From organic waste to compost - a difficult path?
The European Bin2Bean project

Anyone who has ever composted food waste, garden waste and autumn leaves knows that this is a labor-intensive and time-consuming process. Moreover, you can only get good compost as a soil conditioner if you don't mix in any other waste. These simple insights also apply to the industrial manufacture of products from bio-waste:

- Both aerobic and anaerobic processes require space and time. Microorganisms must find ideal living conditions in order to produce usable compost and - in the case of fermentation - as much methane as possible (as a component of the biogas).
- Unsuitable quality input material makes the biochemical process more difficult, while impurities lead to unusable compost.

Around 71 million tons of kitchen and garden waste are currently collected and treated separately in the EU (2017, including the UK) [1]. In order to achieve a recycling rate of 65% for municipal waste, as prescribed by the EU in the 2018 Waste Framework Directive, around an additional 40 million tons would have to be separated by waste producers and processed aerobically or additionally anaerobically [2]. The Bin2Bean project [3] is therefore addressing a number of challenges that lie ahead in achieving this target:

- The necessary bins for separate collection of bio-waste are often difficult to place in densely populated residential areas and need to be emptied frequently in hot weather to avoid hygiene problems.
- People need to be motivated to collect organic and green waste separately - they spend time on pre-sorting and walk extra distances to the organic waste bin.
- The proportion of impurities, especially plastic waste, in organic waste containers is sometimes very high and hampers or prevents the subsequent application of the product.
- Compost from bio-waste meets with reservations even if it is of very good quality, although its marketability as a ‘soil improver’ [4] is only possible if numerous quality characteristics and limit values are met.

Achieving the target would not only result in more waste being sensibly utilized. Soil in the EU are highly endangered by erosion or are over-fertilized; their humus content is often insufficient. According to the Agri-Soil Mission Board, an advisory body to the EU Commission on soil protection issues, around 75% of all soils in the EU fail at least one quality criterion for healthy soil [5]. Soil improvers such as bio-waste composts are therefore intended to help achieve further agricultural and climate policy goals:

- Due to their humus content, composts strengthen the resilience of soils against erosion and increase their ability to store rainwater.
- Compost increases the available nutrient content to improve harvests.
- In the case of anaerobic treatment, biogas is also produced which, after purification, can be used to power vehicles as a substitute for natural gas or for district heating.
- The incorporation of compost stores carbon in the soil. This carbon sequestration currently binds around 1.2 million tons of CO_2 per year [1] in the EU in the soil.

Objectives of the Bin2Bean project

BIN2BEAN aims to help cities in the EU achieve the targets for healthy soils through their regeneration. It therefore makes sense to promote the utilization of bio-waste as a soil improver through innovative and economically interesting value chains [2]. The project is not about groundbreaking new findings, but about optimizing several steps in the value chain (see Figure 1) in the respective region:

- Maintaining or increasing the quality of collected organic waste in the long term while increasing collection volumes.
- Raising public awareness of the need to separate bio-waste and the importance of healthy soils.
- Utilization of compost produced from organic waste through suitable business models.
- Creation of an assessment scheme for the entire value chain as a tool for local decision-makers to set up or optimize their system from bio- and green waste to a suitable compost-based soil improver.

