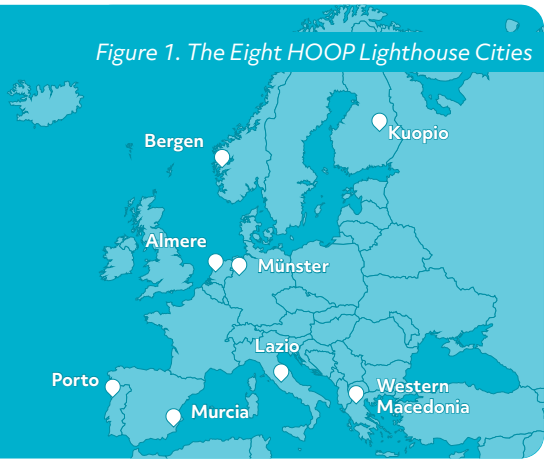
Urban metabolism of HOOP Lighthouses

Author: Research 4 Life

The HOOP project

The "**H**ub of circular cities b**OO**sting **P**latform" HOOP project supports eight European Lighthouse Cities and Regions, home to 2.8 million inhabitants, in developing large-scale circular bioeconomy initiatives that will focus on making bio-based products from urban biowaste and wastewater sludge. These 8 pilot territories are called "Lighthouses". The HOOP cities and regions are: Albano Laziale (Italy), Almere (Netherlands), Bergen Region (Norway), Kuopio (Finland), Münster (Germany), Murcia (Spain), Greater Porto Region (Portugal) and Western Macedonia (Greece) (Figure 1).

Figure 1. The Eight HOOP Lighthouse Cities

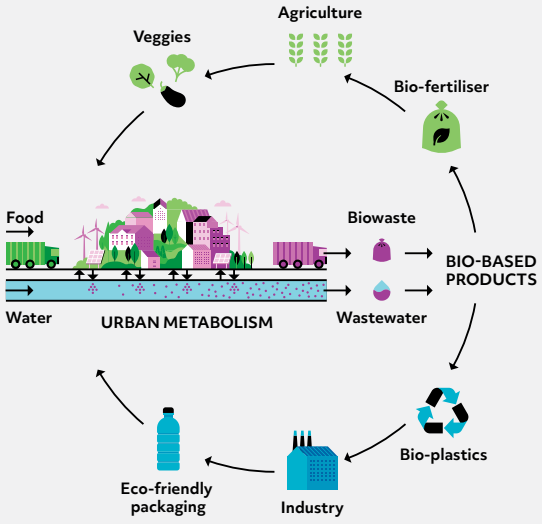


Urban Metabolism

"The sum total of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy and elimination of waste [1]."

Urban Metabolism (UM) considers cities as living organisms that use resources, produce waste and interact with their surrounding biophysical environment (Figure 2).

Figure 2. Urban metabolism encompassed in the urban circular bioeconomy concept



Parameters for a basic urban metabolism

The urban metabolism of the eight HOOP Lighthouse Cities and Regions was analyzed using a five-layer indicator set for a basic urban metabolism assessment [2]. The data and sources are presented in Table 1.

Through the indicators, data on the following flows are obtained: supply of food, green biomass, wood and water (input) and the corresponding waste generated (output). For **urban circular bioeconomy**, the following waste streams are of interest: mixed municipal waste (consisting of an organic and a non-organic fraction), food waste, garden and park waste, post-consumer wood and waste water. Options for waste treatment are also reported: landfilling, incineration, composting, anaerobic digestion (AD), material recovery and wastewater treatment. End-products may be heat, biomethane, electricity, compost, digestate, recycled materials or sewage sludge. The material of UM is usually represented using a Sankey diagram (Figure 4).

