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Systems Analysis of Nutrient Recycling from Organic Waste

Magnus Dalemo
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Huibert Oostra
Ulf Sonesson

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Preface

Nutrients for growing of crops are normally supplied from mineral fertilisers. However, with increasing source separation of municipal and industrial waste, the quantity of organic fertilisers is increasing. The main question in the present project was to study the energy, economic and environmental consequences of using organic fertilisers originating from wastes, in comparison with mineral fertilisers.

The project was initiated and financially supported by Hydro Agri Europe, and started in August 1997. The work was conducted by Huibert Oostra, JTI, Ulf Sonesson, SLU and Anna Björklund, KTH. Project leader was Magnus Dalemo, JTI. Co-ordinator of the project at Norsk Hydro was Avtar S. Jasser.

We wish to thank all those involved in the completion of this project.

Ultuna, Uppsala in November 1997

Björn Sundell
Managing Director

Summary

Organic fertilisers such as anaerobic digestion residues and compost are compared with addition of nutrients by means of mineral fertiliser. Four scenarios are simulated using the ORWARE model. The scenarios are primarily evaluated from an environmental point of view using the Life-cycle assessment method. Some economic calculations are also included.

From both environmental and economic views, the emissions and costs arising from production of mineral fertilisers has a minor influence on the results of the studied system. The waste management processes together with soil emissions are responsible for the major part of the emissions. The net energy yield from waste management also has a large impact on the environmental evaluation.

The scenario with the largest net energy yield is the mineral fertiliser scenario followed by the anaerobic digestion residue scenario. However, the anaerobic digestion residue is the only scenario with net electricity production. To make the scenarios comparable from an environmental point of view, external heat and electricity production are included. External production of electricity from oil results in a major environmental impact, while heat production from wood chips has less influence.

The environmental impacts global warming potential, eutrophication and acidification are studied. Calculation of the impact categories human health and ecotoxicity to water and soil are also included, but the weighting factors, and therefore the results, for these categories are insecure.

For global warming potential the anaerobic digestion residue scenario has the lowest contribution in the large city region. The other scenarios have larger emissions from the waste management. Furthermore, the total emissions from these scenarios are larger due to emissions from external electricity production and minor emissions from nitrogen fertiliser production. The relation between the scenarios is almost the same in the small town region as in the large city region.

The largest potential eutrophication impact in all scenarios is from sewage sludge put on landfill. However these emissions will primarily arise in the long term. The immediate emissions from waste management are on the same level for all four scenarios, both in the large city and small town region. The major part of these emissions are from landfilling and soil.

The lowest contributions to acidification arise from the mineral fertiliser and reactor compost scenarios in the large city region. The emissions from waste management are larger from the anaerobic digestion residue scenario and the windrow composting scenario. In the small town region, the anaerobic digestion residue scenario has the largest total emissions, while the emissions from the other scenarios are similar.

The spreading of organic carbon as a source of humus is largest in the reactor composting scenario in both regions. However, the differences between the scenarios are quite small since most of the organic-bound carbon spread on farmland originates from sewage sludge and manure in all scenarios.

Sewage sludge contains the largest amount of both fertiliser and heavy metals in the large city region. In the small town region, manure is the dominating source. However, the metal content has to be reduced, especially for the sewage sludge and household waste if the metal content in organic fertilisers, compost, anaerobic digestion residue and sewage sludge, should be below the permitted levels per kg phosphorus proposed by the Swedish EPA for year 2000.

The calculation of costs results in almost similar costs for the four scenarios in the large city region. However, the income from energy gives the mineral fertiliser scenario the lowest total cost followed by anaerobic digestion. In the small town region, the large volume of manure to be transported and treated in the anaerobic digestion residue scenario results in the largest cost for this scenario.

Summary in Swedish

Huvudsyftet med projektet var att jämföra framställning och användning av organiska gödselmedel och mineralgödselmedel. Fyra olika scenarier studerades; mineralgödselanvändning (och förbränning av avfallet), rötning av avfall och gödsel, strängkompostering av avfall och reaktorkompostering av avfall. Det avfall som ingår i studien är växtnäringsrikt avfall från samhälle och gödsel från gårdar, samt slam från reningsverk. Slammet och gödseln går direkt ut på åkermark i alla scenarier utom i rötningsscenariot där också gödseln behandlas. Konsekvenserna beräknades både för en storstadsregion (Uppsala kommun) och en region med en mindre ort (Ystads kommun). Simuleringsmodellen ORWARE användes för beräkningarna.

Scenarierna utvärderas huvudsakligen ur miljösynpunkt med hjälp av livscykel-analysmetodik. Miljöeffekterna växthuseffekt, övergödning och försurning, samt flöden av metaller studeras. Även kategorierna; påverkan på människors hälsa (toxikologisk, dock ej arbetsmiljö) och ekotoxicitet till vatten och mark beräknas. Viktningsfaktorerna och därmed också resultaten är dock mer osäkra för dessa kategorier. Beräkningarna av miljöpåverkan kompletteras med några företags-ekonomiska beräkningar.

Processer och ämnen som fick stor inverkan på resultaten

Några översiktliga iakttaganden från projektet är att:

- Produktion av mineralgödsel har relativt liten betydelse i de studerade scenarierna, både ur miljösynpunkt och ekonomisk synpunkt.
- Avfallsbehandlingsprocesserna tillsammans med emissioner från åkermark står för den största påverkan på miljön.
- Nettoutbytet av energi från avfallshanteringen har också stor påverkan vid utvärdering av miljön.

De aktiviteter och ämnen som har störst påverkan på växthuseffekten i de stude-rade scenarierna var CO_2 från extern elektricitetsproduktion, CH_4 från deponering och ökade utsläpp av N_2O från åker orsakade av organiska gödselmedel. Den dominerande källan för övergödning var läckage av P från deponering på lång sikt,

och NO_3^- från åkermark. Störst påverkan på försurning har utsläpp av NH_3 från de organiska restprodukterna och olika utsläpp från avfallsbehandlingsprocesserna.

Dessa resultat understryker vikten av att undvika deponering av organiskt material både på grund av dess höga innehåll av näring och nedbrytbarhet. Vidare är det viktigt att använda bästa möjliga appliceringsteknik för organiska restprodukter för att begränsa emissionerna från mark. Störst miljöpåverkan från behandlingen av avfallet är förbrännings- och rötningsprocessen utsläpp av NO_x och SO_2 och för komposteringsprocesserna utsläpp av NH_3 och CH_4. Dessa emissioner påverkas naturligtvis av hur processerna sköts och vilken reningsutrustning som används.

Jämförelse av de fyra scenarierna i en storstadsregion

Mineralgödselscenariot med förbränning av största delen av avfallet ger det största bidraget till växthuseffekten (bild 1). Detta gäller om värmen som produceras vid förbränningen ersätter värme från biobränsle. Om den istället ersätter olja skulle situationen bli annorlunda. Det stora bidraget till växthuseffekten i detta scenario beror på deponering av fettvatten, produktion av mineralgödselkväve, långtidseffekter från deponering av aska och att ingen elektricitet produceras från avfallet utan istället från oljekondens i detta scenario. Utsläpp av övergödande ämnen från mineralgödselscenariot är i samma storleksordning som i de andra scenarierna och kommer från förbränningsprocessen, näringsläckage från gödsel och slam på åkern och långtidseffekter från deponering av aska. Försurningseffekten från mineralgödselscenariot är lågt och kommer huvudsakligen från ammoniakemissioner från slam och gödsel.

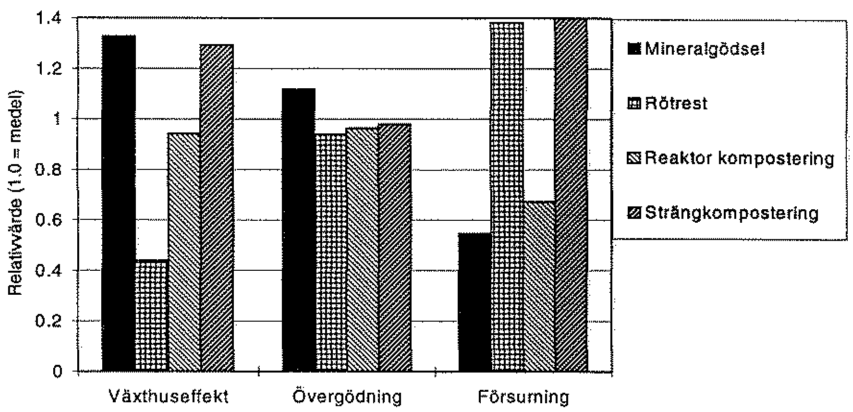

Bild 1. Miljöpåverkan från de fyra olika scenarierna i en storstadsregion (inklusive långtidseffekter från deponering). Se vidare Figure 3, 5 och 7.

Rötning är att föredra ur växthuseffektsynpunkt om biogasen ersätter fossila bränslen. När det gäller övergödning resulterar rötrestscenariot i reducerade emissioner av kväve från åker tack vare att läckaget av nitrat från organiskt bundet kväve minskar. Dock ökar ammoniakemissionerna något. Dessa ammoniakemissioner tillsammans med utsläpp av NO_x och SO_2 från förbränning av biogasen innebär att rötningsscenariot medför störst utsläpp av försurande ämnen.

Komposteringsscenarierna har relativt höga emissioner av gaser som bidrar till växthuseffekten beroende på emissioner från komposteringsprocessen, samt att vare sig elektricitet eller värme produceras från denna avfallsbehandling. Emissionerna av växthusgaserna N_2O och CH_4 från komposteringsprocessen är starkt beroende av substrat och hur processen sköts. Dessa emissioner reduceras i reaktorkomposteringsalternativet genom rening av utgående luft. Övergödningsemissionerna från komposteringsscenarierna beror huvudsakligen på den stora andelen organiskt bundet kväve i restprodukten. Med hög andel organiskt bundet kväve blir dock ammoniakemissionerna låga. Komposteringsprocessen resulterar dock i relativt höga ammoniakemissioner med en stor påverkan på försurningseffekten. Komposten har stor positiv effekt på jorden då den innehåller en hög andel mullbildande ämnen.

Övriga slutsatser

Om man istället studerar en region med en mindre ort genereras en mindre mängd kommunalt organiskt avfall, vilket medför att gödseln blir det dominerande avfallet. Eftersom gödseln går direkt ut på åkermarken i alla scenarier utom i rötrestscenariot blir det naturligtvis inte någon större skillnad mellan dessa scenarier (bild 2). Rötrestscenariot medför dock betydligt lägre utsläpp av växthusgaser och högre utsläpp av försurande ämnen beroende på att gödsel också tas in och behandlas vid rötningsanläggningen.

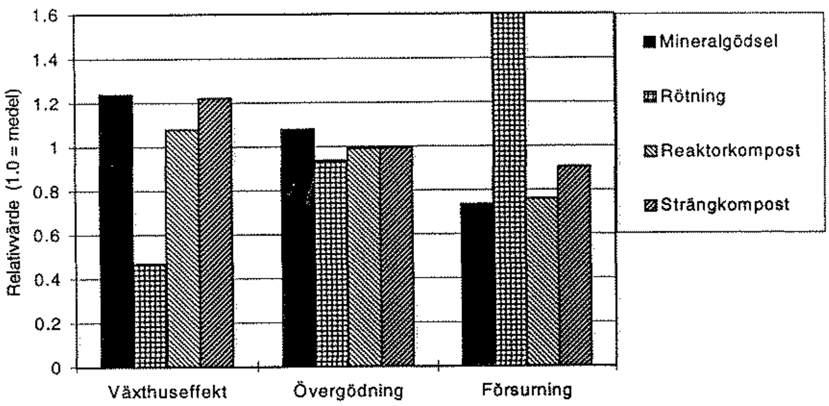

Bild 2. Miljöpåverkan från de fyra olika scenarierna i en region med en mindre ort (inklusive långtidseffekter från deponering). Se vidare Figure 20, 21 och 22.

Beräkning av de företagsekonomiska kostnaderna för de olika scenarierna resulterar i likartade totalkostnad för alla alternativ i storstadsregionen. Tack vare inkomsten från energi innebär dock mineralgödselscenariot de lägsta totala kostnaderna, följt av rötningsscenariot. I småstadsregionen resulterar rötningsscenariot i de högsta totala kostnaderna p g a den stora volymen gödsel som skall transporteras och behandlas.

Introduction

In the present project, four scenarios for addition of fertiliser are studied in two areas.

The four scenarios for addition of fertiliser:

- Mineral fertiliser. Incineration of the municipal organic waste fraction. Manure is transported and spread directly on farmland.
- Sludge from anaerobic digestion of all organic waste and manure. Manure is collected with return transport for residues.
- Compost from a windrow composting plant for municipal organic waste. Straw is used as amendment. Manure is transported and spread directly on farmland.
- Compost from a reactor composting plant for municipal organic waste. Straw is not used as amendment. Manure is transported and spread directly on farmland.

In all scenarios, 50 % of the sewage sludge is landfilled and 50 % is spread on farmland.

The two areas:

- Uppsala, a densely populated area with large amounts of municipal organic waste and a minor amount of manure.
- Ystad, a relatively small town with less municipal organic waste and more manure.

Waste fractions included in the study are easily degradable organic waste from municipal sources and farms.

Municipal organic waste:

- households in flats, detached houses and rural areas
- restaurants and trades
- grease separators
- sewage sludge

Farm waste:

- Slurry manure from cows
- Slurry manure from pigs

The processes included in the present study, and their type of emissions, are presented in Table 1. Energy turnover and economy are also calculated for these different activities.

Table 1. Emissions from different processes.

	Air emissions	Water emissions	Soil emissions
Landfilling	X	X	
Landfilling of sludge	X	X	
Incineration	X	X	
Anaerobic digestion	X		X
Reactor composting	X		X
Windrow composting	X		X
Collection of waste	X		
Transport of residues	X		
Spreading	X		
Soil	X	X	
Sludge			X
Manure			X
Straw			X

A simulation model, ORWARE, is used for calculation of energy turnover, economy and emissions from all the processes. This model has been developed in a previous project (Dalemo et al., 1997).

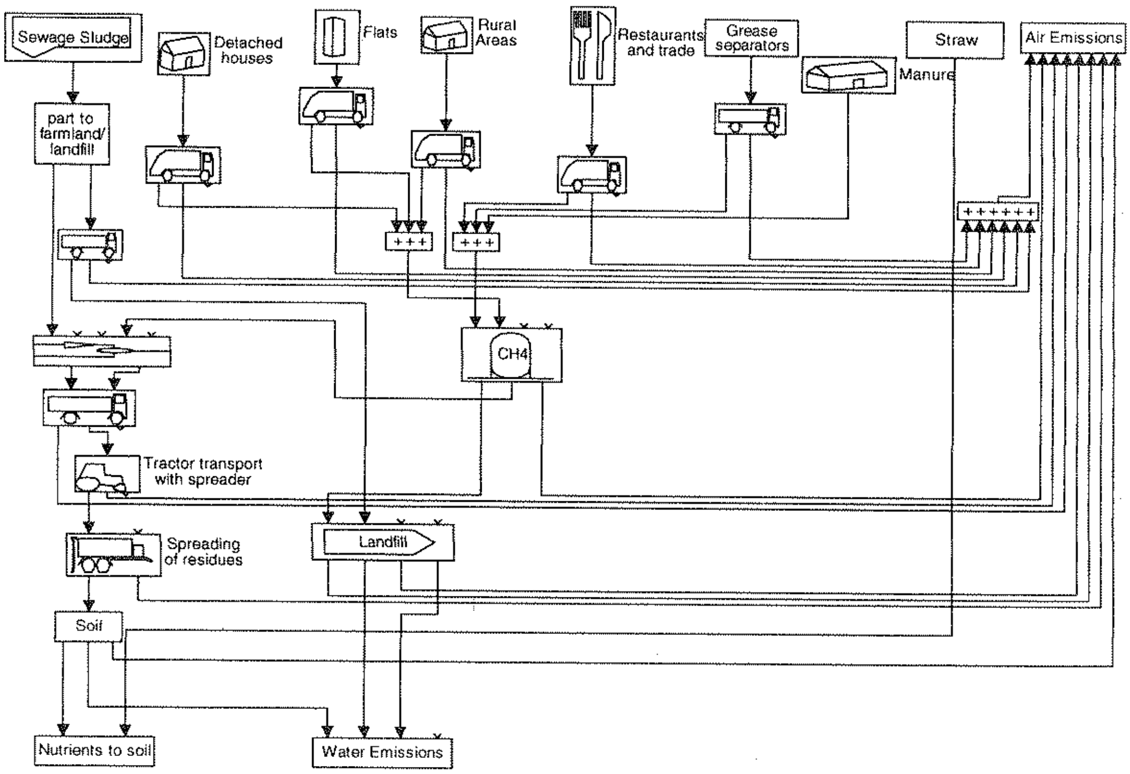

Figure 1. The anaerobic digestion scenario, as an example of a scenario in the ORWARE-model.

To reduce the data for evaluation of the results, life-cycle analysis methodology is used to aggregate the emissions in environmental impact categories. In this project the global warming potential, eutrophication, acidification, human health and eco-toxicity effects are studied.

Scenarios

Life-cycle assessment (LCA) techniques are adopted to help when choosing system boundaries and functional units. System boundaries and functional units are chosen to make all scenarios comparable with respect to the amount of waste treated, nutrients supplied to arable land, and the provision of district heating and electricity. Therefore production of mineral fertiliser is included in a quantity so that all scenarios result in the same amount of nitrogen and phosphorus spread on farmland as in the anaerobic digestion scenario. In this scenario 170 tonnes of nitrogen and 111 tonnes of phosphorus are recirculated to the crops as organic fertiliser. With the same principle, heat production from wood chips and electricity production from oil are included in the scenarios in a quantity so that all scenarios produce the same net amount of heat and electricity. The largest production of heat from waste is found in the mineral fertiliser scenario (77 TJ), and the largest production of electricity is found in the anaerobic digestion scenario (17 TJ).

Mineral fertiliser

In the mineral fertiliser scenario the easily degradable organic fraction of the municipal waste from restaurants, trade and households is incinerated. The ash from incineration is landfilled. Grease water from grease traps at, e.g., restaurants, is very wet and therefore landfilled. Slurry manure from pigs and cows in the surrounding area is stored and spread directly on farmland. The straw from cereals is left on the farmland without any treatment. Half of the sludge from the sewage plant is stored and spread on farmland and half is landfilled.

This handling of the waste results in 77 TJ of heat produced, together with organic fertiliser (sludge and manure) spread on farmland containing 98 tonnes nitrogen and 93 tonnes phosphorus. Therefore external production of nitrogen (72 tonnes), phosphorus (18 tonnes) and electricity 17 TJ are included in this scenario.

Table 2. Material flow in the mineral fertiliser scenario of a large city.

Mineral fertiliser	1000 tonnes/year	Treatment		Output
Organic waste				
Restaurants and trade	3 ┬ →	Incineration		77 TJ heat
Households	13 ┘	↘		
Grease water	3	→	Landfill	
Manure	25 ┐			
Straw	3 ┼	→	Farmland	98 tonnes N
Sludge →	8 ┘			93 tonnes P
↘	8	→	Landfill	
External production		Natural gas	Nitrogen	72 tonnes N
		Ore	Phosphorus	18 tonnes P
		Oil	Electricity	17 TJ electricity

Anaerobic digestion residue

In the anaerobic digestion residue scenario, organic waste from restaurants, trades, households, grease traps and manure from pigs and cows is anaerobically digested. The residue from digestion is stored and spread on farmland. Manure is collected with trucks for transportation to the anaerobic digestion plant. Emissions from this collection are not included, since the manure is collected by trucks on their way back when digester sludge has been transported to farms for storage. An extra tractor transport is added for transportation of residues from the farm to farmland for spreading. Straw is not collected, but left on farmland. Half of the sludge from the sewage plant is stored and spread on farmland and half is landfilled.

The biogas from digestion is used for production of heat and electricity and this scenario results in a net production of 32 TJ heat and 17 TJ electricity. The organic fertiliser (anaerobic digestion residue and sludge) spread on farmland contains 170 tonnes of nitrogen and 111 tonnes of phosphorus. Therefore only external production of heat with 45 TJ is included in this scenario.

Table 3. The material flow in the anaerobic digestion residue scenario of a large city.

A. D. residue	1000 tonnes/year	Treatment		Output
Organic waste				
Restaurants and trade	3			32 TJ heat
Households	13			17 TJ electricity
Grease water	3	Anaerobic dig.		170 tonnes N
Manure	25	↘		111 tonnes P
Straw	3	→	Farmland	
Sludge	8			
	8	→	Landfill	
External production		Wood chips	Heat	45 TJ heat

Reactor compost

In the reactor compost scenario, organic waste from restaurants, trades, households and grease traps is composted. The compost is stored, and spread on the fields. Slurry manure from pigs and cows in the surrounding area is stored and spread directly on farmland without any treatment. Straw is not collected, but left on farmland. Half of the sludge from the sewage plant is stored and spread on farmland and half is landfilled.

The organic fertiliser (compost and sludge) spread on farmland contains 127 tonnes of nitrogen and 111 tonnes of phosphorus. Therefore only external production of nitrogen (43 tonnes) is included. Reactor composting does not result in any production of electricity and heat. Therefore also electricity production from oil (17 TJ) and heat production from wood chips (77 TJ) are included in this scenario.

Table 4. The material flow in the reactor composting scenario of a large city.

