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Decentralised Composting of Market Waste and Recirculation in Peri-Urban Agriculture - A Case Study in Guinea (West Africa)

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Abstract
The Institute of Waste Management and SENASOL carried out the project "*Recirculation of local organic waste in urban and rural agriculture - the impact on soil functions in Guinea / West Africa*" funded by the Austrian Academy of Sciences (July 2005 to October 2006). Based on the lessons learnt from former composting initiatives within the development cooperation context it was jointly decided with the project partners in Guinea to choose a small-scale approach in order to generate a sustainable solution (Linzner and Soumah, 2006; Mentler et al., 2002). This paper aims to give a brief overview of the project activities and to outline the major factors promoting and constraining the implementation of this small-scale project from the initial project stage (sustainable knowledge transfer, collection of waste and construction of the composting facility) to the final project stage (compost quality and compost application, dissemination activities). This paper should serve as a decision support for future implementation activities in small-scale composting within the development cooperation context.

1 Introduction and project goals
The possibility of converting urban wastes or a substantial portion of these into organic fertilizers is an adequate way of closing the nutrient cycle as occurs in nature. Very high population growth rates in West African cities are the reason for widening the spatial gap between the production and consumption of food. The increase in urban food demand leads to intensive food production systems in and around cities requiring large amount of inputs, including plant nutrients. Once the food is consumed or processed in the city, related market and household waste contributes to urban pollution as large amounts of nutrients are simply wasted. If the nutrients are not recirculated, this leads to a lack of nutrients and humus in the affected soils, as well as to related problems such as soil degradation and erosion problems. Composting of the organic fraction of waste and the subsequent application of compost was therefore considered to be a solution in the course of development cooperation projects. However, several efforts made

in promoting composting technology turned out to be nonviable due to different reasons (Linzner and Wassermann, 2006).

In addition to a previous project it was intended to research the possibility of producing organic fertilizer (compost) using an adapted low-technology approach for a sustainable urban agriculture. The intended transfer of sustainable knowledge supported by the applying of an adapted low budget technology is crucial in view of the fact that the parties involved should in future be in a position to carry out compost production and application unaided. A female cooperative carrying out peri-urban agriculture was involved in training activities. The goals of this project were:

- The installation and operation of an adapted, small-scale and decentralized composting facility in the capital Conakry.
- The application of good quality compost on test plots in Conakry with different application rates and analysis of the impact on the maize yields in peri-urban agriculture.
- The transfer of an adapted technology and of knowledge concerning the production and application of compost including the motivation for a self-dependent implementation of the collection and composting of organic market waste.

Investigations of the compost with regard to organic matter quality and heavy metal contents were carried out at the Institute of Waste Management to assess the benefits and to ensure the harmlessness of the product. Additional samples originating from different composting stages provided some information on process operation. Based on modern analytical methods and multivariate data analysis the composting process and the final product were evaluated.

2 Overview on the project activities

2.1 Literature research and workshop in Vienna

Based on a literature research (Linzner and Wassermann, 2006) to determine the factors constraining or promoting compost as a technology within the development cooperation framework a first workshop in Vienna was carried out in order to train the project partners in the basic biological degradation processes and composting technology. Furthermore the compost facility was designed jointly and a work plan and a bill of material were set up.

2.2 Installation of the composting plant and start of operation

After installation of the compost plant and initiation of the collection of market waste the composting process started at the beginning of December 2005. In January 2006 two technicians from the Institute of Waste Management joined the project partners in Conakry in order to assess the progress of the work and to jointly implement possible improvements. The project partners in Conakry carried out the sampling procedure and the accompanying measurement to control the process conditions. Therefore the main topics of the first visit to Conakry



Fig. 1: Composting plant in operation

were the completion of the technical design of the composting plant; the improvement of the composting process (including input material); the coordination of the sampling procedure; visits to different markets in Conakry and networking activities.

2.3 Execution of field trials

The produced compost was used in field trials set-up by SENASOL together with the female cooperative. 12 plots with an area of 20 m^2 each were cropped with maize by applying 0 t/ha, 10 t/ha and 15 t/ha compost with 3 replications. The goal was to analyze the produced biomass after harvesting (October 2006). In addition, compost samples and soil samples were analyzed in Vienna.

