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Environmental assessment of sludge spreading practices and equipments: A simplified LCA tool (acv3E) designed for stakeholders

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Introduction

Cemagref research teams aim to improve environmental performances of sewage sludge and organic products spreading by combining Life Cycle Assessment approaches and technologies ecodesign². One of the research project objectives conducted these last years refer to the question of project result transmission to the different stakeholders (equipment designers, spreading contractors, farmers, sewage managers, policymakers...).

This leads us to develop a simplified LCA tool, acv3E³, to help stakeholders to better understand the environmental contributions of a spreading process. This software allows the environmental impact assessment of spreading practices from sludge's transportation to spreading including fuel consumption and nitrogenous emissions.

In this paper, we will present the software structure, its interface, the results that can be obtained and their possible uses (for spreader ecodesign or for sludge spreading management).

Material and methods

LCA system boundaries and functional unit

The LCA system boundaries are shown in Figure 1. The software is designed for sewage sludge spreading but recent development will take into account other organic fertilisers (manure, slurry...).

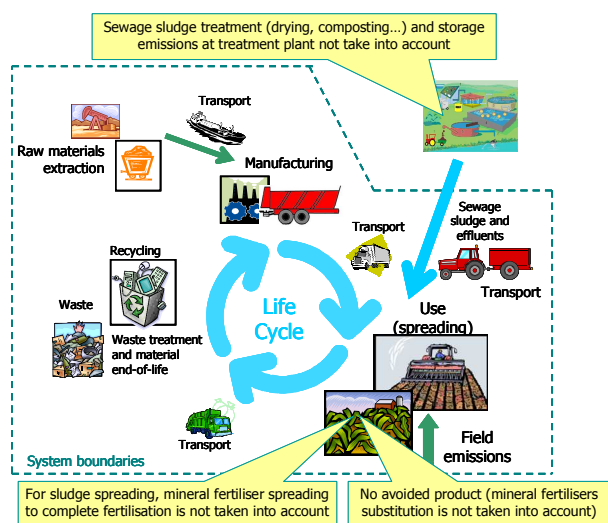


Figure 1. LCA boundaries in acv3E

The software is designed to assess the environmental impact of spreading scenario from initial sludge storage place (usually the wastewater treatment plant) to the field with a possible storage at farm. No sludge pre-treatment is taken into account (drying, granulation...) nor emissions on-site storage. The substitution (avoided impacts) of mineral fertilisers is not taken into account as well as a second passage of mineral fertiliser to complete fertilisation.

The environmental impacts are assessed for **1 dry matter ton of sewage sludge spread in the field.**

Software structure

The software has a three-framed structure: a database frame, a scenario frame and a result frame (Figure 2).

The database frame inventories all the processes needed to build spreading scenarios. This database includes transport processes (lorries, tractors, trailers, boats...), sludge processes (including agronomic characteristics) and specific equipments used for spreading and incorporation such as tractors, spreaders, loaders, and harrows.

¹ ITAP and Philippe Roux are member of the ELSA group (Environmental Lifecycle & Sustainability Assessment) www.elsa-lca.org

² Ecodesign is an approach to design a product with special consideration for the environmental impacts of it during its whole lifecycle.

³ acv3E means "Evaluation Environnementale des Epanchages (3E) à l'aide de l'ACV" (Environmental assessment of spreading practices through the use of Life Cycle Assessment)

