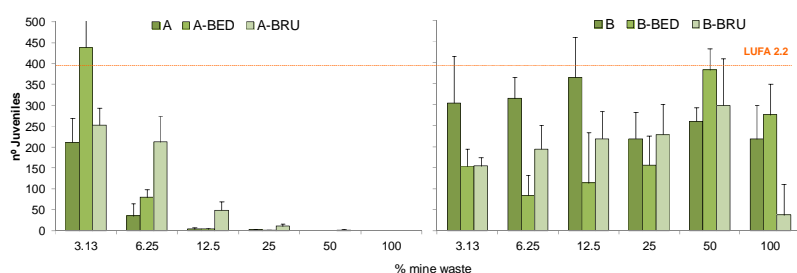


Figure 3. Effect on reproduction in waste A, A-BED and A-BRU

Figure 4. Effect on reproduction in waste B, B-BED and B-BRU

	LC ₅₀	EC ₅₀
A	29 [4.0 - 54.3]	3.4 [2.73 - 3.97]
A-BED	89 [30.6 - 147]	6.1 [-]
A-BRU	48 [-]	5.9 [3.87 - 7.96]
B	>100 [-]	>100 [-]
B-BED	>100 [-]	>100 [-]
B-BRU	95 [-]	>100 [-]

Table 2. Effect on *E. crypticus* survival and reproduction observed in the different treatments.

Reproduction resulted to be a more sensitive endpoint than survival, the number of juveniles was reduced to 50% (in respect to the control) at a ratio of 3.4% of the mine waste A (Table 2). When amended with both types of biochar (BED and BRU), the toxic effect of waste A on reproduction decreased. In waste A-BED and A-BRU, EC₅₀ values of 6% and 5.9% were estimated, respectively (Figure 3). No significant differences were found between both types of biochars.

CONCLUSIONS

- ✓ The application of biochar was effective in reducing the toxicity of the acid mine waste
- ✓ Biochar from waste water treatment plan showed the best efficacy.

RESULTS & DISCUSSION