Using the urban metabolism concept to evaluate and promote valorisation routes for urban biowaste

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16th March 2022

The HOOP project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°101000836

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  - Treatment
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- Conclusion

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Municipal Solid Waste

- Urbanisation
  - >50% of the population living in cities
  - Amount of waste increases
  - Share of (non-)degradables
- Policy targets relate to reduction of waste volumes, and enhanced recycling.
- Urban, regional and national strategies are intertwined, linking health and safety issues with economic and environmental targets.

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Addressing MSW issues

- Hiearchy in waste management
  - Prevent, Re-use, Recycle, Recover (energ Dispose
  - Upcycle
- Direct and indirect recycling
- Collection system design
  - Separate at source – or not
  - Public and private collection
  - Drop-off points
  - Park and garden waste

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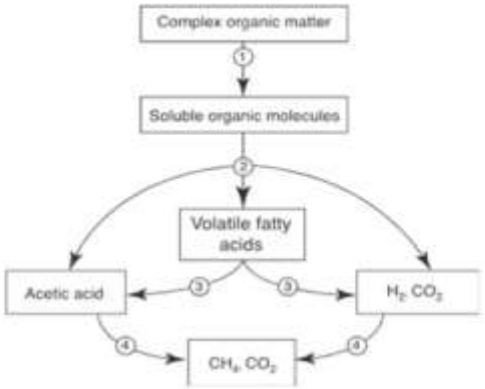
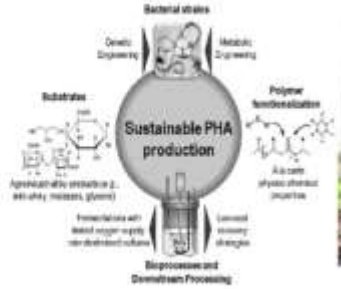
Valorisation

- Mixed waste: OFMSW, non-organic fraction
- Dedicated biodegradable waste streams
- Processing and treatment routes
  - Compost and Anaerobic Digestion (AD)
  - Wastewater treatment => Sewage sludge
  - Generation of bioplastics, biomaterials and dedicated outputs
- Interactive process
  - Development of business models
  - Stakeholder mobilisation





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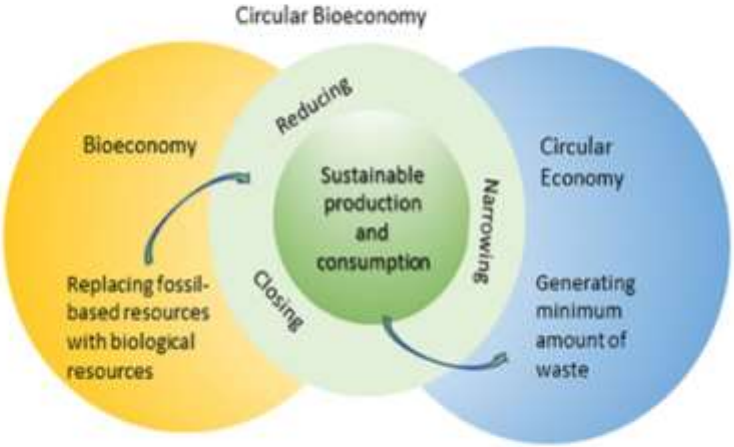
Circular economy

- In the Circular economy bioproducts are returned to the economic loop instead of ending in a landfill. Waste streams from renewable bio-resources are used as resources for the technosphere.