Reactor compost	1000 tonnes/year	Treatment		Output
Organic waste				
Restaurants and trade	3 ┐			
Households	13 ┼→	Reactor c.		127 tonnes N
Grease water	3 ┘	↘		111 tonnes P
Manure	25 ┐		Farmland	
Straw	3 ┼	↗		
Sludge →	8 ┘			
↘	8	→	Landfill	
External production		Natural gas	Nitrogen	43 tonnes N
		Oil	Electricity	17 TJ electricity
		Wood chips	Heat	77 TJ heat

Windrow compost

In the reactor compost scenario, organic waste from restaurants, trades and households is composted. Straw is used for amendment. However, processes of collection and "pressing" of straw are not included in the study. The compost is stored, and spread on farmland. Grease water from grease traps at, e.g. restaurants is very wet and therefore landfilled. Slurry manure from pigs and cows in the surrounding area is stored and spread directly on farmland without any treatment. Half of the sludge from the sewage plant is stored and spread on farmland and half is landfilled.

The organic fertiliser (compost and sludge) spread on farmland contains 112 tonnes of nitrogen and 111 tonnes of phosphorus. Therefore only external production of nitrogen (58 tonnes) is included. Reactor composting does not result in any production of electricity and heat. Therefore, also electricity production from oil (17 TJ) and heat production from wood chips (77 TJ) are included in this scenario.

Table 5. The material flow in the reactor composting scenario of a large city.

Reactor compost	1000 tonnes/year	Treatment		Output
Organic waste				
Restaurants and trade	3 ┐			
Households	13 ┼→	Windrow c.		112 tonnes N
Straw	3 ┘	↘		111 tonnes P
Manure	25 ┬	→	Farmland	
Sludge →	8 ┘			
↘	8	→	Landfill	
Grease water	3	↗		
External production		Natural gas	Nitrogen	58 tonnes N
		Oil	Electricity	17 TJ electricity
		Wood chips	Heat	77 TJ heat

Sources and processes

A lot of different sources and processes for waste management can be included in the ORWARE model. A brief description is given below of some of the assumptions used in this study. A more complete description of the model can be found in Dalemo et al. (1997). A thorough description of the transportation and composting models (Sonesson, 1996), incineration and landfilling (Mingarini, 1996), and sewage plant and anaerobic digestion models (Dalemo, 1997) are published in separate reports.

Sewage sludge

The sewage sludge composition is primarily taken from the sludge in Uppsala. However, for the content of heavy metals, figures from statistics on sewage plants <25000 pe are used for the sludge in Ystad and >100000 pe for the sludge in Uppsala.

Slurry manure

Slurry manure from farms within a distance of about 10 km is included in the study. Solid manure is fairly rare around Uppsala and Ystad. Slurry manure is preferred for anaerobic digestion while solid manure would be better in composting processes. However, there is no advantage in including manure in a composting plant from an economic viewpoint or for the process. Therefore, the slurry manure is treated in the anaerobic digestion residue scenario, but spread directly on farmland in the mineral fertiliser and composting scenarios.

Energy sources

Oil is assumed to be used for production of electricity in a condensation plant. This is because the electricity produced from waste is from biogas in the anaerobic digestion residue scenario and this is produced all year around. The most expensive electricity source consumed all year is imported electricity from coal or oil condensation plants in Denmark and Finland. The electricity from biogas production is therefore assumed to substitute electricity production from oil condensation plants.

Biofuel (wood chips) is the source used for heat production. In new district heating systems the most common fuel is wood chips. Heat production from waste in the mineral fertiliser scenario is therefore substituted with heat production from wood chips in the other scenarios.

Incineration

The incineration plant model mirrors the waste incineration facility in Uppsala, which has a capacity of incinerating 250 000 tonnes/year. It is equipped with flue gas condensation, dust removal in electrostatic precipitators, SNCR with urea for NO_x-reduction, and dry removal of acid gases with $CaCO_3$ and $Ca(OH)_2$. There is no electricity production, all heat is recovered for district heating.

In the Uppsala scenarios, the facility is located near the centre of town, as is the case today. In the Ystad scenarios, it is not considered realistic that such a small town has its own incineration facility. The waste is instead transported to a larger city 50 kilometers away with an incineration facility of the same capacity and equipment as in Uppsala.

Landfilling

The landfill model mirrors an average Swedish landfill, and is thus not specifically adjusted to any site specific circumstances. Four specific submodels are included, landfilling of household waste, sewage sludge, incinerator bottom ash and incinerator fly ash. The leachate is treated for removal of phosphorus and nitrogen. 50 % of the landfill gas is collected and burned in a gas engine, generating heat and electricity.

To meet the difficulties arising from the time lag between the addition of waste material to the landfill and emissions occurring from that same material, the landfill emissions are modelled as occurring either during surveyable time or during remaining time. Surveyable time is in the order of 100 years, and covers the most active phases of landfill degradation. Remaining time is defined as leading to complete degradation and spreading of all landfilled material, thereby giving maximum potential emissions.

The conditions modelled in the household waste landfill during surveyable time are anaerobic methanogenic. Under these conditions, easily and moderately degradable carbon fractions are almost entirely degraded, generating about 50 % each of CO_2 and CH_4. Metals are only emitted to a very small extent during surveyable time. Remaining time includes some oxygen intrusion and erosion, so that CH_4-emissions are lower.

Landfilling of sludge is modelled in an approach different to that used for household waste. Most of the sludge is used as final cover. Therefore a larger part is degraded aerobically. We assume that 90 % of the sludge is used as final cover, and is consequently completely aerobically degraded to CO_2. The leaching of phosphorus is lower under aerobic conditions than anaerobic. During remaining time, 50 % of the remaining cellulose and hemicellulose will degrade anaerobically, the rest being aerobically decomposed together with lignin after intrusion of oxygen or erosion of landfill material.

Anaerobic digestion

The anaerobic digestion plant simulated includes pre-treatment of the waste in the form of separation, maceration and different levels of hygienisation. The substrate is diluted with fresh water if exceeding 15 % DM. The digester is a continuous, single stage, mixed tank reactor (C.S.T.R.) operating under mesophilic temperature. After digestion the residue passes through a heat exchanger, reducing the microbial activity and transferring the heat to the influent substrate. The digested material is finally stored in covered lagoons until the spreading season. The gas produced is used for production of electricity and heat in a stationary engine without any previous treatment.

Reactor compost facility

The reactor compost facility modelled is a rotating drum, followed by maturing in open air windrows with controlled aeration. The rotation of the drum is driven by electricity and the open air windrows are managed with mobile, diesel-fuelled, equipment. The exhaust gas equipment is first a condensation step and thereafter a biofilter consisting of mature compost. The waste is treated in the drum for approximately one week. During that time half of the total degradation takes place, and all gases produced during the reactor phase are treated in the exhaust gas equipment. The gases produced during maturation are to 80 % treated in the exhaust gas equipment, the rest is emitted to air.

Windrow compost facility

The windrow compost facility modelled is an open-air compost with forced aeration but no exhaust gas equipment. All operations necessary for managing the compost, e.g. sieving, turning, loading, is performed with mobile, diesel-fuelled equipment. The compost process is assumed to be the same as for the reactor compost, i.e. the amount of NH_3, CH_4, N_2O formed is a result of the incoming material's contents of nitrogen and carbon of different degradability.

Tractor transport

Energy consumption varies. Studies with an average of 12 tractors gave consumption of 0.24 l/km without load and 0.29 with an 8-tonne load (SMP, 1983). Consumption for trucks is 0.2 l/km without load and 0.4 l/km with 12-tonne load. The model calculates with a consumption of 10 l/h and an average speed on 20 km/h as an average with a slurry spreader with 12 tonnes loading capacity, resulting in about 0.5 l/km on the road. In addition, it takes about 0.5 minutes per tonne to load the spreader at the storage tank. The loading is done with the pump on the spreader and the consumption is assumed to be 10 l/h.

Soil Emissions

Organic fertilisers can be substitutes for mineral fertiliser in agriculture. The losses of nutrients when using organic fertilisers are often larger than for mineral fertilisers. However, the losses vary due to weather conditions, type of soil and crop, and equipment for spreading and time between spreading and cultivation. The efficiency of nutrients in organic waste residues as compost and anaerobic digestion residues is compared with mineral fertiliser. The efficiency is assumed to be 100 % for phosphorus, 80 % for ammonium and 30 % for organic-bound nitrogen.

The environmental impact due to emissions of nutrients from organic fertiliser is primarily as NH_3 to air, NO_3^- to water and small emissions of N_2O to air. Emissions of N_2 are large but have no environmental impact.

Emissions of NH_3 are, among other things, related to the content of NH_4 in the residue. When spreading anaerobic digestion residues in Denmark, NH_3 emissions were found to be about 15 % of the total nitrogen content (Energistyrelsen, 1995).

Nitrate emissions occur when there is water transportation down to the drainage. These emissions are largest in spring and autumn with little vegetation and much rain. About half of the organic-bound nitrogen losses are assumed to be emitted as NO_3^- and half as N_2.

Emissions of N_2O occur under conditions between anaerobic and aerobic. An assumption of these emissions is that about 1.25 % of the total added nitrogen is lost as N_2O (OECD, 1996).

The emissions of nitrogen are related to the content of organic-bound nitrogen and ammonium in the organic fertiliser to be useful for both anaerobic digestion residues and composts. Only the extra emissions compared with mineral fertiliser are included. The assumptions used in the ORWARE model are presented below.

Mineral nitrogen: Of the total 20 % losses, about 75 % is emitted as NH_3, 1.25 % as N_2O and the remaining 23.5 % as N_2.

Organic-bound nitrogen: Of the total 70 % losses, about 50 % is emitted as NO_3^-, 1.25 % as N_2O and the remaining 48.5 % as N_2.

Results for a large city region

In this section, the results from comparison of scenarios for a large city area are presented. Specific parameters needed in the study are primarily taken from Uppsala.

Materials

In the large city area, 25 % of the organic waste is from sludge, 30 % from other municipal waste and 40 % from manure. The remaining 5 % consist of straw used in the windrow composting scenario (Table 6).

Table 6. Waste quantities included in the study of a large city region, and their content of nitrogen and phosphorus (metric tonnes per year).

	Sludge	Flats	Houses	Rural areas	Trade	Restau-rants	Grease water	Cow manure	Pig manure	Straw
Dry matter	3 900	2 161	1 593	801	150	550	108	1 512	288	2 550
Wet weight	16 250	6 175	4 550	2 288	500	2 200	3 000	21 600	3 200	3 000
Total N	152	43.2	31.9	16.0	2.3	12.1	0.1	84.7	17.0	12.8
Total P	137	8.2	6.1	3.0	0.8	0.6	0.1	18.1	4.6	1.8

Energy

The mineral fertiliser scenario has the largest production of heat and the anaerobic digestion residue scenario the largest production of electricity (Figure 2). However, it is important to observe that all energy is added in one diagram, even though the quality of energy differs. When comparing energy turnover in different countries the electricity is often valued as 3 times the heat.

Heat is produced in the incineration plant. Gas from the landfill and anaerobic digestion plant is used for production of heat (2/3) and electricity (1/3). The fuel consumption is primarily from collection of waste, transportation and spreading of manure and residues.

The fuel consumption in the mineral fertiliser scenario consists of collection (70 %), transport of residues to arable land (10 %), and spreading of residues (20 %). In the other scenarios, transports increase as recycling transports and spreading primarily in the anaerobic digestion residue scenario.

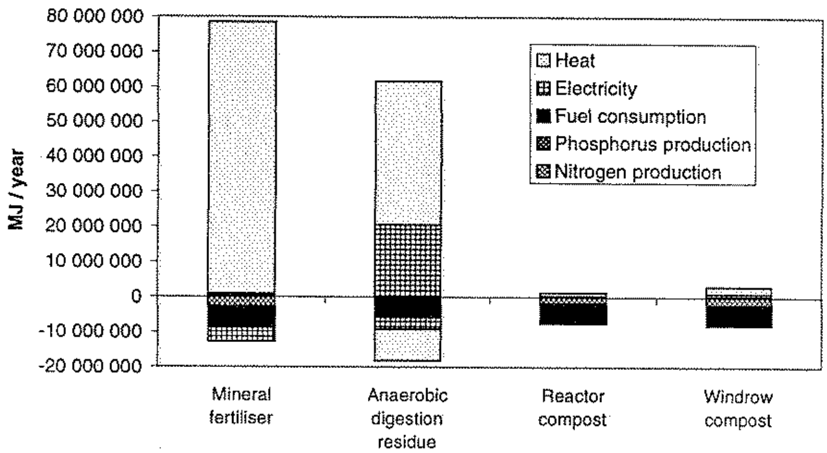

Figure 2. Energy conversion for the studied scenarios in the large city region. Observe that all energy is added in one diagram, even though the quality of energy differs.

In the mineral fertiliser scenario the main part of the heat is produced in the incineration plant. The production of electricity originates from landfill gas produced from landfilling of sludge and grease water. Electricity is consumed in the incineration plant.

In the anaerobic digestion residue scenario electricity and heat are produced primarily from biogas. Heat is consumed for hygienisation and digestion in the anaerobic digestion plant. Electricity is consumed for maceration, pumping and mixing in the plant. This scenario has the largest consumption of fuel due to transportation and spreading of the wet residue.

The reactor compost scenario has production of electricity and heat from landfilling of sludge and a coarse fraction. The windrow compost scenario has slightly larger production since grease water also is landfilled in this scenario.

Global warming

The global warming potential is calculated as CO_2-equivalents using weighting factors for a time-frame of 100 years (Nordic Guidelines on Life-Cycle Assessment, 1995).

Nutrients from anaerobic digestion residue have the lowest potential contribution to the environmental impact global warming, followed by reactor compost, mineral fertiliser and windrow compost (Figure 3). The major emissions come from treatment of waste and emissions from landfill during remaining time (after ca 100 years). The functional units, production of electricity and nitrogen, also result in emissions of importance.

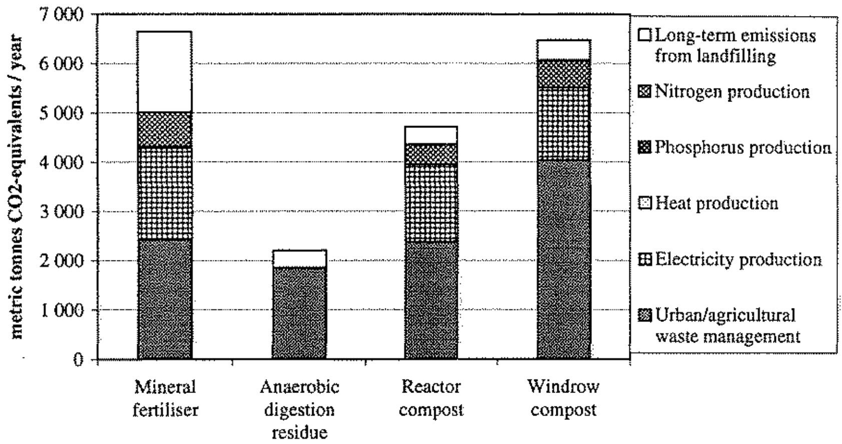

Figure 3. Total contribution to global warming potential from the scenarios in the large city region.

Production of nitrogen, phosphorus, heat and electricity

The emissions from nitrogen production contributing to global warming potential are N_2O (85 %) and CO_2 (15 %). Emissions from production of phosphorus are only CO_2.

Heat production from wood chips does not result in any emissions of greenhouse gases. Production of electricity in oil condensation plant results in CO_2 emissions.

Waste management

The major sources for global warming potential from waste management are soil, landfilling and, in the windrow composting scenario, also the composting process (Figure 4). The transportation also has significant impact. The substances contributing to global warming are from soil N_2O, from landfilling CH_4 and from transportation CO_2. contributing

The mineral fertiliser scenario has large emissions from landfilling of waste due to the landfilling of grease water. The emissions from soil are somewhat lower than in the other scenarios since only manure and sewage sludge are spread as organic fertiliser. There are also emissions of N_2O from incineration (treatment) of the organic waste, but these are small compared with the other sources.

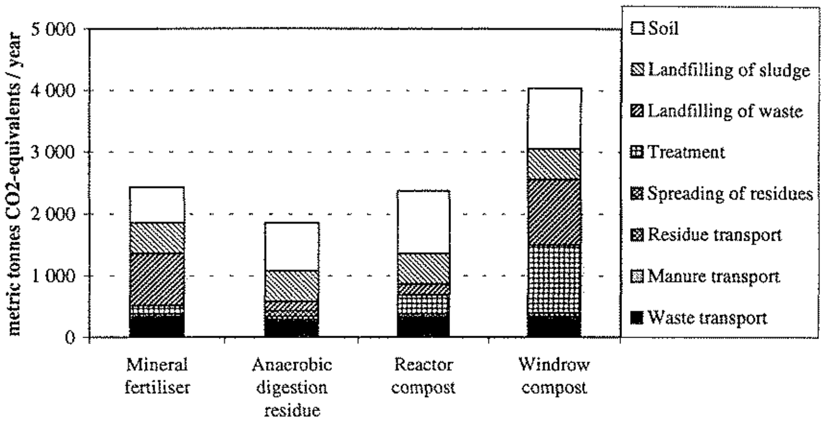

Figure 4. Global warming potential from urban/agricultural waste management in the large city region.

The dominating sources in the anaerobic digestion sludge scenario are from landfilling and soil. The soil emissions of N_2O are larger than in the mineral fertiliser scenario. The addition of total nitrogen to soil is larger with organic fertilisers since the losses of nitrogen are larger. The N_2O emissions are 1.25 % of the total nitrogen added and therefore these emissions are larger in this scenario.

The emissions from the reactor compost scenario are quite similar to the ones from anaerobic digestion. However, the emissions of N_2O from soil are somewhat higher, and there are also some CH_4 emissions from the reactor composting process.

The emissions from landfilling of sludge and soil are the same in the windrow compost scenario as in the reactor compost scenario. However, there are also CH_4 emissions from landfilling of grease water that is landfilled instead of composted as in the reactor compost scenario. The windrow composting process also has larger emissions of CH_4, since this process does not include any purification of exhausted gas as in the reactor composting process.

Eutrophication

The eutrophication category is calculated using weighting factors for a maximum scenario including eutrophication effect from both nitrogen and phosphorus (Nordic Guidelines on Life-Cycle Assessment, 1995).

Nutrients to arable land from anaerobic digestion residues result in the lowest contribution to the eutrophication effect (Figure 5). However, anaerobic digestion residue, reactor compost and windrow compost have almost the same total emissions of eutrophication substances. This primarily consists of emissions of eutrophication substances in the long-term and treatment of waste.

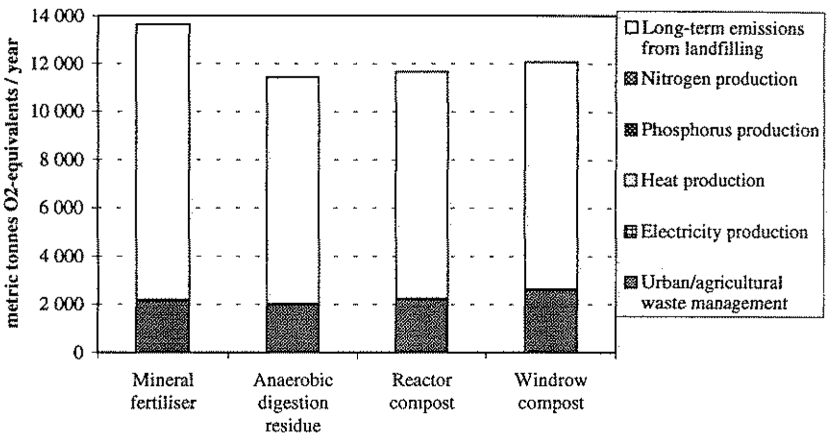

Figure 5. Total potential contribution to eutrophication from the scenarios in the large city region.

Landfilling (remaining time)

It is emission of phosphorus that gives a potential eutrophication effect in the long-term for all four scenarios. The landfilling includes purification of the leachate during surveyable time, but since the sediment residue from purification is put back on the landfill the phosphorus emissions are simply postponed.

Production of nitrogen, phosphorus, heat and electricity

From the production of nitrogen, NO_x (50 %) and NH_3 (50 %) are the major emissions contributing to the eutrophication effect. For production of phosphorus, the eutrophicating emissions originate from NO_x (50 %), and NH_3 (50 %).

Heat and electricity production result in eutrophication effects only from emission of NO_x.

Waste management

The major eutrophication effect from the waste management occurs from nitrogen emissions from soil (Figure 6). Emissions come also from landfilling of sludge (P) and in some scenarios emissions of different substances from the waste treatment process.

In the mineral fertiliser scenario the soil emissions are from sludge and manure as NO_3^- (80 %) and a minor part as NH_3 (20 %). The emissions from incineration (treatment) are as P to water from water used in the gas purification process.

The soil emissions in the anaerobic digestion residue scenario are larger than in the mineral fertiliser scenario. This increase is primarily NH_3 emissions from the digestion residue spread on farmland. Anaerobic digestion of waste and manure result in mineralisation of organic-bound nitrogen. Therefore, this process increases the emissions of ammonia but decreases the nitrate emissions. The nitrogen emissions from soil in this scenario are 32 % NH_3 and 68 % NO_3^-.

