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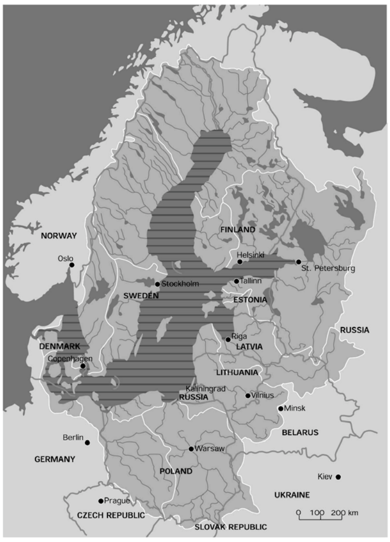
ENVIRONMENTAL IMPACTS OF ECO-LOCAL FOOD SYSTEMS
– final report from BERAS Work Package 2

Artur Granstedt, Olof Thomsson and Thomas Schneider (eds.)



Baltic Ecological Recycling Agriculture and Society (BERAS) Nr. 5

Baltic Sea Region INTERREG III B

Centrum för uthålligt lantbruk CUL

ORGANIC WASTE MANAGEMENT STUDIES

Tiina Lehto, South Savo Regional Environment Centre, Finland

Two different organic waste management systems have been studied in the BERAS project. The most extensive study was of biowaste and nutrient flows in the community of Juva, Finland. In Järna, Sweden, a farm-size biogas plant was studied. Based upon the results of these studies a discussion about the possibilities for combined recycling (re-use of nutrients and humus) and energy 'production' is presented.

Inventory in Juva

The objective of the inventory conducted in Juva was to determine the possibilities for recycling the biowaste (organic waste) produced by local food actors back into agriculture production. The food actors in the study included: food processors, grocery stores, schools, communal kitchens, and private consumers, i.e. all the actors in the food chain except the primary producers, farmers. The research methods used were waste flow and substance flow studies.

The study first looked into the current waste management system within the Juva community and among specific food actors. Special attention was paid to biowaste and nutrient flows. Because biowaste recycling into agricultural fields in Juva was uncommon in 2002, an assessment was made of the possibilities to recycle biowaste back into agriculture.

Recycling of biowaste can put humus and nutrients back into agriculture land. In organic agriculture, nitrogen is fixated by plants but a lack of phosphorus is predicted in the future. Biowaste could complement nitrogen fixation and it could also be a good source of phosphorus. Legislation in Finland restricts the use of biowaste and sewage sludge. For example, neither may be used in organic agriculture. Regulation (EC) No. 1774/2002 was enacted mainly because of the BSC and foot and mouth disease epidemic and lays down health rules concerning animal by-products not intended for human consumption. It restricts the recycling of animal-based by-products, including food waste from kitchens and animal-based biowaste from grocery stores.

Materials and methods

The system under study includes food actors in the Juva population centre: a few food processors in the urban area processing meat, milk, vegetables and cereals; three communal kitchens including schools; three grocery stores and private households. The wastewater entering the communal wastewater treatment plant and the sewage sludge formed there were also studied. The research methods used were waste flow and substance flow studies. The substance flow study looked specifically at nitrogen (N) and phosphorous (P) in the biowaste.

Data for the study was mainly obtained through informal interviews, enquiries and analyses results (Savolab Oy 2003, Jyväskylän yliopisto, 2005). An assessment of the amount of biowaste produced by households was made. This was necessary because an unknown part of the household biowaste ends up as landfill waste. The estimated amount of biowaste produced by households has been calculated based on the following assumptions:

- Juva had a population of 7449 in 2002, and 3628 (48.7 %) live within the population centre and 3821 (51.3 %) live in the surrounding countryside.
- The average per capita annual waste production in the region is about 220 kg (Angervuori 2002);
- About 33 % of all household waste in population centres and about 40 % of the household waste produced in rural areas is biowaste (Statistics Finland 1994);
- In the case of the Juva population centre, about 40 % of the inhabitants are included in separate biowaste collection and about 70 % of their total biowaste is collected. (Rejlers Oy 2000)
- The remaining 60 % in the Juva population centre compost their biowaste on their property (YTI-tutkimuskeskus, 2004);
- The inhabitants of the rural area of Juva are obligated to compost their biowaste.