2.4 Dissemination and networking workshop

In August 2006 two workshops took place in Conakry. One workshop was carried out with interested female cooperatives in Conakry in order to provide information material and to disseminate the possibility of composting organic waste. The second workshop was targeted on the invitation of all stakeholders concerned with composting activities in order to present the project and to set-up a compost network.

3 Results

Between December 2005 and August 2006 eight windrows were set-up, producing approx. 4,000 kg of compost. Composting was carried out by means of natural aerated open windrow process. The windrow dimensions were 5 m length, 2.5 m width and 1.2 m height. In order to secure good aeration, the windrows were turned manually every 1 to 2 weeks and if necessary, water was added during the turning process. Frequently material samples were drawn by taking several single samples, mixing them and dividing the whole material amount by cross section procedure to nearly 1.0 kg WM (wet matter) of sample. All samples were air-dried in the SENASOL laboratory. Due to the lack of equipment for both grinding and sieving, larger parts (> approx. 2 cm) were separated by hand. The small grain size fraction was transported to Austria, ground by vibratory disc mill and sieved to particle size < 0.63 mm. This fraction was analyzed according to several physical/chemical parameters (LOI, TOC, N_{Dumas}, pH-value, conductivity, and humic acids) in order to gain further knowledge about the rotting progress.

During the whole process, rotting temperatures were recorded. Figure 2 shows the development of the average rotting temperatures in windrow 1 (market waste from Gbessia) and windrow 4 (market waste from Enta). The Gbessia waste contained very high amounts of physical contaminants (batteries, metals, expired medication...) and mineral compounds; LOI of the 3 weeks sample was approx. 28 % DM (dry matter). Temperatures did not exceed 55 °C. The development of humic compounds was very poor (Figure 3); after 26 weeks composting process the content of humic acids was 10 % oDM (organic dry matter). High quality composts in Austria show ranges between 25 % oDM and 45 % oDM.

In order to achieve a higher feedstock quality, for windrow 4 waste from the Enta market was used. The market waste seemed to contain lower amounts of physical contaminants and mineral compounds. However, chemical analysis showed only marginal differences compared to wastes from Gbessia (in the one week sample LOI was ~ 31 % DM). Rotting temperatures were higher (max. temp. 62 °C) during the first two weeks. Since week 2 the development was very similar to windrow 1. Until week 3 windrow 4 was characterized by a better development of humic compounds (9.3 % oDM) than windrow 1 (4.3 % oDM), but humification subsequently stopped. After 17 weeks humic acid content showed 8.4 % oDM.

All other composting processes showed similar results. None of the composts examined exceeded humic acid content of 10 % oDM. The reason for poor humification was the unfavorable composition of feedstock. Investigations at ABF-BOKU showed that for humification a high amount and a well balanced composition (from scarcely to easily available) of organic compounds is essential.

For the future composting activities in Conakry (Sonfonia) a source separation of the organic fraction of market wastes is aimed for. Physical contaminants (incl. linked hazardous compounds) and mineral fraction (accumulated by cleaning activities at the market) should be minimized. This action will increase organic

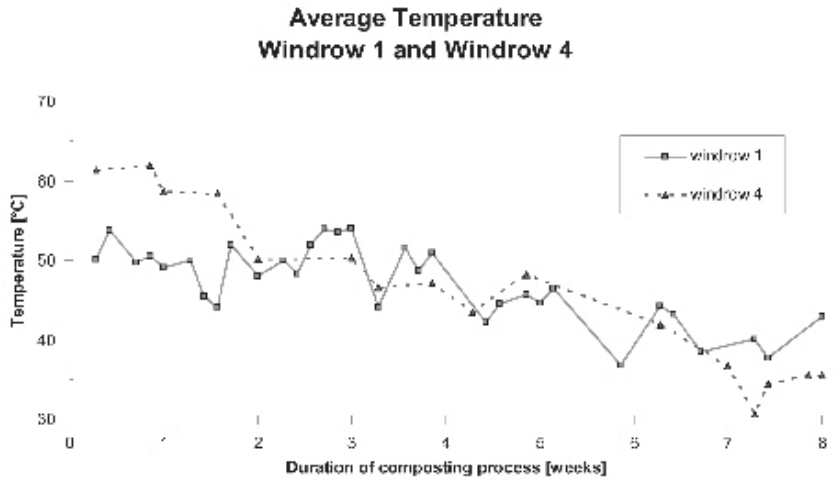


Fig. 2: Rotting temperatures in windrow 1 and 4 (0 - 8 weeks of composting process)