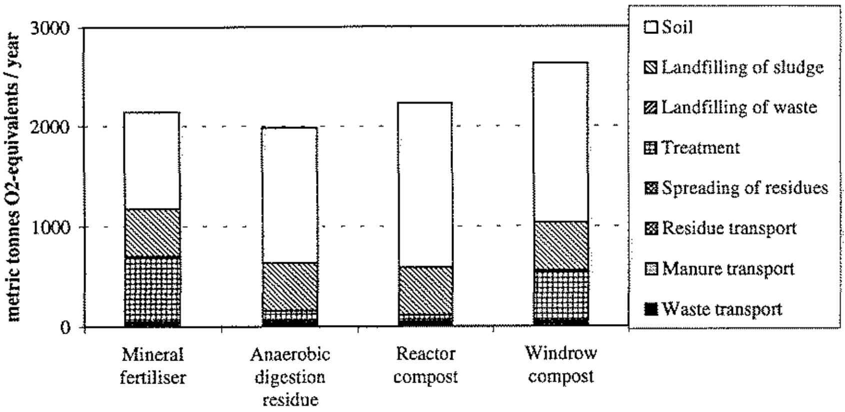

Figure 6. Eutrophication potential from urban/agricultural waste management in the large city region.

In the reactor compost scenario the nitrogen emissions from soil are even larger. These emissions are 88 % NO_3^- and 12 % NH_3. This is because the compost contains primarily organic-bound nitrogen in contrast to the anaerobic digestion residue. The windrow compost process also contributes to the eutrophication effect from emission of NH_3.

Acidification

In this category the potential maximum acidification is calculated (Nordic Guidelines on Life-Cycle Assessment, 1995). This includes acidification from nitrogen compounds.

The scenarios with nutrients from mineral fertiliser and reactor compost have the lowest contribution to the acidification impact (Figure 7). The emissions of acidification gases are primarily from waste handling, but there are also some from the heat production.

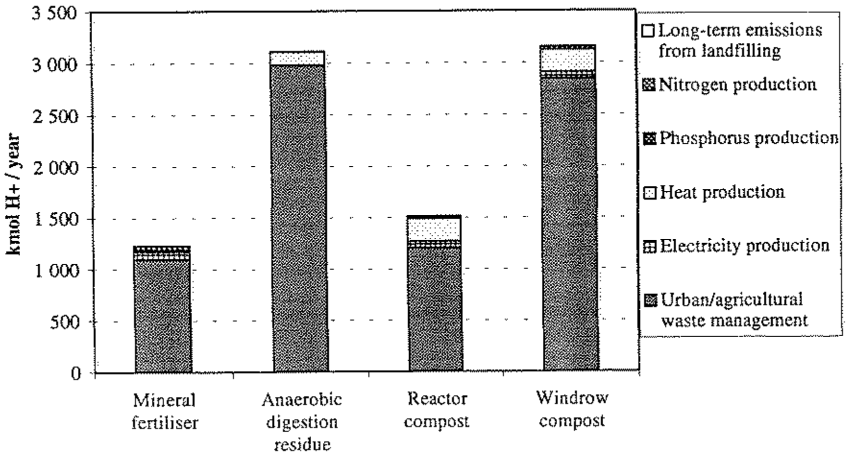

Figure 7. Potential contribution to acidification from the scenarios in the large city region.

Production of nitrogen, phosphorus, heat and electricity

From production of nitrogen, NO_x (50 %) and NH_3 (50 %) are the major emissions contributing to the acidification effect. For production of phosphorus, the acidification emissions originate from SO_2 (80 %), NO_x (10 %) and NH_3 (10 %). Heat production results in acidification effect from SO_2 (45 %) and NO_x (55 %) and production of electricity from SO_2 (50 %) and NO_x (50 %).

Waste management

Emissions of gases contributing to the acidification effect are primarily from soil and the treatment processes (Figure 8). In all scenarios the acidification emissions from soil are NH_3 while the substances from the treatment processes differ between the scenarios.

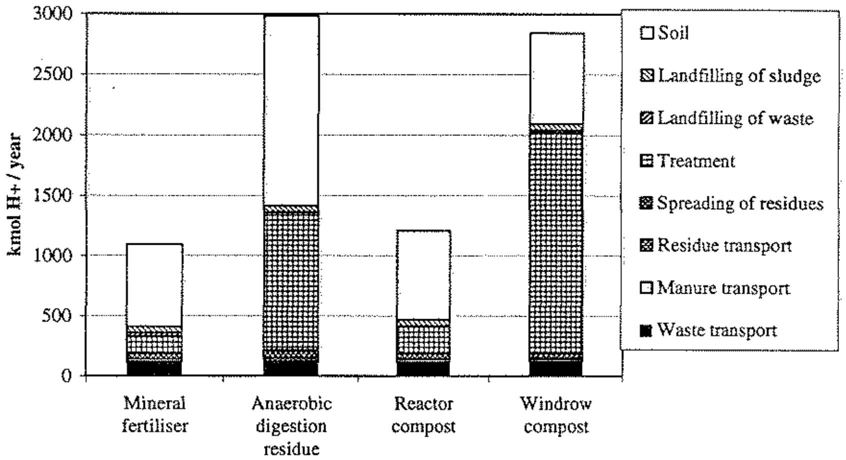

Figure 8. Acidification potential from urban/agricultural waste management in the large city region.

In the mineral fertiliser scenario, the treatment process incineration emits several compounds contributing to the acidification effect. The gases are NO_x (46 %), SO_2 (41 %), HCl (10 %) and NH_3 (3 %).

The acidification emissions from the anaerobic digestion process are NO_x (30 %) and SO_2 (70 %). The large emission from the soil is due to a high proportion of NH_4^+ in the digestion residue.

In the compost scenarios the acidification emissions are primarily as NH_3 emissions both in the reactor and windrow composting process. The lower level in the reactor process is because this process includes purification of the exhausted gas.

Human health

Emissions influencing human health, as toxicological impacts, are calculated using the CML provisional method (Nordic Guidelines on Life-Cycle Assessment, 1995). Impacts in work environment is not included. Moreover, the weighting factors are ***uncertain*** for this category. Toxicological impacts from emissions to air, water and soil are presented below. These can be added together. However, the air emissions have the largest total impact.

The mineral fertiliser and composting scenarios all have low impact on human health from air emissions (Figure 9). In all scenarios the waste management has the largest impact and for all activities it is emissions of NO_x and to a minor part SO_2. The large emissions from the anaerobic digestion residue scenario is primarily from combustion of biogas in a stationary engine producing electricity and heat. This production has no NO_x reducing equipment since the regulation only includes large energy-producing plants. With catalysts, the NOx emissions could be reduced by 90 %.

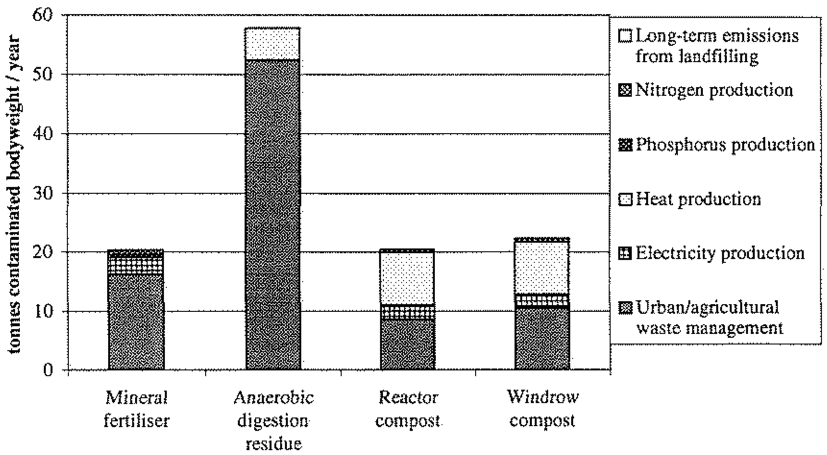

Figure 9. Potential contribution to human health from emissions to air in the scenarios in the large city region. Impacts in work environment are not included.

The anaerobic digestion scenario is preferable when comparing the contribution to human health from emissions to water (Figure 10). The dominating emissions in all scenarios are long-term emissions from landfill leachate as Hg, Pb and Cr, and in the mineral fertiliser scenario also dioxins. From urban/agricultural waste management the NO_3^- from soil.

The mineral fertiliser and composting scenarios have the lowest contribution to human health from emissions to soil (Figure 11). It is emissions of phenols, Cd and Zn that have the major impact. The anaerobic digestion residue scenario has largest emissions because phenols are not to the same extent degraded in this process as in the incineration and composting processes.

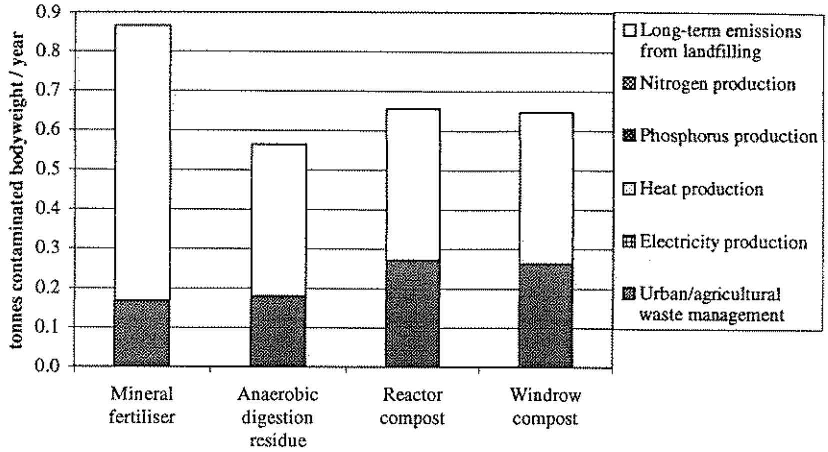

Figure 10. Potential contribution to human health from emissions to water in the studied scenarios in a large city region.

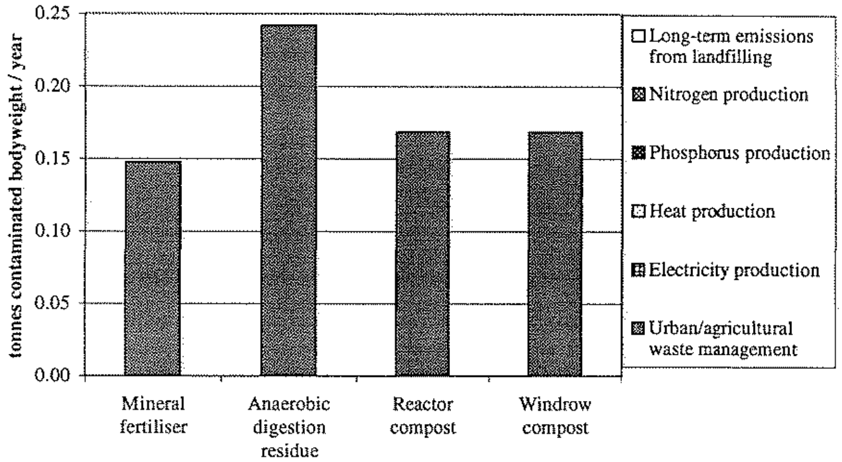

Figure 11. Potential contribution to human health from emissions to soil in the scenarios in the large city region.

Ecotoxicity

Emissions influencing ecotoxicity impacts, are calculated using the CML provisional ecotoxicity method (Nordic Guidelines on Life-Cycle Assessment, 1995). The weighting factors are ***very uncertain*** for this category, since this category includes impact on a wide range of species of animals. Ecotoxicity impacts from emissions to water and soil are presented below. These can not be added together. The heavy metals have the largest impact on ecotoxicity. In the scenarios, the heavy metals from waste are either put on landfills and the result in water emissions with leachate, or they are spread with the residues on farmland. Therefore, it is a choice between ecotoxicity in water or ecotoxicity in soil.

The contributions from the anaerobic digestion residue and compost scenarios have the lowest total emissions (Figure 12). However, the impact is totally dominated by the long-term emissions from landfilling. These are emissions of the heavy metals Cu, Cd and Zn with the leachate.

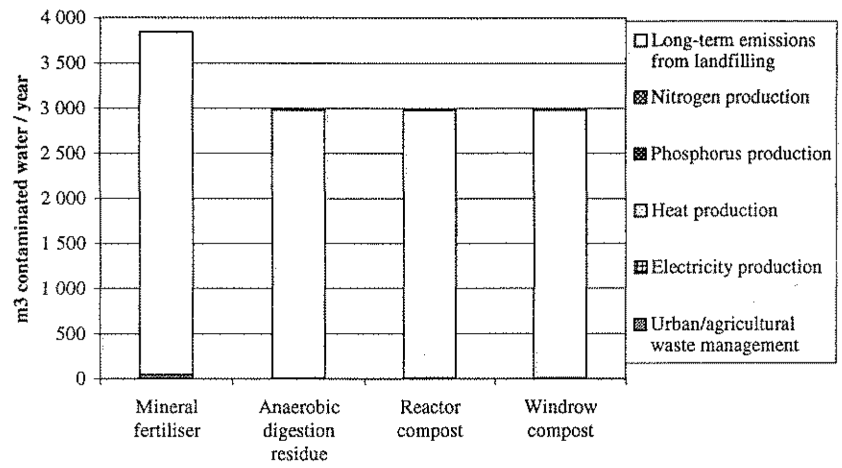

Figure 12. Potential impact on ecotoxicity from emissions to water in the scenarios in the large city region.

If the long-term emissions are excluded, the mineral fertiliser scenario still has the largest impact (Figure 20). From the waste management the largest impact is given by emissions of Cd and Zn with the landfill leachate in the short time (within 100 years).

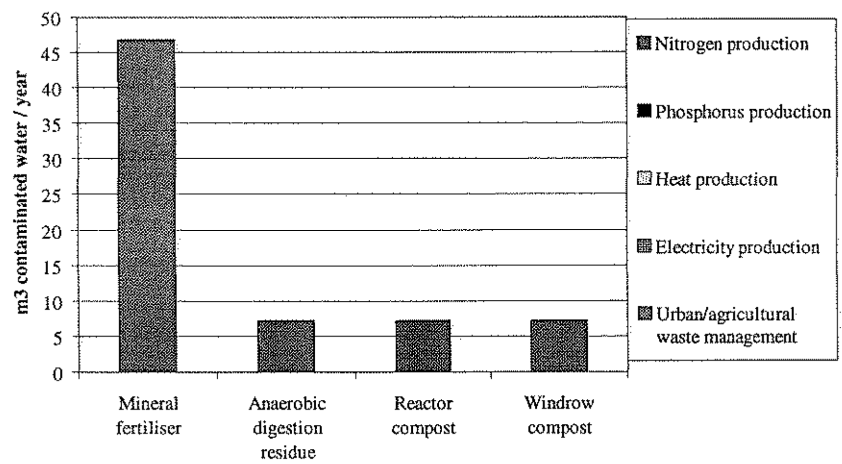

Figure 13. Potential impact on ecotoxicity from emissions to water in the scenarios in the large city region, excluding long-term emissions from landfilling.

The mineral fertiliser scenario has the lowest contribution to ecotoxicity from soil (Figure 21). This is because the urban waste is incinerated and the heavy metals landfilled with the ash. In the other three scenarios, a major part of the urban waste is treated and the residue spread on farmland. The greatest impact is from heavy metals, in particular Zn, emitted to soil from spreading of residues.

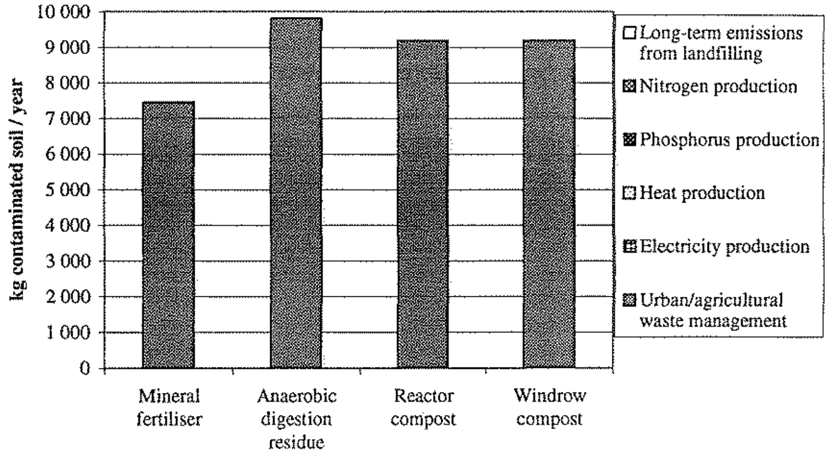

Figure 14. Potential impact on ecotoxicity from emissions to soil in the scenarios in the large city region.

Utilisation of organic carbon as a source of humus

The total amount that is put on farmland is largest in the anaerobic digestion residue and the reactor compost scenario (Figure 15). The mineral fertiliser scenario supplies less carbon to farmland, since some of the organic waste is incinerated. The small amount of carbon from the windrow compost scenario is because the straw is composted and then to some extent degraded (in the other scenarios the straw is assumed to be left in the field, thus supplying all of its carbon to the soil).

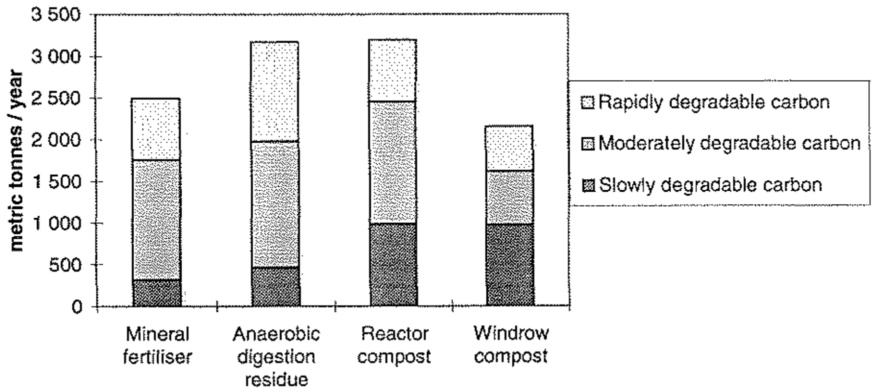

Figure 15. Carbon of different stability spread on arable land with the organic residues from the large city region.

However, the total amount is perhaps of less interest, since the degradability of the carbon is of utmost importance for its effect as humus-forming agent. The slowly degradable carbon, mainly humus and lignin, is clearly important for the humus formation in soil. The two composting scenarios supply the largest amount of slowly degradable carbon to farmland, since edification of bacteria is higher in these aerobic digestion processes.

Another part of the carbon fraction that may be of importance is the semi-degradable part, mainly cellulose and hemicellulose. The spreading of this fraction is almost the same in all scenarios except the windrow compost scenario, since the straw is composted and a part of this carbon fraction is degraded or transformed to humus.

The rapidly degraded carbon is probably of less importance. A large part of this fraction is found in the sewage sludge which is spread on farmland in all scenarios. The anaerobic digestion residue scenario has the largest amount of fast degraded carbon. This is because in the one-stage totally mixed anaerobic digestion process some of the material only has a retention time of one day and therefore still contains rapidly degradable components.

Economy

The basis for economic calculation depends on the demography and also the type and size of the processing plant. The mineral fertiliser scenario result in the largest total cost, followed by the reactor compost, anaerobic digestion and windrow compost scenarios (Figure 16). The costs are roughly distributed on transportation (1/4) treatment of waste (1/2) and landfilling of sludge (1/4).

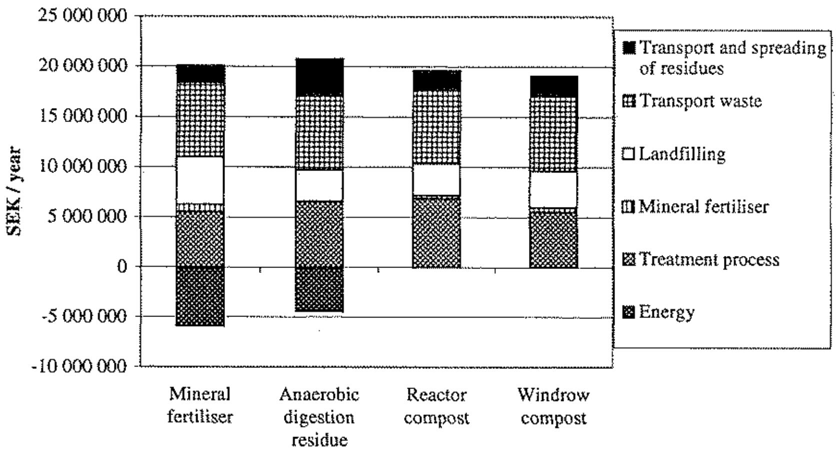

Figure 16. Total costs in the scenarios in the large city region (income below the x-axis).

The costs for collection of waste are primarily from collection of biodegradable waste from households (80 %) (Figure 17).

The major costs are from processing the waste (Figure 18). These costs are highest in the mineral fertiliser scenario followed by the compost and anaerobic digestion residue scenarios.

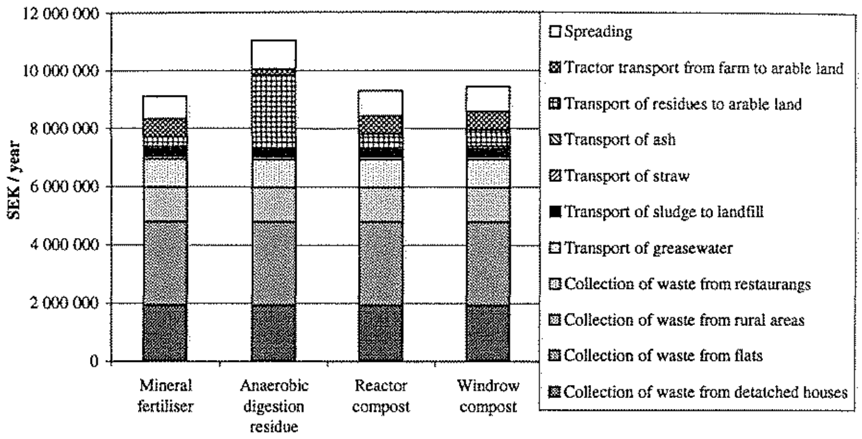

Figure 17. Transportation costs in the scenarios in the large city region.

