Institut
Materialfluss
und Logistik

Institute for Material
Flow and Logistics

Summary

Fraunhofer Study

Life-Cycle Analysis of the Removal of Incontinence System Waste from Public Establishments

Contents

1. Introduction

Knowaste BV has developed and patented an innovative method for processing Incontinence System Waste, or ISA for short. After the method had been tested in a pilot plant in Canada, the first plant was opened in 1999 in Arnhem. This plant is the subject of the life-cycle analysis drawn up by the independent Fraunhofer Institute for Material Flow and Logistics IML in Dortmund. The plant has a capacity of 70,000 tonnes of ISA per annum. This ISA will be collected from care institutions in the Netherlands and Germany.

The German Closed Substance Cycle Waste Management Act (KrW-/AbfG), the basis of German policy on waste, states that waste must, if at all possible, be avoided. Unavoidable waste must be processed in an economically and ecologically responsible way (see appendix). The study question for the life-cycle analysis is:

Is it, in view of environmental acceptability, better to process (recycle) ISA or to definitively dispose of (incinerate) it?

This question is conveyed in the appendix at the point where the red lines change into blue ones. The dark blue lines convey the processing of ISA and the light blue ones the disposal of it. Processing to produce energy only makes sense for substances for which the incineration value is at least 11 MJ/kg. To incinerate substances with a lower incineration value, energy must be supplied; this yields no energy. In view of the fact that the incineration value of the ISA amounts to approximately 7.5 MJ/kg, processing to produce energy is out of the question. In this scheme, definitive destruction remains the only alternative. Definitive destruction can be carried out with or without the recovery of energy. In view of the fact that destruction with energy recovery is the better of the two, this is chosen as the reference process for the processing according to Knowaste.

The aim of the study is:

To quantify and compare the environmental impact of recycling and incinerating and the prevented environmental impact (resulting from the fact that various raw materials and production processes are cut down). The resultant net effects are conveyed in selected environment categories.

The system boundaries (the study territory) of this life-cycle analysis include the collection, transshipment, transportation and treatment (recycling or incineration) of the ISA and the transportation of the resulting end products. All logistical and production technology processes for making energy and raw materials available are included in the life-cycle analysis.

Figure 1 illustrates the average composition of ISA from care institutions.

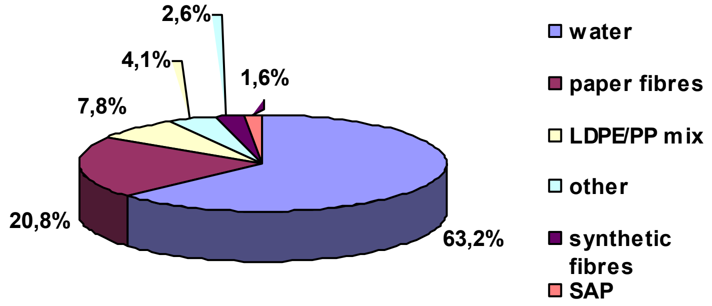


figure 1: composition of ISA

2. Processing of ISA by Knowaste

Figure 2 illustrates the material analysis for the processing of ISA by Knowaste through maximum utilisation of the capacity.