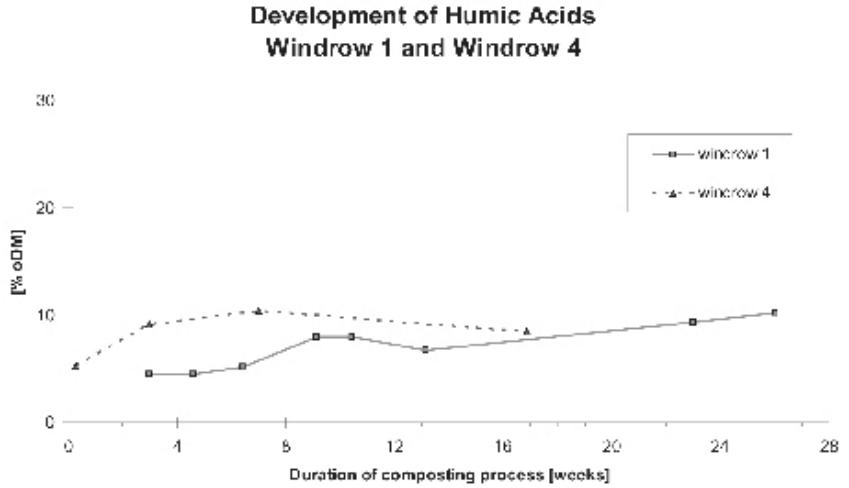


Fig. 3: Development of humic acids in windrow 1 and 4 (0 - 26 weeks of composting process)

content of the feedstock as well as decrease heavy metal content. Due to the geological background in the region higher heavy metal contents were expected (Cr, Ni, Co). To distinguish the natural background level from polluted materials soil samples were investigated as well. The heavy metal contents for Chromium and Nickel in the compost samples lie in the range of 2,600 to 3,800 mg/kg DM (Cr) and 110 to 230 mg/kg DM (Ni). The related limit values in the Austrian Biowaste Ordinance (Class A) are 70 mg/kg DM for Cr and 60 mg/kg DM for Ni.

4 Lessons learned

Climate: Conakry is situated in a region with heavy summer rainfall (June to September) with approx. 3,000 to 4,000 mm annual precipitation. This is a major regional peculiarity which has to be taken into consideration when planning the construction and operation of a composting facility. During the rainy season it is necessary to protect the compost against heavy rain and the collection and processing of the input material is a quite difficult task.

Input material and compost quality: in this particular case the input materials from two different markets in Conakry turned out to be mixed market waste. No source separation took place, making it necessary to install a manual and labor-intensive sorting process before setting up the windrows. In order to produce good quality compost source separated input material should be used in future activities. In addition, the sources of the high loads of Cr and Ni have to be traced and recommendations for future improvement shaped. Experience has taught us that it is not easy to get input materials for free. In particular where organic waste is to be provided by municipalities working under financial constraints, specific demands automatically led to the establishing of a price.

Sampling procedure: a proper sampling method and handling is a prerequisite for obtaining reliable results of the physical and chemical properties of compost in a scientific frame. Both sampling and preparation of the samples for shipment have to be further developed.

Capacity building and knowledge: although composting is an easily understandable and reproducible process the transfer of a basic knowledge of the biodegradation process, the technology and influencing factors are major requirements for a sustainable project implementation. Workshops, courses and easily understandable training materials are helpful in securing independent future composting activities. Furthermore the best learning process is the gaining of experience in the field.

Preparing and conducting workshops on location: the given regional context requires an efficient advance preparation of planned workshops. If politicians and media are involved in this process it is advisable to prepare well structured invitations with overall and detailed workshop goals. Furthermore, it should be kept in mind that the copying and delivering of invitations, transportation of stakeholders to the workshop location, booking computers and beamers,

providing electrical power etc. may be time consuming activities.

Field trials: compost application should lead to soil improvement where stable organic matter increases the low organic matter content in soils. This effect becomes visible after a long-term application. Therefore field experiments were performed to assess the impact of the produced compost on maize yields. Problems occurred due to the fact that the rainy season was delayed in 2006 and some test plots showed a moisture build-up which may have influenced the results concerning compost impact on yields. Beside the proposed project composting activities will continue in 2007 and the application of compost will be extended to vegetables on the same test plots. It is scheduled to propose a follow-up project with a long-term compost application.

