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Boldrin, Alessio

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Garden Waste - Results

Results for environmental Assessment of Garden Waste in Herning Kommune

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Alessio Boldrin
Institut for Miljø & Ressourcer
Danmarks Tekniske Universitet

Content

Introduction

This report is part of a project with the objective to perform a lifecycle assessment of the management of household waste in Herning Kommune, Denmark.

The results for treatment of garden waste in Herning Kommune are presented in this report, while the system description (in Danish) is found in appendix 4. A Danish summary of the results is given in the main report of this project.

Results for the basic scenario

The current management of garden waste in Herning Kommune is based on composting of the waste in Østdeponi Affaldsbehandlingsanlæg as described in Annex 4, system description for management of garden waste. Figure 1 reports potential non-toxic environmental impact for the current management scheme.

Transportation of waste to the collection centre by means of private car and the composting process at Østdeponi Affaldsbehandlingsanlæg are the two main sources of environmental impacts of the system. Contributions to photochemical ozone formation come from emissions of Volatile Organic Compounds (VOC) and CO during fuel combustion in engines. Potential impacts on global warming are due to greenhouse gases (GHG) emitted during fuel combustion or during the composting process. The composting process is the main contributor to nutrient enrichment (eutrophication): NO_x are emitted to air from fuel combustion during the use of heavy machinery, ammonia is evaporating to air during the degradation process, nitrate is present in run-off and leaching when compost is used on land. NO_x and ammonia together with SO_2 from engines are also contributing to acidification.

The main credit to the system is due to the use of compost in substitution of peat, especially in terms of global warming (carbon from peat is considered to be of fossil origin). The global warming credit which is attributed to the use of compost on land is mainly due to avoided use of energy for production of commercial fertilizers and carbon bound to soil at the end of the LCA time frame (100 years).

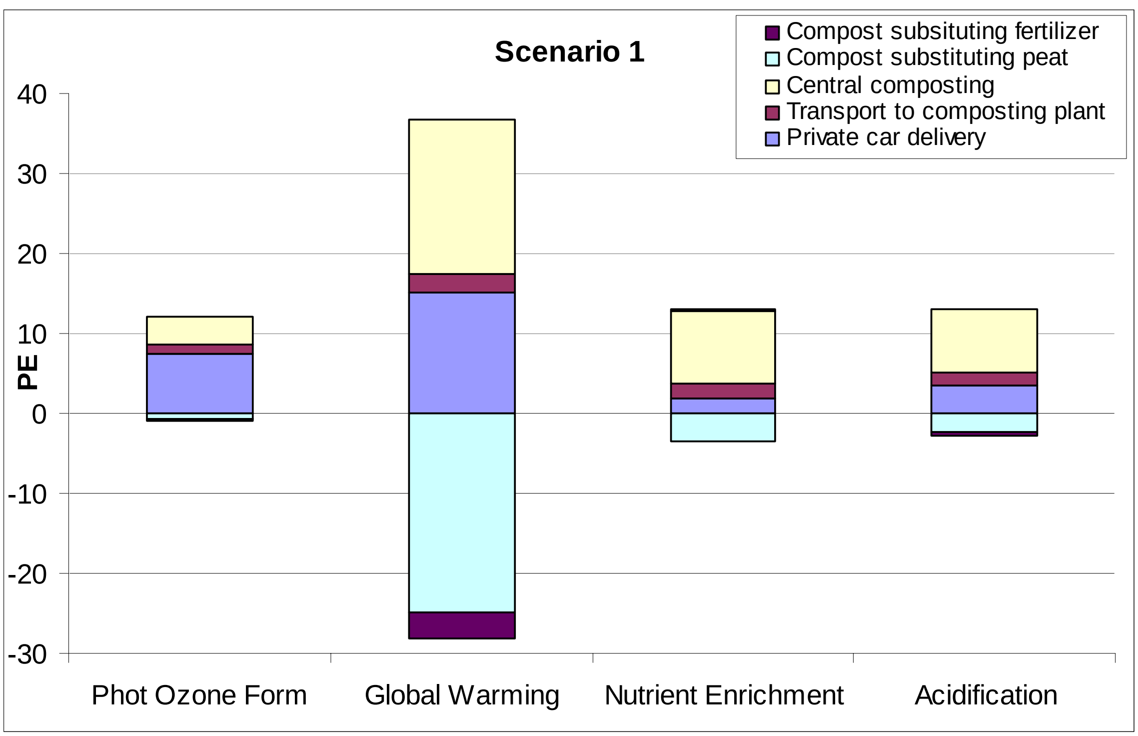

Figure 1 - Potential non-toxic environmental impacts from the current management (3440 tonnes waste).

Figure 2 shows the potential toxic environmental impacts from the current management of garden waste. The impact on human toxicity through soil is very high. Two substances are mainly contributing to it: VOC and heavy metals.
VOC are released during fuel combustion in collection and transportation means and heavy machineries used in the composting facility. Heavy metals are contained in the waste and then spread on land with compost, as they are not degraded during the degradation process. This might anyway not be a realistic situation. In fact, this LCA methodology calculates toxicity based on amount of heavy metals, without considering concentrations. In contrast, as presented in Annex 4, compost respects legal and quality standards, and the chemical composition shows low heavy metals concentrations. This means that compost can be used on land without any significant risks. This can be explained by the fact that most of the heavy metals were originally contained in the soil fraction (see waste chemical composition) and do not contribute to an increase of the background concentration of heavy metals in the soil when they are spread again. This LCA methodology, however, considers all emissions of metals as potentially toxic impacts, even though metals like iron, aluminium and manganese are found in considerably amounts (and concentration) in natural minerals. In this assessment is the characterization of iron from compost set to zero because it occurs natural in soil minerals.
The contribution of waste transportation with private cars to ecotoxicity in water is also due to some compounds from fuel combustion.