The nutrient values used for different foodstuffs and biowastes Table 7-1) are based on the Fineli-Finnish Food Consumption Database of the National Public Health Institute (National Public Health Institute, 2005). The dry matter content has been estimated based on the feed tables produced by Agronet (2005). Separately collected biowaste is assumed to contain 20 g N and 4 g P per kg dry matter (dm). The dry matter content is assumed to 35 mass-percent (Sokka et al. 2004).

Table 7-2 shows the estimates of the nutrients included in household wastewater based on the estimates presented by Eilersen et al. (Magid et al. 2002) and data for the incoming and outgoing wastewater at the sewage treatment plant obtained from Savolab Oy (2003). The latter data are based on the average daily nutrient concentration of five samples analysed in laboratory conditions. The conversion factor used for biowaste is 0.3 tonnes/m^3.

Laboratory analyses of sewage sludge samples from the Juva wastewater treatment plant and from compost samples from the Juva stack-composting area (Jyväskylän yliopisto, 2005) to determine total nutrients available for recycling at present and whether the heavy metal concentrations are below the regulated limits were made in the study.

Results – the waste system in Juva

Figure 7-1 shows the biowaste flows produced by the various food actors in 2002 and Figure 7-2 presents an assessment of the nutrient flows included in biowaste. The total amount of solid biowaste produced by the various food actors was about 1150 tonnes. This contained 27.6

Table 7-1. The nutrient values used for different kinds of foodstuffs and biowaste.

Waste component	N	P	Dry matter
Lettuce (g/kg)	1.76	0.4	10.3 %[1]
Oat husk (g/kg)	28[2]	4.3 [2]	88 %
Turkey offal (g/kg)	35.2	1.5	35 %
Raw milk (g/kg) (Tuhkanen 2005)	5.2	1	12 %
Organic milk (g/kg)	4.8	0.9	12 %
Pig carcass (g/kg)	27.5	1.8	35 %
Separately collected biowaste (g/kg dry matter)	20	4	35 %
Household wastewater	14	2.2	135
- faeces g/cap/day	1	0.5	35
- urine g/cap /d	11	1.5	60
- kitchen liquid waste g/cap/d	0.5	0.1	20
- bathroom, grey water g/cap/d	1	0.3	20
Nutrients to treatment plant, kg/d (Savolab Oy 2003)	60.4	12.8	
Nutrients into water systems, kg/d (Savolab Oy 2003)	49.2	0.46	

[1] Dry matter of cabbage.
[2] Nutrients in oat bran.

tonnes of N and 1.6 tonnes of P (excluding poultry waste). About 214 tonnes were treated in the communal waste management system by stack-composting the waste. The biowaste in the stack-compost contained about 0.71 tonnes of N and 0.15 tonnes of P. The stack-composted biowaste originated mainly from households (45 t) and from one vegetable processor (150 t); the remainder came from grocery stores (12 t) in the population centre and from communal kitchens (7 t). About 10% of the biowaste originating from grocery stores was estimated to be former animal-based foodstuffs. A maximum of 12 % of the biowaste was treated in the food actors' own small-scale composting systems but little appears to have been utilised on fields to benefit food production. About 70 % of the biowaste produced was transported outside Juva; a large amount going to the animal fodder industry. This contained as much as 89 % (24.6 t) of the nitrogen and 66 % (1.05 t) of the phosphorous in the biowaste produced by the food actors covered by this study. A smaller amount appears to have ended up in a landfill in Mikkeli (50 km away) along with mixed waste.

