Sustainable waste treatment as resource management.

By Markus Bieri PhD, visiting scientist of ICIPE-Ethiopia and lecturer in soil biology at the Swiss Federal Institute of Technology, Zurich, Switzerland. Address: Bahnhofstrasse 30, CH-8803 Rueschlikon.

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Summary

In future, sanitation and waste management concepts have to be part of decentralised holistic recycling systems. The separation of the waste into its components has to be done at the source (household, grocery store, hotels, animal keeping systems etc.). Most of the inorganic residues can be provided to recyclers. In Addis Ababa about 60 % of waste is organic. On the countryside the organic part exceeds this ratio. If the residual organic materials are not contaminated with hazardous components (heavy metals), they represent a real value as animal feed, energy and plant nutrient source. In the last decades several new technologies were developed that enable material conversion on site in small units distributed all over a residential area (biogas, composting, nitrification, and small incineration installations and waste water treatment with water plants). Decentralisation reduces collection and transport costs, whereas the produced energy and goods directly can be used by the inhabitants and the farmers.

The inherent plant nutrients of residuals from energy production (sludge from biogas, ashes from incineration) as well as urine, bones, horns, claws and feathers can be converted into useful organo-fertilisers. They can be delivered to farmers, vegetable growers or used for fast growing wood, fibre or energy plant production (Eucalyptus, Bamboo, Papyrus etc.).

Wastewater from energy production systems are biologically treated in ponds with water plants. The cleaned and hygienic save water also can be used for irrigation at seasons with water shortages.

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According to the Health Bureau of the City of Addis Ababa about 400 t of waste per working day are collected and brought to the land fill area outside the city. About 60 % are organic material that causes problems like as bad odours, uncontrolled methane production and contamination of the river systems etc. The inherent values of the organic residues can be estimated as follows:

Total amount of organic material	75'100 t/year
Potential for biogas energy	90 TJ
Equivalent in diesel oil	2'100 m^3
Nitrogen (N) content	385 t
Equivalent in urea fertiliser	840 t
Phosphorous (P) content	43 t
Equivalent in P_2O_5 fertiliser	99 t
Potassium (K) content	415 t
Equivalent in K_2O fertiliser	500 t

On the countryside, the priorities of the population are different. Most farmers are aware of positive effects on plant growth and soil erosion prevention with applying organic materials and ashes. Ensete plants are usually transplanted into 0.2m to 0.4m deep pits. Cattle dung, organic materials (dry grasses, dry ensete leaves) and ashes from the cooking fire are usually added to the transplanted plants. The highest amount is given in the first and second year of cultivation (Bierwirth et al. 2001). Studies on plant nutrient recycling were carried out by ICIPE at the Gurage location and the technique introduced to farmers. Those farmers who implemented this technique are highly satisfied by the results. Further investigations are carried out for improving the nutrient recycling systems for farmers. Most attention is given to the increase of the nitrogen content of those self-made organo-fertilisers (Greiling et al. 2000). Methods to improve nutrient recycling from animal droppings are studied and the integration of farmers in waste management programmes of nearby settlements are discussed.

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For the fast growing cities new and sustainable solutions for the inhabitants and the administrations have to be identified. The actual centralised city sanitation installation of European and the US cities are neither economically nor ecologically efficient. The costs of investments require long term planning. Whereas the installations consider high running costs and energy consumption. The maintenance of these plants imply the establishment of extensive transporting and sewer systems that nowadays become a costly burden for these societies.

In the last years new methods, mainly based on biological processes, were found and developed to convert residual materials into energy and organic fertilisers. All these conversion processes create useful products that can marketed. Waste management under these conditions gets a completely different image and perspective, compared to the actual state of the art.

Biological and small scale self sufficient systems are advantageous, because they can be run and maintained locally close to the end users of energy and other products. Obviously he costs for transport and for sewer systems can be reduced. The converted products weigh less and have a reduced volume that simplifies the transport and the distribution. Short circuit systems also motivate inhabitants to maintain a functioning waste treatment installation in a good shape. Decentralisation of wastewater cleaning and solid waste management leads to a higher stability and security in city sanitation measures. A break down of a single unit does not affect the whole city. The cities however are obliged to supervise and co-ordinate the activities of these local groups.

In awareness of this situation, ICIPE-Ethiopia worked out in co-operation with ESRDF and the city administrations of Addis Ababa, Dire Dawa and Wolkite pilot projects for sustainable and decentralised city sanitation, with the following objectives:

1. Improvement of the general sanitary situation leading to better living and health conditions of the inhabitants and the visitors of the cities.
2. Creation of useful and marketable products such as biogas (energy), mats made from old plastic bags, card board manufacturing using paper pulp, organic fertilisers and protein for animal feeding.
3. Providing job opportunities and income generation. Including different professions in the administration, laboratories, training sites, specialists for biogas and organic fertiliser production, specialists in wastewater treatment, manufacturers of equipment's for waste conversion and wastewater treatment systems.
4. Reduction of public costs (investments and running costs) for waste management. By implementing biological self running systems with low investment and running costs.
5. Build up of a decentralised organisation distributed over the whole area of the cities to reduce waste collection and transport costs.
6. Development for an efficient organisation and quality management for a decentralised city sanitation management.
7. Enhancement of the international reputation of the Ethiopian Cities leading to an improved tourism industry. Ethiopia with its rich cultural heritage and natural treasures is highly attractive to people of America, Europe and Asia.