Table 1. Data types and sources used in the urban metabolism analysis

Layer	Description	Source
Layer 1: Context	Examine context of the city: spatial boundaries, constituent cities, population, economy	Maps, national and urban statistics
Layer 2: Biophysical characteristics	Land area, urbanized area, climate, and gross floor area built	Maps, literature, statistics
Layer 3: Resource metabolism	Consumption of water, food, energy and materials, waste generation during processing and consumption	National and urban statistics
Layer 4: Ownership	Distributors and suppliers of resources (water, energy), stakeholders in collection, consumption and treatments of resources and waste streams	National and urban statistics
Layer 5: Policies	Overview of policies that shape the direction of resource flows	Literature

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Waste generation and treatment

The average generation of biowaste in the HOOP Lighthouses, excluding wood, amounts to 149 kg per person per year which is in the range of the European average of 168 kg [3]. The eight cities and regions together generate 905 kton of mixed municipal waste (MMW) of which 317 kton is biowaste. Another 148 kton of biowaste is collected separate. Nearly 32 % of the biowaste is separately collected but large differences exist between the cities and regions, with the share of separately collected biowaste ranging from 4 % to 94 %.

Mixed Municipal Waste (MMW) contains a considerable amount of organic matter; the average share of biowaste among the Lighthouses in MMW is 34 %, ranging from 10 to 47 %. Main treatment options of biowaste in the HOOP lighthouse cities are presented in Figure 3.

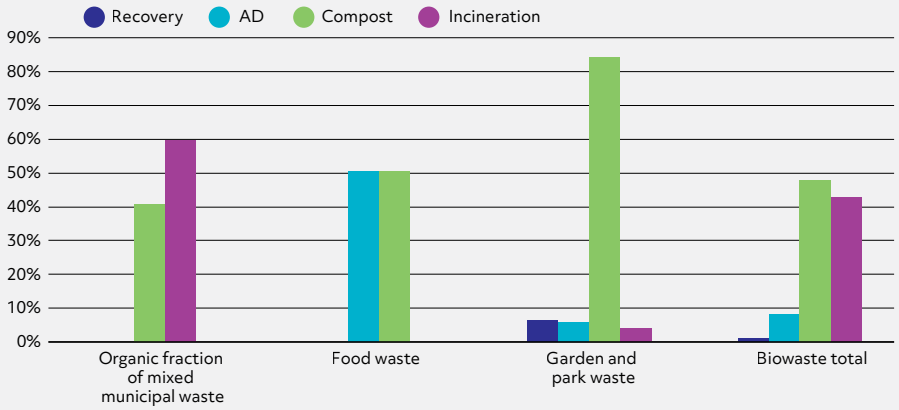

Figure 3. Treatment of biowaste in the HOOP lighthouse cities

MMW, including its organic fraction, is often incinerated; in the Lighthouses, nearly 60% of the biowaste is treated in this way. Over 40 % of the organic fraction of MMW is composted after mechanically sorting. Composting is the prevalent treatment for separately collected garden and park waste. About 50% of the separately collected food waste is treated by AD, sometimes combined with composting of the digestate. The other ~50% of separately collected food waste is directly composted. No landfill of biowaste has been reported.

Regarding Urban Wastewater Sludge (UWWS), more than 150 kton arise from the treatment of 247 million m^3 of wastewater in the Lighthouses. These are often fed to AD or composting facilities. High use of sewage sludge has been reported in some cities and regions through AD. Other common uses include agriculture and composting.

Figure 4. Sankey diagram for the materials of urban metabolism

Conclusion

Urban biowaste generates feedstocks for advanced biobased production chains. The HOOP project contributes to the bioeconomy by identifying available urban biowaste and selecting promising valorisation routes. Urban Metabolism analysis is an analytical instrument to quantify flows of food, water and generated biowaste. In the eight HOOP cities and regions about 60 % of the biowaste is treated by AD and or composting. A high proportion of biowaste still ends up in the mixed municipal waste that is incinerated. An improved system for separate biowaste collection is a precondition to optimise the use of biowaste in a more circular way.

References

1- J. Kennedy, C.A.; Cuddihy, J.; Engel Yan, 2007, The changing metabolism of cities," J. Ind. Ecol., vol. 11, no.2, pp. 43–59.

2- B. Musango, J.K.; Currie, P.; Robinson, 2007, Urban metabolism for resource efficient cities: from theory to implementation, Paris UN Environ.

3- European Environment Agency (EEA), "Bio-waste in Europe- turning challenges into opportunities. Report No 04/2020," 2020.

Acknowledgments

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