Wastewater led to the Juva wastewater treatment plant is mainly from households. The major industrial plants in the area are a dairy and a slaughterhouse, adding BOD (biological oxygen demanding substances) and nutrients to the incoming wastewater. In addition waste water from a vegetable processor, a printing house and a fur refinery are led to the waste water treatment plant. The wastewater treatment plant in Juva is a BIOLAK treatment plant built in 1982. More recently a facility for phosphorus precipitation by iron(II)sulphate has been added on. The resulting sewage sludge is subjected to filter-pressing; with polymers being used as aiding agents. In 2002, the incoming wastewater to the treatment plant amounted to 421000 m^3. This had a solid matter content of 134 tonnes and contained 22.0 tonnes of N and 4.7 tonnes of P. The amount of iron(II)sulphate used was 80.7 tonnes

(Savolab Oy 2003) and the removal efficiency of phosphorous was 96 % and that of nitrogen 19 %.

The amount of sewage sludge formed in 2002 was 512 m^3 (about 395 tonnes[1]) with a dry matter content of 18 % (wet base). According to the 2005 analyses results (\h Table 7-3), the sewage sludge dry matter was 4.4 % N and 2.9 % P. Thus, the sewage sludge contains a maximum of 4.1 tonnes of N and 2.7 tonnes of P. Nitrogen can escape from the process through denitrification and evaporation, but phosphorus is believed to be slightly soluble because of phosphorus precipitation. The heavy metal concentrations of the sewage sludge are below the regulated level for agricultural use with exception of chromium. The chromium concentration was much higher than the permitted amount.

The sewage sludge formed was composted in the communal stack-composting area along with the separately collected biowaste. Tree bark, leaves and gravel were mixed in with the sludge and biowaste to promote the composting process and to produce a final product of better quality. The nutrient concentrations of the compost as analysed in 2005 were low; 0.28 % N and 0.32 % P, but the heavy metal concentrations were well below the required levels. The concentration of nutrients in the biowaste is assumed to be the same as in 2002, because no noteworthy changes in biowaste flows or treatment have occurred. According to a decision of the Ministry of Agriculture and Forestry (46/1994), the humus content of compost has to be at least 20 % of the dry matter content. The compost product has previously been used in green areas and in road construction, and now it is being stored for the purpose of landscaping an old landfill.

Discussion

In 2002, biowaste composted in stacks in Juva could not be recycled back into agriculture. The treatment process did not fulfil the requirements, especially the by-product directive 1774/2002 as the compost included former animal-based by-products in the form of food waste and former animal-based foodstuffs from grocery stores. The final product could only be used in landfills (as covering or filling material). If the final product is to be used in agriculture or in greening areas in the future, then the composting treatment has to fulfil the requirements of the by-product directive. Another alternative is to compost only the biowaste of vegetables and other non-animal-based by-products and sewage sludge.

Alternative treatment processes for recycling biowaste nutrients and humus are biogas treatment and composting (centralized or small-scale co-digestion treatment plant). The treatment of biowaste and wastewater causes nutrient losses and all nutrients in the treated biowaste do not become available to plants. Figure 7-3 shows total nutrient and dry matter percentages of the biowaste produced by the

[1] According to analysis made in 2005 volume weight was 771 g/l (Table 7-2).