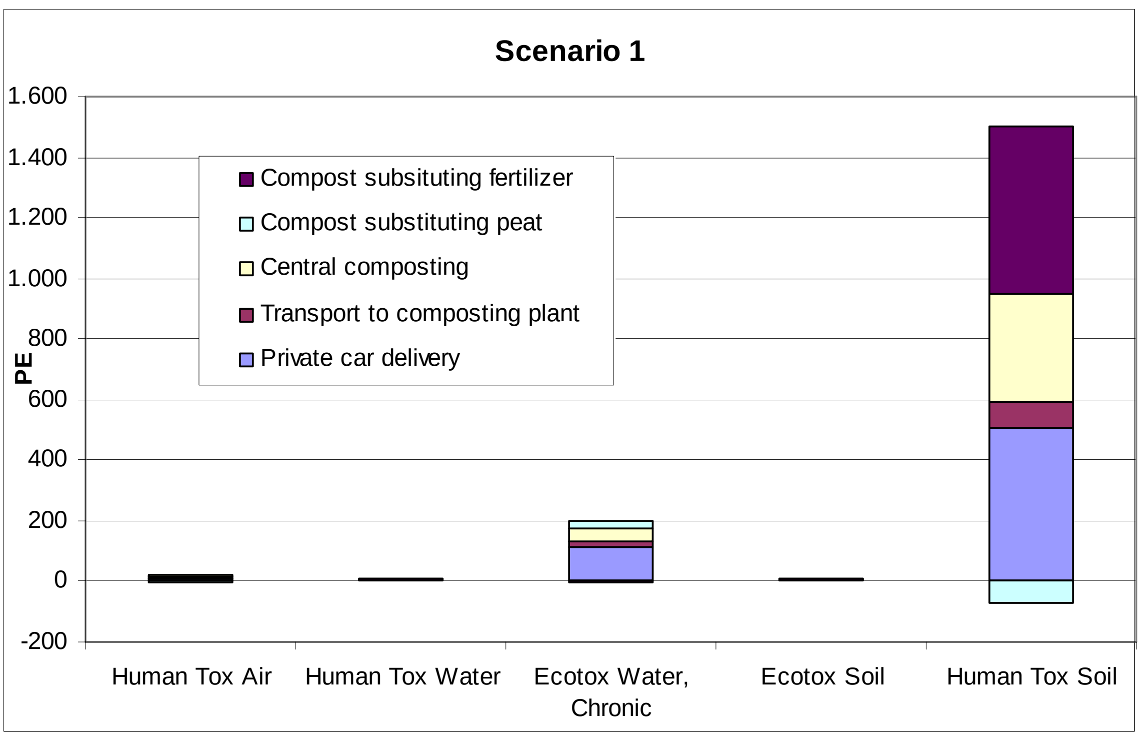

Figure 2 - Potential toxic environmental impact from the current management (3440 tonnes waste).

Results for Scenario 2

Scenario 2 is described in Annex 2 and includes incineration of a part of the garden waste collected at the collection centre.
Figure 3 presents potential non-toxic impacts for scenario 2. All the waste is collected at Nederkærgård Genbrugs- og Affaldsplads and therefore the impact of transportation with private car is the same as in the basic scenario.

Energy produced by incineration in Knudmoseværket offsets energy produced by a nearby plant co-fired with biomass and natural gas. Incineration has, however, a net impact on global warming, acidification and eutrophication. This is mainly due to the fact that the energy substitution is less efficient in Herning Kommune because incineration of garden waste replaces burning of biomass and natural gas and results in additional supply of electricity based on coal. The substitution of energy produced by the incinerator is further described in Annex 1.

The main impact on the environmental is probably nutrient enrichment (eutrophication), with important contribution from both treatments. Incineration is contributing through NO_x produced during the combustion, while composting is contributing with ammonia evaporated during the process and nitrates leaching or running off when compost is used on land. Impact on acidification is similar to Scenario 1. NO_x, which form during combustion in engines, is in fact the main contributor. Reduced emissions from decreased use of heavy machinery are counterbalanced by NO_x emitted from the incinerator.

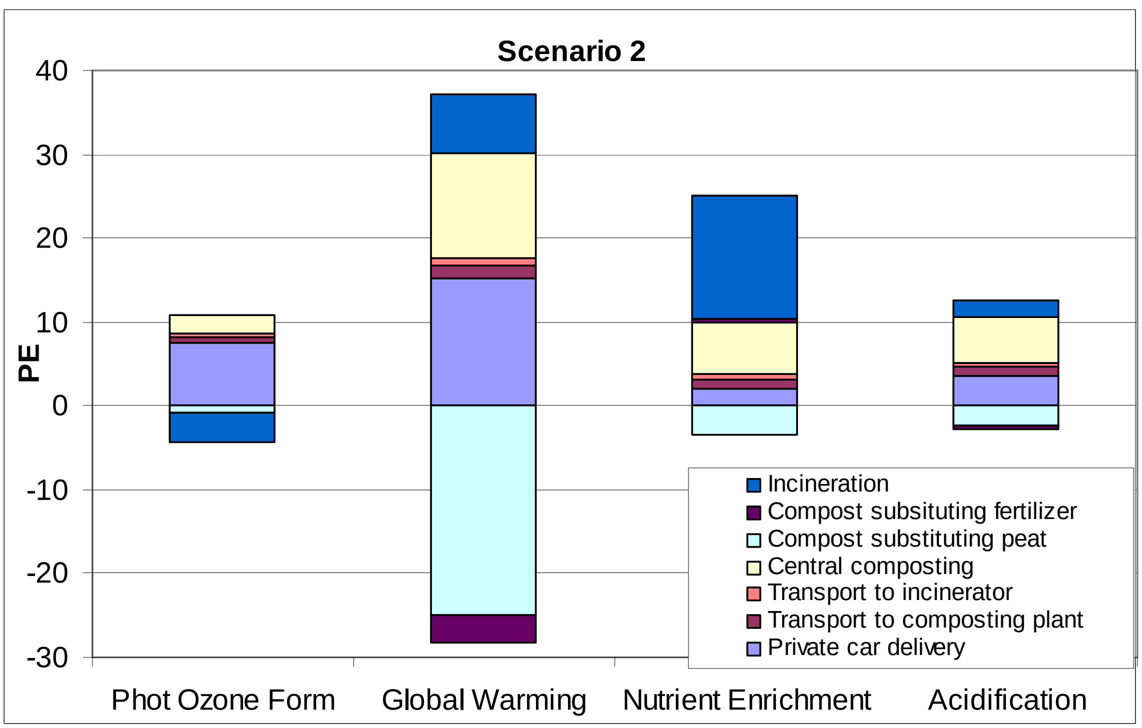

Figure 3 - Potential non-toxic environmental impacts from Scenario 2 (3440 tonnes waste).

Figure 4 presents results for the potential toxic environmental impacts for Scenario 2. Human toxicity through soil is still very high for the same reasons explained before (heavy metals in compost and VOC from fuel combustion). Incineration is lowering the impact on human toxicity through soil, as less waste is treated with composting with consequent lower emissions of VOC from heavy machinery. As it was assumed the amount of compost sold is still 500 tonnes (as in the basic scenario), the toxicity caused by heavy metals contained in compost is obviously the same as in the basic scenario.

