Environmental assessment of bioethanol production from lignocellulosic crops

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Novelty: A multi-scale approach using agro-ecosystem and landscape models is developed to calculate the emissions of greenhouse gases (GHG), especially N_2O, related to crop and landscape management. This approach is used to improve the Life Cycle Assessment (LCA) of second generation biofuels.

Context: 20% of fuel have to be produced from renewable origin in 2020, and meet a 50% decrease of GHG emission compared to fossil fuel (RED Directive, 2009/28/CE). Besides, agriculture represents 10 to 15% of GHG emissions in France and especially 65% of N_2O emissions which have a huge global warming potential (310 times higher than CO2, according to IPCC 2007). Therefore, it is essential to carefully develop, evaluate and use relevant methods to assess the environmental balance of lignocellulosic crops (2nd generation biofuels).
Even if they all demonstrate a net reduction in GHG emissions, LCA of 2nd generation biofuels do not present any common methodology (Cherubini and Stromman, 2011). Main differences during the crop cycle are due to the generic factors used to calculate GHG emissions and the lack of consideration for land use change. A multi-scale approach is required to fulfill a complete LCA. Indeed, GHG emissions are strongly bound with local pedo-climatic conditions and technological options (especially N application rates). This approach is used to estimate direct GHG emissions, downstream indirect GHG emissions and emissions due to land use change.

Scope: The LCA is carried out for a lignocellulosic bio-ethanol industrial unit, located in France, supplied by a mixture of feedstocks: annual and dedicated crops (triticale and fiber sorghum), perennial crops (miscanthus and switchgrass), forest and crop residues (straw) and possibly short rotation coppice (SRC). The study focuses mainly on a supply area around the industrial unit located in the Champagne-Ardenne region. However, we aim at developing generic methods.

Material and methods: The agro-ecosystem model CERES-EGC (Gabrielle *et al*., 2006) is used to simulate GHG emissions at plot scale (i.e., a few hectares). This model calculates direct emissions in relation to local soil and climate conditions.
Downstream indirect emissions are simulated from the NitroScape model (Duretz *et al*. 2011), that accounts for hydrological and atmospheric transfers of reactive nitrogen between landscape elements (e.g., plots, farm buildings). That model works at a scale of typically a small watershed or a few (20-30) square kilometers and make it possible to estimate uncertainties made when considering only direct emissions.
The CERES-EGC model will be possibly used at regional scale and combined with prospective scenarios of land use change from conventianl crops towards lignocellulosic crops.

Results and discussion: The methodological approach for assessing LCA is currently under development. Primary results are expected for the end of 2011 (November). They should present LCA simulated at farm gate for a mixture of feedstock and integrated at plot and regional scales.

Conclusion: This method is useful to reduce uncertainties in estimates of GHG emission, one of the steps that have important impact in biofuel LCA. Moreover it will be applied in the French project FUTUROL to assess the sustainability of a project of bio-ethanol production plant.

References

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