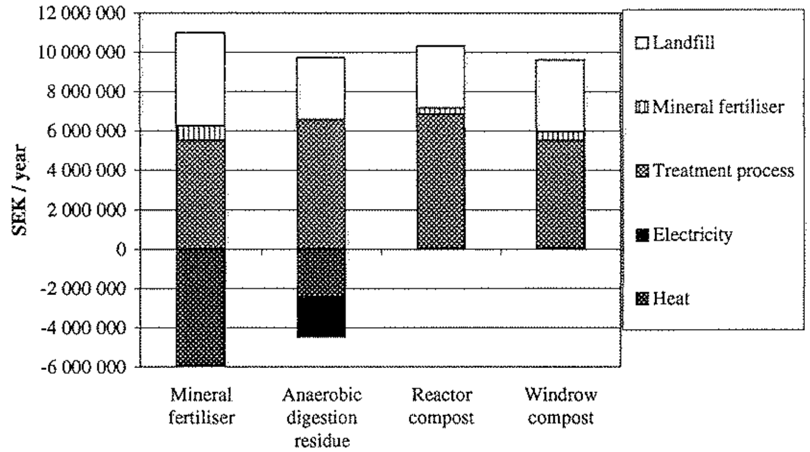

Figure 18. Processing costs in the scenarios in the large city region (incomes below the x-axis).

In the mineral fertiliser scenario the total investment cost for an incineration facility with a capacity of 250 000 tonnes/year, is 550 mill. SEK. The yearly cost for the entire facility is 88 mill. SEK, distributed on 50 % capital cost and 50 % running cost. The organic waste in the large city region only constitutes 16 000 tonnes/year, giving a cost of 5.5 mill. SEK/year.

For the anaerobic digestion treatment the total investment costs are ca 45 mill. SEK. The yearly costs are distributed on 70 % capital cost, 10 % staff cost and the remaining 20 % running cost.

"In the reactor compost scenario the investment cost for the compost facility is only 3.4 mill. SEK. The yearly costs are divided in capital costs 5 %, wages 15 % and running costs, mainly fuel, electricity and maintenance, 80 %. The windrow compost facility has an even lower investment cost, 2 mill. SEK. The yearly costs are divided as follows: capital costs 5 %, wages 10 % and running costs 85 %."

Results for the small town region

In this section the results from comparison of scenarios for a small town area is presented. These results are not presented in such detail as in the large city region. Specific parameters needed in the study are primarily taken from Ystad.

Materials

Manure in the small town region (Ystad) is the dominating source of both dry matter (75 %), wet weight (>90 %), nitrogen (90 %) and phosphorus (75 %). The remaining parts originate from sewage sludge and, regarding DM, also solid urban waste and straw contributes significantly.

Table 7. Quantities and nutrient content in waste from different sources in the small town and the surrounding rural area (metric tonnes per year).

	Sludge	Flats	Houses	Rural areas	Trade	Restau-rants	Grease water	Cow manure	Pig manure	Straw
Dry matter	1 163	228	403	209	41	74	16	1 995	1 665	510
Wet weight	5 815	650	1 150	598	136	295	450	28 500	18 500	600
Total nitrogen	40.7	4.5	8.0	4.2	0.6	1.6	0.0	111.7	98.2	2.6
Total phosphorus	38.4	0.9	1.5	0.8	0.2	0.1	0.0	23.9	26.6	0.4

Energy

The anaerobic digestion scenario has the largest energy turnover, this is explained by the very large amount of manure that is handled (Figure 19).

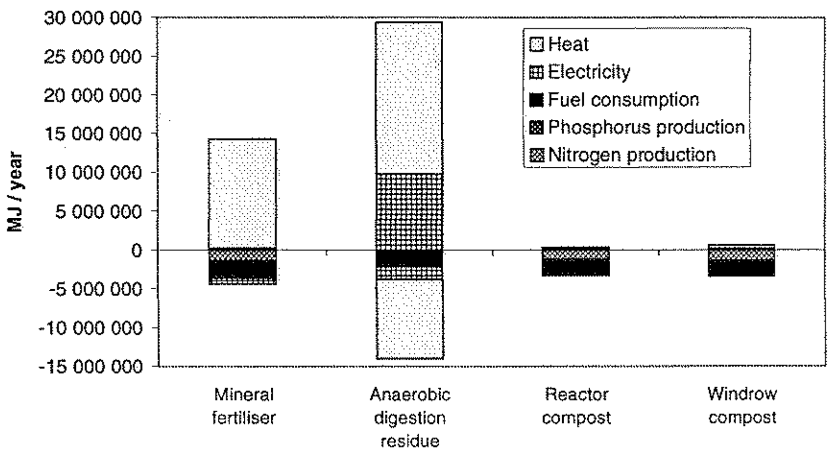

Figure 19. Energy conversion for the scenarios in the small town region.

The energy production in the anaerobic digestion scenario is approximately five times bigger than in the incineration scenario, the composting scenarios produce non-usable energy. The energy consumption is also approximately five times the mineral fertiliser scenario and seven times the composting scenarios (mainly heat for heating the large volume of manure before digestion, but also some electricity for pumping).

The fuel consumption for spreading of residues together with the transport, either by truck or tractor, accounts for about 60 % of the total energy consumption. The fuel consumption in the anaerobic digestion scenario increases due to transports of the increased volumes, but not near the increase in energy production. The fuel consumption for spreading the digestion residue is slightly larger than spreading the manure slurry.

Global warming

The largest potential contribution to global warming is from the mineral fertiliser scenario and the windrow compost scenario; the reactor compost scenario is somewhat lower and the anaerobic digestion scenario is clearly lowest (Figure 20). In all scenarios the major contribution is from waste treatment, and for all scenarios except the anaerobic digestion scenario the production of electricity and nitrogen mineral fertiliser is almost in the same range as the treatment. The long-term emissions from the landfill do not affect the results significantly.

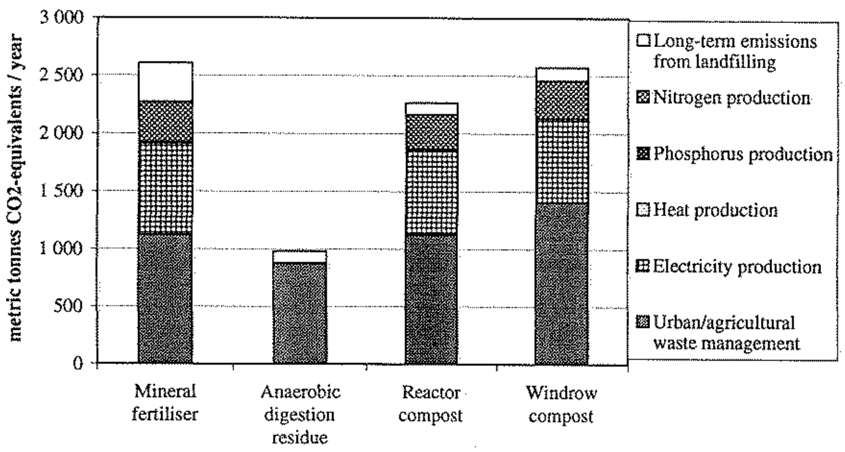

Figure 20. Contribution to global warming potential from the scenarios in the small town region.

Waste management

In all scenarios the major source of greenhouse gases is emissions of N_2O from farmland. Since the windrow compost scenario has the largest amount of organically bound nitrogen, the largest nitrogen losses from farmland, the N_2O emissions, are largest from that scenario. Other sources are CO_2 from transports and CH_4 from the landfilling of sewage sludge, and for the mineral fertiliser scenario and windrow compost scenario also grease water.

In the mineral fertiliser scenario, the emission of greenhouse gases from farmland is 54 % of the total, the landfill emits 30 % and transports and spreading 14 %. The remaining 2 % is from incineration.

The anaerobic digestion scenario has approximately the same proportions (farmland 55 %, landfill 25 % and transports and spreading 17 %) but the level of emissions is lower, since the amount of organically bound nitrogen that is spread on farmland is lower than in all the other scenarios.

The proportions of emissions in the reactor compost scenario is also rather similar to the mineral fertiliser scenario; farmland 60 % of the total, the landfill accounts for 23 %, transports and spreading 13 %, and the remaining 4 % is from the compost (mainly CH_4 that is not oxidised in the biofilter).

The windrow compost scenario has the largest emissions of greenhouse gases from the waste management. The windrow compost has no exhaust gas cleaning, and thus emits all the CH_4 and N_2O produced in the composting process. These emissions represent 15 % of the total emissions of greenhouse gases. The fact that all grease water is landfilled also increases the emissions from the landfill, the proportion, however, is in the same range as in the other scenarios (27 %). Soil emits 48 % and transports and spreading 10 %.

Production of nitrogen, phosphorus, heat and electricity

In the mineral fertiliser scenario and the two composting scenarios, production of both electricity and mineral nitrogen fertiliser contributes significantly to the global warming potential, the reactor compost scenario has the smallest contribution from nitrogen production and mineral fertiliser scenario the smallest contribution from electricity, but the differences are small compared with the overall level of global warming potential.

The emissions from nitrogen production contributing to global warming potential are N_2O (85 %) and CO_2 (15 %). Production of electricity in an oil condensation plant results in CO_2 emissions.

Eutrophication

The eutrophication effect largely consists of long-term effects from landfilling half of the sewage sludge, and in the mineral fertiliser scenario also the ashes from the incineration (Figure 21). We have assumed that all phosphorus that is landfilled will leach out even if there is leachate water treatment at the landfill. This is explained by the fact that a leachate treatment only returns the caught sludge to the landfill; the phosphorus in that sludge will sooner or later leach out again. Since the leachate treatment will never be able to catch all phosphorus, ultimately all phosphorus put into the landfill will reach the recipient. Cleaning the leachate is simply postponing the emissions of phosphorus.

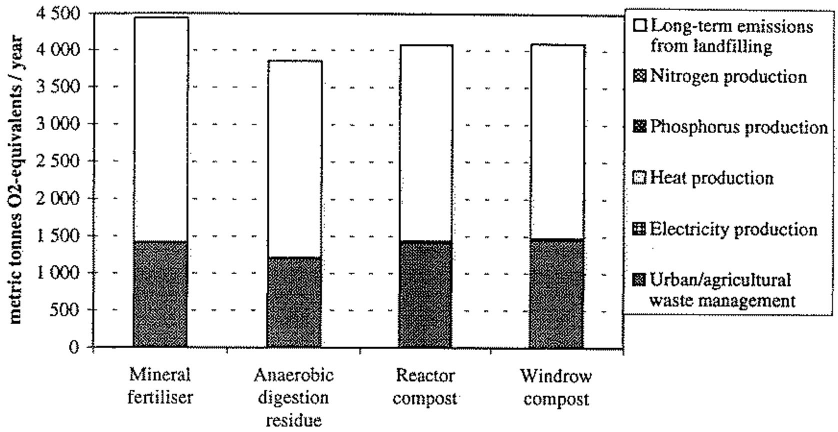

Figure 21. Potential contribution to eutrophication from the scenarios in the small town region.

Waste management

Within the surveyable time, the anaerobic digestion scenario has the lowest emissions from the waste treatment. The contribution from the waste management system in the other scenarios are mainly NO_3^- from soil (56-64 %) and NH_3 from spreading sewage sludge and manure (23-24 %), the remaining emissions are short-term leachate from the landfill (7-9 %), untreated gases from the windrow compost (6 %), phosphorus due to the wet fluegas cleaning in the incineration (8 %) and finally transports (1-3 %).

In the anaerobic digestion scenario, the NH_3 emissions are 36 % of the total and emissions of NO_3^- stand for 34 %. This is due to the fact that more of the nitrogen, both in solid waste and manure, is in mineralised form, thus causing lower losses of nitrogen. The remaining emissions are NH_3 from slurry storage and also from the same sources as in the other scenarios.

Production of nitrogen, phosphorus, heat and electricity

No emissions from production of nitrogen, phosphorus, heat or electricity have a significant impact on the overall result for any scenario.

Acidification

The main sources of emissions of acidifying substances are the waste treatment; the anaerobic digestion scenario has the highest total emissions and the mineral fertiliser scenario the lowest, 45 % of the anaerobic digestion scenario (Figure 22). Also the two composting scenarios have low emissions, 47 % for the reactor- and 57 % for the windrow compost scenario of the anaerobic digestion scenario.

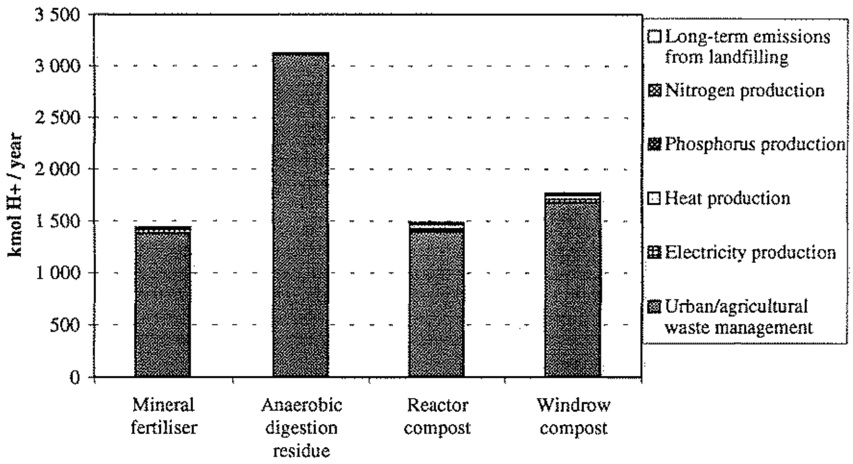

Figure 22. Potential contribution to acidification from the scenarios in the small town region.

Waste management

The absolutely dominating source is NH_3 from spreading of residues. For the mineral fertiliser scenario and the reactor compost scenario this source accounts for 89 %, the remaining emissions come from transports. Also in the windrow compost scenario, the emissions of NH_3 from spreading of residues is the largest contribution (74 %) but the composting process accounts for 19 %, due to emissions of NH_3 in the exhaust gases.

The emissions from spreading depend on the amount of mineralised nitrogen found in the residues that are spread. Since the slurry from anaerobic digestion has the largest proportion of mineralised nitrogen, the absolute emissions will be largest for that scenario. The part of acidifying substances that originates from spreading is lower, however (61 %), since the combustion of biogas also results in emissions (35 %) of NO_x and SO_2 in the anaerobic digestion scenario.

Production of nitrogen, phosphorus, heat and electricity

None of these sources has any major effect on the overall outcome of any scenario. The production of nitrogen causes some acidification in the mineral fertiliser scenario and two composting scenarios. The production of heat causes some acidification in all scenarios except the mineral fertiliser scenario.

Human health

The weighting factors for this category are uncertain. Also in the small city region the contribution of emissions to human toxicity is primarily from gaseous substances. These emissions are primarily from waste management and a small part from heat production (Figure 23).

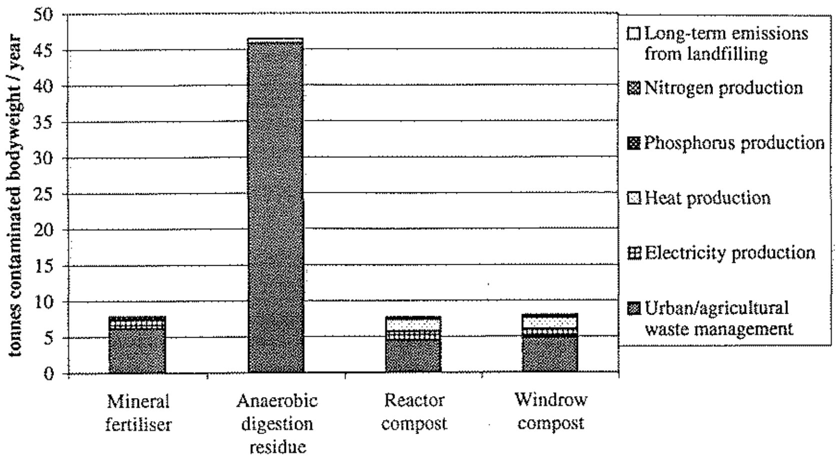

Figure 23. Potential contribution to human health from emissions to air in the scenarios in the small town region.

In the mineral fertiliser scenario the emissions contributing to human health toxicity are NOx from transportation (40 %) and spreading (25 %), and also NOx from incineration (20 %). The dominating emissions from anaerobic digestion residue scenario are NOx and SO2 from the digestion process (90 %). In the composting scenarios, it is emission of NOx from transportation (45-50 %) and spreading (30-35 %).

Ecotoxicity

The weighting factors for this category are very uncertain. For the effect category we have called ecotoxicity from water emissions, the relation between the scenarios is dominated by long-term emissions in the small town region as in the large city region. The heavy metals, especially Pb, Zn and Cu are the major sources.

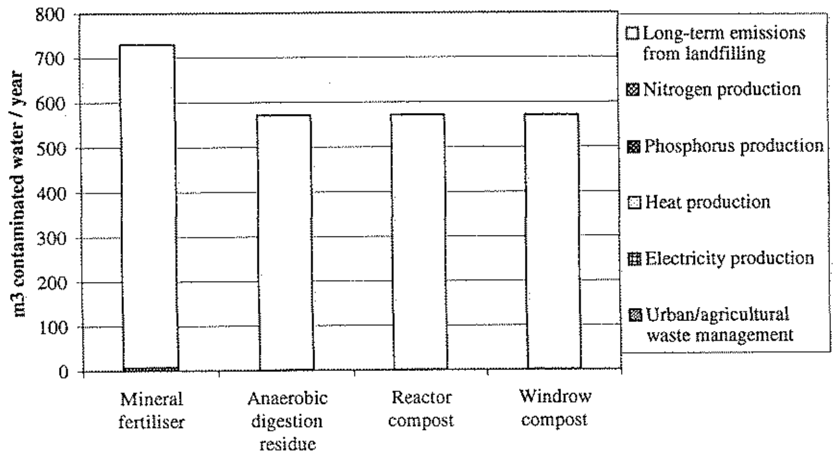

Figure 24. Potential impact on ecotoxicity from emissions to water in the scenarios in the small town region.

For ecotoxicity from soil, the dominating source is the urban/agricultural waste management. There are only small differences between the scenarios. This is because the dominating sources are sludge (20 %) and manure (80 %) and these residues are spread on farmland in all scenarios. The major impact is caused by Zn.

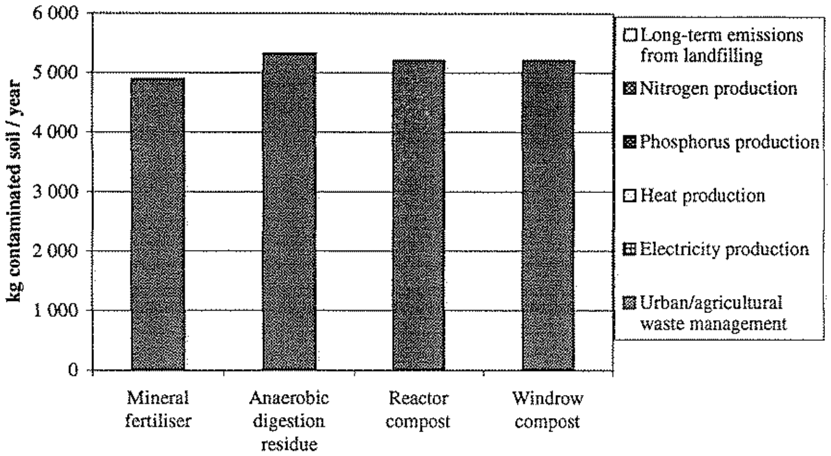

Figure 25. Potential impact on ecotoxicity from emissions to soil in the scenarios in the small town region.

Utilisation of organic carbon as a source of humus

The total amount of organic carbon put on farmland is highest in the reactor compost scenario. The mineral fertiliser scenario utilises a little less. This is due to the incineration of urban waste, which produces no organic carbon, as done by the composting process. The windrow compost scenario is third, since straw is brought into the process and to some extent degraded before it is spread on farmland. The anaerobic digestion scenario has the lowest total amount of carbon to farmland. This is explained by the digestion of manure, a large part of the carbon in manure is degraded to CH_4 and CO_2 in that scenario compared with the other scenarios, where the manure is spread directly on the field.

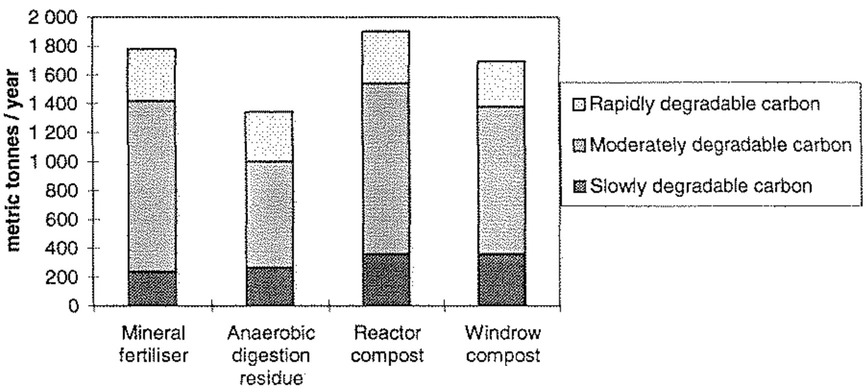

Figure 26. Carbon of different stability spread on arable land with the organic residues in the small town region.