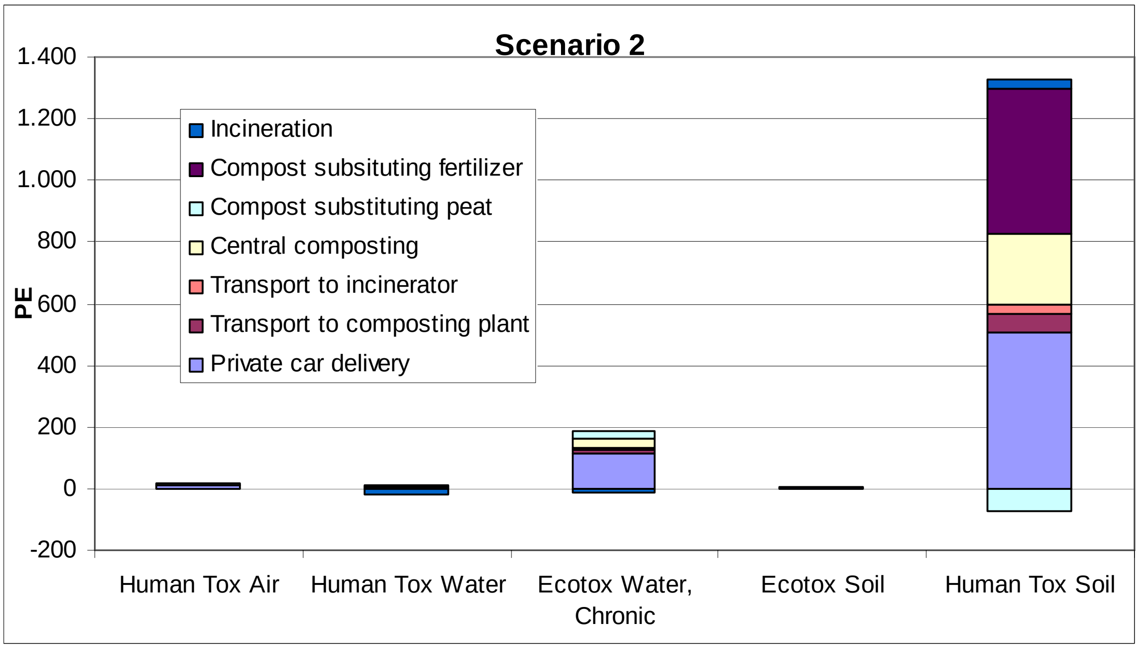

Figure 4 - Potential toxic environmental impact for scenario 2 (3440 tonnes waste).

Results for scenario 3

Scenario 3 is described in Annex 4. Source separation is performed, part of the waste is home composted and the rest is collected and composted in the central facility.

For the non-toxic categories of impact presented in Figure 6, home-composting will have two main benefits. Less waste is transported by mean of private car with a consequent lower impact from the collection phase. Increased utilization of the produced compost results in large crediting for all the impact categories. The reduced use of heavy machinery during central composting has a very beneficial effect on both photochemical ozone formation and acidification, because of the important reduction in VOC and NO_x emissions.

Results on the potential toxic environmental impacts for Scenario 3 are presented in

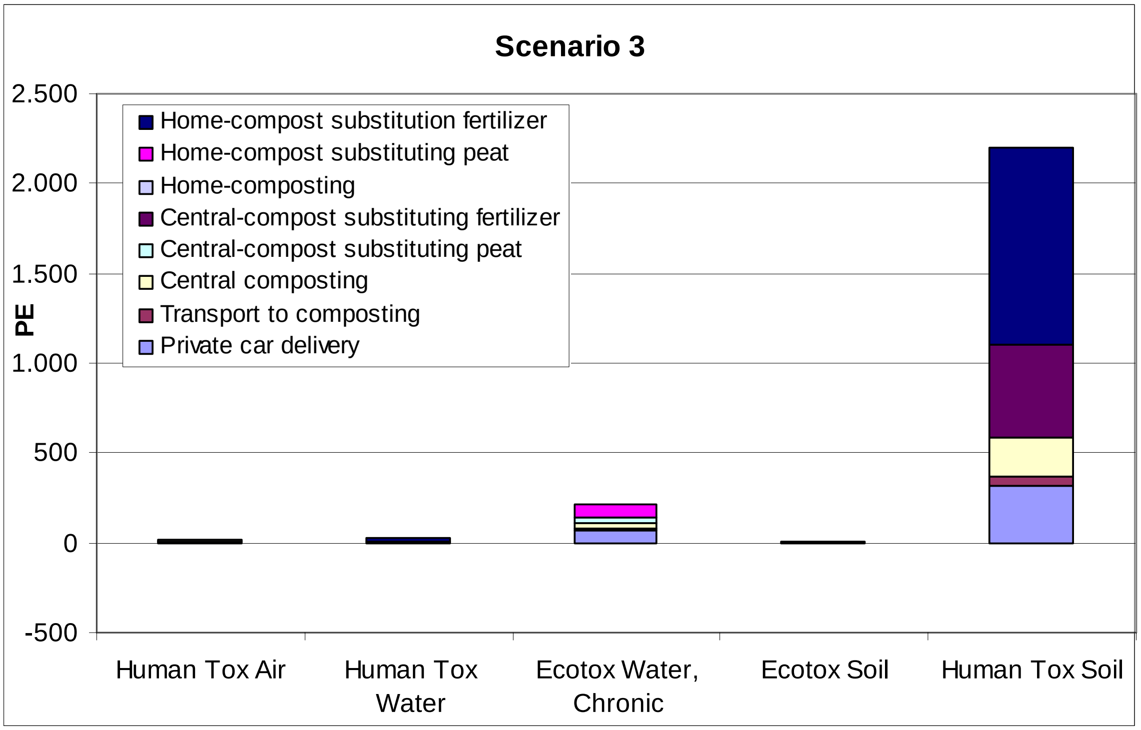

Figure 7. The reduced use of car transportation would result in a lower toxicity from fuel combustion. A major utilization of compost on land shows a higher human toxicity through soil as a consequence of the heavy metals spread on land. The explanation regarding heavy metals on soil made in scenario 1 is also valid here.

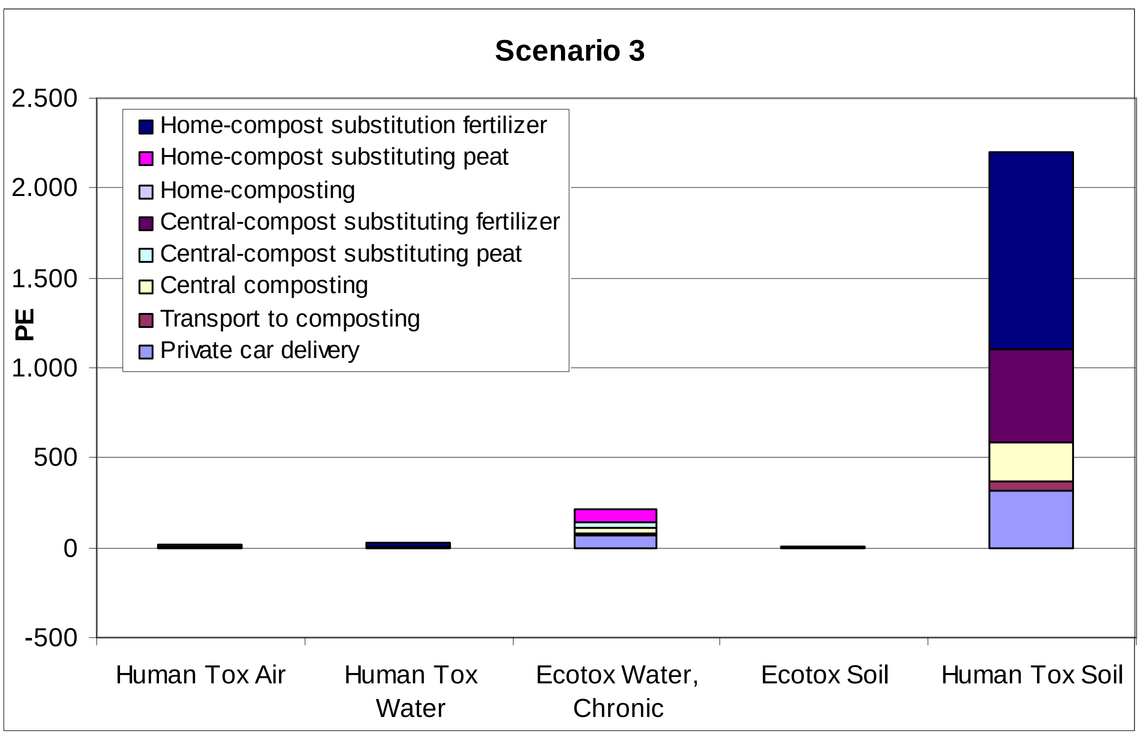

Figure 5 - Potential toxic environmental impacts for scenario 3 (3440 tonnes waste).