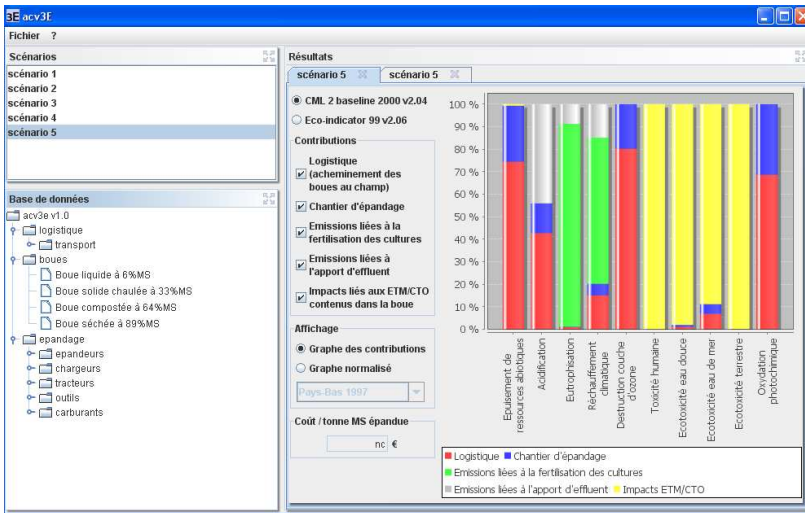


Figure 2. Screen grab of "acv3E" software main window (database & scenario on the left, results on the right)

The scenario frame includes 5 typical spreading scenarios for different type of sludge (liquid sludge spread with splash plate, liquid sludge incorporated with injectors, composted sludge, solid limed sludge, and dry sludge).

These scenarios are based on typical French sludge spreading scenarios but acv3E gives the possibility to create as many scenarios as needed.

After the creation of a scenario, both LCA results and nitrogenous emissions can be shown on the result frame.

LCA Database

All LCA database processes are built in the same manner as the spreader process shown in Figure 3. Each process is characterized by 13 characterization values (10 CML baseline 2000 and 3 Ecoindicator 99 values). These values are based on LCA results conducted with Simapro V.7.2 software. The 13 impacts indicators and the economic cost of each process are calculated for a specific unit (hour for spreading and incorporation equipments, ton.kilometer for transports, dry matter ton for sludges, liter for fuel).