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1.
The HOOP project

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The HOOP project

- Hub of circular cities bOOsting Platform to foster investments for the valorisation of urban biowaste and wastewater.
- Urban circular bioeconomy for European cities and regions
- Baseline studies, selection of biobased investment options, project development assistance
- Analysis of **urban metabolism**, state-of-the-art of available technologies

Start: October 2020

End: September 2023

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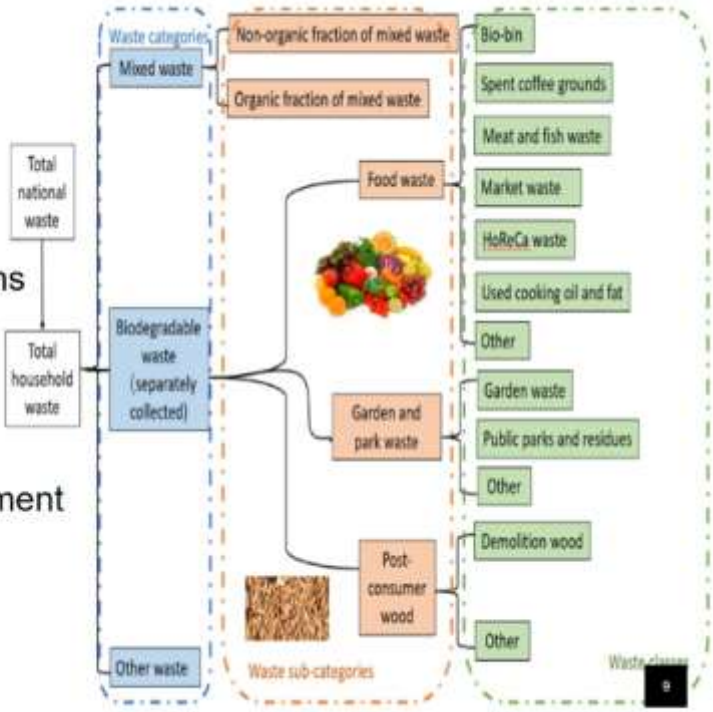
Waste streams

- Mixed waste
  - Organic Fraction (% of MSW)
  - Non-organic fraction
- Dedicated biodegradable waste streams
  - Food waste
  - Garden and park waste
  - Post-consumer wood
- Other municipal waste
- Sewage sludge from wastewater treatment



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8 HOOP Lighthouse Cities and Regions

HOOP Network of Cities and Regions

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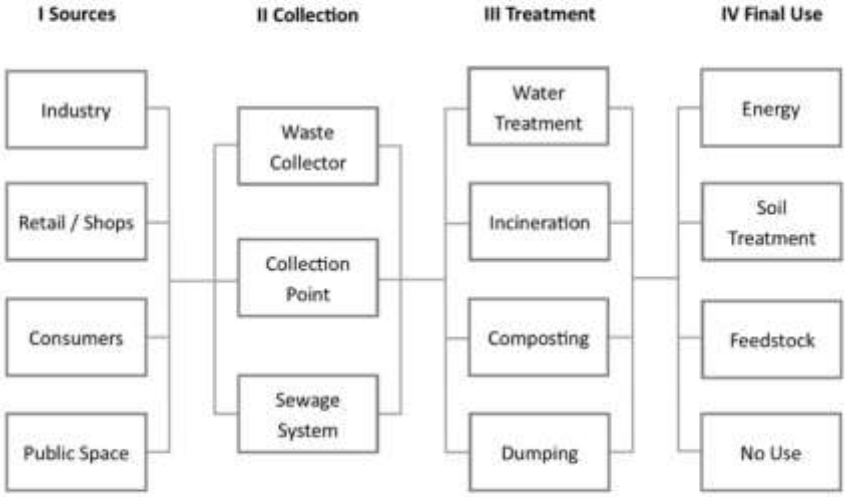
WASTE STREAMS

- **Sources**
- **Collection process**
- **Treatment / conversion**
- **Final destination**
- **Recycling, use**



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Conversion and valorisation

- Existing conversion routes
- Options for recycling
- Alternatives
- Biobased options
  - Waste streams
  - Treatment
  - New production chains

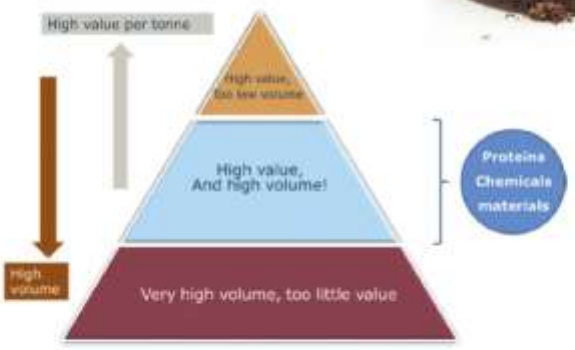

FIGURE 2.1 Ecopyramid.