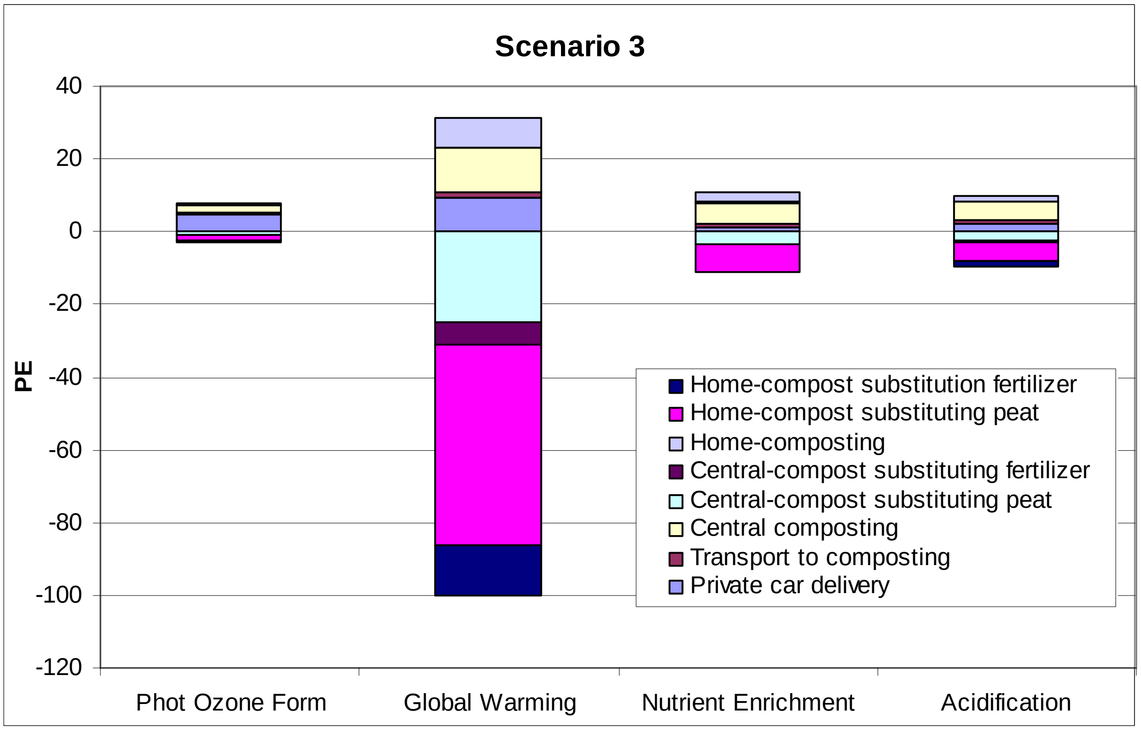

Figure 6 - Potential non-toxic environmental impacts for scenario 3 (3440 tonnes waste).

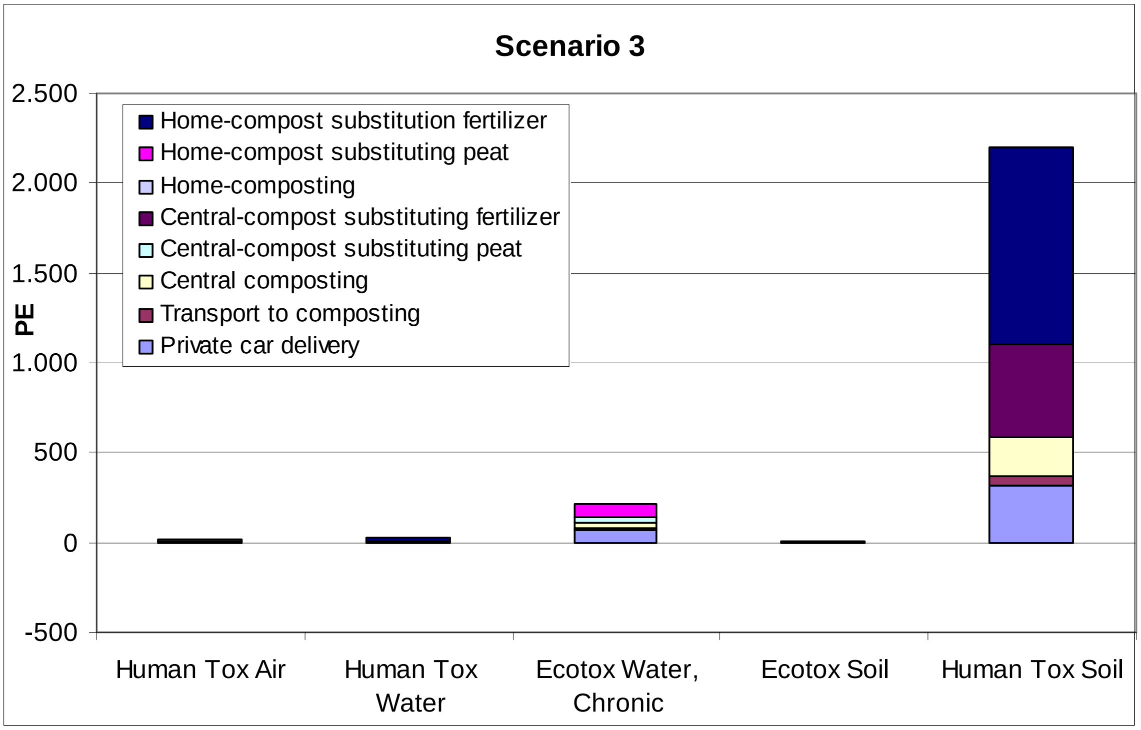

Figure 7 - Potential toxic environmental impacts for Scenario 3 (3440 tonnes waste).

Results for scenario 4

Scenario 4 is described in Annex 4. Source separation is performed, part of the waste is home composted and the rest is collected in Nederkærgård Genbrugs- og Affaldsplads after transportation with private car. The coarse fraction is then incinerated, while the finer fractions are composted in the central facility.

Figure 8 and Figure 9 present potential impacts for Scenario 4. It is the results of positive and negative contributions described before for Scenario 2 and 3 since this scenario is a combination of the two other scenarios. Among the positive: reduced transportation by car, reduce use of heavy machinery, increased use of compost. Among the negative: increased spread of heavy metals on soil, emission of NO_x during incineration contributing to eutrophication.