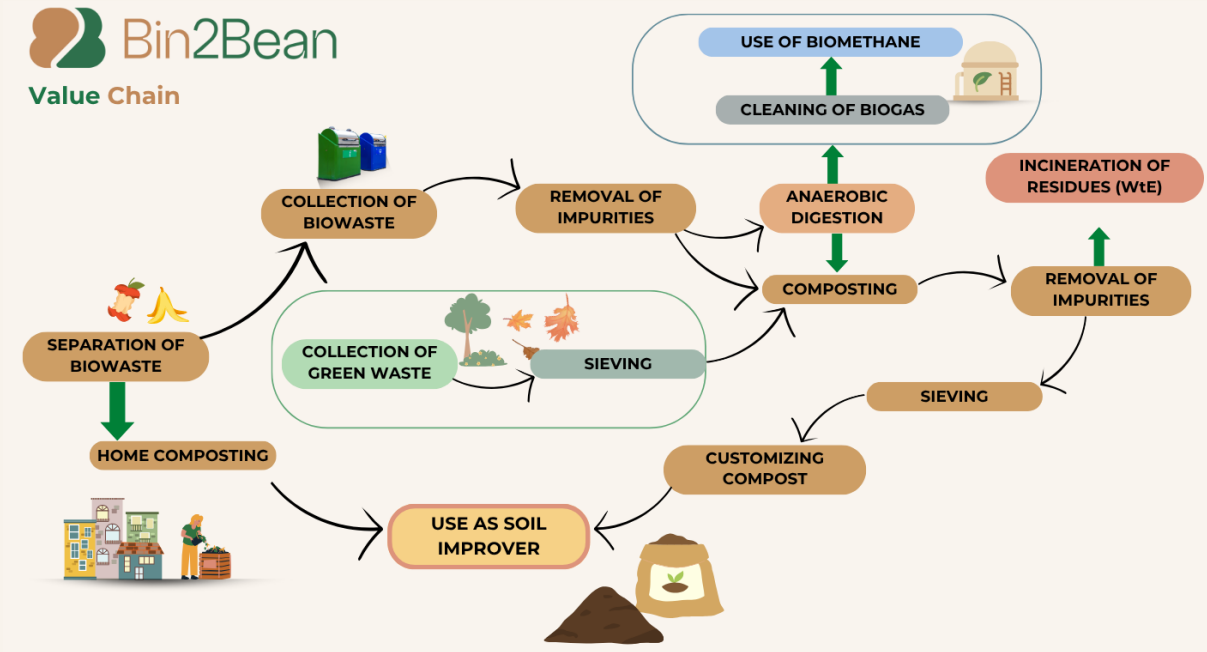

Figure 1: Value chain of the transformation of bio- and green waste into customized soil-improvers (simplified)

Eleven partners from seven EU countries have joined forces to investigate these complex issues. (Table 1).

Tasks in the "Living Labs"

In order to realize these goals with a view to their practical feasibility, the project established three 'Living Labs' in the cities of Hamburg, Amsterdam and Egaleo near Athens. In a 'Living Lab', the development and application of new products, services and system solutions are co-designed in real environments with users and relevant stakeholders. All three cities are characterized by a very high population density. The 'Living Labs' (LLs) are supervised by local partners, e.g. Stadtreinigung Hamburg, and consist of local stakeholders along the value chain, i.e. interested private and commercial waste producers, teachers, environmental initiatives, representatives of agriculture or horticulture, scientists from regional institutions and, of course, experts from the waste management sector and bio-waste processing plants [6]. The Bin2Bean team prepares material flow analyses (MFA) for the LLs, among other things. The system boundary is the respective city. The material flow begins with the supply and consumption of food and ends with the products made from unavoidable leftovers, whereby the nutrient content is recorded as far as possible.

Table 1: Members of the Bin2Bean consortium

Name	Tasks	Member State
Consorzio Italbiotec	Project management, business models, EU policy	Italy
Wageningen University, Urban Economics	Material Flow Analysis, System analysis (barriers & enablers), Socio-economic analysis/criteria, willingness to adopt/change	The Netherlands
N³ Nachhaltigkeitsberatung Dr. Friege & Partner	Optimisation of separate collection and processing of organic waste, communication strategy, transfer of business models	Germany
RUOKAVISTA (Finnish Food Authority)	Analyses of samples from waste, compost, soils; quality assurance, quality control	Finland
Danmarks Tekniske Universitet	Indicators for soils and ecosystem services, „scoring system"	Denmark
Wageningen University & Research, Applied ecology	Field trials, "scoring system", App for estimation of nutrient availability from soil improver solutions	The Netherlands
Energia, Trasporti, Agricoltura S.R.L.	Public relations, plan for the dissemination and exploitation of results from Bin2Bean	Italy
City of Egaleo, Dpt. for Planning	Management and support of the Living Lab Egaleo	Greece
Amsterdam Institute for Advanced Metropolitan Solutions	Management and support of the Living Lab Amsterdam; "food waste grinder"	The Netherlands
Stadtreinigung Hamburg AöR and Hamburg Institute for Innovation, Climate Protection, and Circular Economy (HiiCCE)	Management and support of Living Lab Hamburg, participation in the work on financial incentives and communication issues	Germany
Euroquality	Management and support of the Stakeholder Forum; evaluation of existing regulations and former projects; organization of workshops	France

Furthermore, the project team analyses the respective status of bio-waste recycling and discusses possible optimizations in collection systems, fee structures, communication and process technology with the LLs.

