Biogas in Cities – A New Trend?

Anaerobic Digestion of Kitchen and Market Waste in Developing Countries

So far, several million conventional biogas plants, using predominantly animal manure as feedstock, have been successfully installed in rural areas of developing countries. However, can anaerobic digestion also be a suitable technology to treat organic household waste in urban and peri-urban areas to alleviate the solid waste crisis in cities of the developing world? Yvonne Vögeli, Chris Zurbrügg

In many cities of developing countries, the most serious environmental and health problems are related to inadequate solid waste management (SWM). Progressing urbanisation and rapid population growth lead to increasing amounts of waste, thereby also increasing pressure on local authorities responsible for the provision of safe and reliable public services. Municipal Solid Waste (MSW) in developing countries is rich in organic material (up to 70 %). However, if this organic fraction is not managed adequately, it causes nuisance for urban dwellers and pollutes the environment due to its easily biodegradable nature. Unreliable collection leads to smelly dumps in neighbourhoods and attracts animals, such as rodents, the typical transmitters of diseases. Lack of treatment or non-engineered and unsafe disposal causes soil, surface water and groundwater pollution through leachate, and uncontrolled methane emissions contribute to global warming. Consequently, particular attention should be given to the organic fraction of municipal solid waste. Some treatment options for biodegradable waste, such as aerobic composting or direct animal feeding have been identified in practice and are more or less well-recognised as proven solutions in certain contexts. Nevertheless, there is still scope for improvement by increasing the value and further potential benefits of the treatment steps and generated products. Aside from using worms or larvae to digest the waste (as described in another article of this Sandec News issue), anaerobic digestion (AD) or biomethanation of organic solid waste is likely to be a promising treatment option. Under anaerobic conditions, bacteria break down the organic matter and produce biogas. This mixture of CO_2 and methane (CH_4) can be used as an energy source for cooking, lighting or even to generate electricity, thereby replacing other fuels. The digestate, similar to compost, can be used as soil conditioner in agriculture or landscaping since it contains nutrients and is rich in organic matter. AD of organic solid waste is already widespread in industrialised countries and is gaining importance given the growing demand for renewable energy and high market prices for fuel. To date, AD of livestock manure, as major feedstock, is common mainly in rural areas of low and middle-income countries. In urban or peri-urban settings, where organic solid waste is predominantly available as feedstock, the accessible knowledge and information on technical and operational feasibilities, challenges and opportunities is limited. This lack of research and development and/or limited spread of knowledge and information is astonishing in the light of the enormous waste problems faced by most urban areas in low and middle-income countries.

Situation analysis in South India

A literature review and Internet search [1] conducted by Sandec on anaerobic digestion of organic solid waste in developing countries identified South India as a location characterised by numerous research, development and implementation activities. Research institutions, NGOs and commercial organisations active in the sector have jointly generated much knowledge and experience in anaerobic digestion of kitchen/market waste as well as organic household waste. In August 2007, an on-site assessment and evaluation study examined 16 biogas plants in different South Indian cities. All the visited plants developed by Indian research institutes, private enterprises or local NGOs were specifically designed to treat organic solid waste rather than manure. Plant size and scale of operation vary from smallest household plants (1–5 kg/d), medium-size facilities at institutional and municipal level (< 3 t/d) to large-scale facilities of up to 100 t/d capacity.

The feedstock used for digestion comprises kitchen waste from households, canteens and restaurants, market waste

Photo 1: BIOTECH biogas plant fed with canteen waste (30 kg/d) in Trivandrum, India.

(vegetables, fish), waste from slaughterhouses and – in a few plants – also toilet waste. The biogas generated by the anaerobic digestion process is generally used directly for cooking in close proximity to the plant. This is the easiest and most efficient way of using the gas, as complicated storage and transport are not required nor any further treatment steps (e. g. hydrogen sulphide removal). In other cases, the generated gas is used for street lighting or converted into electricity. The type of gas use depends not only on the daily amount generated, but also on the spatial and site-specific location of the plant.

The main motivation of plant developers and operators is driven by the need to find *waste treatment solutions.* The perceived comparative advantage of anaerobic digestion is its controlled and contained (closed) waste treatment process perceived as a technically advanced but "clean" solution not requiring much surface area. In this sense, generation of biogas is seen as a welcome added value of the technology and not necessarily as the decisive factor for choosing anaerobic digestion over another organic waste treatment option. Furthermore, little attention is often paid to the digested residues (solid and liquid fractions) and their agricultural, gardening or landscaping value. Scarcity of well-documented information on gas generation rates in relation to loading rates, types of waste, reactor volume, retention time, or also characteristics and composition of residues is therefore not surprising.

To date, all the evaluated experience points to the fact that the initiative and motivation to support, develop, invest, and operate biogas plants is driven by the interest of researchers, private enterprises or NGOs. Though national government agencies, such as the Ministry of New and Renewable Energy (MNRE) or the Indian Renewable Energy Development Agency Limited (IREDA) promote, develop and provide financial assistance to renewable energy and energy efficiency/conservation projects, the support from local governments, specifically from municipal authorities responsible for waste management is largely lacking. These waste treatment options are rarely embedded in the urban strategic waste management plan and therefore often remain isolated individual initiatives. This is all the more surprising as India has an innovative legal framework and city authorities are liable to promote waste segregation at source to avoid biodegradable waste disposal in landfills. According to current legislation, biodegradable waste must be processed by composting, vermicomposting, anaerobic digestion or by any other appropriate biological process. Unfortunately, legislation is not yet fully implemented. However, the existence of such a legal framework, in combination with the interest of municipal authorities in finding solutions to comply with these rules, can significantly contribute to promoting biogas plants in India. Furthermore, promotion of anaerobic digestion can achieve substantial momentum, since the technology qualifies as a CDM project (avoiding uncontrolled methane emissions from dumped waste on landfills). CDM is an arrangement under the Kyoto Protocol, allowing industrialised countries with a greenhouse gas reduction commitment to invest in projects that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries. CDM investments may thus further boost development and implementation of AD facilities in developing countries.

Experience from India shows that AD of organic solid waste is a promising technology in developing countries with a tropical climate. Biogas plants treating organic solid waste in urban areas have a great potential. Sandec's solid waste research activities will look at the performance of small and medium-size biogas units to collect scientific evidence on gas production, gas composition and effluent quality, as well as study the economic aspects of this waste treatment method. Preliminary monitoring results of a household biogas plant in Tanzania will be available at the end of 2008 (cf. box).

Anaerobic digestion of kitchen waste at household level in Dar es Salaam, Tanzania

Photo 2: ARTI biogas plant in Dar es Salaam, Tanzania.

The ARTI Compact Biogas Plant is a small household system developed in India for the daily treatment of 1–2 kg of food waste. This widespread system in South India is now being promoted in Tanzania and Uganda. Though a seemingly successful approach, data on its performance in Africa is still scarce. Further information will be required to obtain a detailed assessment of this treatment option. Monitoring of an ARTI biogas plant at household level and experiments at the Ardhi University of Dar es Salaam shall provide reliable data on daily gas production, gas composition, effluent quality, and suitability of this technology with different feedstock, including convenience of operation. This project will be launched in July 2008 in collaboration with the Ardhi University of Dar es Salaam and the University of Applied Sciences in Zurich.
For further information on this technology, kindly consult www.arti-india.org

[1] Müller, C. (2007): Anaerobic Digestion of Biodegradable Solid Waste in Low and Middle-Income Countries. Sandec Report, May.