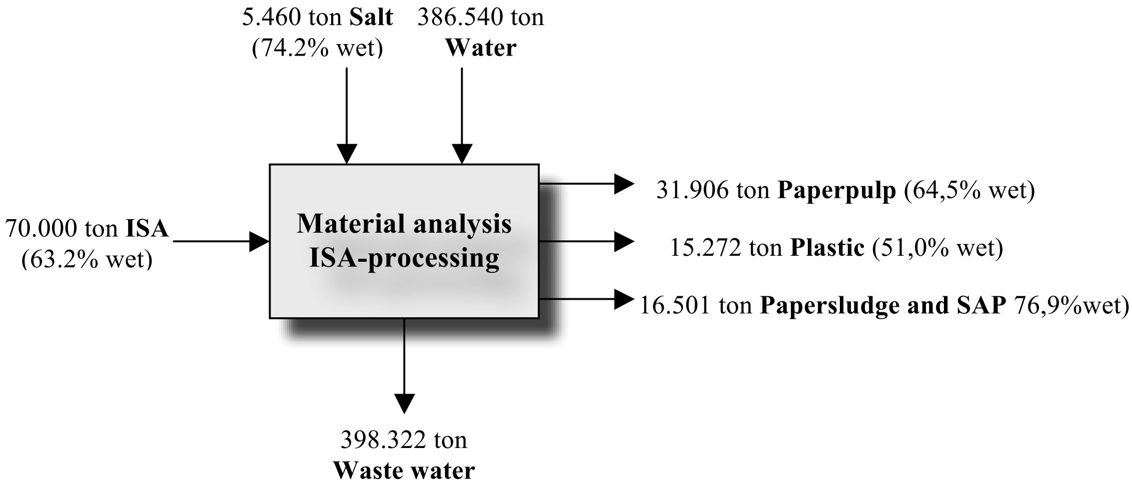


Figure 2: Knowaste Material analysis

The Knowaste process starts with the collection and transportation of the ISA from care institutions. Once it has arrived at Knowaste the ISA is put through a shredder. The shredded ISA is mixed with water into a pulp, which means the plastic can be detached and separated. The mixture is disinfected. The *plastic* is washed, dehydrated and pressed into bales. The remaining pulp mixture is filtered and the SAP grains are deactivated using inorganic salt. The mixture then undergoes several filters, cycles and washes which clear the paper of SAP and other contaminants. The *paper pulp* is also pressed into bales. The *paper sludge and the SAP grains* remain as residual current and are discharged into containers.

Paper pulp
The reclaimed paper pulp can replace primary paper pulp. The re-use of Knowaste paper pulp leads to a saving in the production of primary paper pulp.

Plastic
The plastic can be recycled to produce substances or recover energy. Three scenarios have been devised:
1. Plastic is recycled fully to produce energy, which results in a saving in the normal production of thermal energy.
2. Plastic is recycled at a rate of 51.4% to produce energy and 48.6% to produce substances. As well as a saving on the normal production of thermal energy this also leads to a saving in the production of a similar plastic.
3. Plastic is recycled at a rate of 97.2% to produce substances and 2.8% to produce energy.

Paper sludge and SAP
There was still no range of applications for SAP at the time the study was carried out. The SAP is, therefore, not (yet) separated individually but is added to the paper sludge. The paper sludge and the SAP are dried, and then recycled to produce energy. This leads to a saving in the normal production of thermal energy.

As well as the collection and processing of the ISA in the Knowaste plant the following processes are included in the analysis:

Processes to be carried out	**Processes avoided**
Transportation of paper pulp, plastic and paper sludge	Production of primary paper pulp
Plastic incineration	Production of primary plastic (*not in scenario 1*)
Plastic granulation (*not in scenario 1*)	Production of thermal energy
Drying paper sludge	
Incinerating paper sludge	
Biological water purification	

Figure 3 illustrates the modular structure of the three Knowaste scenarios.