The amount of slowly degradable carbon, important for humus formation in soil, is more equal between the scenarios. The mineral fertiliser scenario is lowest, the two composting scenarios are highest and the anaerobic digestion scenario in between.

The spreading of the moderately degradable fraction is highest for the mineral fertiliser scenario and the reactor compost scenario, due to the high content of semi-degradable carbon in straw and manure. The windrow compost scenario is slightly lower since the straw is composted and a part of this carbon fraction is degraded or transformed to humus. The anaerobic digestion scenario is lowest due to the degradation of manure carbon in the process.

The rapidly degradable carbon is relatively constant when comparing the scenarios, since a large part of this fraction is found in the sewage sludge which is spread on farmland in all scenarios. However, the anaerobic digestion scenario shows the lowest figure here since the manure also consists of some rapidly degradable carbon which is degraded in the process.

Economy

The largest cost is for the anaerobic digestion scenario and this is mainly due to the treatment of manure. The increased cost is larger than the increase in revenue from heat and electricity. Another large part of the cost is the transport of residues, which is also explained by the manure, in all scenarios the manure has to be transported, either to the anaerobic digestion plant or directly to farmland. Another cost is landfilling, mainly of sewage sludge but in the mineral fertiliser scenario also ashes and grease water, and in the windrow compost scenario grease water. The cost for treating waste in the mineral fertiliser scenario and the two composting scenarios is less than 25 %. The cost for mineral fertiliser is relatively small (3-5 % of total).

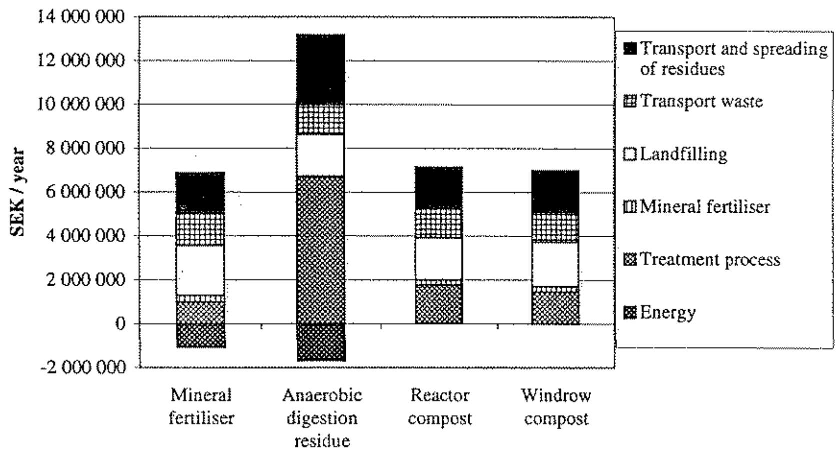

Figure 27. Total costs for the scenarios in the small town region.

Regarding the transport costs, the cost for collecting the waste is smaller than residue transports (incl. spreading). The collection of waste from rural areas has a cost that is bigger per tonnes of waste than from detached houses in towns and even more expensive than collecting from flats. In the mineral fertiliser scenario the incineration plant is situated 50 km from the city, but this extra transport has little effect on the total cost for transporting waste. The transport of residues is proportional to the amount of wet weight transported.

Flows of metal and nutrients in the large city and small town

As a complement to the impact categories, also the content of metals and nutrients in waste and residues are presented.

Metal flows

In the two areas, Uppsala and Ystad, the metals originate from the different sources as presented in Table 8 and Table 9.

Table 8. Heavy metals in organic waste in Uppsala, total inflow and % contribution from different fractions [1]

Element	Total inflow [kg/year]	sewage sludge [% of total]	household waste [% of total]	restaurants & trade [% of total]	grease [% of total]	manure [% of total]
Cd	8	76	17	0.2	0.0	7
Ni	112	70	12	0.0	0.0	18
Zn	4322	74	14	0.2	0.0	13
Cr	199	84	11	2	0.0	2
Pb	296	82	15	0.0	0.0	3
Hg	8	93	5	0.0	0.0	1
Cu	1709	81	5	0.0	0.0	14

[1] Straw is assumed to be free from heavy metals.

Table 9. Heavy metals in organic waste in Ystad, total inflow and % contribution from different fractions [1]

Element	Total inflow [kg/year]	sewage sludge [% of total]	household waste [% of total]	rest & trade [% of total]	grease [% of total]	manure [% of total]
Cd	2	60	12	0.0	0.0	27
Ni	35	34	7	0.0	0.0	59
Zn	3786	14	3	0.0	0.0	83
Cr	71	54	6	2	0.0	39
Pb	92	43	9	0.0	0.0	48
Hg	2	69	4	0.0	0.0	27
Cu	1491	19	1	0.0	0.0	80

[1] Straw is assumed to be free from heavy metals.

Sewage sludge contains the largest amount of metals from the included organic waste fractions in Uppsala. Household waste and manure also contain considerable amounts of heavy metals.

The larger amounts of manure produced in Ystad in relation to the size of the city, result in a different partitioning among heavy metal sources. Sewage sludge still dominates as sources of Cd, Hg and Cr, whereas the other heavy metals originate mainly from manure. Household waste is a minor contributor to heavy metals in Ystad's organic waste fractions.

Metals contaminating the organic waste fractions will be distributed differently in residues in the scenarios. There are two restrictions for using sludge products on farmland in Sweden. First the heavy metal in sludge has to be below certain limits measured as mg/kg dry matter (SFS 1993:1271). All residue products in this project are below these limits. The second restriction is defined as heavy metal limits spread per hectare (ha) and year (SNFS 1994:2). The normal dosage of residue is a quantity corresponding to 20 kg phosphorus per ha. However, If the metal content is high related to the phosphorus content, the dose of residue has to be reduced due to the restrictions of heavy metals spread per ha. Table 10 presents the metal dosage per hectare in relation to the present (1995) and the forthcoming (2000) limits in the various organic products in the large city region. The results for the residues in the small town region is almost similar.

Table 10. Metal content per ha with a dosage of 20 kg P/ha for organic fertiliser products in the large city region, in comparison with permitted levels by year 1995 and 2000, proposed by the Swedish EPA, figures over 100 imply exceeding the limits

Metal	limits by 1995	limits by 2000	sewage sludge	anaerobic dig. residue	reactor compost	windrow compost	manure
	[g/ha]	[g/ha]	[% of maximum by 1995 (2000)]				
Pb	100	25	53 (213)	39 (157)	73 (292)	67 (267)	12 (47)
Cd	1.75	0.75	91 (183)	94 (188)	148 (295)	135 (270)	51 (102)
Hg	2.5	1.5	69 (114)	16 (27)	29 (49)	27 (45)	6 (9)
Cu	600	300	51 (101)	40 (79)	25 (49)	22 (45)	52 (104)
Cr	100	40	37 (92)	20 (49)	36 (91)	33 (84)	6 (15)
Ni	50	25	34 (69)	49 (99)	44 (88)	40 (81)	54 (108)
Zn	800	600	87 (116)	103 (138)	120 (160)	110 (146)	90 (120)

With the organic fertilisers sewage sludge, anaerobic digestion residue and manure it is possible with a dosage of 20 kg phosphorus per ha without exceeding the heavy metal limits. For the reactor and windrow compost residues it is necessary to reduce the phosphorus dosage due to the high content of Cd and Zn. However, with the forthcoming restrictions (by the year 2000) heavy metal contents has to be reduced for all the organic fertiliser products, if a full 20 kg dosage of phosphorus per ha should be possible.

Nutrient flows

In the two areas, Uppsala and Ystad, the conditions for recycling nutrients in organic waste are very different, because of significant differences in the types of organic waste produced in the area. In Table 11 and Table 12, the nutrient inflow to the system is listed for the various waste fractions.

Table 11. Nutrient inflow to Uppsala, total inflow (kg/year) and % contribution from different fractions of organic waste.

Element	Total inflow [kg/year]	sewage sludge [% of total]	household waste [% of total]	rest & trade [% of total]	grease [% of total]	manure [% of total]	straw [% of total]
P	179 770	76	10	1	0.0	13	1
N	372 060	41	25	4	0.0	27	3

In Uppsala, sewage sludge is the dominating source of nutrients in organic waste.

Table 12. Nutrient inflow to Ystad, total inflow (kg/year) and % contribution from different fractions of organic waste.

Element	Total inflow [kg/year]	sewage sludge [% of total]	household waste [% of total]	rest & trade [% of total]	grease [% of total]	manure [% of total]	straw [% of total]
P	164 980	23	2	0.2	0.0	74	0.2
N	571 720	7	3	0.4	0.0	89	0.4

Manure is produced in larger amounts in Ystad, and consequently manure is the dominating source of nutrients in organic waste.

Despite the larger number of inhabitants in Uppsala than in Ystad, the total inflow of nutrients in organic waste to the system is about the same in both areas. This is, of course, due to the larger agricultural activity in Ystad. The smaller amounts of primarily sewage sludge, but also of household waste in Ystad, are compensated by manure.

If we compare nutrient flows and heavy metal flows, we find that the best nutrient sources in each area, are also the largest sources of heavy metals; both sewage sludge and manure are nutritious but contaminated.

Major differences in results from Ystad compared with the results from Uppsala

Materials

The total amount of material included in the large city area (Uppsala) is 63 000 metric tonnes per year and in the small town region (Ystad) 67 000 metric tonnes per year. However, the main difference is the proportion of manure, that is much larger in the small town region than in the large city region, 92 % and 53 %, respectively. The amount of nitrogen is approximately 30 % higher and the amount of phosphorus is slightly lower.

Economy

In the large city region, the reactor and windrow compost scenarios have the highest net costs. The mineral fertiliser and anaerobic digestion scenario have almost the same costs but due to income from energy net costs are lower. In the small town region the anaerobic digestion residue scenario has the largest costs. The income from energy has not increased in the same proportion as the costs when treating a larger amount of manure. Therefore, the anaerobic digestion residue scenario has the highest net cost in the small town region, followed by the reactor and windrow compost scenarios, and finally the mineral fertiliser scenario.

Energy

In the small town region, the anaerobic digestion residue scenario has the largest energy turnover followed by the mineral fertiliser scenario. In the large city region they are in the opposite order. However, the total energy turnover quantity in the anaerobic digestion scenario in Uppsala is approximately twice as large as the one in Ystad, since the dry matter and energy contents in the municipal organic waste are higher than in the manure. The composting scenarios use proportionally the same energy in Ystad as in Uppsala.

Global warming

When comparing the scenarios for global warming, the overall outcome is essentially the same in the large city and the small town region. The difference is that soil emissions (N_2O) account for a larger part. Since manure is the dominating waste, the emissions from landfilling, both sewage sludge and other waste, are of less importance.

The importance of mineral nitrogen fertiliser and electricity has the same relative impact in Ystad as in Uppsala.

Eutrophication

The small town region has a lower total eutrophication. However, the relation between the scenarios is almost the same in the two regions. The long-term emissions (leachate) from the landfill do not have as large impact in Ystad as in Uppsala. The soil emissions, especially NO_3^-, have greater importance since the total amount of nitrogen in Ystad is approximately 30 % larger than in Uppsala.

Acidification

For the mineral fertiliser, anaerobic digestion and reactor compost scenarios, the level of acidification is approximately the same in Ystad as in Uppsala, even though the amount of urban waste treated decreases radically. This is because there is more nitrogen spread on farmland (more manure) which causes large emissions of both NH_3 during spreading and, for the anaerobic digestion scenario, also more SO_2 and NO_x. For the windrow compost scenario the level of acidification is approximately half as large in Ystad as that in Uppsala. This is explained by the fact that in the windrow compost scenario a large part of the acidifying emissions originate from the composting process, and that process treats much smaller amounts in Ystad than in Uppsala.

Human health

The results on the impact on human health in the small town region are almost the same as in the large city region. The emissions from the mineral fertiliser scenario are somewhat lower.

Ecotoxicity

For the effect category we have called ecotoxicity from water emissions, the relation between the scenarios are the same in the small town region as in the large city region. However, the level of contribution is about 20 % since the urban waste fractions are smaller. The heavy metals are the major sources for this category.

Also for ecotoxicity from soil, the relation between the scenarios is the same in the small town region as in the large city region. The levels are half the level in the large city region. The major source is Zn from manure.

Utilisation of organic carbon as a source of humus

In Ystad there are not such large differences regarding the important part of the organic carbon (slowly degradable), between the scenarios as in Uppsala. This is because such a large part of the slowly degradable carbon originates from manure, which is treated equally in all scenarios except the anaerobic digestion scenario. In Uppsala, the solid waste has a greater impact, which separates the scenarios since the solid organic waste is treated differently.

Conclusions and discussion

General conclusions for both the large city region and the small town region are:

- None of the scenarios are best in all of the studied environmental impact categories. The anaerobic digestion residue scenario has the lowest emissions of global warming, while the mineral fertiliser scenario and reactor composting scenario have the lowest for acidification.
- The largest contribution to the global warming effect in this study comes from electricity production (CO_2), landfilling (CH_4) and soil (N_2O).
- The eutrophication effect is dominated by long-term emissions of phosphorus from landfilling. The largest immediate emissions are NO_3^- and NH_3 from soil.
- An important source for acidification is NH_3 from soil. In the windrow composting scenario, also NH_3 from the composting process, and in the anaerobic digestion residue scenario, NO_x and SO_2 from burning the gas.

- The source for the main part of nutrients and heavy metals is the sewage sludge. The household waste also has a fairly large content of heavy metals.
- The weighting factors for the environmental categories human health and ecotoxicity are uncertain.

In the large city region the total costs are lowest for the mineral fertiliser scenario and the anaerobic digestion scenario. However, this implies a market for the energy all year around and in the mineral fertiliser scenario, and also that a large incineration plant is built, receiving waste from other surrounding city areas.
In the small town region, the anaerobic digestion residue has the largest costs. This depends on the low energy content in the manure. With a larger degree of municipal waste from industries or neighbouring towns as substrate, the costs would decrease. The mineral fertiliser scenario presumes a large incineration plant 50 kilometers away.

Organic fertilisers result in increased environmental impact from soil. The soil contributes to the global warming potential with N_2O, to the eutrophication with NO_3^- and NH_3, to acidification with NH_3. The emissions of N_2O are related to the total quantity, the NO3 to the content of organic-bound nitrogen and the NH_3 to mineralised nitrogen (NH_4) in the organic fertilisers. Only the extra emissions from organic fertilisers in comparison with mineral fertilisers are included in the calculations. As an example from the large city region, one kilogram of total nitrogen in the compost results in emissions of 0.30 kg NO_3^- 0.29 kg N_2 and 0.0075 kg N_2O, and one kilogram of total nitrogen in the anaerobic digestion residue results in emissions of 0.07 kg NH_3, 0.19 kg NO_3^-, 0.21 kg N_2 and 0.006 kg N_2O.

The incineration process results in environmental impact due to the landfilling of ashes, emission of, e.g. NO_x and N_2O. However, the incineration process includes purification equipment reducing the NOx emissions.

The environmental impact from the anaerobic digestion process is primarily emissions of NO_x and SO_2 from the combustion of gas in a stationary engine. The emission of NO_x would be lower if using a catalyst, or if only heat were produced. The gas from anaerobic digestion could also be used as vehicle fuel substituting diesel or petrol. Instead of larger NO_x emissions than the other scenarios this would result in lower emissions, since NO_x emissions from gas are around 1/3 compared with diesel fuel. The overall effect from gas used as vehicle would probably result in large positive effects for the anaerobic digestion residue scenario in the majority of impact categories, even though refining the gas involves electricity consumption and minor methane emissions.

The most serious emissions from the composting processes are CH_4, NH_3 and N_2O. The emissions of these substances depend on the aeration, temperature, C/N ratio and pH, and could be either increased or decreased by other amendments, waste fractions and operation of the process. In the reactor composting process, the air emission substances are reduced through purification of the exhausted gas.

The aim of this study was to compare organic fertilisers with mineral fertiliser. However, the production of mineral fertiliser has only a minor influence on the results. The major impact is from the waste management systems. The waste sources and processes chosen therefore have major impact on the results.

To produce attractive organic fertilisers it is important to reduce the content of heavy metals in the waste. The largest heavy metal content is found in sewage sludge and household waste. Therefore, further development of source separation systems and information to the households to reduce the levels is necessary.

An important advantage with organic fertilisers is their content of organic carbon as a source for humus. However, a lack of knowledge regarding different carbon qualities and sources for building up humus has been identified, which makes it impossible to compare the scenarios in this respect.

Further studies

The aim of the present pilot study was to compare organic fertilisers with mineral fertiliser in two regions. With these results as base, a couple of interesting questions can be posed for further studies.

More detailed description of the soil emissions

The soil emissions have a large impact on the overall environmental impact. However, the calculation model for soil emissions is generalised. Improved management of the organic fertiliser products might change the results. The emissions from soil differ with type of soil. Simulation of the results for soil with, primarily, sand or clay would also give other results.

A more detailed simulation of fertiliser dosage and number of spreading occasions would also influence the simulation results.

Location and equipment of the processing plants

The equipment of the treatment plants is of major importance when evaluating environmental impact. Other sorts of processing plants than the one used in this study might lead to different results being obtained. Also using, e.g. the biogas for vehicle fuel instead of producing electricity and heat, would influence the results.

The anaerobic digestion and composting plants could be located outside the city and then have closer transport distance for residue transport. Different sizes of plants would also primarily influence the costs for waste management. The quantity of manure included in the system could also be optimised from an economic or environmental point of view. Some of the manure could also be replaced by ley crops, resulting in higher gas production and nitrogen content.

Evaluation of humus as a replacement for peat or production of crop biomass

The carbon in organic fertiliser as a source of humus was calculated. However, the differences in carbon to soil are not included in the evaluation of environmental impact. This could be done by including emissions from addition of carbon with peat or growing of a ley crop with the purpose of increasing the humus content in the soil.

References

Dalemo M., 1996. Modelling of an Anaerobic Digestion Plant and a Sewage Plant in the ORWARE Simulation Model, Report 213, Department of Agricultural Engineering, SLU, Uppsala, Sweden.

Dalemo M., Sonesson U., Björklund A., Mingarini K., Frostell B., Jönsson H., Nybrant T., Sundqvist J-O. & Thyselius L., (1997) ORWARE - A simulation model for Organic Waste Handling Systems, Part 1: Model Description, *Resources, Conservation and Recycling vol. 21 pp. 17-37.*

Energistyrelsen, 1995. Biogasfaellesanlaeg - fra idé til realitet. Copenhagen.

Mingarini K., 1996. Systems Analysis of Organic Waste - with Emphasis on Modelling of the Incineration and the Landfilling Processes. Licentiate Thesis. Department of Environmental Engineering and Work Science, The Royal Institute of Technology. Stockholm. Sweden.

Nordic Guidelines on Life-Cycle Assessment, 1995. Nord 1995:20. Nordic Council of Ministers, Copenhagen.

OECD, 1996. IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. http://www.iea.org/ipcc/guideline/

Sonesson U., 1996. Modelling of the Compost and Transport Processes in the ORWARE Simulation Model. Department of Agricultural Engineering, Swedish University of Agricultural Sciences. Report 214. Uppsala. Sweden.

SFS 1993:1271. Svensk författningssamling om avloppsslam för jordbruksändamål.

SMP, 1983. Statens Maskinprovningar meddelande nr. 2849 (In Swedish).

SNFS 1994:2. Naturvårdsverkets författningssamling om användning av avloppsslam i jordbruket.

Bilaga 1

ENVIROMNENTAL WEIGHTING FACTORS

Global Warming potential	
CO2-f	1
CH4	24.5
N2O	320

Eutrophication	
NOx	6
NH3	16
NH4	15
NO3	4.4
P	140
COD	1

Acidification	
SO2	0.031
HCl	0.027
NOx	0.022
NH3	0.059

Ecotoxicity emissions to water	
Phenols	5.9
CHX	5.9
PAH	40
PCB	160
Dioxin	0
Pb	2
Cd	200
Hg	0.33
Cu	2
Cr	1
Ni	0.33
Zn	0.38

Ecotoxicity emissions to soil	
CHX	5.3
PAH	5.9
Phenols	5.3
PCB	40
Dioxin	1400
Pb	0.43
Cd	13
Hg	29
Cu	0.77
Cr	0.42
Ni	1.7
Zn	2.6

Human health, emissions to air	
NOx	0.78
NH4	0.02
SO2	1.2
CO	0.012
PAH (benzo pyrene)	17
Dioxin (2,3,7,8-TCDD)	3300000
Pb	160
Cd	580
Hg	120
Cu	0.24
Cr	6.7
Ni	470
Zn	0.033

Human health, emissions to water	
NH4	0.0017
NO3	0.00078
P-tot	0.000041
CHX	0.1
PAH	1.4
PCB	32
Dioxin	290000
Pb	0.79
Cd	2.9
Hg	47
Cu	0.02
Cr	0.57
Ni	0.057
Zn	0.0029
Phenols	0.048

Human health, emissions to soil	
CHX	3.3
PAH	0.013
Phenols	0.62
PCB	13
Pb	0.025
Cd	7
Hg	0.15
Cu	0.0052
Cr	0.018
Ni	0.014
Zn	0.007

ECONOMIC FACTORS

Electricity	0.12 SEK/MJ
Heat	0.078 SEK/MJ
Diesel	0.11 SEK/MJ
N	7.7 SEK/MJ
P	10.5 SEK/MJ

Bilaga 2

Emission data from the large city region

Data from the ORWARE simulation model are presented on the following pages. The first page presents data for the waste fractions. These are data used in the calculations. The other pages present results from the calculations. These are data before grouping and weighting in environmental impact categories.