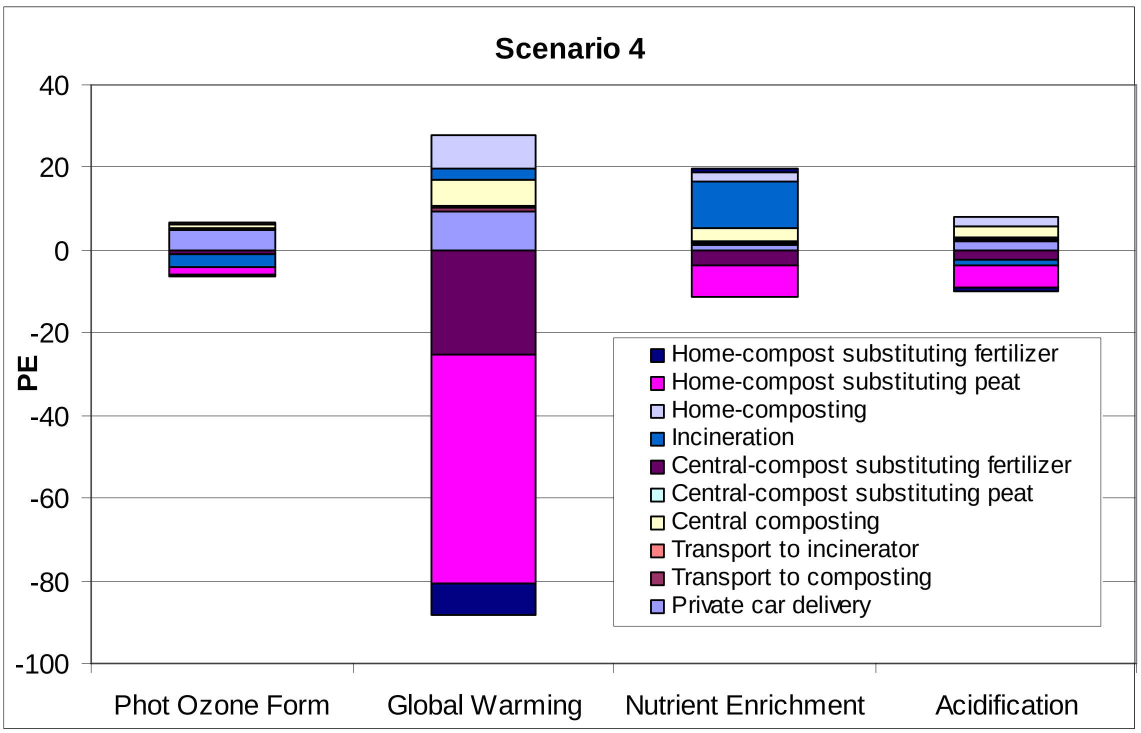

Figure 8 - Potential non-toxic environmental impacts for scenario 4 (3440 tonnes waste).

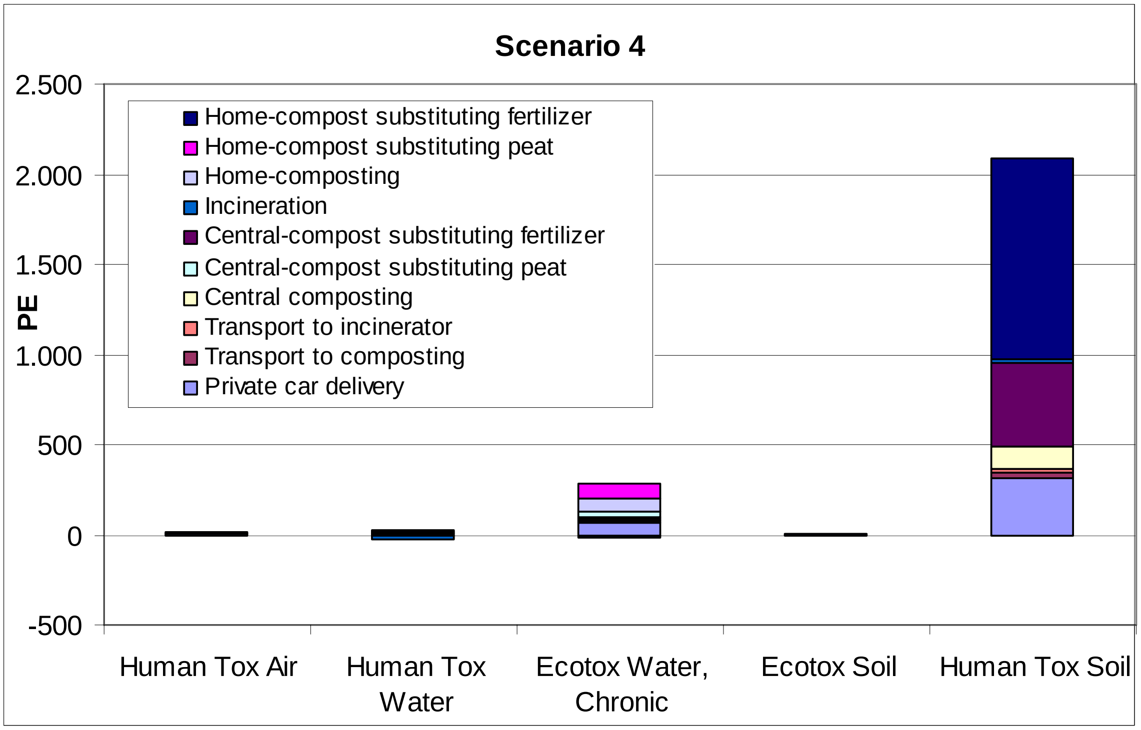

Figure 9 - Potential toxic environmental impacts for Scenario 4 (3440 tonnes waste).

Scenarios comparison

Figure 10 and Figure 11 present results on potential impact for all the analyzed scenarios in a comparative form.

For the non-toxic categories the introduction of home composting is improving the environmental performance in all the categories, which was shown in Scenario 3 and 4. The main reasons for it are the reduced transportation of waste by mean of private cars and the utilization of compost (both as a fertilizer and as a pet substitute) to a larger extent. Especially, the substitution of peat is important because it avoids emission of carbon of fossil origin.

Incineration that was a treatment option in Scenario 2 and 4 performs better than central composting for photochemical ozone formation, because of the decreased emissions of VOC from heavy machineries used during composting. Composting performs better than incineration for nutrient enrichment category. The difference is due to high emissions of NO_x during incineration. The difference for acidification is less pronounced, but is slightly in favour of incineration.

