Life cycle assessment of biodiesel produced from sunflower oil from soil phytoremediation

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Abstract. - *Soil contamination is a current problem, especially when this contamination is caused by heavy metals. In order to promote soil decontamination, less aggressive and economically feasible alternatives for soil remediation have been studied. For this purpose, the concept of phytoremediation emerges as an alternative. This technique consists in the use of plants with the purpose of decreasing the toxicity and the concentration of soil, water or air contaminants. The application of phytoremediation allows contaminated soils to be useful again, promoting the sustainability concept.*

In order to evaluate the sustainability of using phytoremediated soils for biodiesel production, a life cycle assessment (LCA) study was conducted.

LCA is considered a suitable tool for sustainability evaluation, which allows the quantification of environmental impacts caused by a specific product/process, helping in decision making in the selection of products or processes that have less impact on the environment. Therefore, the LCA study performed in this work intended to characterize the environmental performance of the different stages of biodiesel production, in order to investigate if the use of seeds grown in phytoremediated soil are a good alternative for the reuse of contaminated land.

To implement the LCA methodology, the ISO 14040:2006 and ISO 14044:2006 standards were used as a guide for the development of the practical work. The performed Life Cycle Assessment study followed a cradle-to-gate approach, where all life cycle steps were considered from raw material cultivation to the obtaining of the final product. The functional unit was defined as 1 kg of biodiesel. In order to quantify the environmental impacts, the ILCD 2011 Midpoint+ V1.10 / EC-JRC Global, equal weighting method was used, in which ten relevant environmental impact categories for the study were selected.

Four scenarios were considered for the study: baseline scenario, which considered the use of the national energy mix as the energy source and 100% virgin hexane for oil extraction; scenario 1, which considered the use of photovoltaic renewable energy and 100% virgin hexane for oil extraction; scenario 2, which considered the use of the national energy mix as the energy source with 80% recycled and 20% virgin hexane for oil extraction; scenario 3, in which the use of photovoltaic renewable energy and 80% recycled and 20% virgin hexane for oil extraction was combined.

From this study, it could be concluded that the impacts generated by biodiesel from sunflower oil from plants from industrial soil phytoremediation, in all the presented scenarios, differ at most about 35% compared to the control soil, and the impacts were always higher in the contaminated soil. Of all the biodiesel production stages, cultivation was the one that produced the greatest impacts. The values obtained in the cultivation did not change in the different scenarios because they only depend on water consumption. From this stage, the biggest environmental impacts

ISSN: 2594-1925

associated with the impact categories of climate change (CC) and freshwater ecotoxicity (FEC) stand out, with values of 1.16 x 10^2 kg CO_2 eq and 1.25 x 10^3 CTUe for the control soil and 1.56 x 10^2 kg CO_2 eq and 1.67 x 10^3 CTUe for the industrial soil, respectively. As for the remaining steps involved in biodiesel production, it was unanimous that the categories that caused the most impacts were those associated with climate change and freshwater ecotoxicity.

In this study, it was also determined, for both soils, the relative importance of the different materials used throughout the life cycle, for the baseline scenario and considering the use of 80% recycled hexane without changing the energy source. From this analysis, it can be concluded that in both scenarios, water causes the greatest impacts, followed by hexane as a contributing material. Making an overall analysis, compared to the baseline scenario, the other scenarios present lower impacts in almost all impact categories.

In order to ensure the best use of industrial soil, the scenario that should be taken into consideration to cause the lowest environmental impacts, is the one that compiles the change of the national energy mix with the replacement of the solvent hexane 100% virgin with recycled hexane, therefore, the last scenario.

To conclude, it can be expected that the use of sunflower from phytoremediation of contaminated soils in the production of biodiesel is a good alternative to avoid unnecessary use of arable land and to promote the reuse of unused soils, allowing an additional valorization of biomass resulting from phytoremediation of contaminated soils, while the soils cannot be used for food crops.

Keywords: Biodiesel; Life cycle assessment; Heavy metal contaminated soil; Phytoremediation; Sunflower biomass.

ISSN: 2594-1925