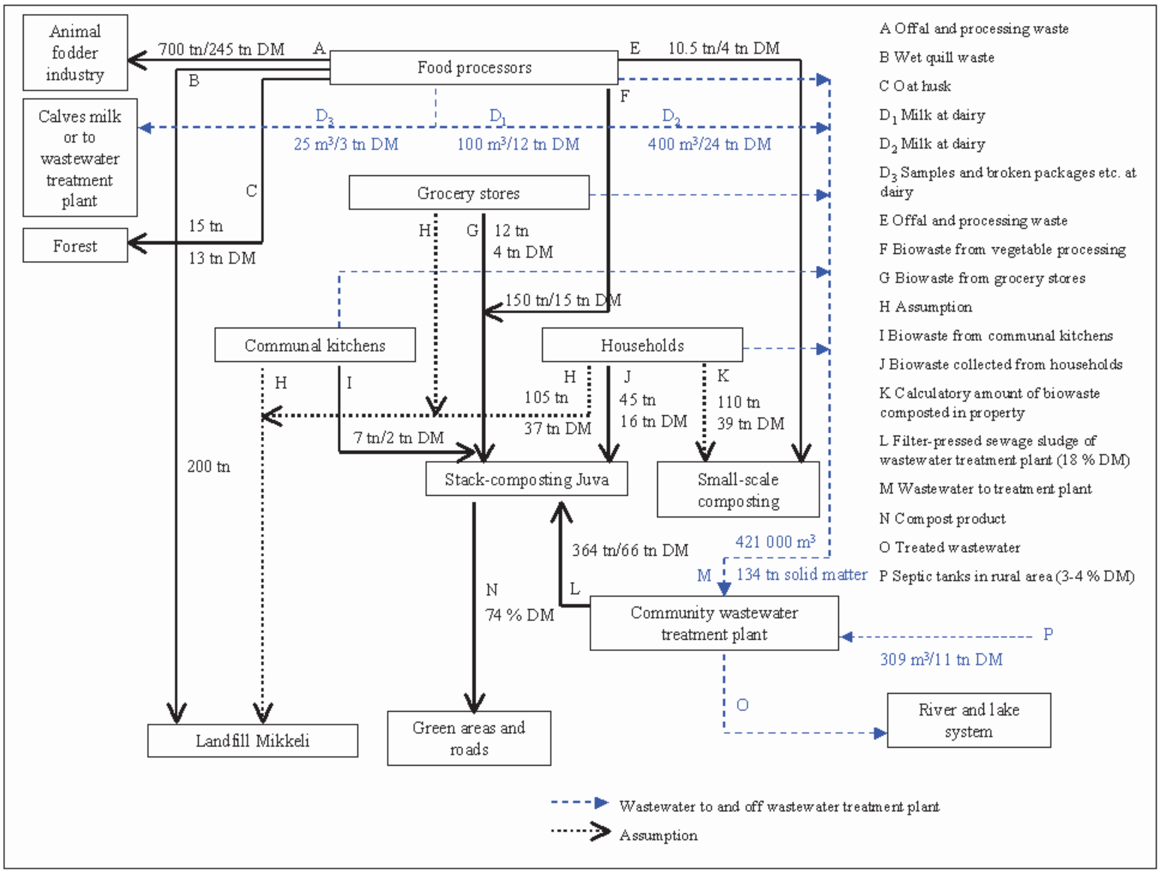


Figure 7-1. Biowaste flows involving Juva food actors in 2002 (DM = dry matter).

