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ENVIRONMENTAL IMPACTS OF ECO-LOCAL FOOD SYSTEMS

– final report from BERAS Work Package 2

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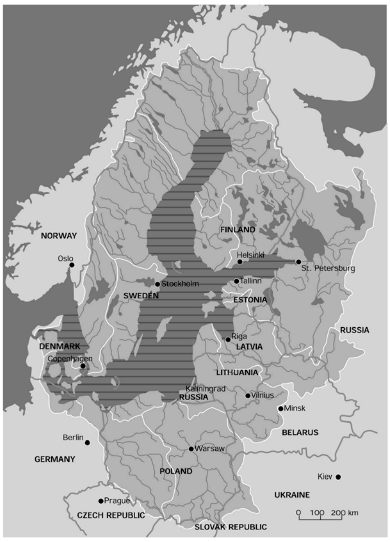

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Biogas plant in Järna

The Biodynamic Research Institute in Järna developed an on-farm biogas plant integrated within the highly self-supporting farm organism, Skilleby-Yttereneby, one of the farms studied in the BERAS project. The biogas plant digests dairy cattle manure and organic residues originating from the farm and the surrounding food processing units. The input of stable manure and food residues contain 17.7 to 19.6 % total solids. This recently developed technology is in the process of testing and refinement. In a two-phase process the hydrolysis reactor is continuously filled and discharged. The output from the hydrolysis reactor is separated into a solid and liquid fraction. The solid fraction is composted. The liquid fraction is further digested in a methane reactor and the effluent is used as liquid fertiliser. Initial results show that anaerobic digestion followed by aerobic composting of the solid fraction improves the nutrient balance of the farm compared to when mere aerobic composting is used.

Methodology

Manure from 65 adult bovine units kept in a dairy stanchion stall is shifted by an hydraulic powered scraper into the feeder channel of the hydrolysis reactor. The urine is separated in the stall via a perforated scraper floor. The manure is a mixture of faeces, straw and oat husks. From the feeder channel the manure is pressed via a 400 mm wide feeder pipe to the top of the 30° inclined hydrolysis reactor of 53 m^3 capacity. Gravitation slowly pulls the manure down mixing it with the substrate. After a hydraulic retention time of about 22 to 25 days at 38°C, the substrate is discharged through a bottomless drawer in the lower part of the reactor into the transport screw beneath. Every drawer cycle removes about 100 l substrate from the hydrolysis reactor. From the transport screw the major part of the substrate partly drops into a down crossing extruder screw where it is separated into solid and liquid fractions. The remaining material in the transport screw is conveyed back to the feeder channel and inoculated into the fresh manure. The solid fraction from the extruder screw is stored in the dung yard for composting. The liquid fraction is collected in a buffer container and from there pumped into the methane reactor with a 17.6 m^3 capacity. Liquid from the container and from the methane reactor partly returns into the feeder pipe (to the hydrolysis reactor) to improve the flow ability. After an hydraulic retention time of 15–16 days at 38°C the effluent is pumped into a slurry store covered by a floating canvas. The gas generated in both reactors is collected and stored in a sack and fed by a compressor to the process heater and the furnace of the estate for heating purposes. The anaerobic digestion of manure (including the liquid phase) and the following aerobic composting of the solid fraction are referred to as process A in Results.

For the compost trials (10.5.2004–13.8.2004 and 27.10.2004–16.3.2005) samples of 50 l manure and 50 l solid fraction from the hydrolysis reactor were aerobically digested (composted) at 15°C and 20°C respectively in the climate chamber of MTT/Vakola. Compost of manure is referred to as process B in Results

Results

The results concerning the nutrient contents are presented in more detail in a separate report. (Schäfer et al. 2005).

During the anaerobic digestion in process A, 14.6–15.4 % of the carbon was found in the biogas. During the aerobic composting in process A, 26–31 % of the input carbon of the solid fraction escaped. In process B 58-60 % of the carbon escaped during aerobic composting. Even if the biogas yield were to be increased by threefold, there would still be 41–42.5 % of carbon available for composting of the solid fraction. This confirms the hypothesis that biogas production before composting has a minimal negative impact on the humus balance (Möller, 2003), and much less than aerobic composting.