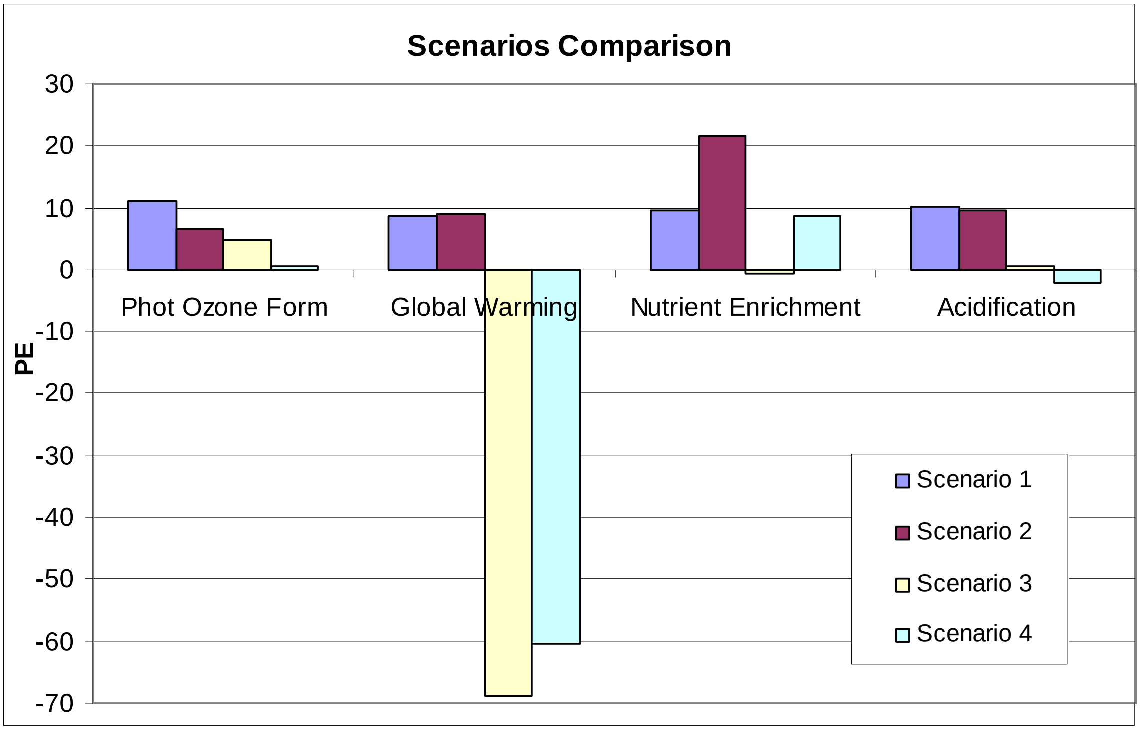

Figure 10 - Comparative potential non-toxic environmental impacts for analyzed scenarios (3440 tonnes waste).

Toxic categories show high potential impact on human toxicity through soil for all the analysed scenarios. The last two scenarios with home-composting perform worse. It is in fact assumed that the home-composting option will lead to more compost to be used on land. The human toxicity through soil is therefore increased as more heavy metals are spread on land with the compost. On the other side, home-composting has a reduced toxicity related to VOC emitted from fuel combustion (especially from private cars), which was the main contributor to this category for the first two scenarios.

The variation between the scenarios for the other toxic impact categories is less pronounced. In general, it seems that incineration performs better than composting and central composting performs better home-composting.

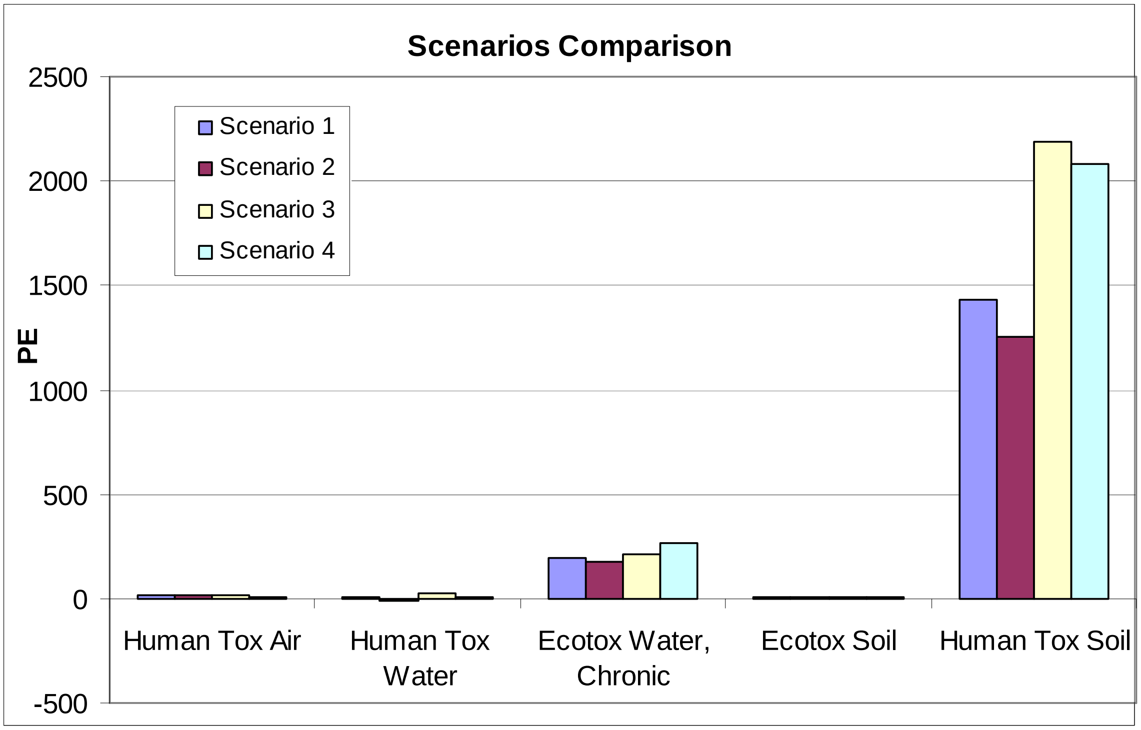

Figure 11 - Comparative potential toxic environmental impacts for analyzed scenarios (3440 tonnes waste).

Figure 12 presents the potential natural resource consumption for the four analyzed scenarios. Only two resources are relevant for the assessment: crude oil and natural gas. They are both related to energy utilization, as a fuel in cars and heavy machineries or as credited fuel in the incinerator. In both cases the magnitude of the impact is quite low, in the order of few PR.