Source: Sanders and Langeveld (2020)

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2.

Urban metabolism

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Urban metabolism

- Urban Metabolism, introduced in 1965, is defined by Kennedy et al. (2007) as: **"the sum total of the technical and socio-economic process that occur in cities, resulting in growth, production of energy and elimination of waste."**
- By identifying the use of water, materials, energy, and nutrients, it provides insights into the changing metabolism of cities
- Material flows can be evaluated at a generic (taking into consideration all) or partial (some of them) level, at different scales

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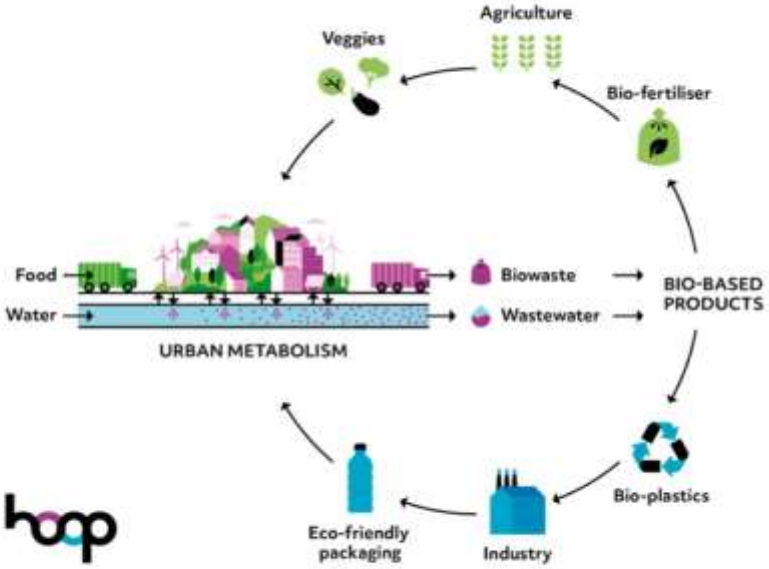
Urban metabolism

- Context
  - Spatial boundaries, population, economy
- Biophysical characteristics
  - Geography, location, surface, climate
- Urban metabolism parameters
  - Import and supply of food, wood an water
  - Waste generation and collection
  - Treatment and destination
- Policy frameworks and commitment
  - Waste policies on waste
  - Expectations and commitment



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Urban metabolism

- Concept
  - Analytical instrument
  - Implementation and use
- Streams
  - Food
  - Garden and parks
  - Wood
  - Water
  - (Energy)
- Performance and targets
  - Sankey diagrams
  - Indicators

Parameters for a basic urban metabolism

Main categories	Sub-categories	Classes
Mixed municipal waste		
Biowaste (separately collected)	Food waste	Bio-bin Spent coffee grounds Meat- and fish waste Market waste Horeca waste Used cooking oil and fat Other
	Garden and park waste	Garden waste Public parks and roadsides Other
	Post-consumer wood	Post-consumer wood
Other municipal waste		
Total municipal solid waste		