In the tables, emissions of NH_4^+ to water and soil are presented in the row for NH_3.

Waste composition

(kg/year)	Sludge 16 250 000	Households:flats 6 175 000	small houses 4 550 000	rural areas 2 288 000	Trade 500 000	Restaurants 2 200 000	Grease water 3 000 000	Cow manure 21 600 000	Pig manure 3 200 000	Straw 3 000 000
Ctot-b	1 109 940	937 982	691 145	347 547	65 400	248 600	76 680	559 440	106 560	1 275 000
Cch-stable	38 200	62 676	46 183	23 223	1 800	14 300	0	78 624	14 976	204 000
Cch-biodegr	187 902	209 641	154 473	77 678	32 250	45 650	4 644	0	0	204 000
C-fat	444 600	291 769	214 988	108 108	4 650	100 100	71 928	7 560	1 440	0
C-prot	255 938	142 643	105 105	52 853	7 200	37 400	0	69 552	13 248	0
BOD	0	0	0	0	0	0	75 600	0	0	0
VS	1 950 000	1 729 000	1 274 000	640 640	145 500	440 000	101 520	1 179 360	224 640	2 371 500
TS	3 900 000	2 161 250	1 592 500	800 800	150 000	550 000	108 000	1 512 000	288 000	2 550 000
CO2-f	0	0	0	0	0	0	0	0	0	0
CO2-b	0	0	0	0	0	0	0	0	0	0
CH4	0	0	0	0	0	0	0	0	0	0
VOC	0	5	4	2	0	1	0	0	0	0
CHX	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0	0	0	0
PAH	9	1	1	0	0	1	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0
phenols	296	59	44	22	4	15	0	0	0	0
PCB	1	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0
O-tot	0	620 279	457 047	229 830	62 100	144 650	16 524	544 320	103 680	1 083 750
H-tot	0	125 353	92 365	46 446	8 250	17 050	12 528	55 944	10 656	1 020 000
H2O	12 350 000	4 013 750	2 957 500	1 487 200	350 000	1 650 000	2 892 000	20 088 000	2 912 000	450 000
N-tot	152 100	43 225	31 850	16 016	2 250	12 100	108	84 672	16 992	12 750
NH3-N	23 400	0	0	0	0	0	0	42 336	9 504	0
NOx-N	0	0	0	0	0	0	0	0	0	0
NO3-N	0	0	0	0	0	0	0	0	0	0
N2O-N	0	0	0	0	0	0	0	0	0	0
S-tot	0	5 187	3 822	1 922	225	1 100	108	9 223	2 304	25 500
SOx-S	0	0	0	0	0	0	0	0	0	0
P-tot	136 500	8 213	6 052	3 043	765	605	54	18 144	4 608	1 785
Cl-tot	0	8 429	6 211	3 123	585	2 145	1 080	5 897	1 123	12 750
K	4 290	20 100	14 810	7 447	1 785	6 545	22	80 136	10 656	17 850
Ca	117 000	60 515	44 590	22 422	4 410	15 400	22	30 240	5 760	7 650
Pb	242	22	16	8	0	0	0	8	1	0
Cd	6	1	0	0	0	0	0	0	0	0
Hg	8	0	0	0	0	0	0	0	0	0
Cu	1 381	43	32	16	0	1	0	195	41	0
Cr	168	11	8	4	0	0	0	3	1	0
Ni	78	6	5	2	0	0	0	12	8	0
Zn	3 179	281	207	104	1	6	0	416	129	0
Cch-medium	183 300	231 254	170 398	85 686	19 500	51 150	0	405 216	77 184	867 000
Particles	0	0	0	0	0	0	0	0	0	0
COD	0	0	0	0	0	0	0	0	0	0

Air Emissions from scenario: Mineral fertiliser

(kg/year)	Waste transport	Manure transport	Residue transport	Spreading of residues	Incineration	Anaerobic digestion	Reactor compost	Windrow compost	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil
Ctot-b	78 604	5 623	1 583	12 873	2 211 912	0	0	0	82 091	533 964	63 750	21 631	0
Cch-stable	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-biodegr	0	0	0	0	0	0	0	0	0	0	0	0	0
C-fat	0	0	0	0	0	0	0	0	0	0	0	0	0
C-prot	0	0	0	0	0	0	0	0	0	0	0	0	0
BOD	0	0	0	0	0	0	0	0	0	0	0	0	0
VS	0	0	0	0	0	0	0	0	0	0	0	0	0
TS	0	0	0	0	319	0	0	0	0	0	0	0	0
CO2-f	287 143	20 746	5 772	47 495	0	0	0	0	23 084	22 783	0	0	0
CO2-b	0	0	0	0	2 221 954	0	0	0	231 309	2 815 027	145 583	43 480	0
CH4	4	1	0	2	0	0	0	0	32 666	18 597	53 301	13 360	0
VOC	147	36	5	81	0	0	0	0	33 071	18 843	53 301	13 360	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	7	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0	0	0	0
CO	521	99	0	226	8 017	0	0	0	110	108	0	0	0
phenols	0	0	0	0	0	0	0	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	0	0	0	0	4 137 350	0	0	0	33 290	36 910	300 000	200 000	0
N-tot	1 681	268	41	615	1 283	0	0	0	302	979	21	76	52 669
NH3-N	0	0	0	0	63	0	0	0	0	342	10	38	9 531
NOx-N	1 669	268	41	615	964	0	0	0	434	372	0	0	0
NO3-N	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O-N	10	10	0	23	256	0	0	0	47	32	0	0	1 158
S-tot	98	6	7	13	969	0	0	0	78	6	0	0	0
SOx-S	98	6	7	13	962	0	0	0	9	6	0	0	0
P-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl-tot	0	0	0	0	489	0	0	0	0	0	0	0	0
K	0	0	0	0	1 554	0	0	0	0	0	0	0	0
Ca	0	0	0	0	7 988	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-medium	0	0	0	0	0	0	0	0	0	0	0	0	0
Particles	36	0	1	0	16	0	0	0	0	0	0	0	0
COD	0	0	0	0	0	0	0	0	0	0	0	0	0

Water Emissions from scenario: Mineral fertiliser							To soil from scenario: Mineral fertiliser						
(kg/year)	Incineration	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil	Sludge	Anaerob dig. residue	Compost from reactor	Compost from windrow	Manure	Straw	Phosphorus
Ctot-b	0	794	5 331	15 912	218	0	554 970	0	0	0	666 000	1 275 000	0
Cch-stable	0	0	0	0	0	0	19 100	0	0	0	93 600	204 000	0
Cch-biodegr	0	0	0	0	0	0	93 951	0	0	0	0	204 000	0
C-fat	0	0	0	0	0	0	222 300	0	0	0	9 000	0	0
C-prot	0	0	0	0	0	0	127 969	0	0	0	82 800	0	0
BOD	0	649	3 998	24	7	0	0	0	0	0	0	0	0
VS	0	0	0	1 015	0	0	975 000	0	0	0	1 404 000	2 371 500	0
TS	0	0	0	1 080	0	0	1 950 000	0	0	0	1 800 000	2 550 000	0
CO2-f	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2-b	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	0	0	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0	0	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	1	0	0	0	0	0	0	0	0	0
PAH	0	0	0	2	0	0	4	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0	0	0
phenols	0	0	0	0	0	0	148	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	165	0	0	0	0	0	0	648 000	1 083 750	0
H-tot	0	0	0	125	0	0	0	0	0	0	66 600	1 020 000	0
H2O	4 597 055	34 558 239	16 250 000	2 700 000	1 800 000	0	6 175 000	0	0	0	23 000 000	450 000	0
N-tot	41	12	6 776	2 075	7 529	39 961	28 665	0	0	0	56 419	12 750	0
NH3-N	41	10	6 776	1 038	3 764	0	9 360	0	0	0	41 472	0	0
NOx-N	0	0	0	0	0	0	0	0	0	0	0	0	0
NO3-N	0	19	0	1 048	3 803	39 961	0	0	0	0	0	0	0
N2O-N	0	0	0	0	0	0	0	0	0	0	0	0	0
S-tot	194	174	0	3 288	0	0	0	0	0	0	11 527	25 500	0
SOx-S	0	0	0	0	0	0	0	0	0	0	0	0	0
P-tot	4 371	42	2 252	14 321	65 998	0	68 250	0	0	0	22 752	1 785	0
Cl-tot	0	887	0	2 448	0	0	0	0	0	0	7 020	12 750	0
K	14 853	11 465	1 716	22 832	429	0	2 145	0	0	0	90 792	17 850	0
Ca	47 201	7 049	40 950	98 803	17 550	0	58 500	0	0	0	36 000	7 650	0
Pb	0	0	0	46	121	0	121	0	0	0	9	0	1
Cd	0	0	0	1	3	0	3	0	0	0	1	0	0
Hg	0	0	0	0	4	0	4	0	0	0	0	0	0
Cu	0	0	2	92	688	0	690	0	0	0	236	0	1
Cr	0	0	0	23	84	0	84	0	0	0	4	0	1
Ni	0	0	0	14	39	0	39	0	0	0	20	0	1
Zn	0	26	5	574	1 584	0	1 589	0	0	0	545	0	2
Cch-medium	0	0	0	0	0	0	91 650	0	0	0	482 400	867 000	0
Particles	0	0	0	0	0	0	0	0	0	0	0	0	0
COD	0	2 371	15 994	2 390	655	0	0	0	0	0	0	0	0

Air Emissions from scenario: Mineral fertiliser

(kg/year)	Waste transport	Manure transport	Residue transport	Spreading of residues	Incineration	Anaerobic digestion	Reactor compost	Windrow compost	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil
Ctot-b	78 604	5 623	1 583	12 873	2 211 912	0	0	0	82 091	533 964	63 750	21 631	0
Cch-stable	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-biodegr	0	0	0	0	0	0	0	0	0	0	0	0	0
C-fat	0	0	0	0	0	0	0	0	0	0	0	0	0
C-prot	0	0	0	0	0	0	0	0	0	0	0	0	0
BOD	0	0	0	0	0	0	0	0	0	0	0	0	0
VS	0	0	0	0	0	0	0	0	0	0	0	0	0
TS	0	0	0	0	319	0	0	0	0	0	0	0	0
CO2-f	287 143	20 746	5 772	47 495	0	0	0	0	23 084	22 783	0	0	0
CO2-b	0	0	0	0	2 221 954	0	0	0	231 309	2 815 027	145 583	43 480	0
CH4	4	1	0	2	0	0	0	0	32 666	18 597	53 301	13 360	0
VOC	147	36	5	81	0	0	0	0	33 071	18 843	53 301	13 360	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	7	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0	0	0	0
CO	521	99	0	226	8 017	0	0	0	110	108	0	0	0
phenols	0	0	0	0	0	0	0	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	0	0	0	0	4 137 350	0	0	0	33 290	36 910	300 000	200 000	0
N-tot	1 681	268	41	615	1 283	0	0	0	302	979	21	76	52 669
NH3-N	0	0	0	0	63	0	0	0	0	342	10	38	9 531
NOx-N	1 669	268	41	615	964	0	0	0	434	372	0	0	0
NO3-N	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O-N	10	10	0	23	256	0	0	0	47	32	0	0	1 158
S-tot	98	6	7	13	969	0	0	0	78	6	0	0	0
SOx-S	98	6	7	13	962	0	0	0	9	6	0	0	0
P-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl-tot	0	0	0	0	489	0	0	0	0	0	0	0	0
K	0	0	0	0	1 554	0	0	0	0	0	0	0	0
Ca	0	0	0	0	7 988	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-medium	0	0	0	0	0	0	0	0	0	0	0	0	0
Particles	36	0	1	0	16	0	0	0	0	0	0	0	0
COD	0	0	0	0	0	0	0	0	0	0	0	0	0

Water Emissions from scenario: Mineral fertiliser | To soil from scenario: Mineral fertiliser

(kg/year)	Incineration	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil	Sludge	Anaerob dig. residue	Compost from reactor	Compost from windrow	Manure	Straw	Phosphorus
Ctot-b	0	794	5 331	15 912	218	0	554 970	0	0	0	666 000	1 275 000	0
Cch-stable	0	0	0	0	0	0	19 100	0	0	0	93 600	204 000	0
Cch-biodegr	0	0	0	0	0	0	93 951	0	0	0	0	204 000	0
C-fat	0	0	0	0	0	0	222 300	0	0	0	9 000	0	0
C-prot	0	0	0	0	0	0	127 969	0	0	0	82 800	0	0
BOD	0	649	3 998	24	7	0	0	0	0	0	0	0	0
VS	0	0	0	1 015	0	0	975 000	0	0	0	1 404 000	2 371 500	0
TS	0	0	0	1 080	0	0	1 950 000	0	0	0	1 800 000	2 550 000	0
CO2-f	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2-b	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	0	0	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0	0	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	1	0	0	0	0	0	0	0	0	0
PAH	0	0	0	2	0	0	4	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0	0	0
phenols	0	0	0	0	0	0	148	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	165	0	0	0	0	0	0	648 000	1 083 750	0
H-tot	0	0	0	125	0	0	0	0	0	0	66 600	1 020 000	0
H2O	4 597 055	34 558 239	16 250 000	2 700 000	1 800 000	0	6 175 000	0	0	0	23 000 000	450 000	0
N-tot	41	12	6 776	2 075	7 529	39 961	28 665	0	0	0	56 419	12 750	0
NH3-N	41	10	6 776	1 038	3 764	0	9 360	0	0	0	41 472	0	0
NOx-N	0	0	0	0	0	0	0	0	0	0	0	0	0
NO3-N	0	19	0	1 048	3 803	39 961	0	0	0	0	0	0	0
N2O-N	0	0	0	0	0	0	0	0	0	0	0	0	0
S-tot	194	174	0	3 288	0	0	0	0	0	0	11 527	25 500	0
SOx-S	0	0	0	0	0	0	0	0	0	0	0	0	0
P-tot	4 371	42	2 252	14 321	65 998	0	68 250	0	0	0	22 752	1 785	0
Cl-tot	0	887	0	2 448	0	0	0	0	0	0	7 020	12 750	0
K	14 853	11 465	1 716	22 832	429	0	2 145	0	0	0	90 792	17 850	0
Ca	47 201	7 049	40 950	98 803	17 550	0	58 500	0	0	0	36 000	7 650	0
Pb	0	0	0	46	121	0	121	0	0	0	9	0	1
Cd	0	0	0	1	3	0	3	0	0	0	1	0	0
Hg	0	0	0	0	4	0	4	0	0	0	0	0	0
Cu	0	0	2	92	688	0	690	0	0	0	236	0	1
Cr	0	0	0	23	84	0	84	0	0	0	4	0	1
Ni	0	0	0	14	39	0	39	0	0	0	20	0	1
Zn	0	26	5	574	1 584	0	1 589	0	0	0	545	0	2
Cch-medium	0	0	0	0	0	0	91 650	0	0	0	482 400	867 000	0
Particles	0	0	0	0	0	0	0	0	0	0	0	0	0
COD	0	2 371	15 994	2 390	655	0	0	0	0	0	0	0	0

Air Emissions from scenario: Anaerobic digestion residue

f	Waste transport	Manure transport	Residue transport	Spreading of residues	Incineration	Anaerobic digestion	Reactor compost	Windrow compost	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil
Ctot-b	77 091	1 842	12 302	18 953	0	1 827 318	0	0	16 913	533 964	2 755	21 631	0
Cch-stable	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-biodegr	0	0	0	0	0	0	0	0	0	0	0	0	0
C-fat	0	0	0	0	0	0	0	0	0	0	0	0	0
C-prot	0	0	0	0	0	0	0	0	0	0	0	0	0
BOD	0	0	0	0	0	0	0	0	0	0	0	0	0
VS	0	0	0	0	0	0	0	0	0	0	0	0	0
TS	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2-f	281 626	6 797	44 846	69 926	0	0	0	0	365	22 783	0	0	0
CO2-b	0	0	0	0	0	6 696 107	0	0	58 389	2 815 027	7 510	43 480	0
CH4	4	0	1	3	0	67	0	0	6 012	18 597	980	13 360	0
VOC	142	12	40	120	0	67	0	0	6 080	18 843	980	13 360	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0	0	0	0
CO	521	32	0	332	0	1	0	0	2	108	0	0	0
phenols	0	0	0	0	0	0	0	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	0	0	0	0	0	0	0	0	6 236	36 910	300 000	200 000	0
N-tot	1 641	88	322	905	0	0	0	0	13	979	1	76	76 471
NH3-N	0	0	0	0	0	0	0	0	4	342	0	38	21 878
NOx-N	1 630	88	321	905	0	5 039	0	0	30	372	0	0	0
NO3-N	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O-N	10	3	2	34	0	0	0	0	7	32	0	0	1 547
S-tot	91	2	56	19	0	12 882	0	0	5	6	0	0	0
SOx-S	91	2	56	19	0	12 882	0	0	2	6	0	0	0
P-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
K	0	0	0	0	0	0	0	0	0	0	0	0	0
Ca	0	0	0	0	0	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-medium	0	0	0	0	0	0	0	0	0	0	0	0	0
Particles	35	0	8	0	0	0	0	0	0	0	0	0	0
COD	0	0	0	0	0	0	0	0	0	0	0	0	0

Water Emissions from scenario:	Anaerobic digestion res						To soil from scenario:	Anaerobic digestion residue					
	Incineration	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil	Sludge	Anaerob dig. residue	Compost from reactor	Compost from windrow	Manure	Straw	Phosphorus
Ctot-b	0	170	5 331	28	218	0	554 970	1 334 217	0	0	0	1 275 000	0
Cch-stable	0	0	0	0	0	0	19 100	239 990	0	0	0	204 000	0
Cch-biodegr	0	0	0	0	0	0	93 951	92 842	0	0	0	204 000	0
C-fat	0	0	0	0	0	0	222 300	249 351	0	0	0	0	0
C-prot	0	0	0	0	0	0	127 969	194 789	0	0	0	0	0
BOD	0	127	3 998	1	7	0	0	75 600	0	0	0	0	0
VS	0	0	0	364	0	0	975 000	2 552 804	0	0	0	2 371 500	0
TS	0	0	0	455	0	0	1 950 000	3 971 585	0	0	0	2 550 000	0
CO2-f	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2-b	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	0	0	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	11	0	0	0	0	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	4	3	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0	0	0
phenols	0	0	0	0	0	0	148	124	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	131	0	0	0	999 163	0	0	0	1 083 750	0
H-tot	0	0	0	26	0	0	0	145 025	0	0	0	1 020 000	0
H2O	0	260 260	16 250 000	2 700 000	1 800 000	0	6 175 000	40 329 692	0	0	0	450 000	0
N-tot	0	81	6 776	90	7 529	47 301	28 665	128 560	0	0	0	12 750	0
NH3-N	0	81	6 776	45	3 764	0	9 360	107 322	0	0	0	0	0
NOx-N	0	0	0	0	0	0	0	0	0	0	0	0	0
NO3-N	0	0	0	46	3 803	47 301	0	0	0	0	0	0	0
N2O-N	0	0	0	0	0	0	0	0	0	0	0	0	0
S-tot	0	2	0	103	0	0	0	10 900	0	0	0	25 500	0
SOx-S	0	0	0	0	0	0	0	0	0	0	0	0	0
P-tot	0	1	2 252	172	65 998	0	68 250	41 310	0	0	0	1 785	0
Cl-tot	0	142	0	36	0	0	0	28 415	0	0	0	12 750	0
K	0	339	1 716	85	429	0	2 145	141 077	0	0	0	17 850	0
Ca	0	893	40 950	383	17 550	0	58 500	182 084	0	0	0	7 650	0
Pb	0	0	0	0	121	0	121	54	0	0	0	0	0
Cd	0	0	0	0	3	0	3	2	0	0	0	0	0
Hg	0	0	0	0	4	0	4	1	0	0	0	0	0
Cu	0	0	2	1	688	0	690	327	0	0	0	0	0
Cr	0	0	0	0	84	0	84	27	0	0	0	0	0
Ni	0	0	0	0	39	0	39	34	0	0	0	0	0
Zn	0	0	5	6	1 584	0	1 589	1 137	0	0	0	0	0
Cch-medium	0	0	0	0	0	0	91 650	558 936	0	0	0	867 000	0
Particles	0	0	0	0	0	0	0	0	0	0	0	0	0
COD	0	510	15 994	83	655	0	0	0	0	0	0	0	0

Air Emissions from scenario: Reactor compost

f	Waste transport	Manure transport	Residue transport	Spreading of residues	Incineration	Anaerobic digestion	Reactor compost	Windrow compost	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil
Ctot-b	77 091	5 623	2 483	13 856	0	0	760	0	20 454	533 964	3 125	21 631	0
Cch-stable	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-biodegr	0	0	0	0	0	0	0	0	0	0	0	0	0
C-fat	0	0	0	0	0	0	0	0	0	0	0	0	0
C-prot	0	0	0	0	0	0	0	0	0	0	0	0	0
BOD	0	0	0	0	0	0	0	0	0	0	0	0	0
VS	0	0	0	0	0	0	0	0	0	0	0	0	0
TS	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2-f	281 626	20 746	9 050	51 120	0	0	2 770	0	525	22 783	0	0	0
CO2-b	0	0	0	0	0	0	6 045 462	0	70 186	2 815 027	8 487	43 480	0
CH4	4	1	0	2	0	0	10 580	0	7 323	18 597	1 122	13 360	0
VOC	142	36	8	88	0	0	21 172	0	7 406	18 843	1 122	13 360	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0	0	0	0
CO	521	99	0	243	0	0	12	0	2	108	0	0	0
phenols	0	0	0	0	0	0	0	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	0	0	0	0	0	0	0	0	7 590	36 910	300 000	200 000	0
N-tot	1 641	268	65	661	0	0	6 691	0	16	979	1	76	87 656
NH3-N	0	0	0	0	0	0	3 115	0	5	342	1	38	10 287
NOx-N	1 630	268	65	661	0	0	34	0	37	372	0	0	0
NO3-N	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O-N	10	10	0	25	0	0	65	0	8	32	0	0	2 020
S-tot	91	6	11	14	0	0	3	0	5	6	0	0	0
SOx-S	91	6	11	14	0	0	3	0	3	6	0	0	0
P-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
K	0	0	0	0	0	0	0	0	0	0	0	0	0
Ca	0	0	0	0	0	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-medium	0	0	0	0	0	0	0	0	0	0	0	0	0
Particles	35	0	2	0	0	0	0	0	0	0	0	0	0
COD	0	0	0	0	0	0	0	0	0	0	0	0	0