The BioFarm in Addis Ababa will be extended into a competence centre with training and education facilities in co-operation with ICIPE (Baumgärtner et al. 2001). Also, it will provide scientific and technical support to city administrations and communities in all aspects of city sanitation. However, the general goal is, to establish several centres all over Ethiopia. The people will regularly meet for seminars and experience exchange. National and international co-operations with universities, research institutes and technical centres have to be established.

The purpose of the research group at BioFarm is to develop easy adaptable and efficient systems for waste wastewater and solid waste treatment that can be integrated into existing structures, built and maintained in the country. Many of these systems are developed outside of Ethiopia and have to be adapted and optimised for the specific conditions and needs of the different climatic zones of this country.

Optimisation of wastewater and solid waste treatment includes:

- Development of devices that can be made by locally made of easily available materials.
- Identification of systems that can be run with minimum input in energy and labour.
- Construction of save installations with no hazard for people, animals and the environment, like as fire hazards, emissions of unpleasant odours or breeding places for mosquitoes or filth flies.
- Production of high quality products that can be marketed, like high quality biogas, combustible biomass, uncontaminated animal feed rich in protein, nitrogen rich organo-fertiliser with suppressive effects on soil borne pathogens etc.

The planned technopark also serves as demonstration and training place for specialists to be formed for maintaining and running installed systems.

The following systems as integrated parts of sustainable waste management will be evaluated:

1) Development of modular low cost biogas units with a high methane yield

Nowadays biogas technology is a common technology used almost all over the world. In China and India special research and development centres exist.

A broad literature on biogas including the biological processes of methanisation and all kinds of designs for biogas plants is available. Most of the described biogas plants are fix installations with a given capacity. For further developments the design of modular standard units that easily can be installed and transported, seems to be the most promising approach.

In the projects of the Ethiopian cities prototypes of a standard biogas reactors for Ethiopia will be planned, built and evaluated. The biogas production for different organic materials will be optimised.

In parallel to these studies different techniques to increase the methane content of biogas will be evaluated. The percentage of methane in raw biogas betrays is 50 to 70 percent. The rest is CO_2 with some traces of H_2S. For both gases an efficient gas cleaning procedure will be installed that easily can be implemented. The reduction of CO_2 in the burner gas leads to a better energy output and reduces the need of storage volume.

2) Evaluation of high quality solid burner for plastic, cardboard, wood and other combustible wastes

Wood, cardboard, bagasse, plastics and other combustible wastes have high contents of caloric energy. Today a challenge task is to find incinerators for smaller quantities subjected to clean burning procedure. This means an incineration process with a maximum oxidation of the materials without noxious gas and dust emissions.

Low temperature distillation showed to be the most promising technique. An almost complete burning of the organic materials with a high-energy can be achieved. In Europe most of the newly installed wood heatings function by this principle. For Ethiopia appropriate stoves have to be evaluated and optimised.

Efficient and reliable incinerators can play an important role in energy concepts. Energy produced with fast growing plants (e.g. Eucalyptus, Bamboo, Papyrus etc.) becomes a backbone in energy self-sufficiency, whereas combustible solid waste also serves as heating material.

In co-operation with foreign universities the conversion of the caloric energy into electricity or kinetic energy (steam engine, Stirling engines, gas motors etc.) has to be investigated.

3) Improvement of vermicomposting systems for high quality organic fertiliser production.

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Vermicomposting is a common composting technique that is practiced at BioFarm. Studies are under way to improve the nitrogen content of organo fertilisers and to find appropriate endemic earthworms. Vermicomposting systems are an integral part of the waste management treatment chain to convert biogas sludge into a marketable organic fertiliser.

For the use and for marketing of organic fertilisers, quality standards have to be defined (Berner & Bieri, 1992, Bieri, 1998, Fuchs & Bieri, 2000), and a quality controlling system will be established.

4) Production of nitrogen rich organo fertilisers.

Nitrogen rich residues like feathers, claws, horns, inedible fish, residues from slaughtering etc. but also to some extend urine, can be degraded in old compost layers. Experiments at BioFarm have shown that the amount of plant available nitrogen of such composts can be highly increased.

In arid zones nitrogen conservation of urine can be realised by nitrifying the inherent nitrogen. In the planned nitrifying devices nitrogen can be harvested as $Ca(NO_3)_2$, a water soluble salt, that can be added to the irrigation water in drip irrigation systems.

5) Development of a waste water treatment plant in using duckweed and other aquatic plants.

In Bangladesh and in South East Asia already exist wastewater treatment devices where duckweed is used as biological agent to assimilate the nutrients from water. The systems in this climate are highly prolific. The generated income by selling duckweed as fish or hen feed covers fully the running costs (Iqbal, 1999, Leng, 1999). The cleaning effect by water plants also gives better results compared to actual wastewater treatment plants of Europe or US standard.

In Ethiopia studies have to be carried out to evaluate suitable endemic water plants for for wastewater ponds. The goals of water plant production depend on the local situation and the actual needs. If there is a market for protein feed, protein rich plants will be produced. Growing energy plants is also an option e.g. papyrus in arid regions. Studies in the Sudan by O Philipp (1981, Diss. University of Hohenheim) on the utilisation of the wide spread water pest, the water hyacinth, showed that it is a suitable source for biogas production. Water hyacinths or water fern (Azolla) also can be used as raw material for vermicompost.

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