The Potential of Slow Pyrolysis of Urban Biowaste in Tanzania

Tests with the new vertical slow pyrolysis reactor had promising results in regards to char quality and energy balance. A comprehensive local stakeholder assessment showed that although the technology attracts high interest, implementation requires overcoming major challenges. Imanol Zabaleta[1], Manuel Rohr[2], Christian Riu Lohri[1], Fabia Zermin[3], Chris Zurbrügg[1]

Introduction

Sandec is partnering with the University of Dar es Salaam to analyse the potential of treating urban biowaste by slow pyrolysis to generate a marketable char product that could be used as cooking fuel. If successful, this treatment and valorisation process could help address the waste management and deforestation problems in Tanzania. In Dar es Salaam alone, it is estimated that about 4 100 tons of waste are generated daily (roughly 60 % is biowaste) of which only 40 % is collected. Most of it is inadequately dumped [1]. Wood-based charcoal is the primary cooking fuel in Tanzania, and is used by over 90 % of the households. Its use has caused widespread deforestation in the country.

Experimental set up

A small scale, semi-continuous slow pyrolysis reactor was designed and constructed at the University to test the effectiveness of this technology. It is comprised of a furnace, two oil-barrels and a chimney, stacked on top of each other (Figure 1). Each barrel has seven metal pipes, containing the feedstock, and the pipes are sealed at the top and have metal lids at the bottom. The furnace is fuelled by LPG (HHV=50 MJ/kg), heating the bottom barrel to achieve carbonisation. Pyrolysis gas exits the pipes, generating additional heat, and the excess heat from the bottom heats the upper barrel, drying the feedstock within it.

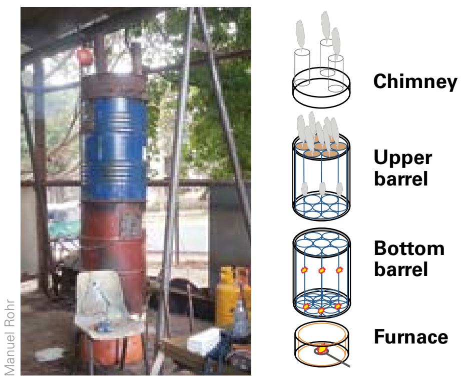

Figure 1: Prototype of the vertical reactor.

First results

8 kg_{db} of shredded cardboard waste were used for the first experiments. All resulting chars showed satisfactory high heating values (HHV) (21.6–24.3 MJ/kg_{db}) similar to those of bituminous coal. The volatile solids (VS) content decreased from 79 $\%_{db}$ (cardboard) to between 8.5–40 $\%_{db}$ in the chars (lower values indicate a higher quality). The fixed carbon (FC) increased considerably from 8 $\%_{db}$ (cardboard) to values around 50 – 57 $\%_{db}$ in the chars, and the char yields ranged from 23–27 $\%_{db}$. Figure 2 presents the proximate analysis and HHVs observed in the best practice mode experiments. Three of these were conducted with only one barrel (Series 1) and two with two barrels (Series 2). Both series compared well with previous slow pyrolysis tests [2].

The trials with one barrel had a net positive energy balance (Figure 3). In the best case (experiment 1.2), 0.67 MJ of LPG were needed to generate 1 MJ of char. The trials with two barrels had a negative energy balance. We assume this is because the double stacking of barrels increased the flow velocity of hot air, i.e. the chimney effect, rapidly removing the hot air from the system and diminishing the heating rate in the lower drum. Further research is underway to optimise this air flow and to evaluate the emissions of the slow carbonisation process.

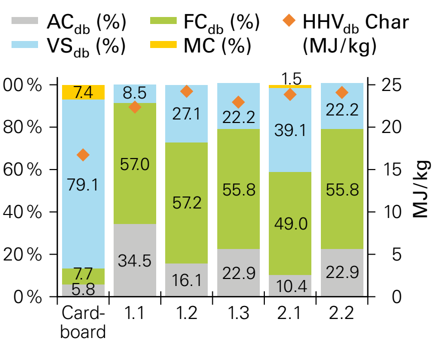

Figure 2: Proximate analysis and HHV of cardboard and obtained chars.

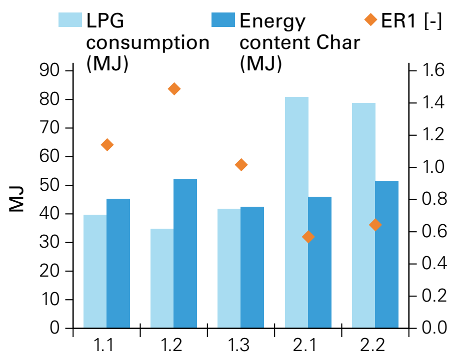

Figure 3: Energy balance per experiment.

Assessment of local stakeholders

62 local stakeholders were identified who had connections to the charcoal business or the waste management and recycling sectors. Their potential to become future successful biowaste-to-char producers was evaluated using a set of criteria developed with local experts. The criteria included: access to biowaste, access to capital, access to space and available skill levels. Two stakeholders showed especially great potential: a waste collection enterprise currently servicing the city centre and a large recycling company that already processes different fractions of waste, but not yet biowaste. Interviews with the stakeholders revealed great interest in biowaste carbonisation among many of them, while also disclosing several bottlenecks needing to be addressed, i.e. limited market demand by households for char briquettes, limited access to space in the city for a scaled-up facility, and difficulties in accessing well sorted biowaste.

[1] Breeze, R. (2012): Municipal Solid Waste Management in Dar es Salaam. Prepared for the World Bank.

[2] Lohri, C.R., Faraji, A., Ephata, E., Rajabu, H.M., Zurbrügg, C. (2015): Urban biowaste for solid fuel production: Waste suitability assessment and experimental carbonization in Dar es Salaam, Tanzania. Waste Management & Research *33(2)*, 175–182.

[1] Eawag/Sandec, Switzerland
[2] Jokela Turbine, Frutigen, Switzerland
[3] ETH Zurich, Switzerland
Contact: imanol.zabaleta@eawag.ch