**Data intensive based tool for supporting circular economy in agri-food process.**

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**Highlights**

* To support circular economy with agri-food waste valorization.
* To propose a life cycle thinking based approach for selecting biomass and process.
* To take benefit from public and scientific data.

 Each year, agriculture generates 700 million tonnes of waste in Europe and with the increase of the world population this number increases. This augmentation of the waste production creates an increase of its environmental impacts. However, a part of this agricultural waste consists in lignocellulosic by-products which can be transformed into bio-energy, biomolecules or biomaterials. A solution to reduce the agricultural waste is to transform these lignocellulosic by-products thanks to sustainable process operations. The assessment of the sustainability is now integrated to more and more agrifood process. The sustainable development for the agricultural by-product valorization must be economically efficient, socially fair and environmentally sustainable like every sustainable development. A new business model appeared recently -the circular economy and industrial ecology- to lead a more sustainable development [1]. It contributes to reconcile the environmental, economic and social aspects of sustainability. Our application to contribute at this reconciliation is the creation of an approach to help for the choice between different biomasses and industrial paths. The tool created from this approach allows to compare six different biomasses (rice straw, bagasse, corn stover, sugarcane straw, wheat straw and spruce chips) and their associated processes.

To help the reconciliation, it is possible to use the Life Cycle Thinking (LCT), which considers the full life cycle of the agriculture supply chain. This thinking is used in the Life Cycle Assessment (LCA) method to evaluate the potential environmental impact of a product or service over its entire life cycle. A lot of articles are published to compare different waste management systems under a LCA. The data can be obtained by two ways: directly, by on-site measurement, or indirectly – from different data bases. Generally, the data for the foreground system are obtained directly and for the background system indirectly. There are more and more scientific articles published describing agricultural by-product valorization processes and operations. These articles are a high added value data source for the foreground system. As the on-site measurements are expensive and time-consuming, in this way the scientific articles allows the LCA researcher to save time and money. Yet, prospecting a huge quantity of unstructured data is difficult and cannot be done without some degree of automation. The utilization of the Big Data tools can be relevant to structure knowledge into formal representations for exploitation by computers. The main goal of this work is to develop a data intensive approach and the associate tool to supporting the decision in the context of circular economy in the domain of the agri-food industry. The three objectives set of this goal are (1) to benefit from a large quantity of data for a same process thanks to all the experiments carried out by the researchers all around the world (2) to avoid experiments which are time consuming and expensive (3) to place the LCA upstream in a preliminary eco-design approach in order to select agriculture supply chain or to fix trends.

The approach proposed in this paper is based on big data tools, sustainability engineering and life cycle thinking for supporting decisions on agricultural by-product valorization dedicated to engineers, academics, managers and policy decision makers. The approach is divided into five steps - It is always possible to return to the previous stage to complete the data or to add details:

 1. Definition of the goal and scope of the study

 2. The extraction of relevant information from heterogeneous data sources (from big data)

 3. Life cycle inventory

 4. Indicators calculation (from Life Cycle Impact Assessments, “green chemical” metrics and economic indicators calculations)

 5. Ranking the results and analysis (from data visualization)

To validate the approach, a tool is created with VBA-Excel. This tool allows to extract the process data, to make the LCI thanks to the EcoInvent v3 database, to calculate the environmental and economic impacts and then to visualize the results for the comparison of lignocellulosic biomass pretreatment processes. The bioconversion of lignocellulosic biomass is a promising method for the production of bio-energy, biomolecules or biomaterials. This bioconversion involves the enzymatic hydrolysis of the biomass to release glucose. Biomass pretreatment is essential, to decrease crystallinity, increase the specific surface area and porosity, and separate the major constituents.

Corn stover illustrates the approach (picture beside). 7 processes involving different technologies are under study. Their sequence of unit operations are of 3 kinds: only mechanical operations (P7), mechanical and physico-chemical operations with press and separation (P3, P4, P5, P6), and mechanical, physico-chemical operations with press, separation and extrusion (P1, P2). LCA impact indicator “Fossil depletion” from ReCiPe 2008 end-point is shown. The approach should enable researchers, and other users, to identify the “best” process for a specific biomass. That could be improved by enhancing ranking procedures and including scaling (to address industry needs). The interactive visualization also allows the approach user to move in different levels of the results. Furthermore, in the tool created, the environmental indicators from LCA could be combined with economic indicators, providing a more general overview of the various processes and technologies regarding to sustainability management.

**References**

1. JP Belaud, C Adoue, C Sablayrolles, C Vialle, A Chorro, Decision making approach for industrial ecology: layout and commercialization of an industrial park, Chemical Engineering Transactions 57, 1561-1566, 2017.