research for policy 4
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Municipal solid waste with a high biowaste fraction in Kumasi, Ghana (image: sandec)

Biowaste Management:

the key to sustainable municipal solid waste management

Appropriate management of municipal solid waste is critical for public health and environmental protection. With denser settlement patterns, the challenge and threat becomes more acute. Managing biowaste with appropriate recycling strategies can reduce waste amounts by more than 50%, and create economic opportunities. Value products from biowaste include soil amendment and fertilizer, animal feed or a carbon neutral renewable source of energy. Biowaste management can also act as driving force for overall waste management when, for instance, the economic value of biowaste-derived-products incentivizes waste collection or the new revenue opportunities enhance financial sustainability of the waste management system. The key to success is keeping the biowaste separate from other waste fractions and selecting appropriate treatment technologies that respond to market demand for waste derived value products.

6 points to consider

1. Consider the high amount and threat of municipal biodegradable waste
2. Assess the current situation and develop a data baseline
3. Separate waste at source to keep it clean for successful recycling
4. Select the biowaste recycling technology which best fits the technical, economic and social context
5. Support with policy instruments and legislation
6. Ensure transparency and dissemination of lessons learned

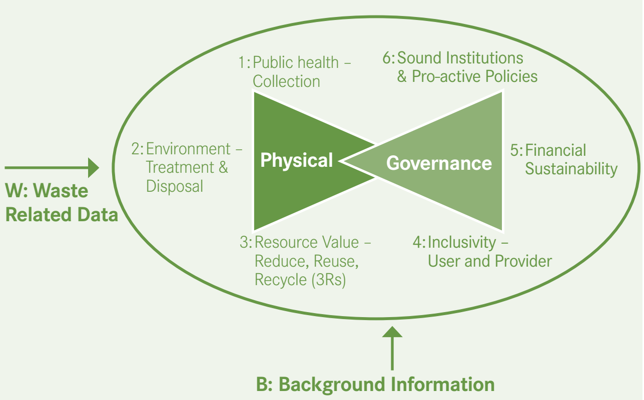
Mismanaged waste transfer station in Managua, Nicaragua (image: sandec)

Multi-stakeholder situation assessement in Bangalore, India (image: sandec)

1. Consider the high amount and threat of municipal biodegradable waste

"Solid Waste" is any unwanted solid product or material generated by people or industrial processes that has no value for the one who discards it. Waste contains different materials. Most of the solid waste in low- and middle-income countries consists of organic waste coming from food and kitchen waste as well as fruit and vegetable waste. Such biowaste is typically 50 to 70% of all municipal solid waste [1]. Therefore, if we can safely manage this fraction we can contribute significantly to an improved solid waste management system. If not managed appropriately, this biowaste fraction will attract various animals that transmit diseases, such as flies, rats, or other animals scavenging the garbage. If collected and disposed at dumpsites, the biowaste fraction undergoes anaerobic degradation and generates methane, a greenhouse gas that is 25 times more potent than carbon dioxide (CO_2) thus severely contributing to global warming. For example, one ton of food waste in a dumpsite emits ~1.9 tons of $CO_{2\ eq}$, comparable to the consumption of 820 litres of petrol[1]. In neighbourhoods as well as dumpsites, soil and water in contact with waste, become rapidly contaminated threating soil quality, food safety, as well as surface and groundwater resource quality. Solid waste littered into drainage channels will cause blockage, flooding or stagnant ponds. This can propagate the breeding of mosquitoes that transmit malaria, dengue, Zika virus, and yellow fever. Finally yet importantly, indiscriminately dumped solid waste in a settlement area is unappealing. It lowers the attractiveness for economic activity (e.g. tourism) and lowers the resilience and self-esteem of communities.

Integrated Solid Waste Management Framework



2. Assess the current situation and develop a data baseline

A waste assessment and monitoring programme helps establish a baseline of waste generation and composition and assists in planning appropriate services. You cannot manage what you do not measure! The cost of such an assessment is negligible, compared to the total investment in biowaste management and will be largely compensated by the savings it generates. Once established, the data will help track waste management performance, the associated cost, as well as environmental and operational savings. In biowaste management, a special focus must be set on questions such as: *who generates how much and what type of biowaste in your area? Who are the key stakeholders involved? What institutional and legal arrangements apply to biowaste management? What biowaste practices exist (e.g. collection, recycling)? What customer groups and demands*

1 watchmywaste.com.au

Source segregation: Separate bins for different waste fractions segregated at household level, Surabaya, Indonesia (image: sandec)

Sieving and bagging compost in Valparaiso, Chile (image: sandec)

exists for specific products derived from biowaste? This information together with some technical expertise should enable you to build the business case for your program and/or project. In parallel, a good forward planning is necessary, in order to anticipate future developments and design the system accordingly.