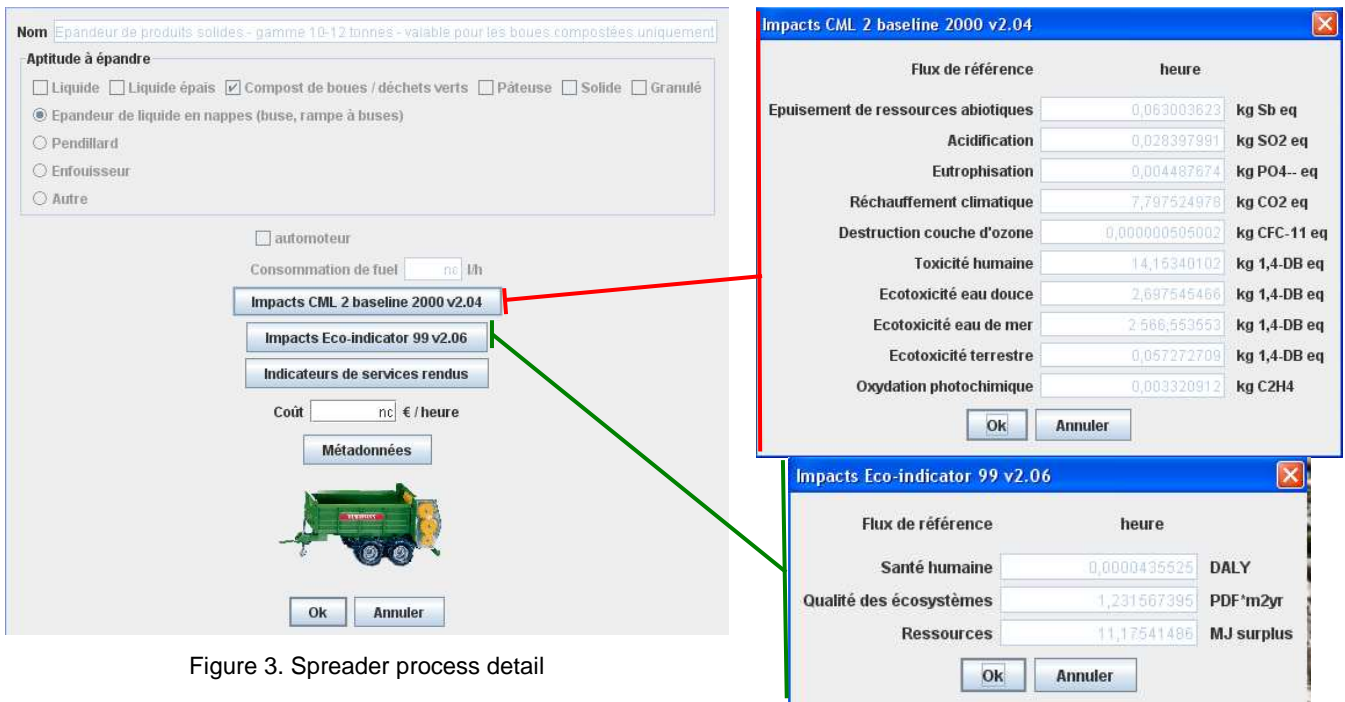


Figure 3. Spreader process detail

Scenario construction

Using database processes, a spreading scenario can be built as shown in Figure 4.

A spreading scenario is characterized by :

Sludge transport from wastewater treatment plant to an intermediate storage (usually at the farm or in the field). The acv3E user needs to choose the transport mode as well as the distance (in km), the type of sludge and the application rate.

Spreading operation including loading, transport from intermediate storage to the field and the spreading itself. The acv3E user needs to choose the spreading equipment (spreader, tractor, fuel consumption, type of fuel) and the spreading characteristics (loading time in % of the total spreading operation, spreading operation efficiency in ha/h)

Incorporation of the sludge after spreading can be taken into account. If so, he needs to choose the incorporation equipment, the delay as well as the incorporation operation efficiency (in ha/h).

Figure 4. Scenario construction

LCA results

acv3E allows to choose among 2 LCA methods: CML, an "impact oriented" method with 10 mid-point indicators or Ecoindicator 99, a "damage oriented" method with 3 areas of protection. In addition, spreading costs can be assessed. acv3E has the possibility to distinguish nitrogenous emissions due to the specific sewage sludge application as field emissions such as ammonia volatilisation, nitrate leaching and nitrous oxide emission were linked to sludge characteristics and spreader technical performances by the means of agronomic simulation models (Figure 5).

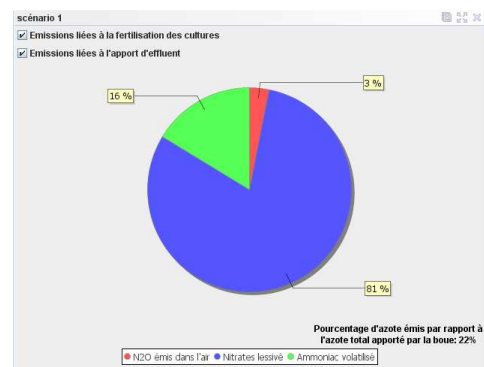


Figure 5. Nitrogenous emissions graphic

Results and discussion

As the software is really easy to use, a mass of scenario can be created with acv3E. As a result, many scenario comparisons can be done.

Ecodesign use

Figure 6 compares two scenarios: a scenario based on the real performances of the slurry tanker and a scenario with possible ideal performances of the same slurry tanker. This type of scenario

can be used for ecodesign as only technical spreader performances, and so nitrogenous emissions, change from a scenario to the other.