5 Outlook

A widely quoted argument in literature is that low-tech options are better solutions in composting when considering economical viability (Drechsel, 2004; Linzner and Wassermann, 2006). Through a joint effort it was possible to design a decentralized composting facility and start up operations. After an improvement phase it is very likely that good quality compost with low contents of pollutants can be produced and applied in urban agriculture.

Drechsel (2004) stated that prices of compost products, household waste service fees and local government subsidies were all found to be low and therefore taken together could not compensate for high production costs. Prices of close substitutes such as "black soil", animal manure and poultry droppings were cheaper in all countries during the study year (2001), compost producers were compelled to sell their products at prices far below the costs of production. Small-scale composting approaches are often set-up in neighborhood communities in an attempt to solve the local situation (hygienic problems etc.). Having a stake in a project can improve the participation of inhabitants in small-scale composting. For instance, manual work (installation of the compost station, sorting process, turn-over of the windrows etc.) or financial contributions (collection fees) are provided by the inhabitants. In addition, possible problems (e.g. odor emissions) are increasingly accepted.

Future research should be performed to focus specifically on the additional benefits of composting. The quantification of cost or emission savings due to compost production / application (e.g. reduced landfilling of organic waste, improved soil characteristics etc.) and the possible implications involved in promoting small-scale composting approaches should be taken into ample consideration within the context of developing countries. These additional benefits include cost avoidance (external diseconomies, externalities) of particular importance regard to calculation of the cost coverage of composting. Most of the time it is impossible to take into consideration all costs and revenues involved due to the fact that to date very few studies have assessed the implication of externalities and the corresponding amount of money saved. In fact, costs saved through avoidance of

collection, transport or disposal are understandable arguments geared towards promotion of composting, although the information may not prove to be of use in facilitating composting in the context of development cooperation. One possibility for the future could be the integration of Clean Development Mechanisms (CDM) in the decentralized composting context. A critical analysis of several aspects of this new funding opportunity is mandatory; e.g. which emissions should be taken into consideration or is it possible to incorporate secondary effects of compost application (lower emissions due to the substitution of mineral fertilizer etc.)? Furthermore the question as to whether these efforts promote only large-scale composting facilities or whether several decentralized schemes may all be integrated into one project for CDM approval should be answered.

References

Drechsel, P. (2004): Closing the rural-urban nutrient cycle. Options for municipal waste composting in Ghana. Final Scientific Report on IDRC project 100376. International Water Management Institute (IWMI). Accra, 2004.

Linzner, R., Binner, E., Mentler, A., Smidt, E., Salhofer, S. and Soumah, M. (2007): LPCC-Guinée: Recirculation of local organic waste in urban and rural agriculture - the impact on soil functions in Guinea / West Africa. End-report of Project 139 on behalf of the Commission for Development Studies at the Austrian Academy of Sciences. Vienna, 2007.

Linzner, R. and Wassermann, G. (2006): Factors constraining and promoting the implementation of small-scale composting in West African Countries. ORBIT 2006: Biological Waste Management. From Local to Global; Proceedings of the International Conference ORBIT 2006 / Eckhard Kraft (Hrsg.). Weimar: Verlag ORBIT e.V.; ISBN 3-935974-09-4. Weimar, 2006.

Linzner, R. and Soumah, M. (2006): LPCC-Guinée: Recirculation of local organic wastes in peri-urban and rural agriculture and their effect on the soil functions in Guinea / West Africa (KEF Project 139). Gemeinsam forschen – gemeinsam lernen. Forschungspartnerschaften in der Entwicklungszusammenarbeit. Verlag der Österreichischen Akademie der Wissenschaften, ISBN 3-7001-3767-2 (ISBN 978-3-7001-3767-2). Vienna, 2006.

Mentler, A., Partaj, T., Strauss, P., Soumah, M., Blum, W. (2002): Effect of locally available organic manure on maize yield in Guinea, West Africa. In: IUSS (Ed.): 17th World Congress of Soil Science, 14. - 21.8.2002, Bangkok/Thailand; Abstracts, Volume II, 441, Bangkok/Thailand (KEF Project 106), 2002.

Linzner, R., Meissner, F., Sakho, Y., Soumah, M., Sylla, F. (2006): Compostage – un guide pratique (Composting – a practical guide).
Link: http://www.oeaw.ac.at/kfe/download/kef%20projects/P139_Compostage_un_guide_pratique.pdf (Last access: January 2007).