3. Separate waste at source to keep it clean for successful recycling

Amid a growing threat of climate change and increasing restrictions on supply of resources, a strategy of circular economy and low-carbon footprint is an essential element of municipal solid waste management. A 3R (reduce, reuse and recycle) approach, reduces final waste disposal volumes and contributes to sustainable cities. When mixed with other waste, biowaste becomes contaminated and more difficult to valorise. It also contaminates and lowers the value of "dry recyclable" waste materials such as metals, paper, glass and textiles. Therefore, success of all recycling depends critically on materials being kept separate and clean after waste is generated. The solution is "household or commercial segregation" into at least two fractions: 1) organic "wet" waste and 2) non-organic "dry" waste. Fostering waste segregation at the level of waste generator requires a dynamic and vigorous interaction with community and/or private sector members to incentivize their participation and change of behaviour.

4. Select the biowaste recycling technology which best fits the technical, economic and social context

Regardless of what biowaste treatment technology is used [2], it is essential to evaluate and understand which key factors are crucial for durability and sustainability of this operation. Overall, we can distinguish three different feasibility domains:

Typical examples of biowaste processing are (see annex 1):

Technologies/Processes	Products	End-Use
Composting [4, 5] Windrows Bins/In-vessel	Compost	Crop production
Vermicomposting	Worms Compost	Meat/fish production Other (pharmaceuticals) Crop production
Black Soldier Fly Processing [7]	Larvae Residue	Meat/fish production Crop production
Anaerobic Digestion [6]	Biogas Digestate	Heat Energy Electrical Energy Crop production
Slow Pyrolysis [8]	Char	Heat Energy Crop production Other (active carbon)

1. Technical feasibility: which includes the space and materials required for construction and operation, the technical skills and capacity to build and operate the facility, and the suitability and accessibility of biowaste type, quantity and quality.
2. Economic feasibility: comprises the expected capital and operational costs of a facility, as well as the possible revenue streams based the value and demand for the product derived from biowaste recycling.
3. Social feasibility: includes all aspects of community, and stakeholder social acceptance and support for the specific biowaste recycling facility and/or its derived products.

Careful evaluation of these factors will help decide what type of biowaste treatment technology is most feasible for implementation. Eawag has developed a manual to help structure and assist in the process of selecting the most promising biowaste treatment option for a given case study: the SOWATT manual: **S**electing **O**rganic **W**aste **T**reatment **T**echnologies [3] .

5. Support with policy instruments and legislation

As safe management of biowaste can contribute significantly to an overall improved solid waste management system. Local and national governmental authorities must ensure that this issue is listed as a high priority strategic goal and is followed-up on one hand with policies, policy instruments, regulations and legislation, and on the other with technology selection support, as well as financing structure. Direct regulation includes legislation and its enforcement. It serves to protect common interests in a society, such as public health and the environment. For instance, waste generators can be given the duty and made responsible for waste segregation, or local authorities are made responsible to "….facilitate implementation of any appropriate processing for biostabilisation of biodegradable wastes…". A 'direct regulation' approach needs monitoring, inspection and enforcement; therefore, a commitment to good and continuous data management are essential.

Economic policy instruments on the other hand help direct stakeholder behaviours and practices towards biowaste management using market-based incentives and disincentives. For instance by subsidizing compost to increase its competitiveness with regard to the already subsidized chemical fertilizers, or fiscal benefits for companies engaging in biowaste recycling. Finally, 'social' policy instruments, can be supported and implemented to strengthen the biowaste management approach. These are based on communication and interaction with stakeholders, such as awareness raising campaigns to impact on people's waste attitudes and behaviours or leading by example (e.g. using compost in public spaces).

6. Ensure transparency and dissemination of lessons learned

Biowaste management and recycling needs lessons learned. Although various projects have been implemented at different scales and with different outcome, these are seldom documented comprehensively. Available data, is rarely analysed, and often not even saved in a form, which allow good analysis. Especially transparent cost-revenue information is key to understanding financial feasibility of the case for future replication and scaling.

References and further readings

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Annex 1: Comparative overview of the biowaste treatment technologies [3]

	Windrow Composting	In-Vessel/Bin Composting	Vermicomposting	Black Soldier Fly (BSF) Processing	Anaerobic Digestion	Slow Pyrolysis
						