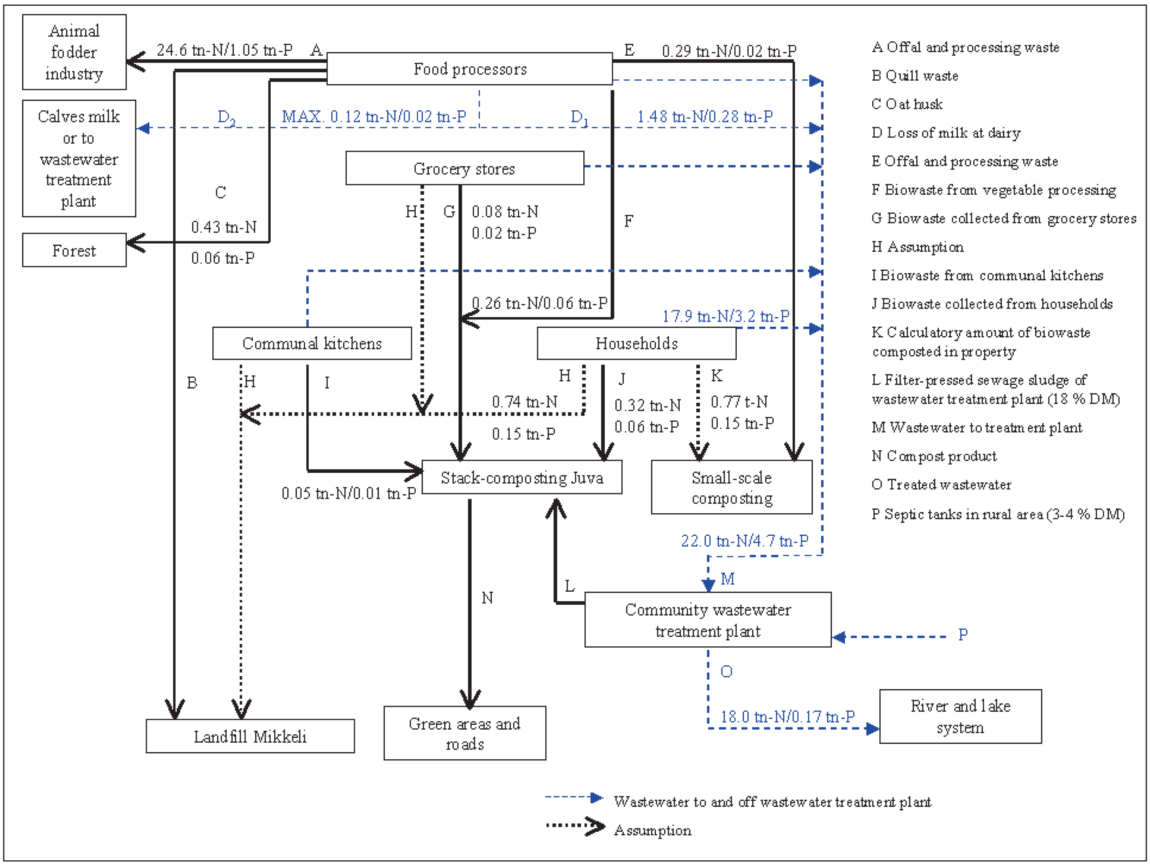


Figure 7-2. Nutrient flows of biowaste involving Juva food actors in 2002.

Table 7-2. Analyses results for the compost product from the stack-composting area and the sewage sludge from the wastewater treatment plant in Juva (Jyväskylän yliopisto, 2005).

Analysed property	Unit	Sewage sludge from Juva	Vnp[1] 282/1994	MMMp[2] 46/1994	Compost from Juva
Volume weight	g/l	771			696
Conductivity	mS/m	30.6			2.70
pH-value	pH	6.5			6.6
Ignition loss	% DM	65			33
Dry matter (DM)	%	18			74
Total nitrogen	% DM	4.4			0.28
Total phosphorus	% DM	2.9			0.32
Total potassium	% DM	0.20			0.18
Total magnesium	% DM	0.16			0.21
Total calcium	% DM	1.1			0.28
Mercury	mg/kg DM	0.24	1.0	2.0	0.07
Cadmium	mg/kg DM	0.6	1.5	3.0	< 0.5
Total chromium	mg/kg DM	530	300	-	21
Copper	mg/kg DM	240	600	600	39
Lead	mg/kg DM	31	100	150	6
Molybdenum	mg/kg DM	3	-	-	< 1
Nickel	mg/kg DM	20	100	100	7
Sulphur	mg/kg DM	6 800	-	-	520
Zinc	mg/kg DM	480	1 500	1 500	88

DM = dry matter
[1] Decision of the Council of State (Vnp) No 282/1994.
[2] Decision of Ministy of Agriculture and Forestry (MMMp) No 46/1994.

different food actors, including wastewater to the treatment plant, in Juva in 2002. Most of the nutrient-containing components originated from food processors and from urine. Slaughterhouse waste and food-processing waste contained 52 % of the N and 19 % of the P of the total nutrients which is the equivalent of 93 % of the N and 75 % of the P in the solid biowaste fraction. Urine contained 29 % of N and 32 % of P of the total nutrient which is the equivalent of 66 % of the N and 43 % of the P in the wastewater fraction. Slaughterhouse waste contains a lot of nutrients. However the current regulations pertaining to use of animal-based by-products prevent the recycling of these nutrients back to agricultural land.