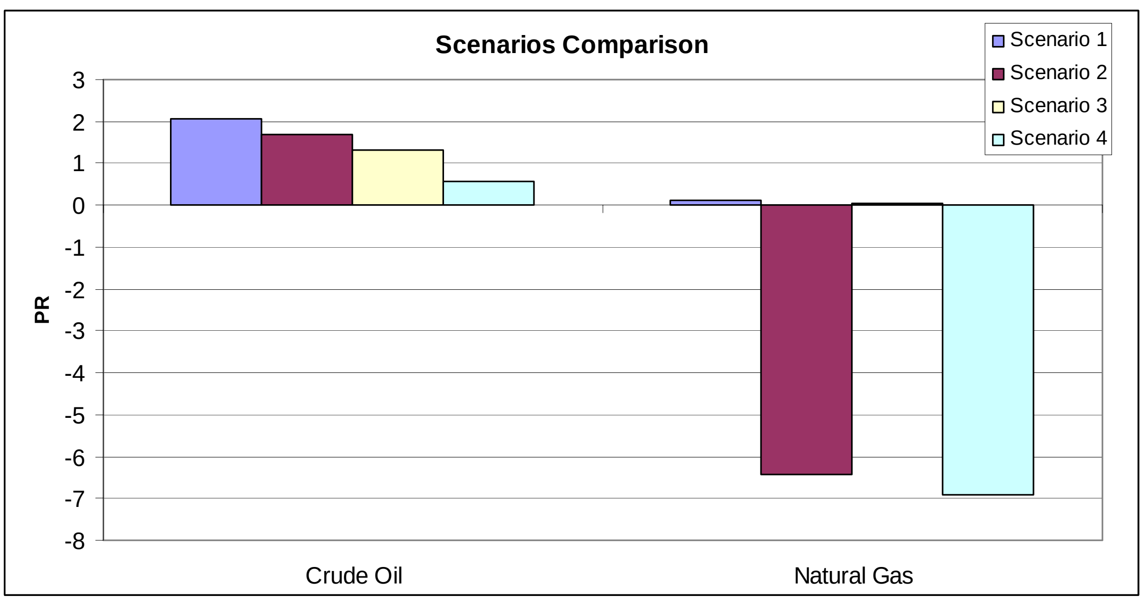

Figure 12 - Potential natural resource consumption for the analyzed scenarios (3440 tonnes waste).

Scenario 4 performs better than the others for the both resources. For crude oil the explanation is in the reduced use of heavy machineries and car transportation. Natural gas has a negative consumption result because burning of waste in Knudmoseværket prevents use of natural gas in co-fired biomass and natural gas plant. This amount of natural gas is therefore credited to the system.

Ideal current management

Possible improvements in the current scenario without introducing new technologies or schemes have been simulated. It was considered that all the compost produced at Østdeponi Affaldsbehandlingsanlæg was sent back to the collection centre, distributed to citizens and finally used as a soil improver. It was assumed that 70 % of the produced compost was substituting peat in growing media and 30 % was used on land as substitute for commercial fertilizers.

Figure 13 reports potential non-toxic environmental impacts for an ideal Scenario 1 compare to the original scenario 1. Replacements of peat or mineral fertilizers result in reduced environmental loads for all the considered impact categories. For global warming there is a consistent benefit, mainly due to avoided peat-related emissions of carbon dioxide.

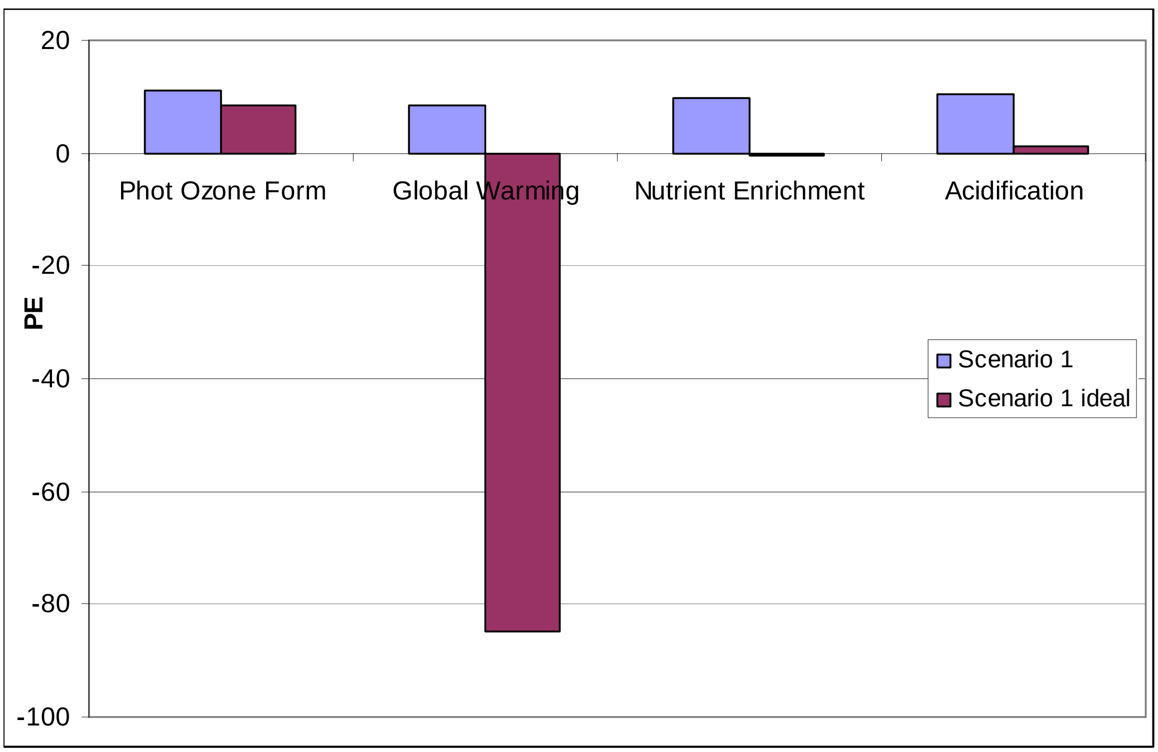

Figure 13 - Potential non-toxic environmental impacts for ideal Scenario 1 (3440 tonnes waste).

Figure 14 presents a comparison of the real and the ideal Scenario 1 in terms of potential toxic impact categories. A major use of compost results in increased human toxicity through soil, as a bigger amount of heavy metals is spread on the environment. Interpretation and explanation of such results can be the same as presented for scenario 1.