Process	Organic material is degraded and stabilized into compost mainly by microbiological processes. Microbial activity happens under aerobic conditions (oxygen). Biowaste is piled up in long heaps (windrows). Heaps are turned to improve porosity and supply oxygen.	Organic material is degraded and stabilized into compost mainly by microbiological processes in rotating vessels. Microbial activity happens under aerobic conditions (oxygen). Waste is in rotating vessels, where conditions (e.g. turning, temp.) are controlled. This accelerates the composting process.	Organic materials is degraded and stabilized by microorganisms and worms under aerobic conditions (oxygen). The products are worms and compost. Surface worms are suitable for this technology, such as *Eisenia fetida* and *Lumbricus rubellus.* The complete life cycle of *E. fetida* lasts 70 days.	Organic material is degraded by insect larvae and microorganisms under aerobic conditions (oxygen) The products are larvae and compost-like residue. Larvae of BSF feed on organic waste and generate insect fat and protein. Larvae develop and are harvested before pupation.	Organic material is degraded and stabilized into digestate mainly by microbiological processes in closed airtight vessels (digester). The products are biogas and digestate. Microbial activity under anaerobic conditions (no oxygen) producing biogas. 3 types of digesters are common. All are one-stage, wet, continuous and mesophilic.	Organic material is transformed by thermo-chemical processes into char, liquid residue and gas. Temperature range of 300–600°C and anaerobic conditions (no oxygen). Proportion of end-products depends on the feedstock, design of the reactor and operating parameters (heating rate, final temperature, residence time).
Lifetime	15–30 years	15–30 years	15–30 years	10 years	3–20 years (depends on type)[2]	10 years
Process time	3–6 months	1 month	1.5–2.5 months	14 days	10–40 days	Hours to days
Mass reduction	35–40%	20–50%	40–80%	50–80% (larvae yield 25%)	20% (solids reduction)	65–75%
Labor needs	1 (<1 t/d) or 1–2.5 (>1 t/d)	1 (<1 t/d) or 1–2 (>1 t/d)	1 (<1 t/d) or 1–2 (>1 t/d)	3 (<1 t/d) + 1–2 for add. t/d	1 (<1 t/d) or 1–2 (>1 t/d)	3–5 (<1t/d)
Ambient Temp[1]	>0°C (big) or >15°C (small)	>0°C (big) or >15°C (small)	Opt: 20–25°C, Max: 35°C	Opt: 28–32°C	Opt: 25–30°C, Max: 40°C	Min: >0°C
Space:	180–300 m^2/t*d	85 m^2/t*d	300–580 m^2/t*d	50 m^2 (nursery) +100 m^2/ t*d	100–530 m^2/t*d	30-50 m^2/t*d
Water:	20–70 L/t	10–35 L/t	35–50 L/t	Depends on waste moisture	Depends on waste moisture	none
Energy:	30–55 kWh/t or none	165–190 kWh/t or none	30–55 kWh/t or none	80–105 kWh/t or none	30–55 kWh/t or none	300–900 kWh/t
Waste moisture	Coarse: 70–75%; Fine: 55–65%	Coarse: 70–75%; Fine: 55–65%	70–90%	70–80%	80–95%	10–15%
Accept. C:N:	20–50	20–50	15–25	Non influential	16–25	Non influential
pH	5.5–7.5	5.5–7.5	Optimum: 7.5–8	4.5–8.9	6–7.5	Non influential
Waste feedstock	Garden trimming, Vegetable waste, Fruit waste, Fish or meat waste, Animal manure	Garden trimming, Vegetable waste, Fruit waste, Fish or meat waste, Animal manure	Vegetable waste, Fruit waste, Animal manure, Kitchen waste	Vegetable waste, Fruit waste, Fish or meat waste, Animal manure	Vegetable waste, Fruit waste, Fish or meat waste, Animal manure	Dry, homogeneous, substrate, preferably with high carbon & low ash content, e.g.: woody materials
Products & End-Use	*Compost,* a stable, dark brown, soil like material which improves soil structure and increases the nutrient availability in the soil. Besides compost, other outputs produced are leachate, water vapor and CO_2.	*Compost* is a stable, dark brown, soil like material which improves soil structure and increases the nutrient availability in the soil. Besides compost, other outputs produced are leachate, water vapor and CO_2.	*Vermicompost* is a stable, dark-brown, granular, soil-like material. which has shown to have higher levels of nutrients than compost. *Leachate (worm-tea)* from the worm bins can also be used as fertilizer. *Worms* are rich in protein and can be used as animal feed.	*Larvae:* contain 40% crude protein and 30% fat. The larvae are suited as a (partial) replacement of fish meal in animal feed. *Residue* still contains valuable nutrients and can be used as a soil amendment after a maturation phase.	*Biogas* is a combustible gas fuel, composed of CH_4 (55–60%), CO_2 (35–40%) and "impurities" such as hydrogen sulphide, nitrogen, oxygen and hydrogen. *Digestate* is rich in nitrogen and can be utilized in agriculture as a nutrient fertilizer or organic amendment.	*Char* can be briquetted and used as fuel (22–29 MJ/kg), or used as a soil amendment. *Bio-oils* have significant heating values (13–18 MJ/kg), and can be converted into valuable chemicals and fuels. *Syngas* (10–20 MJ/Nm^3), is a flammable gas and is used for fuelling the process.

[1]Operating temp.: shows the minimum, optimum and maximum possible ambient temperatures for the treatment technology to operate.
[2] Fixed-dome: 15–20; Floating-dome: 3–5 (humid climate), 8–12 (dry climate); Tubular: 3