One sub-project is dedicated to the question of whether the grinding of kitchen waste and its removal in a separate collection system (food waste grinder') could be an ecologically sensitive alternative to organic waste bins for the collection of organic waste in high-rise buildings.

There are still some reservations of the use of soil improvers made from waste in agriculture. High quality and quality control systems are therefore a top priority in order to ensure the marketability of composts. To prevent plastic waste from being carried over to the soil via bio-waste, the EU has set strict limits for the finished compost. Germany is currently introducing additional limits for the contamination of the bio-waste itself, which will be checked at the entrance to the plants from now on.

Furthermore, the project aims at new opportunities: Adapting the products to regional requirements could open up business models for compost as a soil improver, e.g. in the area of growing media or as a peat substitute. To this end, the team includes microbiologists, biochemists and agricultural scientists who deal with the processing methods and their influence on the composts, as well as economists who look at potential business models. Fortunately, numerous composts from bio-waste have already achieved certification for use in organic farming [7].

Status at the 'half-way point'
The project started in September 2023 and will be completed at the end of August 2026. The results will be published; partial outcomes such as the small handbook 'From Bio-Waste to Soil' can already be downloaded from the project website [3].

All stages of the value chain in the three LLs have already been recorded and documented; initial proposals for optimization could be developed in the continuous dialogue between the experts and the LLs. Improvements in communication about the role of bio-waste for soil and climate protection are currently under discussion. A decision matrix (scoring') is being developed from the experience gained with the LLs to help cities organize their systems from the collection of organic waste to its use as a soil improver. Some findings are already emerging at the 'halfway point':

- Quality is key along the complete value chain!
- In terms of quality, the allocation of separately collected bio-waste to one or a few households is the best option because anonymity increases contamination. In large housing estates, households should only be able to use the bio-waste containers with individual chip cards or similar in order to avoid major contamination. Support from the owners (housing association) or their employees (caretakers…) is useful and necessary.

- The communication strategy for separate bio-waste collection must take into account extrinsic and intrinsic motivations as well as questions of the manageability of the system for the individual. The satisfaction of waste producers with already established collection systems plays a major role in the acceptance of bio bins.
- Paying more attention to the needs of soils will improve the understanding for the separation of the organic fraction and also increase the acceptance of composts.
- Sorting of bio-waste should be incentivized by financial instruments. The Waste Framework Directive stipulates that waste producers bear the costs of waste management. Flat-rate charges or financing the collection and treatment of municipal waste from taxes are unfortunately still widespread in Europe. Switching to charges that honor the success of separation of food and green waste requires far more political support by the city councils.
- Information on soil health - such as the lack of nutrients and humus as well as existing pollution - is now available for the entire EU via the European Soil Observatory [8]. This is an opportunity to set the course for ‘customized’ soil improvers from compost at an early stage.
- The separation of pollutants and interfering materials from bio-waste through suitable pre-treatment and post-treatment of the compost is quite efficient in technically advanced plants and can be transferred to other installations. Nevertheless, impurities of more than a few per cent cannot be completely removed.
- The ‘scoring system’ for the best possible utilization of compost is currently being developed. It will take into account the qualities and properties of waste and compost in order to be able to use compost in a targeted manner to improve soil properties (e.g. nutrient and humus content) and develop business models based on this.

The EU regulations for bio-waste, fertilizers, composts and soil improvers as well as the respective national frameworks in the three LLs will be examined at the end of the project in order to identify any problems arising from the legal framework.

Henning Friege
N³ Nachhaltigkeitsberatung Dr. Friege & Partner
Scholtenbusch 11
D-46562 Voerde
www.N-hoch-drei.de

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