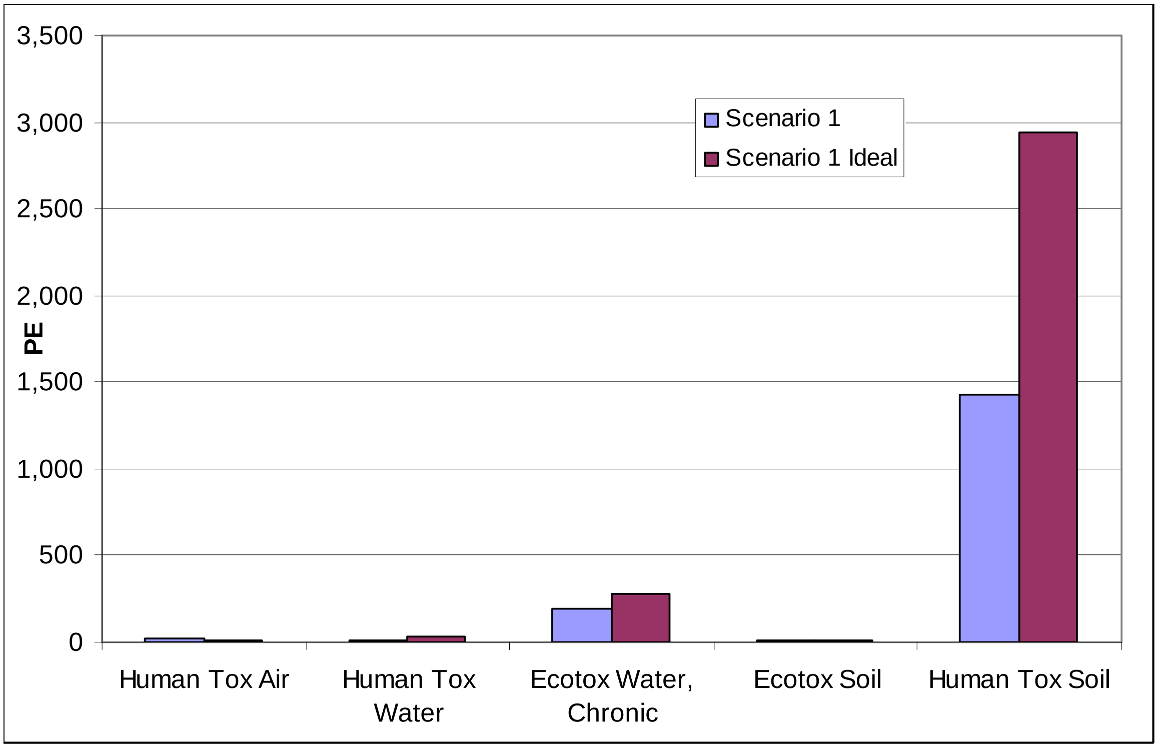

Figure 14 - Potential toxic environmental impact for ideal Scenario 1 (3440 tonnes waste).

Other environmental impacts

The assessment does not include impact assessment of rejects or secondary outputs from the treatments.

At the end of the composting process, the material is screened. The reject fraction is recirculated internally and mixed to waste as structure material. This reject is mainly composed of coarse pieces of wood which have not degraded. In addition, stones and other foreign objects are present, which are eventually separated at a certain point and taken to treatment or disposal. In particular, foreign objects would probably undergo incineration, as they contain plastic, glass, paper and other materials which cannot be separated. As the composition is unknown, the assessment of this stream was not included. However, this stream is very small and probably has not a crucial influence on the final result.

Home compost can also contain foreign objects. It is supposed that these materials (plastic bags, glass, etc.) are removed by the user when spreading compost on the soil and disposed with household waste.

An incinerator has some outputs which are not accounted in the assessment. These outputs are usually routed to further utilization or disposal. Amounts of produced bottom ash and fly ash for the two scenarios including incineration are reported in the next Table 1.

Table 1 – Incineration-related environmental loads not included in the assessment.

		Scenario 2	Scenario 4
Waste input to incineration	Ton	1175	1000
Bottom ash output	Ton	202	112
Fly ash output	Ton	41	23

Sensitivity and uncertainty analysis

Some of the uncertain or assumed parameters were screened to evaluate their impact on the final results. Results are reported in the following Table 2.

The indicated parameters were altered and the computation performed again. Original and new results were compared and the difference was calculated in terms of PE. The relative deviation of the new result from the original value was finally calculated as ratio between the deviation and the total environmental load (both positive and negative loads) of the original scheme. The relative deviation gives an idea of the uncertainty correlated to the considered factor with respect to the environmental load of the considered scenario.

Table 2 - Sensitivity analysis for some key parameters.

Parameter	Base case		Altered assumption	Deviation	Deviation (%)
	Value	Scenario			
Collection with car	12,5 l/ton	1	10 l/ton	GW = -3 PE POF = -0,6 PE NE = -0,4 PE AC = -0,7 PE	-4,6 % -12 % -2,4 % -4,5 %
Methane emissions from central compost	2% of degraded C	1	4% of degraded C	GW = + 5,5 PE	+ 8,5 %
Methane emissions from home compost	3% of degraded C	3	6% of degraded C	GW = + 3 PE	+ 2,3 %
N_2O emissions from central compost	1,4 % of lost N	1	3 % of lost N	GW = +9,5 PE	+ 14,6 %
N_2O emissions from home compost	2,4 % of lost N	3	5 % of lost N	GW = + 5,9 PE	+ 4,5 %
Utilization of compost (peat-fertilizer)	70% peat 30% fertilizer	1	30% peat 70% fertilizer	GW = +14 PE POF = +0,4 PE NE = +2 PE AC = +0,7 PE	+23 % +4 % +12 % +9 %

The response of the system to the performed changes resulted quite low (most of the changes had an influence on the final results around or below 5%). The calculation is therefore quite stable and the system is considered to be buffered towards uncertainties.

When changed, few parameters could make a difference in the final result bigger than 10 %. These parameters can therefore be considered crucial for the assessment. Values used for fuel consumption during collection and N_2O emissions during compost are quite certain value and it is believe they cannot be much different from the assumed ones.

Distribution of compost between different possibilities is instead quite uncertain and it was not verified on the real situation. From the simulation of an ideal scenario 1 (previous chapter) and the sensitivity analysis it can be concluded that the utilization of compost is beneficial to the environment for most of the aspects. The use of compost as peat substitute amplifies such benefits.

Recommendations and conclusion

Clear differences were found among scenarios. Results were quite distinct from each other even after the uncertainties were estimated. It can be concluded that a different approach might convert the management to a more sustainable resources utilization stage, where waste is not only disposed but represents a potential source of recoverable benefits which are not exploited in the current real situation.

Recommendations to the current management:

- Marketing of compost produced at Østdeponi Affaldsbehandlingsanlæg, with both economic and environmental benefits.
- Improvements in the composting technique to decrease emissions of GHG from windrows. Although it is not sure what the real emissions are, it is likely that waste can be composted with lower GHG emissions with the right techniques.
- Consider a possible alternative collection scheme for waste using more efficient mean of transportation and collection schemes.

Recommendations for eventual alternative scenarios:

- If garden waste is used for incineration, the produced energy should displace energy sources with a higher environmental load than biomasses.
- If home composting is to be implemented, a good practice for both process management and use of compost on soil should be ensured to avoid collateral impact such as high GHG emissions or overspreading of nutrients on land.

Results are mainly influenced by:

- Incinerator's performance is very dependent on the energy substitution, which in this case is energy produced in a co-fired biomass and natural gas plant. Therefore there is only low credit in environmental impact terms with respect to the substituted marginal energy. For some emissions there is indeed an additional environmental load.
- Compost produced in the central plant is mainly used on the landfill top cover. This leads to no additional crediting to the system. Utilization of compost both on land and in preparation of growth media leads to several benefits the system can be credited for as it is considered in the case where home-composting is performed.
- Private car has a high impact on the assessment. It is a process with high consumption of fuel per ton of waste, with a consequently high impact on global warming and resource consumption. The exhaust gases cause emissions to atmosphere of NO_x and VOC, having a significant impact on all impact categories and especially on human toxicity through soil, explicated after deposition of VOC on soil. When home composting is performed and car transportation is avoided the environmental load is sensibly decreased.
- Truck transportation has a low environmental impact on all the impact categories, mainly due to the short distance the waste is transported.
- Metals contained in waste are not degraded during the process and are eventually spread on land with compost. Being an important amount of compost, the

environmental load of the metals is very high. The results should be interpreted considering two factors which the LCA method does not account for:

- Toxicity is ruled more by concentration than amount of heavy metals. Soil has a buffering capacity for heavy metals. If good practice for compost production is respected, accumulation of heavy metals in soil to a dangerous level will only take place in a very long time lapse.
- All emissions of metals are considered potentially toxic, even though most of the metals in compost origin from biogenic sources and are bound in natural minerals.