Total nitrogen losses ranged between 19 % and 29 % in process A and between 30 % and 48 % in process B. Similar values were found for ammonium (NH_4): up to 6% losses in process A compared to 96 % in process B. Potassium and phosphorus losses were higher (how much?) in process A than process B. The results confirm the calculations of Möller (2003) that biogas production increases recycling of NH_4 and reduces overall nitrogen losses compared to mere aerobic composting.

The two-phase prototype biogas plant in Järna is suitable for digestion of organic residues of the farm and the nearby food processing units. The prototype put many recent research results into practice. However there is still a lack of appropriate technical solutions for handling of organic material of high dry matter content and for process optimisation. The innovative continuously feeding and discharging technique is appropriate for the consistency and the dry matter content of the organic residues of the farm. It is probably not suitable for larger quantities of un-chopped straw or green cut.

Discussion

Anaerobic digestion of manure and organic residues followed by composting the dry fraction of the hydrolysis reactor improves the energy and nutrient balance compared to mere aerobic composting since it achieves both the production of methane gas (that can be used for heating, electricity production or vehicle fuel) and the conservation of nutrients. Appropriate new technology such as the prototype biogas plant in Järna is a key factor in making this possible.

More measurements are required to see if the results cited above can be confirmed. The optimisation of the plant in respect to hydraulic retention time and load rate may lead to higher gas generation but this would require an improved measuring technique. In addition an economic evaluation is necessary to assess the competitiveness of the new technology. The benefits of an on-farm biogas plant may be more evident if the nutrient balance evaluation considers not only the biogas plant but also the nutrient cycle of the farm organism over a whole crop rotation period. Not only the quantity but also the quality of the nutrients affects soil fertility, fodder quality and animal health and both need to be taken into consideration

Possibilities for developing combined recycling and renewable energy production in Juva and Järna

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The plant nutrients in food stuffs from agriculture end up in slaughterhouse wastes, domestic wastes (wastes from household and food industry) and sewage wastes. These three fractions contain 4, 3 and 2 kg N per capita and year and 2, 0.5 and 1 kg P per capita and year (Calculated from Magid et al. 2002). About 60 % of the nitrogen and 45 % of the phosphorus are in the liquid wastes residues mainly in the human urine fraction. Of the total phosphorus taken up by plants (20 kg P per ha) about 75 % can be recycled within the farming system on ecological recycling agriculture (ERA) farms if nutrients in manure are optimally utilized. However, 15 % of the P is found in the sewage fraction from human consumption. This could be re-circulated for use in agriculture through urine separation if the hygienic aspects can be taken care of in a secure way. Another 10 % of the P is found in slaughter wastes which could also be an important resource for the sustainable agriculture.

Two ways of local recycling of the solid fraction of biowaste, one of which is combined with the production of biogas, have been studied within the BERAS-project. Their goal is the safe recycling of nutrients, reduced emissions of greenhouse gases and reduced emissions of reactive nitrogen. One way is the central recycling at community level described above for Juva that often is combined with production of biogas and other energy recovering systems. However, centralised biowaste treatment raises problems with quality control and with the high risk of contamination from heavy metals, medicaments, and animal (including human) pathogens. For these reasons these nutrients are not allowed to be used on soil for food production.

The second option is to have a smaller-scale system with better opportunities to choose and control the material treated. An example of this is the recycling of food residues introduced in the small-scale biogas plant on Yttereneby farm in Järna described above. This small-scale biogas plant for use at farm level may be a better solution for recycling of nutrients from human food (local processors, ecological public kitchens and consumers) as it provides opportunities for effective control against contamination from pathogens and harmful substances. This technology was established as an essential link in the local ecological recycling system that at the same time reduces emissions of greenhouse