Resources from Urban Biowaste: The RES URBIS Project

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Introduction: Considering the strong EU commitment towards full implementation of a European circular economy, it is necessary to extend and to improve available options for resource recovery from the organic fraction of waste of urban origin, especially towards higher value products than energy and compost.

Within the urban environment, significant amounts of organic residues are originated from the separate collection of organic fraction of municipal solid waste (OFMSW) and the sludge from urban wastewater treatment plants (WWTPs). Altough OFMSW and WWS are originated from the same urban area and contain similar amount of organic carbon of similar nature, these two streams are usually handled separately. This historical separation of treatment options creates an interesting opportunity to identify processes and strategies that allow for the effective conversion of organic carbon contained in urban wastes into useful bio-based products, while also reducing the global impacts on water and climate caused by their treatment and disposal.

The integrated treatment of civil wastewater along with organic solid wastes (mostly of municipal origin, while not excluding residues from food-processing industry of comparable composition) in a novel "bio-waste biorefinery" is a key option to practically implement a synergic treatment of all relevant bio-waste streams of urban origin. Indeed, this integrated and flexible "bio-waste biorefinery approach" can present several advantages, in both environmental and economic terms, especially because it allows to achieve the critical operating capacity of the bio-waste biorefinery even in small "waste basins". In order to define appropriate strategies, it is thus necessary to take into account that driving forces and constraints highly depend on the territorial conditions. In other words, it is necessary to create autonomous clusters where the recovery strategies are affordable and recovery cycles can be closed within the cluster itself, e.g. without the need to transport either bio-waste or the resulting bio-based products for long distances.

Objective: The overall objective of the RES URBIS project is to integrate into a single facility and to use one main technology chain for the conversion of several types of urban bio-wastes into valuable bio-based products, while also minimizing any residual or consequent waste to be disposed of. This objective will be achieved by combining:

- Collection and analysis of data on urban bio-waste production, their characteristics and present management systems in selected territorial clusters.
- Well-targeted experimental activity to solve a number of open technical issues related to the conversion of mixed bio-waste feedstock into close-to-market bio-based products, by using the appropriate combination of innovative and catalogue-proven technologies.
- Market analysis within several economic scenarios and business models for full exploitation of bio-based products (including a path forward to remove regulatory barriers and constraints).

More in detail, urban bio-waste will include:

- The organic fraction from separate collection of municipal solid waste, such as food and kitchen waste from households, restaurants, caterers and retail premises.
- Excess sludge from treatment of urban wastewater.
- Garden and parks waste, and similar.
- Selected waste from food-processing facilities.

This is a novel definition which is coherent with proposal 2015/0275 (COD) for a Directive of the European Parliament and of The Council amending Directive 2008/98/EC on waste. Specific investigation will also include other waste streams, that are usually not collected together with organic waste (e.g. baby nappies), but that could potentially be accepted in the proposed process chain. Another waste stream of great interest is food-processing waste, provided it presents a suitable composition and that better recycling options in the food chain are not available. Of course, if any food-processing waste is included, its collection and transport has to be taken into account in the territorial and economic analysis.

Scenarios: Territorial and economic analyses of the proposed technology chain will be performed by evaluating these three main scenarios:

- o Implementing a well-designed urban biowaste biorefinery
- o Integrating the waste biorefinery into existing anaerobic digestion plants
- o Integrating the waste bioerefinery into existing wastewater treatment plants

The feasibility of the proposed concept and scenarios will be investigated in four territorial clusters, which have been selected in different European countries (Italy, Portugal, Spain, and United Kingdom) and present different characteristics.

Each **economic scenario** will be investigated with reference to at least one territorial cluster and at least one scenario will be investigated at two different sizes. The four clusters will have an experimental platform that will be operated by using the most representative "cocktail" of urban bio-waste for the respective cluster. Two of them will include all main steps of the PHA production from waste fermentation to PHA extraction, whereas two will focus on key step of process upstream, i.e. acidogenic fermentation.

As for **bio-based products**, the project is mostly focusing on polyhydroxyalkanoate (PHA), related PHA-based bioplastics and other ancillary productions, such as bio-based solvents (to be possibly used also in PHA extraction) and fibers (to be used for PHA-based biocomposites).

The RES-URBIS Consortium is aware that several other bio-based products can potentially be obtained from the same bio-waste feedstock; however, after careful consideration, it was agreed that PHA has the best potential to be the main and a self-consisting pillar of the bio-waste biorefinery, especially because:

- • Its production process has the best potential to cope with large heterogeneity of the waste feedstock, in particular because the first production step, i.e. the acidogenic fermentation, is both robust and flexible and provides stable feedstock to the PHA production;
- • PHA includes a whole family of copolymers with a wide range of tunable properties, so that PHA can be the main constituent of several bioplastics and their biocomposites, with a wide portfolio of applications.
- • PHA is bio-based not only because it is produced from organic biomass, but also because it is produced through a process which is mostly biological under mild conditions (e.g. no sterile conditions are required). Thus, the PHA-producing bio-waste biorefinery can be fully sustainable from an environmental point of view, including an easier integration with existing biological plants for waste and wastewater treatment.
- • In comparison with other biological processes, the PHA-producing process does not produce excess of sludge that needs to be handled, as the polymer makes up to 70% of the biomass.

The economic analysis will be based on several PHA-derived bioplastics, which will be produced at pilot scale and tested for their final applications. These will include a full portfolio of applications:

- o Biodegradable commodity film
- o Packaging interlayer film
- o Specialty durables (such as electronics and/or interior design good)
- o Premium slow C release system for groundwater remediation