10th International Conference on Sustainable Solid Waste Management

Mapping the biological feedstock streams: A methodological approach for Material Flow Analysis to support the transition to a Circular Bioeconomy

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Institute Structure & Scientific Approach



10th International Conference on Sustainable Solid Waste Management

EnvES Lab Main Activities



EnvES Lab Main activities



CIRCULAR (BIO-) ECONOMY

Industrial ecology approaches to the design of industrial & urban systems with reduced ecological footprint in order to foster the cyclical economy



SUSTAINABLE AGRICULTURE

Sustainable Production & Waste Management Reverse logistics & Green Supply Chain Solar energy agriculture

applications Wind Energy in Rural Areas

Bioenergy and energy crops



ENVIRONMENTAL INFORMATICS

Computational intelligence methods and tools for environmental assessment

Web-based waste management and information systems

Engineering for investigating and solving problems related to the status and the quality of the environment



ENVIRONMENTAL ASSESSMENT

Environmental Management & Assessment

Advanced technologies for monitoring environmental pollution & waste management

Integrated methodologies to assess the environmental impact



WASTE MANAGEMENT

Logistics & contaminated site management

Recycling & Pricing schemes

Thermal treatment & energy recovery

Alternative agro-waste management

POLLUTION

ENVIRONMENTAL

Air Pollution & Climate Change

Transport & transformation of pollutants

Air quality assessment and management

Environmental impact assessment

Integrated environmental assessment



Develop a comprehensive methodology for a bio-based material flow analysis (MFA), for the quantification of potential feedstocks for the bio-based sectors.

The proposed methodology:

- measures the input-output materials
- exams the pathways of each material flow within the whole system
- provide instructions for producing a generalized Sankey diagram,
- the categorization of biological feedstock resources and their potential uses and applications
- enables the comparison of biomass flows between different regions and countries

General challenges & opportunities

Current management

Predominant management practices include:

- Uncontrolled landfilling and soil disposal
- On-site incineration
- Conventional uses (soil enhancement, feed, bedding)
- Composting



- Land pollution
- Soil leaching
- Underground water pollution
- Eutrophication



Mainly due to decomposition and incineration, leading to the formation of: CO₂, CO, NH₃, SO₂

Untapped potential

In terms of materials...

Biorefinery applications



Bioplastics, biochemicals, bio-lubricants, bio-solvents, biosurfactants

In terms of **energy...**

Thermochemical



conversion (pyrolysis)

Biochemical conversion

(anaerobic digestion)

Material Flow Analysis methodological approach



System boundaries (1/2)





System boundaries (2/2)

Target feedstocks

Agricultural residues

- Straw derived from cereal crops
- Stems derived from oilcrops

Target area

EU-28

Temporal parameters

Year: 2021 – annual basis

Unit

Ktonnes of dry mass

Identification of current uses

- Conversion to energy
- Animal feed
- A large percentage remains on field for soil enhancement purposes

Identification of bio-based applications

- Bioplastics
- Biochemicals
- Biocomposite materials



Worldwide use of harvested forestry and agricultural residual biomass (Zörb et al., 2017)

General assumptions & methodological challenges

Assumptions

- the different biological feedstocks are assumed to be evenly distributed to the potential destinations;
- ii. quantities of bio-based products using residues' valorization are estimated by starting from the number of bio-based products generated and going backwards with process yields and conversion factors to the amount of biological feedstocks used as input
- iii. the available data facilitates the analysis on an EU-level. In this frame, the feedstocks will be aggregated in a broader context (e.g., agricultural residues instead of wheat and pruning)

Challenges

- i. Bio-based products occupy a small fraction of European market
- Lack of a consistent and systematic collection of quantities in terms of specific materials in the different stages of the value chain
- iii. Scarcity of quantitative data, especially with regards to the biobased industry
- iv. The MFA will contribute to the identification of gaps and unsustainable practices in the value chains, indicate opportunities and foster circularity in resource management

Data retrieval sources

- Official databases (Eurostat, FAOSTAT)
- World Integrated Trade Solution Software provided by World Bank
- Grey literature and reports (JRC, Eurostat, OECD reports)
- Well-established scientific books (Bringezu & Moriguchi, 2002; Brunner & Rechberger, 2004)
- Relevant associations (e.g., European bioplastics association)
- Scientific literature



Results (2/2)



- A **comprehensive understanding** of the complete bio-based system, its value chains, and the ways in which biomass stocks and flows are used is **necessary to identify opportunities** for bio-based applications and promote circular bioeconomy.
- The quantities that are destined for conventional uses are 1,000-fold those that are headed to the bio-based sector.
- The bio-based industry is still at an early stage.
- Relatively small quantities of bio-based products are generated, while the available information is very limited (especially in the field of residues valorization).
- Even though **bio-based residual streams are successfully recovered for energy and materials**, there is still the need to increase the amount residual biomass from primary production systems.

The case study

The **BIORECER** project...

BioReCer

…is about "Biological Certifications Schemes "

Resources

...develops a common methodology and defines indicators to monitor, certify and assess the environmental performance and traceability of the biological feedstock used by bio-based industries, deploying guidelines to strengthen the current certification schemes

...addresses a major global challenge of the future: the reduction of the consumption of non-renewable raw materials BIORECER will design and develop a multidimensional framework to improve the assessment of the environmental performance and traceability of biological resources. This adapted assessment methodology will serve as a complement for the available certification schemes.



Overview of the **BIORECER** project

https://biorecer.eu/

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Thank you



https://ibo.certh.gr/



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Step 11

Quantification of the biomass in bio-based industry

The availability of feedstock data is extremely limited. Therefore, a reverse route is followed:







Feedstock quantity

It is crucial to specify the **percentage** of the products that are produced from agricultural residues. This information can be extracted from:

Literature and similar researches

• Assumption based on the low percentage of biorefineries operating with agricultural residues





Quantification of the biomass in bio-based industry

> Bioplastics





Step 11

Quantification of the biomass in bio-based industry

> Biomaterials

- Biomaterials production in Europe amounts to 837 kt/year.
- 2 out of 72 biorefineries in EU use agricultural residues as feedstock (the most prevalent are lignocellulosic crops and forestry) for fibers
- 3 out of 50 biorefineries in EU use agricultural residues as feedstock (the most prevalent are lignocellulosic crops and forestry) for composites

It is assumed that 5% of the produced biomaterials derive from agricultural residues



44.46 kt DM/year