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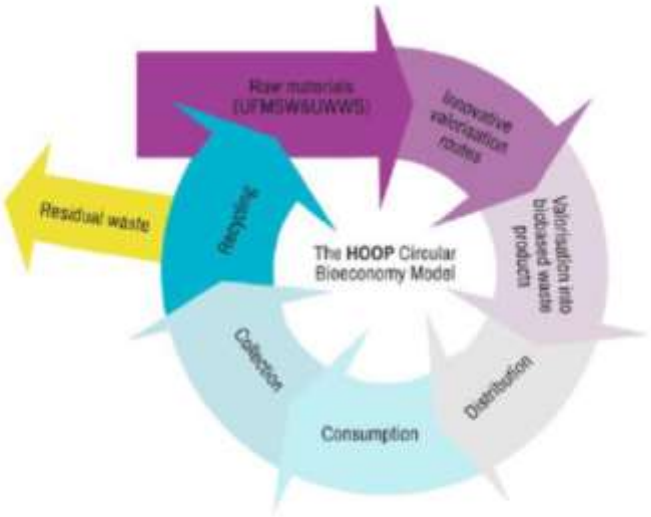
Analysis of lighthouse cities and regions

- Type of biowaste / sources
- Legal status
- Quality / composition
- Location and distribution
- Price or cost
- Current use
- Collection process
- Treatment and conversion options
- Final destination



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Parameters for a basic urban metabolism

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

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Parameters for a basic urban metabolism

Layer	Description	Source
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 treatment 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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Initiating innovative new production chains

State-of-the-art of technologies for the production of biowaste based products from OFMSW and UWWS

- **What are the technologies? how are they now?**
- **State-of-the-art** of technologies for **biowaste products from OFMSW and UWWS.**
  - **Analysis** of the technologies considering diverse aspects (technical, economic, legal, social, environmental)
  - **Comparative table**. Technologies which each city has and the ones to potentially implement.
- **Update** of the State-of-the-art and the comparative table

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Portfolio of technologies

Nr.	Technologies for Organic Fraction MSW
1	Biochemical conversion of the OFMSW
2	Insects reared on HORECA waste
3	Bioprocess involving methanotrophic bacteria using biomethane arising from the anaerobic digestion of the OFMSW
4	Black soldier larvae fed with OFMSW of digestate from anaerobic digestion
5	Nutrients recovered from residual dewatering liquid from anaerobic digestion
6	Fermentation of spent coffee grounds
7	Biochemical production of functional ingredients from animal by-products
8	Bioprocess, production 2,3-butanediol from OFMSW + garden + UWWS
9	Fermentation of used cooking oils
10	Productions of biofertilizers and bioestimulants

Nr	Technologies for Urban Wastewater Sludge
11	Bioconversion of UWWS: CO_2 fermentation with bioelectrochemical systems
12	Bioconversion of UWWS: PHBV production
13	Slow pyrolysis of UWWS
14	Production and purification of volatile fatty acids
15	Cellulosic rejections WWTP to ethyl lactate biosolvents

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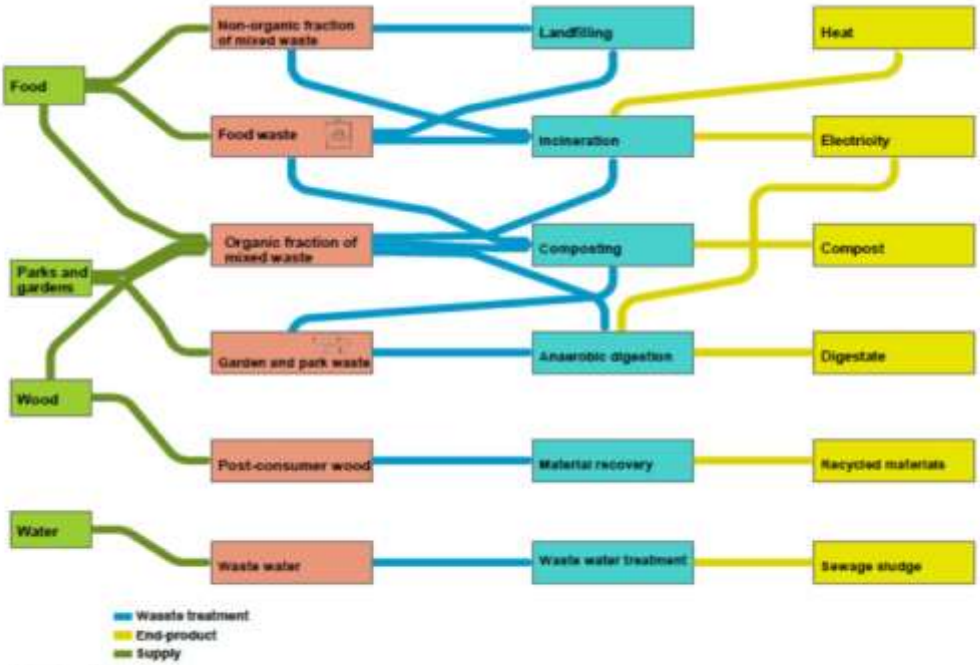
Sankey-diagram



