Market-driven Upcycling of Urban Organic Solid Waste in Indonesia

FORWARD is a research and development project in Sidoarjo, East Java, Indonesia. Driven by market opportunities for conversion products, Sandec is piloting the innovative Black Soldier Fly Larvae technology as the pivot of an integrated organic waste conversion system.

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The challenge

There is a dire need for location-specific municipal solid waste management (MSWM) solutions in rapidly developing small- and medium-sized cities where the authorities often cannot respond adequately to rapidly changing conditions. Indonesia, the fourth most populous nation in the world, is no exception. The island of Java has the highest average population density of all islands worldwide (1 000/km^2) and the urban density approaches 10 000/km^2. This has intensified the waste problem, and in many towns and cities, much of all generated waste is dumped, burned or discharged into rivers. Organic waste (OW) makes up around 60 % of the total generated municipal solid waste (MSW), and is thus by far the largest fraction of MSW. Sustained solutions for this large OW fraction are rare, mainly due to the low (often negative) market value to processing cost ratio of OW conversion products.

Focus on market opportunities

The *From Organic Waste to Recycling for Development (FORWARD)* project evaluates how OW treatment can be driven by local market opportunities for waste conversion products. The aim is to foster a business approach to incentivise private or community OW treatment solutions. *FORWARD* explores and develops technological and managerial innovations for OW management to generate employment and simultaneously facilitate a more complete recycling of the inorganic MSW fraction.

Current situation

The Indonesian law 18/2008 regulates waste management (WM) at the national level. The national government fulfils a supporting and coordinating role, while implementation is a decentralised responsibility of Regency and City authorities. Besides the "reduce, recovery and recycling" (3R) objectives, it describes the rights and obligations of all layers of society, and stipulates that all open dumpsites in the country should be closed or replaced by sanitary landfills before 2014. Today, sanitary landfills are still rare. Open dumpsites are reaching full capacity and local authorities face difficulties to establish new sites. The availability of suitable land, distances and cost of both waste collection and of properly operating sanitary landfills are the main reasons why this is the case.

The rapid filling of landfills can be avoided if they would only need to accommodate the fraction of MSW left after recycling. Keeping the large OW fraction out of landfills reduces waste transportation requirements, extends landfills' lifetimes and reduces the costs of leachate treatment and methane control.

Incineration of mixed MSW is economically and environmentally not feasible for small- and medium-sized cities of Indonesia given the high water content of the waste. Furthermore, controlling air emissions from incineration can only be ensured with sophisticated equipment, which is expensive to operate and maintain.

A sustainable solution lies in source segregation of OW (kitchen, market and garden waste) to allow for appropriate decentralised treatment. This reduces the need for transport to landfills and also enhances the recycling of the inorganic fraction because source segregation increases the quality of recyclables. OW materials can be treated in different ways: they can be decomposed anaerobically into energy products (biogas or biochar), upcycled to animal protein as feed for a range of animals or decomposed aerobically into compost.

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Photo 1: Harvested Black Soldier Fly larvae.

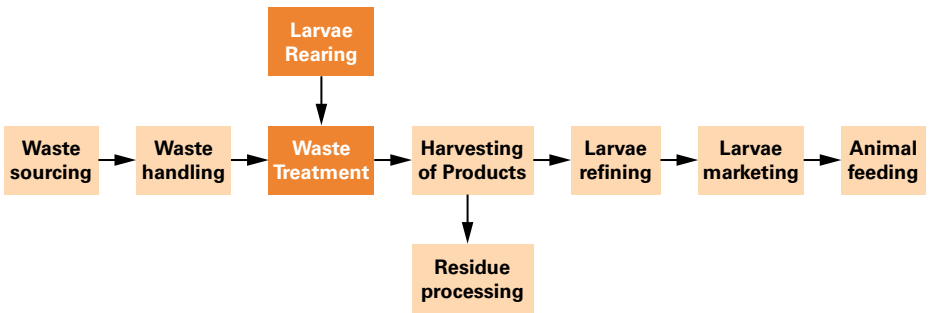

Figure 1: Process steps of an organic waste treatment facility utilising conversion by BSF larvae.