	Water Emissions from scenario:		Reactor compost				To soil from scenario:		Reactor compost				
	Incineration	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil	Sludge	Anaerob dig. residue	Compost from reactor	Compost from windrow	Manure	Straw	Phosphorus fertiliser
Ctot-b	0	205	5 331	32	218	0	554 970	0	0	694 812	666 000	1 275 000	0
Cch-stable	0	0	0	0	0	0	19 100	0	0	667 191	93 600	204 000	0
Cch-biodegr	0	0	0	0	0	0	93 951	0	0	0	0	204 000	0
C-fat	0	0	0	0	0	0	222 300	0	0	0	9 000	0	0
C-prot	0	0	0	0	0	0	127 969	0	0	0	82 800	0	0
BOD	0	154	3 998	1	7	0	0	0	0	0	0	0	0
VS	0	0	0	433	0	0	975 000	0	0	1 080 499	1 404 000	2 371 500	0
TS	0	0	0	536	0	0	1 950 000	0	0	2 132 718	1 800 000	2 550 000	0
CO2-f	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2-b	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	0	0	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0	0	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	4	0	0	2	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0	0	0
phenols	0	0	0	0	0	0	148	0	0	6	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	153	0	0	0	0	0	337 535	648 000	1 083 750	0
H-tot	0	0	0	30	0	0	0	0	0	48 152	66 600	1 020 000	0
H2O	0	374 260	16 250 000	2 700 000	1 800 000	0	6 175 000	0	0	2 132 718	23 000 000	450 000	0
N-tot	0	94	6 776	104	7 529	73 940	28 665	0	0	28 837	56 419	12 750	0
NH3-N	0	94	6 776	52	3 764	0	9 360	0	0	576	41 472	0	0
NOx-N	0	0	0	0	0	0	0	0	0	0	0	0	0
NO3-N	0	0	0	53	3 803	73 940	0	0	0	3 458	0	0	0
N2O-N	0	0	0	0	0	0	0	0	0	0	0	0	0
S-tot	0	2	0	116	0	0	0	0	0	12 240	11 527	25 500	0
SOx-S	0	0	0	0	0	0	0	0	0	0	0	0	0
P-tot	0	1	2 252	187	65 998	0	68 250	0	0	18 544	22 752	1 785	0
Cl-tot	0	173	0	43	0	0	0	0	0	21 357	7 020	12 750	0
K	0	406	1 716	101	429	0	2 145	0	0	50 202	90 792	17 850	0
Ca	0	1 032	40 950	442	17 550	0	58 500	0	0	145 885	36 000	7 650	0
Pb	0	0	0	0	121	0	121	0	0	45	9	0	0
Cd	0	0	0	0	3	0	3	0	0	1	1	0	0
Hg	0	0	0	0	4	0	4	0	0	0	0	0	0
Cu	0	0	2	1	688	0	690	0	0	91	236	0	0
Cr	0	0	0	0	84	0	84	0	0	23	4	0	0
Ni	0	0	0	0	39	0	39	0	0	14	20	0	0
Zn	0	0	5	6	1 584	0	1 589	0	0	593	545	0	0
Cch-medium	0	0	0	0	0	0	91 650	0	0	27 620	482 400	867 000	0
Particles	0	0	0	0	0	0	0	0	0	0	0	0	0
COD	0	616	15 994	95	655	0	0	0	0	0	0	0	0

Air Emissions from scenario: Windrow compost

f	Waste transport	Manure transport	Residue transport	Spreading of residues	Incineration	Anaerobic digestion	Reactor compost	Windrow compost	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil
Ctot-b	78 583	5 623	2 753	13 810	0	0	0	5 698	105 810	533 964	7 826	21 631	0
Cch-stable	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-biodegr	0	0	0	0	0	0	0	0	0	0	0	0	0
C-fat	0	0	0	0	0	0	0	0	0	0	0	0	0
C-prot	0	0	0	0	0	0	0	0	0	0	0	0	0
BOD	0	0	0	0	0	0	0	0	0	0	0	0	0
VS	0	0	0	0	0	0	0	0	0	0	0	0	0
TS	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2-f	287 065	20 746	10 034	50 953	0	0	0	20 771	8 937	22 783	0	0	0
CO2-b	0	0	0	0	0	0	0	9 522 378	329 459	2 815 027	20 713	43 480	0
CH4	4	1	0	2	0	0	0	33 329	42 090	18 597	2 864	13 360	0
VOC	147	36	9	87	0	0	0	33 370	42 577	18 843	2 864	13 360	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0	0	0	0
CO	521	99	0	242	0	0	0	93	42	108	0	0	0
phenols	0	0	0	0	0	0	0	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	0	0	0	0	0	0	0	0	43 128	36 910	300 000	200 000	0
N-tot	1 680	268	72	659	0	0	0	26 299	127	979	1	76	85 370
NH3-N	0	0	0	0	0	0	0	25 247	6	342	1	38	10 483
NOx-N	1 669	268	72	659	0	0	0	255	290	372	0	0	0
NO3-N	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O-N	10	10	0	25	0	0	0	527	51	32	0	0	1 960
S-tot	98	6	13	14	0	0	0	26	23	6	0	0	0
SOx-S	98	6	13	14	0	0	0	26	13	6	0	0	0
P-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
K	0	0	0	0	0	0	0	0	0	0	0	0	0
Ca	0	0	0	0	0	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-medium	0	0	0	0	0	0	0	0	0	0	0	0	0
Particles	36	0	2	0	0	0	0	4	0	0	0	0	0
COD	0	0	0	0	0	0	0	0	0	0	0	0	0

Water Emissions from scenario: Windrow compost	Incineration	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil	To soil from scenario: Windrow compost — Sludge	Anaerob dig. residue	Compost from reactor	Compost from windrow	Manure	Straw	Phosphorus fertiliser
Ctot-b	0	1 044	5 331	79	218	0	554 970	0	0	933 006	666 000	0	0
Cch-stable	0	0	0	0	0	0	19 100	0	0	862 469	93 600	0	0
Cch-biodegr	0	0	0	0	0	0	93 951	0	0	0	0	0	0
C-fat	0	0	0	0	0	0	222 300	0	0	0	9 000	0	0
C-prot	0	0	0	0	0	0	127 969	0	0	0	82 800	0	0
BOD	0	783	3 998	2	7	0	0	0	0	0	0	0	0
VS	0	0	0	1 675	0	0	975 000	0	0	1 470 858	1 404 000	0	0
TS	0	0	0	1 860	0	0	1 950 000	0	0	2 698 485	1 800 000	0	0
CO2-f	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2-b	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	0	0	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0	0	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	4	0	0	2	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0	0	0
phenols	0	0	0	0	0	0	148	0	0	6	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	425	0	0	0	0	0	472 864	648 000	0	0
H-tot	0	0	0	256	0	0	0	0	0	64 988	66 600	0	0
H2O	0	6 374 260	16 250 000	2 700 000	1 800 000	0	6 175 000	0	0	2 698 485	23 000 000	0	0
N-tot	0	115	6 776	128	7 529	71 392	28 665	0	0	26 578	56 419	0	0
NH3-N	0	115	6 776	64	3 764	0	9 360	0	0	726	41 472	0	0
NOx-N	0	0	0	0	0	0	0	0	0	0	0	0	0
NO3-N	0	0	0	64	3 803	71 392	0	0	0	4 354	0	0	0
N2O-N	0	0	0	0	0	0	0	0	0	0	0	0	0
S-tot	0	8	0	456	0	0	0	0	0	37 378	11 527	0	0
SOx-S	0	0	0	0	0	0	0	0	0	0	0	0	0
P-tot	0	1	2 252	258	65 998	0	68 250	0	0	20 258	22 752	0	0
Cl-tot	0	1 130	0	282	0	0	0	0	0	32 910	7 020	0	0
K	0	566	1 716	141	429	0	2 145	0	0	67 852	90 792	0	0
Ca	0	1 100	40 950	471	17 550	0	58 500	0	0	153 438	36 000	0	0
Pb	0	0	0	0	121	0	121	0	0	45	9	0	0
Cd	0	0	0	0	3	0	3	0	0	1	1	0	0
Hg	0	0	0	0	4	0	4	0	0	0	0	0	0
Cu	0	0	2	1	688	0	690	0	0	91	236	0	0
Cr	0	0	0	0	84	0	84	0	0	23	4	0	0
Ni	0	0	0	0	39	0	39	0	0	14	20	0	0
Zn	0	0	5	6	1 584	0	1 589	0	0	593	545	0	0
Cch-medium	0	0	0	0	0	0	91 650	0	0	70 537	482 400	0	0
Particles	0	0	0	0	0	0	0	0	0	0	0	0	0
COD	0	3 133	15 994	237	655	0	0	0	0	0	0	0	0

Bilaga 3

Emission data from the small town region

Data from the ORWARE simulation model are presented on the following pages. The first page presents data for the waste fractions. These are data used in the calculations. The other pages present results from the calculations. These are data before grouping and weighting in environmental impact categories.

In the tables, emissions of NH_4^+ to water and soil are presented in the row for NH_3.

Waste composition

(kg/year)	Sludge 5 815 000	Households:flats 650 000	small houses 1 150 000	rural areas 598 000	Trade 136 000	Restaurants 295 000	Grease water 450 000	Cow manure 28 500 000	Pig manure 18 500 000	Straw 600 000
Ctot-b	330 990	98 735	174 685	90 836	17 789	33 335	11 502	738 150	616 050	255 000
Cch-stable	11 392	6 598	11 673	6 070	490	1 918	0	103 740	86 580	40 800
Cch-biodegr	56 033	22 068	39 042	20 302	8 772	6 121	697	0	0	40 800
C-fat	132 582	30 713	54 338	28 256	1 265	13 423	10 789	9 975	8 325	0
C-prot	76 322	15 015	26 565	13 814	1 958	5 015	0	91 770	76 590	0
BOD	0	0	0	0	0	0	11 340	0	0	0
VS	581 500	182 000	322 000	167 440	39 576	59 000	15 228	1 556 100	1 298 700	474 300
TS	1 163 000	227 500	402 500	209 300	40 800	73 750	16 200	1 995 000	1 665 000	510 000
CO2-f	0	0	0	0	0	0	0	0	0	0
CO2-b	0	0	0	0	0	0	0	0	0	0
CH4	0	0	0	0	0	0	0	0	0	0
VOC	0	1	1	0	0	0	0	0	0	0
CHX	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0	0	0	0
PAH	1	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0
phenols	51	6	11	6	1	2	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0
O-tot	0	65 292	115 518	60 069	16 891	19 396	2 479	718 200	599 400	216 750
H-tot	0	13 195	23 345	12 139	2 244	2 286	1 879	73 815	61 605	204 000
H2O	4 652 000	422 500	747 500	388 700	95 200	221 250	433 800	26 505 000	16 835 000	90 000
N-tot	40 705	4 550	8 050	4 186	612	1 623	16	111 720	98 235	2 550
NH3-N	6 978	0	0	0	0	0	0	55 860	54 945	0
NOx-N	0	0	0	0	0	0	0	0	0	0
NO3-N	0	0	0	0	0	0	0	0	0	0
N2O-N	0	0	0	0	0	0	0	0	0	0
S-tot	0	546	966	502	61	148	16	12 170	13 320	5 100
SOx-S	0	0	0	0	0	0	0	0	0	0
P-tot	38 379	865	1 530	795	208	81	8	23 940	26 640	357
Cl-tot	0	887	1 570	816	159	288	162	7 781	6 493	2 550
K	1 279	2 116	3 743	1 946	486	878	3	105 735	61 605	3 570
Ca	33 727	6 370	11 270	5 860	1 200	2 065	3	39 900	33 300	1 530
Pb	40	2	4	2	0	0	0	10	8	0
Cd	1	0	0	0	0	0	0	1	1	0
Hg	1	0	0	0	0	0	0	0	0	0
Cu	276	5	8	4	0	0	0	257	236	0
Cr	38	1	2	1	0	0	0	4	7	0
Ni	12	1	1	1	0	0	0	16	48	0
Zn	535	30	52	27	0	1	0	549	745	0
Cch-medium	54 661	24 343	43 068	22 395	5 304	6 859	0	534 660	446 220	173 400
Particles	0	0	0	0	0	0	0	0	0	0
COD	0	0	0	0	0	0	0	0	0	0

Air Emissions from scenario: Mineral fertiliser

(kg/year)	Waste transport	Manure transport	Residue transport	Spreading of residues	Incineration	Anaerobic digestion	Reactor compost	Windrow compost	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil
Ctot-b	16 234	10 656	687	12 260	401 098	0	0	0	12 431	159 599	11 557	6 451	0
Cch-stable	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-biodegr	0	0	0	0	0	0	0	0	0	0	0	0	0
C-fat	0	0	0	0	0	0	0	0	0	0	0	0	0
C-prot	0	0	0	0	0	0	0	0	0	0	0	0	0
BOD	0	0	0	0	0	0	0	0	0	0	0	0	0
VS	0	0	0	0	0	0	0	0	0	0	0	0	0
TS	0	0	0	0	58	0	0	0	0	0	0	0	0
CO2-f	59 271	39 317	2 504	45 233	0	0	0	0	3 894	8 153	0	0	0
CO2-b	0	0	0	0	402 919	0	0	0	34 698	839 455	26 399	12 966	0
CH4	1	2	0	2	0	0	0	0	4 901	5 546	9 665	3 984	0
VOC	36	67	2	77	0	0	0	0	4 962	5 621	9 665	3 984	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	1	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0	0	0	0
CO	82	187	0	215	1 454	0	0	0	19	39	0	0	0
phenols	0	0	0	0	0	0	0	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	0	0	0	0	747 113	0	0	0	4 993	11 007	300 000	200 000	0
N-tot	366	509	18	585	232	0	0	0	51	289	4	20	63 464
NH3-N	0	0	0	0	11	0	0	0	0	92	2	10	17 144
NOx-N	364	509	18	585	175	0	0	0	71	129	0	0	0
NO3-N	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O-N	2	19	0	22	46	0	0	0	7	10	0	0	1 301
S-tot	33	11	3	12	176	0	0	0	14	2	0	0	0
SOx-S	33	11	3	12	175	0	0	0	1	2	0	0	0
P-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl-tot	0	0	0	0	89	0	0	0	0	0	0	0	0
K	0	0	0	0	281	0	0	0	0	0	0	0	0
Ca	0	0	0	0	1 451	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-medium	0	0	0	0	0	0	0	0	0	0	0	0	0
Particles	8	0	0	0	3	0	0	0	0	0	0	0	0
COD	0	0	0	0	0	0	0	0	0	0	0	0	0

(kg/year)	Water Emissions from scenario: Incineration	Landfilling of waste	Landfilling of sludge	Mineral fertiliser: Landf. of w. rem. time	Landf. of sl. rem. time	Soil	To soil from scenario: Sludge	Anaerob dig. residue	Compost from reactor	Compost from windrow	Mineral fertiliser: Manure	Straw	Mineral fertiliser
Ctot-b	0	120	1 590	2 885	65	0	165 495	0	0	0	1 354 200	255 000	0
Cch-stable	0	0	0	0	0	0	5 696	0	0	0	190 320	40 800	0
Cch-biodegr	0	0	0	0	0	0	28 017	0	0	0	0	40 800	0
C-fat	0	0	0	0	0	0	66 291	0	0	0	18 300	0	0
C-prot	0	0	0	0	0	0	38 161	0	0	0	168 360	0	0
BOD	0	100	1 192	4	2	0	0	0	0	0	0	0	0
VS	0	0	0	152	0	0	290 750	0	0	0	2 854 800	474 300	0
TS	0	0	0	162	0	0	581 500	0	0	0	3 660 000	510 000	0
CO2-f	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2-b	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	0	0	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0	0	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	1	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0	0	0
phenols	0	0	0	0	0	0	26	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	25	0	0	0	0	0	0	1 317 600	216 750	0
H-tot	0	0	0	19	0	0	0	0	0	0	135 420	204 000	0
H2O	830 126	6 021 603	5 815 000	2 700 000	1 800 000	0	2 326 000	0	0	0	43 340 000	90 000	0
N-tot	7	2	1 813	374	2 015	40 605	7 850	0	0	0	118 389	2 550	0
NH3-N	7	1	1 813	187	1 007	0	2 791	0	0	0	88 644	0	0
NOx-N	0	0	0	0	0	0	0	0	0	0	0	0	0
NO3-N	0	3	0	189	1 018	40 605	0	0	0	0	0	0	0
N2O-N	0	0	0	0	0	0	0	0	0	0	0	0	0
S-tot	35	32	0	593	0	0	0	0	0	0	25 490	5 100	0
SOx-S	0	0	0	0	0	0	0	0	0	0	0	0	0
P-tot	814	8	633	2 665	18 556	0	19 190	0	0	0	50 580	357	0
Cl-tot	0	134	0	438	0	0	0	0	0	0	14 274	2 550	0
K	2 687	2 073	512	4 130	128	0	640	0	0	0	167 340	3 570	0
Ca	8 573	1 280	11 804	17 948	5 059	0	16 864	0	0	0	73 200	1 530	0
Pb	0	0	0	8	20	0	20	0	0	0	18	0	0
Cd	0	0	0	0	1	0	1	0	0	0	1	0	0
Hg	0	0	0	0	1	0	1	0	0	0	0	0	0
Cu	0	0	0	17	137	0	138	0	0	0	494	0	0
Cr	0	0	0	4	19	0	19	0	0	0	12	0	0
Ni	0	0	0	3	6	0	6	0	0	0	64	0	0
Zn	0	5	1	105	267	0	267	0	0	0	1 294	0	0
Cch-medium	0	0	0	0	0	0	27 331	0	0	0	980 880	173 400	0
Particles	0	0	0	0	0	0	0	0	0	0	0	0	0
COD	0	358	4 769	433	195	0	0	0	0	0	0	0	0

Air Emissions from scenario: Mineral fertiliser

(kg/year)	Waste transport	Manure transport	Residue transport	Spreading of residues	Incineration	Anaerobic digestion	Reactor compost	Windrow compost	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil
Ctot-b	16 234	10 656	687	12 260	401 098	0	0	0	12 431	159 599	11 557	6 451	0
Cch-stable	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-biodegr	0	0	0	0	0	0	0	0	0	0	0	0	0
C-fat	0	0	0	0	0	0	0	0	0	0	0	0	0
C-prot	0	0	0	0	0	0	0	0	0	0	0	0	0
BOD	0	0	0	0	0	0	0	0	0	0	0	0	0
VS	0	0	0	0	0	0	0	0	0	0	0	0	0
TS	0	0	0	0	58	0	0	0	0	0	0	0	0
CO2-f	59 271	39 317	2 504	45 233	0	0	0	0	3 894	8 153	0	0	0
CO2-b	0	0	0	0	402 919	0	0	0	34 698	839 455	26 399	12 966	0
CH4	1	2	0	2	0	0	0	0	4 901	5 546	9 665	3 984	0
VOC	36	67	2	77	0	0	0	0	4 962	5 621	9 665	3 984	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	1	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0	0	0	0
CO	82	187	0	215	1 454	0	0	0	19	39	0	0	0
phenols	0	0	0	0	0	0	0	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	0	0	0	0	747 113	0	0	0	4 993	11 007	300 000	200 000	0
N-tot	366	509	18	585	232	0	0	0	51	289	4	20	63 464
NH3-N	0	0	0	0	11	0	0	0	0	92	2	10	17 144
NOx-N	364	509	18	585	175	0	0	0	71	129	0	0	0
NO3-N	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O-N	2	19	0	22	46	0	0	0	7	10	0	0	1 301
S-tot	33	11	3	12	176	0	0	0	14	2	0	0	0
SOx-S	33	11	3	12	175	0	0	0	1	2	0	0	0
P-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl-tot	0	0	0	0	89	0	0	0	0	0	0	0	0
K	0	0	0	0	281	0	0	0	0	0	0	0	0
Ca	0	0	0	0	1 451	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-medium	0	0	0	0	0	0	0	0	0	0	0	0	0
Particles	8	0	0	0	3	0	0	0	0	0	0	0	0
COD	0	0	0	0	0	0	0	0	0	0	0	0	0

