Experimental Char Production of Selected Urban Organic Solid Waste

This project in Dar es Salaam, Tanzania, explores how solid waste management could be improved by producing char from urban biowaste through slow pyrolysis. The char could be briquetted and used as an environmentally friendly substitute for wood based charcoal. Christian Riu Lohri[1], Elia Ephata[2], Adam Faraji[2], Hassan Rajabu[2], Christian Zurbrügg[1]

Introduction

Similar to many cities in developing countries, the solid waste management system in Dar es Salaam (DSM) is characterized by a low collection rate, high organic fraction, and inadequate disposal. Simultaneously, charcoal is the main cooking fuel used by more than 90 % of city households, thereby, contributing to substantial deforestation. The aim of this ongoing project is to assess the suitability of organic wastes for char production and to develop an appropriate experimental pyrolysis system.

Assessing the suitability of urban wastes for char production

Eight biowaste types prevailing in DSM were selected, including wood waste, coconut shell/husks, potato peelings, cardboard, trimmings, seaweed, bagasse from sugar cane juice vendors, and packaging grass/leaves used in markets for transportation of fruit and vegetables. A framework was developed to assess and rank their suitability for making charcoal fuel using two groups of criteria: i) availability and accessibility aspects and ii) physical-chemical properties. The former included assessments of total quantity generated, seasonal variation, competing uses, and degree of centralization. Data were obtained through literature review, interviews, observations, and measurements of volume and weight. Data for the latter were generated from lab experiments, including proximate analysis (moisture, fixed carbon, ash content) and from the physical appearance of the waste when collected (bulk density, particle size uniformity). Results showed that packaging grass, wood waste and cardboard have the highest overall potential for char production in DSM.

Experimental slow pyrolysis unit

A carbonization unit was designed to pyrolyze the identified waste in an efficient, cost-effective and safe manner. The unit shown in Figure 1 consists of an externally heated metal barrel (200 L) as pyrolysis chamber, a rotating and ejection mechanism, and a heat-retaining brick-kiln, in which the barrel is horizontally placed on guiding rails. When starting the process, the 2 cm hole in the barrel is aligned with an exhaust pipe to release the vapour produced in the initial drying stages of pyrolysis. When the whitish gases from the pyrolyzer change colour to yellow, which indicates the inflammability of the gases, the barrel will be rotated 180° using an external mechanism. By burning these gases, the external heating process is enhanced and CH_4 and CO pollution from the unit reduced. The rotation also helps to mix the material in the barrel. During the pyrolyzing process the temperatures inside the drum, brick housing and chimney are continuously measured. After completion of the process, the drum is removed for cooling and a new barrel filled with raw biowaste is loaded into the still hot brick housing (a semi-batch system) [1].

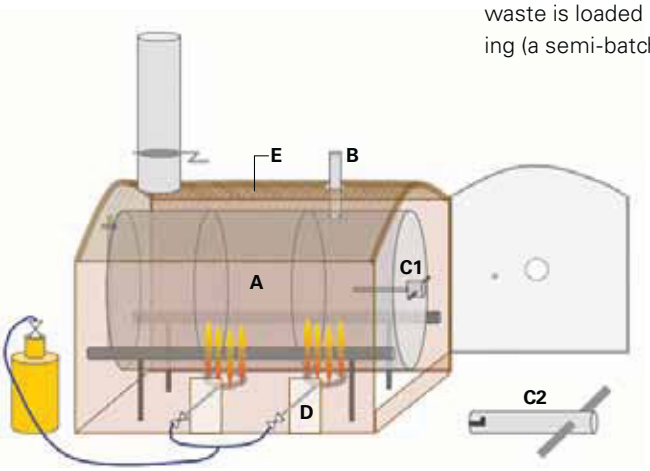

Figure 1: Scheme of pyrolysis unit. A: pyrolysis drum, B: pipe for initial pyrolysis gases, C1: rotating knob, C2: rotating and ejection handle, D: combustion chamber, E: brick kiln.

Other research components

The drying process is a pre-treatment option for wet urban biowaste types (e.g., bagasse); yet, it is also a time- and space-consuming step in the briquetting stage. To speed up the process, a hybrid solar drying system, using direct and indirect heating with forced convection, was designed and fabricated [2]. Its main elements are a solar-energy collector for air heating, a partly glazed drying chamber with several trays, and an extractor fan to suck air through the collector. Two ceramic-lined charcoal stoves can be placed underneath the collector as an alternative heating source to operate on cloudy days. The aim is to reduce the moisture content of raw waste to a level acceptable for pyrolysis and to minimize the drying time of freshly pressed briquettes.

Conclusion

Tests of different biowaste types and varying parameters are ongoing. When completed, they will permit analysis of the overall performance, including efficiencies and energy balances, which will enable the evaluation of the financial feasibilities of the two systems. Up-scaling and implementation issues will also be examined. A possible follow-up project could include emission measurements during char production and testing alternative energy sources (e.g., biogas generated from wet, mixed biowaste) as heat input for the pyrolysis process.

[1] Ephata, E. (2014): Slow pyrolysis of selected urban biowaste for char production in Dar es Salaam. MSc thesis at College of Engineering and Technology, University of Dar es Salaam *(in progress)*.

[2] Faraji, A. (2014): Experimental investigation on drying options of potential urban biowaste for char production in Dar es Salaam. MSc thesis at College of Engineering and Technology, University of Dar es Salaam *(in progress)*.

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