Market potential of waste conversion products

FORWARD evaluated the market potential of different OW conversion products. This market research complemented the assessment of OW generation and of current MSW management practices in the Sidoarjo regency. The steadily growing population and economy indicate a clear need for energy, protein and soil amendment, i.e. compost. However, these requirements do not necessarily translate into viable market opportunities.

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Photo 2: Adult Black Soldier Flies reproduce in "love cages" and the eggs develop into young larvae.

Compost production is relatively simple and can convert most OW fractions. Also, Javanese agricultural soils are low in organic matter due to the ongoing and decennia-long intense agricultural practices and the promotion and subsidising of chemical fertilizers. Thus, compost could play an important role to sustain soil fertility and structure. Yet, without governmental promotion and financing or preferential treatment in the marketplace, compost can barely compete with fertilisers and other soil amendments.

Biogas and biochar production is complex and restricted to specific OW types and mixtures. In the Indonesian consumer energy market, biogas and biochar cannot compete with convenient, clean and subsidized Liquefied Petroleum Gas. OW-derived energy products are feasible only in very specific and rather small on-site applications.

Protein production from organic refuse could meet the needs of the large Indonesian population. Currently, around 80 % of the total soybean and 55 % of the total fishmeal requirements are imported, which weighs on the Indonesian trade balance deficit and contributes to global environmental issues. Local meat production in Indonesia is well below consumption. Up to 80 % of the cost of meat or fish production is the cost of animal feed; thus, local animal production is restricted mainly by the availability of base protein. Indonesia cannot, for example, realise its huge aquaculture potential, which could also serve the export market. The government is eager to achieve food self-sufficiency and often regulates food and feed imports to boost opportunities for local farmers. Growing demand for locally produced base protein to increase local animal production and the relatively high value of protein make OW-to-protein conversion very promising from a market perspective. Direct feeding of selected kitchen and market residues to cattle, goats, fish (especially catfish) and poultry (chicken and ducks) is already common, particularly during the dry season when foraging and grazing are limited. Feeding organic kitchen and market waste to insect larvae of the Black Soldier Fly (BSF) is an alternative solution, linking OW treatment to the production of base animal protein, namely the protein from nutritious insect larvae (Figure 1).

FORWARD pilot operations

FORWARD has established an organic waste conversion site at the Puspa Agro vegetable market in Sidoarjo, where conversion by Black Soldier Fly Larvae (BSFL) has been developed as the core OW conversion technology. BSFL are fed dewatered fresh market waste, and the OW fraction not consumed by BSFL, i.e. the cellulose-rich "garden waste", is composted. The biogas production potential of the liquid from waste dewatering and the residue after BSFL conversion are currently being explored. This on-site energy source could be used for post-harvest processing of larvae (Photo 1). The residue is also being tested for vermiculture.

Ongoing research

FORWARD currently rears enough young BSFL to process 2 ton of fresh OW daily, and this can be flexibly scaled up (Photo 2). Our research now focuses on improving and streamlining the BSFL waste conversion operation, such as finding ways to remove excess water by dewatering and/or mixing different waste types. The goal is to have the final residue dry enough to allow for mechanical harvesting of larvae. Research with Indonesian universities involves evaluating the feeding of larvae to fish, poultry and baby goats, as well as the biogas potential of the liquid and residue fractions. *FORWARD* also interacts with communities to obtain segregated household organic waste and with agribusiness companies to test industrial organic waste streams. The project is also doing market development with potential end-users and commercial partners.

Outlook

Although BSF technology is still in its infancy, stakeholder interest is steadily growing, providing an incentive to explore source segregation of waste, a yet rare practice in Indonesia. To respond to the market potential and to meaningfully impact waste management, more knowledge on OW conversion by BSFL at different scales is necessary, and technology and business models need to be developed and evaluated according to these scale requirements. *FORWARD* is successfully demonstrating to governmental, private, social and academic partners that widespread decentralised OW conversion is key to the overall MSWM challenge and that OW resource recovery can contribute considerably to social, economic and environmental welfare in many ways.

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