It should be noted that urine contains about 1/3 of the nutrients formed within the studied food system and even a greater share of the nutrients in incoming wastewater flow to wastewater treatment plant in Juva in 2002. From the environmental viewpoint, separate urine collection would be preferable to the conventional system. It would increase the amounts of recyclable nutrient available for use on fields and at the same time make possible the decrease of emissions into water systems. In addition, phosphorous would be in a more usable form for plants and the risk of heavy metals would be minor compared to sewage sludge. However, with present technology separate urine collection is not acknowledged as an appropriate system in urban areas.

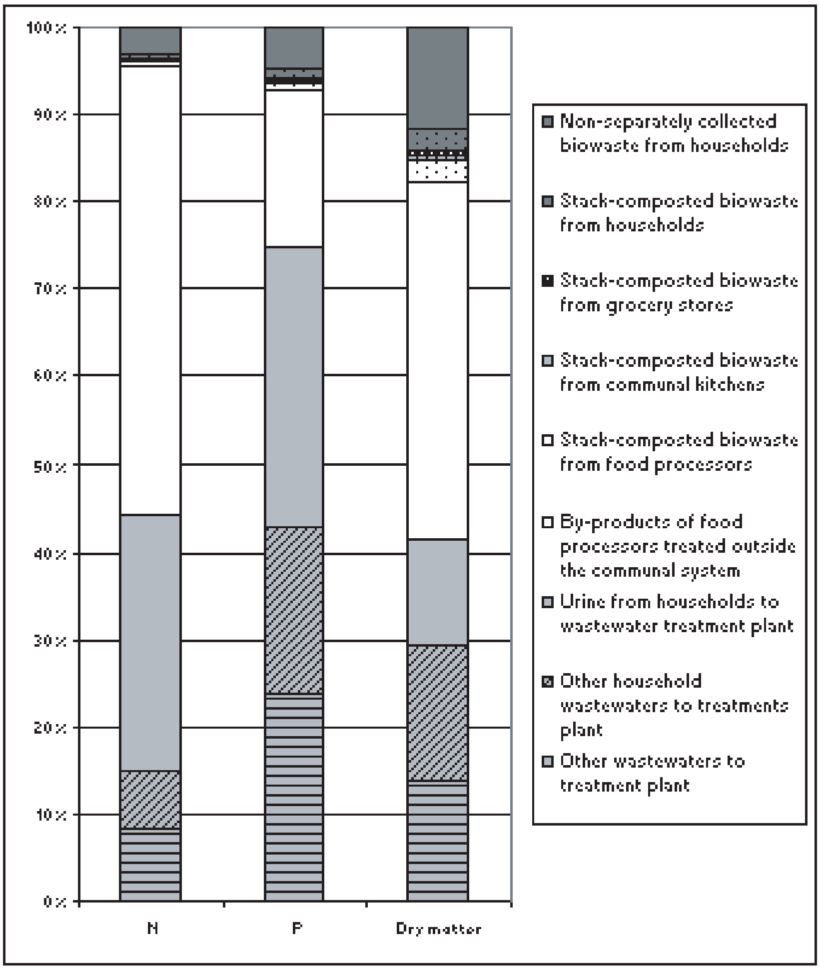


Figure 7-3. N, P and DM flows of biowaste and wastewater to the treatment plant in 2002, Juva. (Dry matter of wastewater is assumed to be double that of solid matter content.)