Water Emissions from scenario: Mineral fertiliser

(kg/year)	Incineration	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil
Ctot-b	0	120	1 590	2 885	65	0
Cch-stable	0	0	0	0	0	0
Cch-biodegr	0	0	0	0	0	0
C-fat	0	0	0	0	0	0
C-prot	0	0	0	0	0	0
BOD	0	100	1 192	4	2	0
VS	0	0	0	152	0	0
TS	0	0	0	162	0	0
CO2-f	0	0	0	0	0	0
CO2-b	0	0	0	0	0	0
CH4	0	0	0	0	0	0
VOC	0	0	0	0	0	0
CHX	0	0	0	0	0	0
AOX	0	0	0	0	0	0
PAH	0	0	0	0	0	0
CO	0	0	0	0	0	0
phenols	0	0	0	0	0	0
PCB	0	0	0	0	0	0
dioxines	0	0	0	0	0	0
O-tot	0	0	0	25	0	0
H-tot	0	0	0	19	0	0
H2O	830 126	6 021 603	5 815 000	2 700 000	1 800 000	0
N-tot	7	2	1 813	374	2 015	40 605
NH3-N	7	1	1 813	187	1 007	0
NOx-N	0	0	0	0	0	0
NO3-N	0	3	0	189	1 018	40 605
N2O-N	0	0	0	0	0	0
S-tot	35	32	0	593	0	0
SOx-S	0	0	0	0	0	0
P-tot	814	8	633	2 665	18 556	0
Cl-tot	0	134	0	438	0	0
K	2 687	2 073	512	4 130	128	0
Ca	8 573	1 280	11 804	17 948	5 059	0
Pb	0	0	0	8	20	0
Cd	0	0	0	0	1	0
Hg	0	0	0	0	1	0
Cu	0	0	0	17	137	0
Cr	0	0	0	4	19	0
Ni	0	0	0	3	6	0
Zn	0	5	1	105	267	0
Cch-medium	0	0	0	0	0	0
Particles	0	0	0	0	0	0
COD	0	358	4 769	433	195	0

To soil from scenario: Mineral fertiliser

(kg/year)	Sludge	Anaerob dig. residue	Compost from reactor	Compost from windrow	Manure	Straw	Mineral fertiliser
Ctot-b	165 495	0	0	0	1 354 200	255 000	0
Cch-stable	5 696	0	0	0	190 320	40 800	0
Cch-biodegr	28 017	0	0	0	0	40 800	0
C-fat	66 291	0	0	0	18 300	0	0
C-prot	38 161	0	0	0	168 360	0	0
BOD	0	0	0	0	0	0	0
VS	290 750	0	0	0	2 854 800	474 300	0
TS	581 500	0	0	0	3 660 000	510 000	0
CO2-f	0	0	0	0	0	0	0
CO2-b	0	0	0	0	0	0	0
CH4	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0
CHX	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0
PAH	1	0	0	0	0	0	0
CO	0	0	0	0	0	0	0
phenols	26	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0
O-tot	0	0	0	0	1 317 600	216 750	0
H-tot	0	0	0	0	135 420	204 000	0
H2O	2 326 000	0	0	0	43 340 000	90 000	0
N-tot	7 850	0	0	0	118 389	2 550	0
NH3-N	2 791	0	0	0	88 644	0	0
NOx-N	0	0	0	0	0	0	0
NO3-N	0	0	0	0	0	0	0
N2O-N	0	0	0	0	0	0	0
S-tot	0	0	0	0	25 490	5 100	0
SOx-S	0	0	0	0	0	0	0
P-tot	19 190	0	0	0	50 580	357	0
Cl-tot	0	0	0	0	14 274	2 550	0
K	640	0	0	0	167 340	3 570	0
Ca	16 864	0	0	0	73 200	1 530	0
Pb	20	0	0	0	18	0	0
Cd	1	0	0	0	1	0	0
Hg	1	0	0	0	0	0	0
Cu	138	0	0	0	494	0	0
Cr	19	0	0	0	12	0	0
Ni	6	0	0	0	64	0	0
Zn	267	0	0	0	1 294	0	0
Cch-medium	27 331	0	0	0	980 880	173 400	0
Particles	0	0	0	0	0	0	0
COD	0	0	0	0	0	0	0

Air Emissions from scenario: Anaerobic digestion residue

(kg/year)	Waste transport	Manure transport	Residue transport	Spreading of residues	Incineration	Anaerobic digestion	Reactor compost	Windrow compost	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil
Ctot-b	12 962	659	12 155	15 313	0	967 706	0	0	3 117	159 599	508	6 451	0
Cch-stable	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-biodegr	0	0	0	0	0	0	0	0	0	0	0	0	0
C-fat	0	0	0	0	0	0	0	0	0	0	0	0	0
C-prot	0	0	0	0	0	0	0	0	0	0	0	0	0
BOD	0	0	0	0	0	0	0	0	0	0	0	0	0
VS	0	0	0	0	0	0	0	0	0	0	0	0	0
TS	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2-f	47 347	2 432	44 310	56 497	0	0	0	0	67	8 153	0	0	0
CO2-b	0	0	0	0	0	3 546 108	0	0	10 760	839 455	1 384	12 966	0
CH4	1	0	1	2	0	32	0	0	1 108	5 546	181	3 984	0
VOC	25	4	40	97	0	32	0	0	1 120	5 621	181	3 984	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0	0	0	0
CO	82	12	0	268	0	0	0	0	0	39	0	0	0
phenols	0	0	0	0	0	0	0	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	0	0	0	0	0	0	0	0	1 149	11 007	300 000	200 000	0
N-tot	280	31	319	731	0	0	0	0	2	289	0	20	60 129
NH3-N	0	0	0	0	0	0	0	0	1	92	0	10	26 471
NOx-N	278	31	317	731	0	2 418	0	0	5	129	0	0	0
NO3-N	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O-N	2	1	2	27	0	0	0	0	1	10	0	0	1 062
S-tot	18	1	56	15	0	15 009	0	0	1	2	0	0	0
SOx-S	18	1	56	15	0	15 009	0	0	0	2	0	0	0
P-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
K	0	0	0	0	0	0	0	0	0	0	0	0	0
Ca	0	0	0	0	0	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-medium	0	0	0	0	0	0	0	0	0	0	0	0	0
Particles	6	0	8	0	0	0	0	0	0	0	0	0	0
COD	0	0	0	0	0	0	0	0	0	0	0	0	0

Water Emissions from scenario: Anaerobic digestion resi

(kg/year)	Incineration	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil
Ctot-b	0	31	1 590	5	65	0
Cch-stable	0	0	0	0	0	0
Cch-biodegr	0	0	0	0	0	0
C-fat	0	0	0	0	0	0
C-prot	0	0	0	0	0	0
BOD	0	23	1 192	0	2	0
VS	0	0	0	67	0	0
TS	0	0	0	84	0	0
CO2-f	0	0	0	0	0	0
CO2-b	0	0	0	0	0	0
CH4	0	0	0	0	0	0
VOC	0	0	0	0	0	0
CHX	0	0	0	0	0	0
AOX	0	0	0	0	0	0
PAH	0	0	0	0	0	0
CO	0	0	0	0	0	0
phenols	0	0	0	0	0	0
PCB	0	0	0	0	0	0
dioxines	0	0	0	0	0	0
O-tot	0	0	0	24	0	0
H-tot	0	0	0	5	0	0
H2O	0	47 960	5 815 000	2 700 000	1 800 000	0
N-tot	0	15	1 813	17	2 015	24 834
NH3-N	0	15	1 813	8	1 007	0
NOx-N	0	0	0	0	0	0
NO3-N	0	0	0	8	1 018	24 834
N2O-N	0	0	0	0	0	0
S-tot	0	0	0	19	0	0
SOx-S	0	0	0	0	0	0
P-tot	0	0	633	32	18 556	0
Cl-tot	0	26	0	7	0	0
K	0	62	512	16	128	0
Ca	0	165	11 804	71	5 059	0
Pb	0	0	0	0	20	0
Cd	0	0	0	0	1	0
Hg	0	0	0	0	1	0
Cu	0	0	0	0	137	0
Cr	0	0	0	0	19	0
Ni	0	0	0	0	6	0
Zn	0	0	1	1	267	0
Cch-medium	0	0	0	0	0	0
Particles	0	0	0	0	0	0
COD	0	94	4 769	15	195	0

To soil from scenario: Anaerobic digestion residue

(kg/year)	Sludge	Anaerob dig. residue	Compost from reactor	Compost from windrow	Manure	Straw	Mineral fertiliser
Ctot-b	165 495	920 593	0	0	0	255 000	0
Cch-stable	5 696	216 398	0	0	0	40 800	0
Cch-biodegr	28 017	17 176	0	0	0	40 800	0
C-fat	66 291	48 951	0	0	0	0	0
C-prot	38 161	105 496	0	0	0	0	0
BOD	0	11 340	0	0	0	0	0
VS	290 750	1 912 883	0	0	0	474 300	0
TS	581 500	2 901 211	0	0	0	510 000	0
CO2-f	0	0	0	0	0	0	0
CO2-b	0	0	0	0	0	0	0
CH4	0	0	0	0	0	0	0
VOC	0	2	0	0	0	0	0
CHX	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0
PAH	1	0	0	0	0	0	0
CO	0	0	0	0	0	0	0
phenols	26	23	0	0	0	0	0
PCB	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0
O-tot	0	865 763	0	0	0	216 750	0
H-tot	0	98 242	0	0	0	204 000	0
H2O	2 326 000	45 633 363	0	0	0	90 000	0
N-tot	7 850	154 615	0	0	0	2 550	0
NH3-N	2 791	138 388	0	0	0	0	0
NOx-N	0	0	0	0	0	0	0
NO3-N	0	0	0	0	0	0	0
N2O-N	0	0	0	0	0	0	0
S-tot	0	12 700	0	0	0	5 100	0
SOx-S	0	0	0	0	0	0	0
P-tot	19 190	54 035	0	0	0	357	0
Cl-tot	0	18 123	0	0	0	2 550	0
K	640	176 434	0	0	0	3 570	0
Ca	16 864	99 733	0	0	0	1 530	0
Pb	20	27	0	0	0	0	0
Cd	1	1	0	0	0	0	0
Hg	1	0	0	0	0	0	0
Cu	138	511	0	0	0	0	0
Cr	19	16	0	0	0	0	0
Ni	6	67	0	0	0	0	0
Zn	267	1 403	0	0	0	0	0
Cch-medium	27 331	536 216	0	0	0	173 400	0
Particles	0	0	0	0	0	0	0
COD	0	0	0	0	0	0	0

Air Emissions from scenario: Reactor compost

(kg/year)	Waste transport	Manure transport	Residue transport	Spreading of residues	Incineration	Anaerobic digestion	Reactor compost	Windrow compost	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil
Ctot-b	12 962	10 656	868	12 437	0	0	133	0	3 683	159 599	568	6 451	0
Cch-stable	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-biodegr	0	0	0	0	0	0	0	0	0	0	0	0	0
C-fat	0	0	0	0	0	0	0	0	0	0	0	0	0
C-prot	0	0	0	0	0	0	0	0	0	0	0	0	0
BOD	0	0	0	0	0	0	0	0	0	0	0	0	0
VS	0	0	0	0	0	0	0	0	0	0	0	0	0
TS	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2-f	47 347	39 317	3 162	45 887	0	0	485	0	92	8 153	0	0	0
CO2-b	0	0	0	0	0	0	1 093 372	0	12 670	839 455	1 539	12 966	0
CH4	1	2	0	2	0	0	1 913	0	1 314	5 546	205	3 984	0
VOC	25	67	3	79	0	0	3 829	0	1 329	5 621	205	3 984	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0	0	0	0
CO	82	187	0	218	0	0	2	0	0	39	0	0	0
phenols	0	0	0	0	0	0	0	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	0	0	0	0	0	0	0	0	1 362	11 007	300 000	200 000	0
N-tot	280	509	23	594	0	0	1 207	0	3	289	0	20	69 774
NH3-N	0	0	0	0	0	0	562	0	1	92	0	10	17 281
NOx-N	278	509	23	594	0	0	6	0	7	129	0	0	0
NO3-N	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O-N	2	19	0	22	0	0	12	0	1	10	0	0	1 456
S-tot	18	11	4	12	0	0	1	0	1	2	0	0	0
SOx-S	18	11	4	12	0	0	1	0	1	2	0	0	0
P-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
K	0	0	0	0	0	0	0	0	0	0	0	0	0
Ca	0	0	0	0	0	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-medium	0	0	0	0	0	0	0	0	0	0	0	0	0
Particles	6	0	1	0	0	0	0	0	0	0	0	0	0
COD	0	0	0	0	0	0	0	0	0	0	0	0	0

Water Emissions from scenario:	Reactor compost						To soil from scenario:	Reactor compost					
(kg/year)	Incineration	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil	Sludge	Anaerob dig. residue	Compost from reactor	Compost from windrow	Manure	Straw	Mineral fertiliser
Ctot-b	0	37	1 590	6	65	0	165 495	0	0	124 405	1 354 200	255 000	
Cch-stable	0	0	0	0	0	0	5 696	0	0	119 357	190 320	40 800	
Cch-biodegr	0	0	0	0	0	0	28 017	0	0	0	0	40 800	
C-fat	0	0	0	0	0	0	66 291	0	0	0	18 300	0	
C-prot	0	0	0	0	0	0	38 161	0	0	0	168 360	0	
BOD	0	28	1 192	0	2	0	0	0	0	0	0	0	
VS	0	0	0	79	0	0	290 750	0	0	193 522	2 854 800	474 300	
TS	0	0	0	97	0	0	581 500	0	0	381 969	3 660 000	510 000	
CO2-f	0	0	0	0	0	0	0	0	0	0	0	0	
CO2-b	0	0	0	0	0	0	0	0	0	0	0	0	
CH4	0	0	0	0	0	0	0	0	0	0	0	0	
VOC	0	0	0	0	0	0	0	0	0	0	0	0	
CHX	0	0	0	0	0	0	0	0	0	0	0	0	
AOX	0	0	0	0	0	0	0	0	0	0	0	0	
PAH	0	0	0	0	0	0	1	0	0	0	0	0	
CO	0	0	0	0	0	0	0	0	0	0	0	0	
phenols	0	0	0	0	0	0	26	0	0	1	0	0	
PCB	0	0	0	0	0	0	0	0	0	0	0	0	
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	
O-tot	0	0	0	28	0	0	0	0	0	60 495	1 317 600	216 750	
H-tot	0	0	0	6	0	0	0	0	0	8 623	135 420	204 000	
H2O	0	65 580	5 815 000	2 700 000	1 800 000	0	2 326 000	0	0	381 969	43 340 000	90 000	
N-tot	0	17	1 813	19	2 015	46 733	7 850	0	0	5 201	118 389	2 550	
NH3-N	0	17	1 813	9	1 007	0	2 791	0	0	104	88 644	0	
NOx-N	0	0	0	0	0	0	0	0	0	0	0	0	
NO3-N	0	0	0	10	1 018	46 733	0	0	0	624	0	0	
N2O-N	0	0	0	0	0	0	0	0	0	0	0	0	
S-tot	0	0	0	21	0	0	0	0	0	2 217	25 490	5 100	
SOx-S	0	0	0	0	0	0	0	0	0	0	0	0	
P-tot	0	0	633	35	18 556	0	19 190	0	0	3 452	50 580	357	
Cl-tot	0	31	0	8	0	0	0	0	0	3 843	14 274	2 550	
K	0	73	512	18	128	0	640	0	0	9 080	167 340	3 570	
Ca	0	187	11 804	80	5 059	0	16 864	0	0	26 500	73 200	1 530	
Pb	0	0	0	0	20	0	20	0	0	8	18	0	
Cd	0	0	0	0	1	0	1	0	0	0	1	0	
Hg	0	0	0	0	1	0	1	0	0	0	0	0	
Cu	0	0	0	0	137	0	138	0	0	17	494	0	
Cr	0	0	0	0	19	0	19	0	0	4	12	0	
Ni	0	0	0	0	6	0	6	0	0	3	64	0	
Zn	0	0	1	1	267	0	267	0	0	109	1 294	0	
Cch-medium	0	0	0	0	0	0	27 331	0	0	5 047	980 880	173 400	
Particles	0	0	0	0	0	0	0	0	0	0	0	0	
COD	0	111	4 769	17	195	0	0	0	0	0	0	0	

Air Emissions from scenario: Windrow compost

(kg/year)	Waste transport	Manure transport	Residue transport	Spreading of residues	Incineration	Anaerobic digestion	Reactor compost	Windrow compost	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil
Ctot-b	13 261	10 656	922	12 433	0	0	0	1 044	16 889	159 599	1 503	6 451	0
Cch-stable	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-biodegr	0	0	0	0	0	0	0	0	0	0	0	0	0
C-fat	0	0	0	0	0	0	0	0	0	0	0	0	0
C-prot	0	0	0	0	0	0	0	0	0	0	0	0	0
BOD	0	0	0	0	0	0	0	0	0	0	0	0	0
VS	0	0	0	0	0	0	0	0	0	0	0	0	0
TS	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2-f	48 435	39 317	3 362	45 872	0	0	0	3 806	1 358	8 153	0	0	0
CO2-b	0	0	0	0	0	0	0	1 797 263	53 077	839 455	3 984	12 966	0
CH4	1	2	0	2	0	0	0	6 290	6 651	5 546	553	3 984	0
VOC	26	67	3	79	0	0	0	6 298	6 728	5 621	553	3 984	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	0	0	0	0	0	0	0
CO	82	187	0	218	0	0	0	17	6	39	0	0	0
phenols	0	0	0	0	0	0	0	0	0	0	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	0	0	0	0	0	0	0	0	6 822	11 007	300 000	200 000	0
N-tot	288	509	24	594	0	0	0	4 584	20	289	0	20	69 509
NH3-N	0	0	0	0	0	0	0	4 401	1	92	0	10	17 320
NOx-N	286	509	24	594	0	0	0	47	45	129	0	0	0
NO3-N	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O-N	2	19	0	22	0	0	0	92	8	10	0	0	1 449
S-tot	20	11	4	12	0	0	0	5	4	2	0	0	0
SOx-S	20	11	4	12	0	0	0	5	2	2	0	0	0
P-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
Cl-tot	0	0	0	0	0	0	0	0	0	0	0	0	0
K	0	0	0	0	0	0	0	0	0	0	0	0	0
Ca	0	0	0	0	0	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0	0	0	0	0	0
Cch-medium	0	0	0	0	0	0	0	0	0	0	0	0	0
Particles	6	0	1	0	0	0	0	1	0	0	0	0	0
COD	0	0	0	0	0	0	0	0	0	0	0	0	0

Water Emissions from scenario: Windrow compost							**To soil from scenario: Windrow compost**						
(kg/year)	Incineration	Landfilling of waste	Landfilling of sludge	Landf. of w. rem. time	Landf. of sl. rem. time	Soil	Sludge	Anaerob dig. residue	Compost from reactor	Compost from windrow	Manure	Straw	Mineral fertiliser
Ctot-b	0	167	1 590	15	65	0	165 495	0	0	173 514	1 354 200	0	0
Cch-stable	0	0	0	0	0	0	5 696	0	0	159 883	190 320	0	0
Cch-biodegr	0	0	0	0	0	0	28 017	0	0	0	0	0	0
C-fat	0	0	0	0	0	0	66 291	0	0	0	18 300	0	0
C-prot	0	0	0	0	0	0	38 161	0	0	0	168 360	0	0
BOD	0	125	1 192	0	2	0	0	0	0	0	0	0	0
VS	0	0	0	277	0	0	290 750	0	0	273 845	2 854 800	0	0
TS	0	0	0	308	0	0	581 500	0	0	497 704	3 660 000	0	0
CO2-f	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2-b	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	0	0	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0	0	0
CHX	0	0	0	0	0	0	0	0	0	0	0	0	0
AOX	0	0	0	0	0	0	0	0	0	0	0	0	0
PAH	0	0	0	0	0	0	1	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0	0	0
phenols	0	0	0	0	0	0	26	0	0	1	0	0	0
PCB	0	0	0	0	0	0	0	0	0	0	0	0	0
dioxines	0	0	0	0	0	0	0	0	0	0	0	0	0
O-tot	0	0	0	74	0	0	0	0	0	88 241	1 317 600	0	0
H-tot	0	0	0	45	0	0	0	0	0	12 091	135 420	0	0
H2O	0	968 580	5 815 000	2 700 000	1 800 000	0	2 326 000	0	0	497 704	43 340 000	0	0
N-tot	0	21	1 813	23	2 015	46 416	7 850	0	0	4 914	118 389	0	0
NH3-N	0	21	1 813	11	1 007	0	2 791	0	0	134	88 644	0	0
NOx-N	0	0	0	0	0	0	0	0	0	0	0	0	0
NO3-N	0	0	0	12	1 018	46 416	0	0	0	805	0	0	0
N2O-N	0	0	0	0	0	0	0	0	0	0	0	0	0
S-tot	0	2	0	84	0	0	0	0	0	7 250	25 490	0	0
SOx-S	0	0	0	0	0	0	0	0	0	0	0	0	0
P-tot	0	0	633	46	18 556	0	19 190	0	0	3 797	50 580	0	0
Cl-tot	0	180	0	45	0	0	0	0	0	6 207	14 274	0	0
K	0	105	512	26	128	0	640	0	0	12 611	167 340	0	0
Ca	0	200	11 804	86	5 059	0	16 864	0	0	28 012	73 200	0	0
Pb	0	0	0	0	20	0	20	0	0	8	18	0	0
Cd	0	0	0	0	1	0	1	0	0	0	1	0	0
Hg	0	0	0	0	1	0	1	0	0	0	0	0	0
Cu	0	0	0	0	137	0	138	0	0	17	494	0	0
Cr	0	0	0	0	19	0	19	0	0	4	12	0	0
Ni	0	0	0	0	6	0	6	0	0	3	64	0	0
Zn	0	0	1	1	267	0	267	0	0	109	1 294	0	0
Cch-medium	0	0	0	0	0	0	27 331	0	0	13 631	980 880	0	0
Particles	0	0	0	0	0	0	0	0	0	0	0	0	0
COD	0	501	4 769	46	195	0	0	0	0	0	0	0	0

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