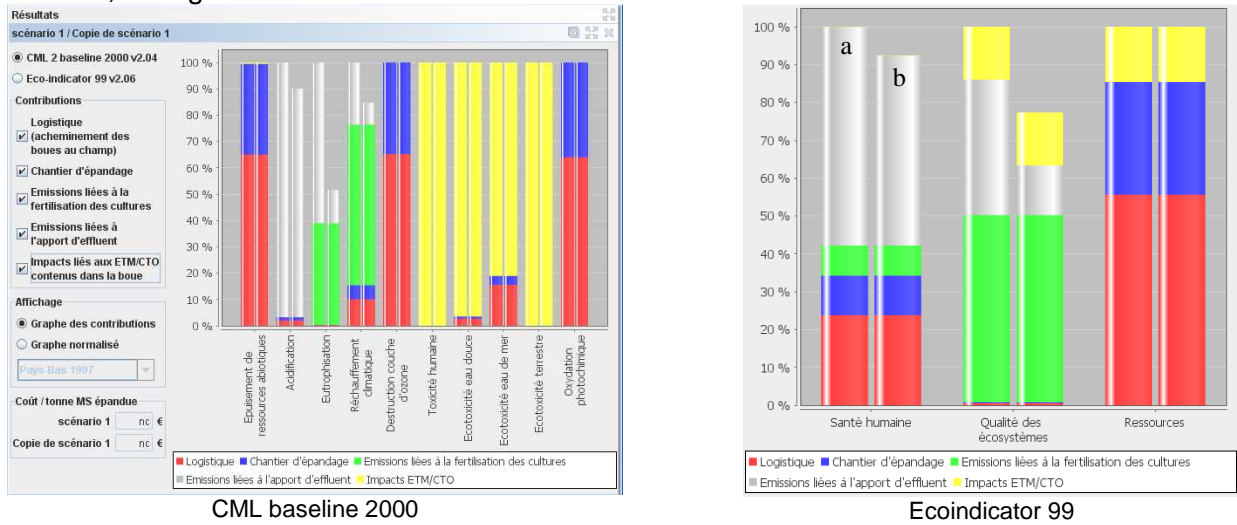


Figure 6. Comparative analysis of real (a, left bar chart series) and ideal (b, right bar chart series) spreader performances

Spreading management use

Figure 7 compares two other scenarios: a scenario with a 4 km distance between the wastewater treatment plant and the field compared to a scenario with a 10 km distance. This type of scenario can be used for spreading management as only transport distance from the wastewater treatment plant to the field changes from a scenario to the other.

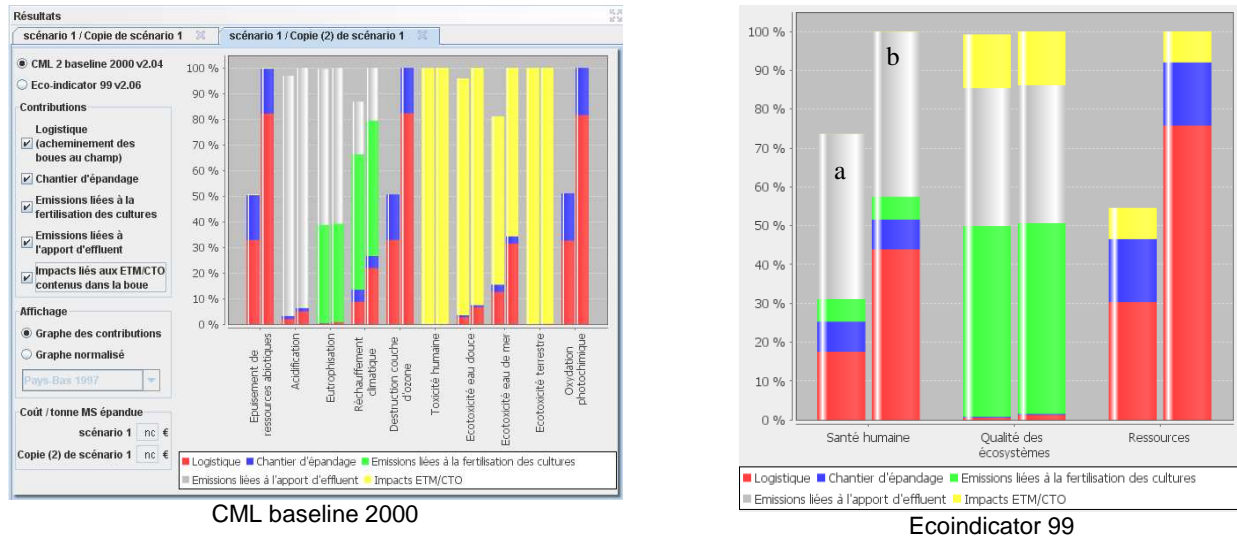


Figure 7. Comparative analysis of 4 km distance (a, left bar chart series) and 10 km distance (b, right bar chart series) between the wastewater treatment plant and the field

Conclusion

In order to improve practices, often states or environmental agencies give recommendations based on an LCA report based on a limited set of "theoretical" scenarios. When LCA is dealing with a huge range of scenarios, it sounds better to supply an assessment tool such as acv3E which allows users assessing their own scenarios based on actual practices. With such a tool, stakeholders will be able to find their own optimum and design the best scenario adapted to their local conditions.

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