BIOFUEL PRODUCTION FROM PHYTOREMEDIATION DERIVED SUNFLOWER BIOMASS

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1. **Keywords**

Soil contamination, phytoremediation, heavy metals, bioenergy products

2. **Highlights**

- Plants growing on metal contaminated soil showed metal accumulation to phytotoxic levels
- Accumulations on the plant tissues varied as follows: roots > stems > flowers > seeds.
- Oil and ethanol produced from plants grown in contaminated soils presented low metal levels
- it was possible to produce biodiesel with the generated energy products

3. **Purpose**

There are presently more than 3 million contaminated sites all over EU, according to the EEA (report 25186 EN). Heavy metal contamination is of particular concern, as metals are not degradable. Phytoremediation 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. Although the fate of harvested biomass is a common obstacle for its implementation, it may represent an opportunity for producing energy.
This work presents a novel integrated strategy comprising the utilization of all plant parts for the generation of biodiesel. Combinations of sunflower and plant growth promoting microbiota were assessed growing in agricultural and metal contaminated soils.

4. **Materials and methods**

Sunflower was propagated exposed to different conditions of HM contamination (target metals were Cd and Zn), namely agricultural (control), industrial (from the area of Estarreja, an industrialized region with a history of Cd and Zn soil contamination and a mining area (Panasqueira, with recognized high levels of Cd and Zn contamination). Plants were harvested after 5 months of and tissue biomass was determined; heavy metal levels in plant tissues were determined through flame atomization atomic absorption spectrophotometry (FA-AAS) analysis of digested plant samples.

From the sunflower seeds collected for each treatment oil was extracted with hexane as a solvent in Soxhlet extractors (NP EN ISO 659:2002) followed by vacuum evaporation at constant temperature with a rotary evaporator.
Sunflower stove was used to produce bioethanol; chemical pre-treatment to promote lignin and hemicellulose fractionation was applied through acid hydrolysis, followed by enzymatic hydrolysis. The resulting hydrolysate, was then fermented to ethanol using *Saccharomyces cerevisea*. To recover the alcohol from the fermentation a distillation using vacuum evaporation at constant temperature with a rotary evaporator was applied.
Biodiesel transesterification with acid catalysis has been optimized for the sunflower oil and etanol, and analysis for FAME's and heavy metals was performed.

5. Results and discussion

Sunflower plants growing on the agricultural soil presented Zn and Cd tissue concentrations bellow the ones indicated as phytotoxic in literature for all plant sections, while plants growing in Estarreja soil showed metal accumulation to phytotoxic levels (with the exception of the harvested seeds), with the accumulations varying as follows: roots > stems > flowers > seeds.
The volumes of recovered oil were 25 and 15 ml m^{-2} for the agricultural and industrial treatments respectively (in optimal conditions in the field sunflower can produce up to 80 ml m^{-2})– with similar extraction yields of ca. 32% (when considering the ml extracted per g of seeds produced).
However, and concerning the levels of the target HM via FA-AAS, the oil produced in Estarreja soil presents low metal levels (1.8 mg Zn l^{-1} and no Cd), while none of the metals was detected in the oil derived from plants growing in the control soil
Concerning ethanol, production yields were of 27.8 and 19.4% (m/v) for the control and Estarreja treatments respectively - corresponding to 280 and 162 ml m^{-2}. Heavy metal levels of the obtained bioethanol, were determined by FA-AAS and no metals were detected in the ethanol produced from control plants, while only a low level of Zn was found for the ethanol produced from Estarreja grown plants (1.1 mg Zn l^{-1}).

6. Conclusions and perspectives

The production of energy products in metal contaminated soils appears as a possibility to counterpart the growing world energy needs, while providing a solution for degraded soils

7. References

(1) Ana P.G.C. Marques, Nídia S. Caetano, Paula M.L. Castro, "Strategies for enhancing soil phytoremediation and biomass valorisation", peered for publication in the Handbook of Environmental Remediation: Classic and Modern Techniques, edited by Chaudhery Mustansar Hussain. The Royal Society of Chemistry, Cambridge, UK