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3.

Results

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Genaral outputs

- Selection of Best Available Technologies
- Screening of business models
- Investment schemes. Open Market Consultation
- Assessment of Lighthouse Cities scene
- Indicators for Circularity Level
- Replicability of results: Best Practices and State-of-the-art handbooks

Biowaste treatment in HOOP lighthouse cities and regions

- Most biowaste in HOOP lighthouse cities and regions is ending in **mixed municipal waste plus separate biowaste collection.**
- Nearly half of biowaste is **composted**.
- **AD** with or without composting is gaining importance.
- **No landfill** of biowaste.

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Anaerobic digestion and compost,

- In eight HOOP lighthouse cities and regions, most of anaerobic digestion and some of composted is generated from mixed municipal waste, food waste, garden and park waste and biowaste.
- Nearly half of selectively collected food waste (SC) is directly composted.

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Foodwaste

A quarter of food available to lighthouse cities and regions is food waste.

Woodwaste

Separate collection of post-consumer wood is also remarkable.

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Wastewater

- Most biowaste in HOOP lighthouse cities and regions is ending in mixed municipal waste plus separate biowaste collection.
- A significant portion of the wastewater is treated.
- Most sewage sludge (UWWS) is recovered from treatment plants. This is often fed to AD or composting facilities.

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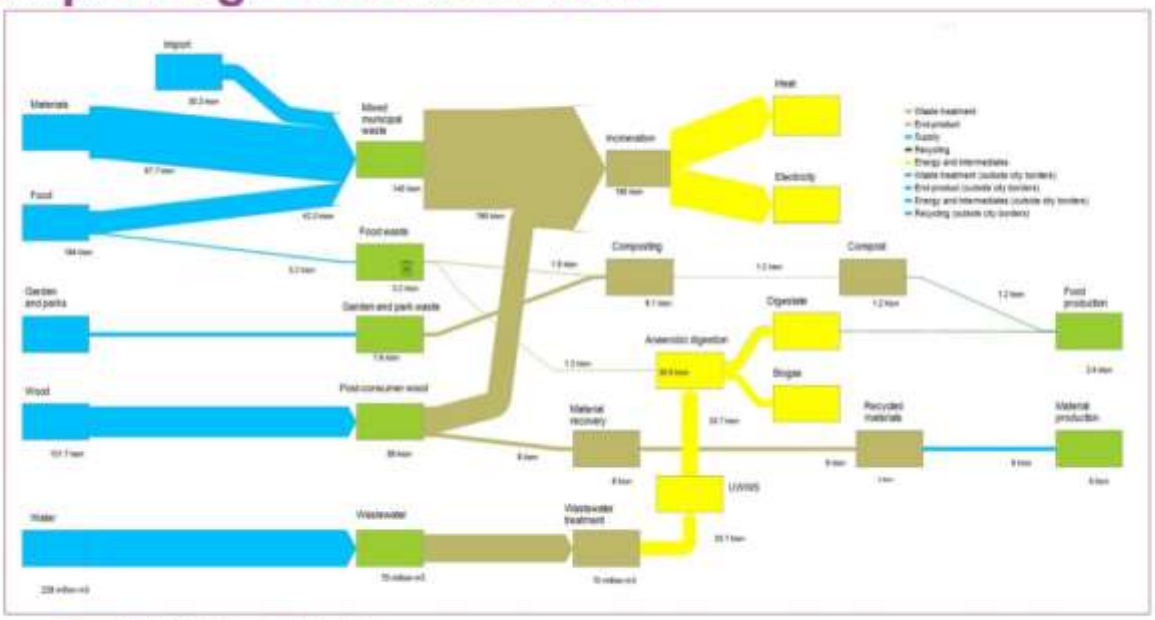
Example: high treatment rate



