BIOFUEL PRODUCTION FROM PHYTOREMEDIATION DERIVED SUNFLOWER BIOMASS

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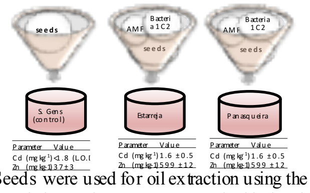
Introduction

There are presently more than 3 million contaminated sites all over EU, according to the EEA (report 25186 EN). Heavy metal (HM) contamination is of particular concern, as metals are not degradable and only transferable form one matrix to another [1]. Phytoremediation, a biologically based technology, is gaining attention from the public and is an attractive low cost alternative for soil requalification, by establishing a vegetation cover which will stabilize the site, avoiding dispersion of contamination and simultaneously removing pollutants present in the brownfield [1]. Although the fate of harvested biomass is a common obstacle for its implementation, it may represent an opportunity for producing biofuels. However, and although it has been proposed theoretically as an excellent option, the information available in literature concerning practical applications is scarce, despite the considerable degree of success reported [2,3,4].

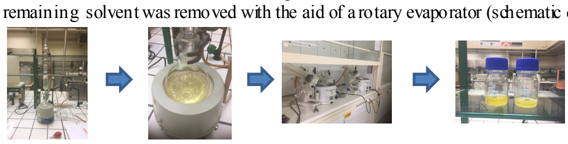
The use of biomass grown in degraded and abandoned soils, not involving agricultural soils for energy crop cultivation, may increase the sustainability of utilizing biomass for fuel generation, while it may allow for increasing the available agricultural soil through the consequent gradual decontamination of such brownfields. This work presents a novel integrated strategy comprising the utilization of sunflower phytoremediation derived biomass for the generation of several energy products.

Methods

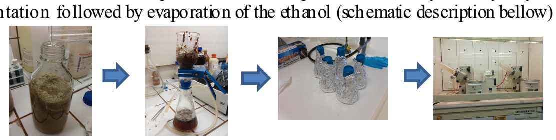
Sunflower was propagated on a greenhouse in 3 different treatments: control soil (agricultural) and industrial soil (near an industrial complex at Estarreja, Portugal, where in the past waste and effluents were directly discharged to the soils) and a mining soil (from the Panasqueira mining area in Portugal)* the last two inoculated with an arbuscular mychorrizal fungi (*Rhizophagus irregularis*) and a plant growth promoting rhizobacteria (*Ralstonia eutropha*). Growth occurred for 6 months, after which plants were separated in flowers, stems, roots and seeds, dried and grinded (schematic description bellow).



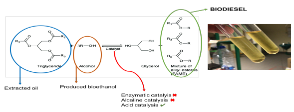
Seeds were used for oil extraction using the Soxhlet method with hexane as a solvent, and then the remaining solvent was removed with the aid of a rotary evaporator (schematic description bellow)



Stems were used for bioethanol production via acid pre-treatment, enzymatic hydrolysis and fermentation followed by evaporation of the ethanol (schematic description bellow)



Biodiesel generation from the extracted oils via acid-catalysed transesterification with the bioethanol produced was performed



*No growth occured on plants seeded on the Panasqueira soil

Results and Conclusions

Table 1. Biomass of sunflower

Treatment	Biomass (g)			
	roots	stems	flowers	seeds
Control	33.66	750.12	223.77	62.57
Industrial	19.35	620.21	199.36	51.92

Biomass for all the plant sections is described in Table 1; it is possible to see that Control > Estarreja

Metal accumulation is shown in Table 2. It is possible to see that Control (bellow phytotoxicity levels) < Industrial and that for plants grown in the Industrial soil Zn_{root}, Zn_{stem} e Zn_{flower} > phytotoxic levels (100 mg/kg) and Cd_{root}, Cd_{stem} e Cd_{flower} > phytotoxic levels (5 mg/kg)

Table 2. Metal accumulation in sunflower

Treatment	Zn (mg/kg dry weight)				Cd (mg/kg dry weight)			
	root	stem	flower	seeds	root	stem	flower	seeds
Control	67 ± 3	56 ± 5	36 ± 11	2 ± 1	1.6 ± 0.2	1.0 ± 0.1	n.d	n.d
Estarreja	434 ± 6	343 ± 9	129 ± 7	4 ± 2	24 ± 2	15 ± 2	5.3 ± 0.6	0.5 ± 0.2

The volume and metal concentrations of the oil extracted from the collected sunflower seeds is registered in Figure 1; similarly to biomass production, an probably as a consequence of it, volume of oil extracted decreased for plants growing in metal contaminated soils. The oil produced in Industrial soil presents only low Zn levels and none of the metals were detected for the oil derived from plants growing in the control soil

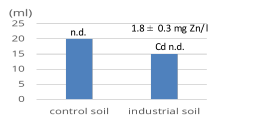


Figure 1. Oil production from sunflower (ml)

Table 3. Production yields of bioethanol

	Production yield % (m/v)	Total yield (ml/m²)
Control	**27.8**	280
Industrial	**19.4**	162

Table 4. Metal levels in bioethanol

	Zn (mg/l)	Cd (mg/l)
Control	n.d.	n.d.
Industrial	1.1 ± 0.1	n.d.

Production yields and metal levels of biotehanol are respectively shown in Tables 3 and 4. Concerning the yields it was observable that Control > Industrial; for metal concentrations it was possible to conclude that low levels were found for the ethanol produced from Industrial soil grown plants and that no metals were detected for the ethanol produced from control plants

No metals were detected in the produced biodiesel after transesterification of the extracted oils with the produced ethanol

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