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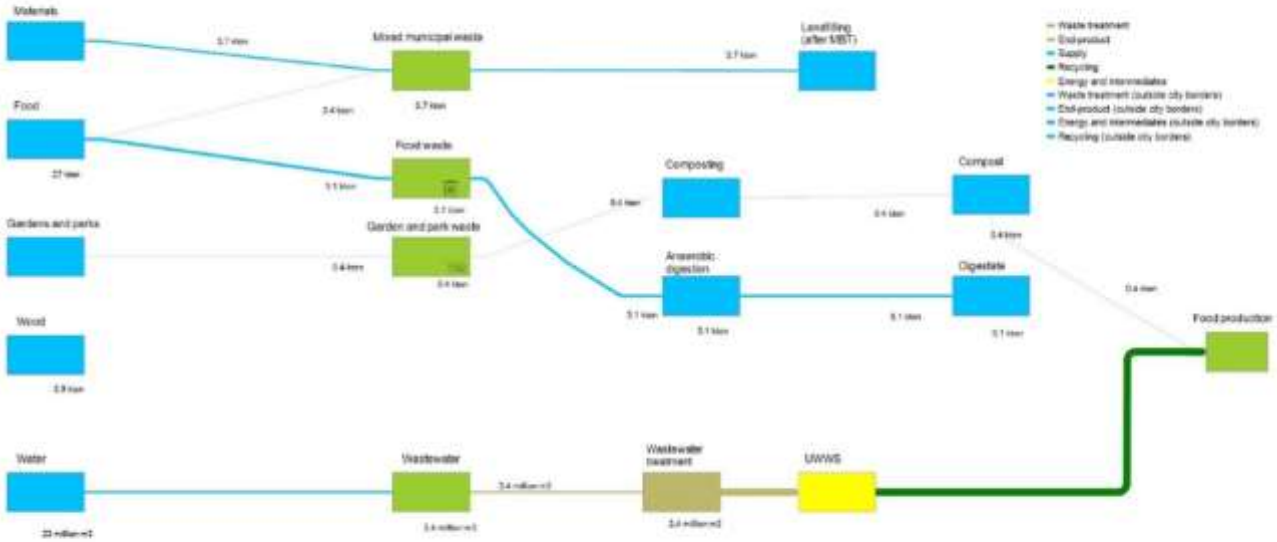
Example: low treatment rate



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Biowaste in mixed municipal waste streams

Dashboard: biowaste in mixed municipal waste as share of total municipal biowaste in 2019

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Conclusion

- Large amounts of the organic fraction of MSW can serve as feedstocks for advanced biobased production chains.
- The HOOP project identifies available biodegradable waste and selects promising valorisation routes.
- Eight lighthouse cities serve as nodules in testing and development.
- Urban Metabolism is used as an analytical instrument to depict (waste) streams.
- Impacts of project activities include reduction of landfilling and incineration, increased recycling and improved environmental and economic performances.
- The lighthouse cities and regions included in the HOOP project are a representative sample of the way waste is generated and treated in the EU. Large differences are, however, found between the individual lighthouse cities and regions.

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