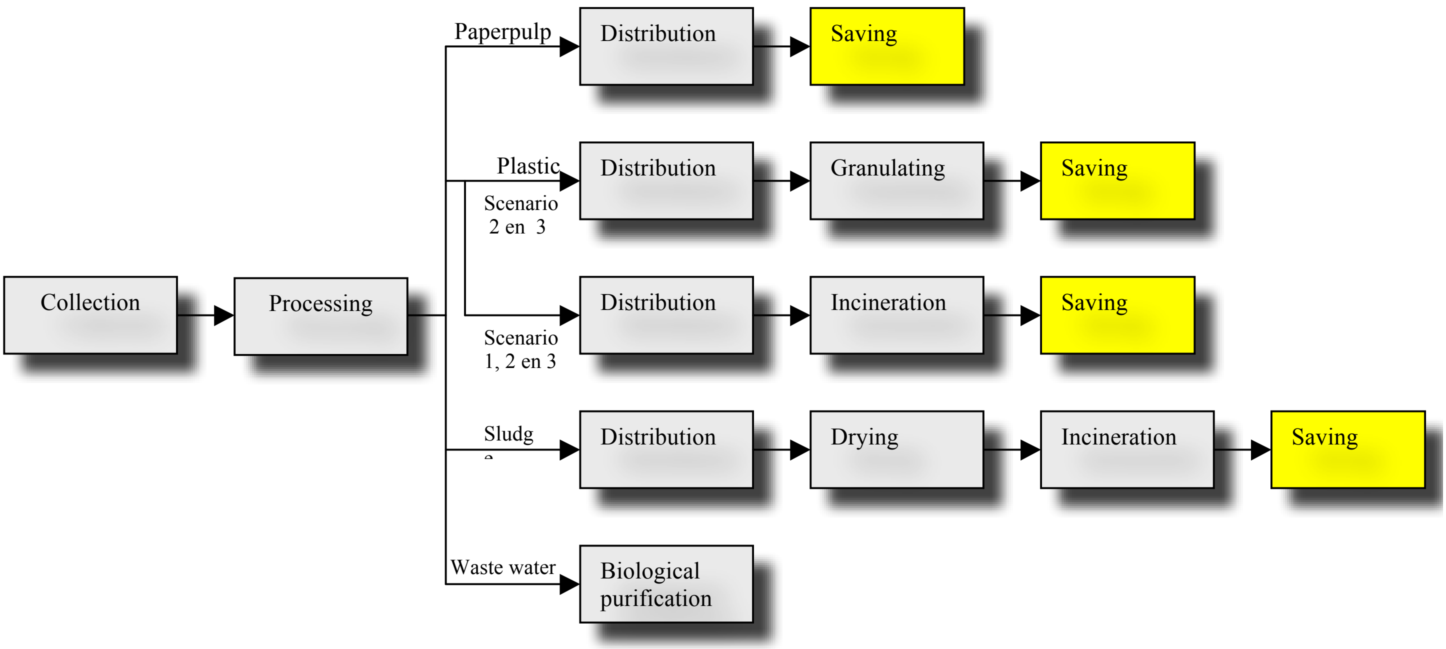


Figure 3: Modular structure of the three Knowaste scenarios

3. Thermal processing of ISA

The thermal processing of ISA was chosen as a reference process in the Borsigstraße waste incineration plant (WIP) in Hamburg. This WIP was chosen because it makes use of the best techniques available for processing waste. The starting point for a collection and transportation model was the ideal situation: a high population density and short transport distances. The thermal processing of ISA can therefore be labelled as best practice: the most favourable method for processing an ISA thermally.

The process starts with the collection and transportation of ISA as part of the company waste from care institutions. Once at the WIP the waste is shredded and homogenised. It is then incinerated in furnaces and steam is produced. Part of the steam is used internally and the rest is used for district heating.

In addition to the collection of the ISA and the incineration in the WIP the following processes are included in the analysis:

Processes to be carried out	**Processes avoided**
Transportation of steam, gypsum and acids	Production of thermal energy
	Production of Gypsum
	Production of acids

Figure 4 illustrates the modular structure of the disposal scenario with the recovery of thermal energy.

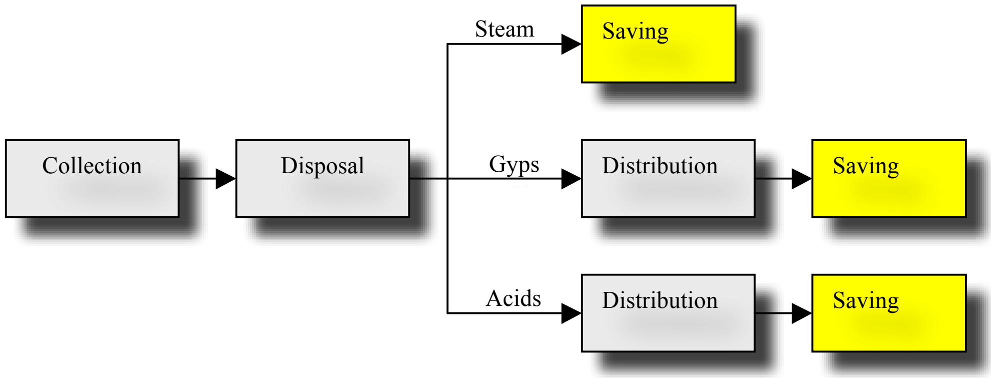


Figure 4: Modular structure of the WIP reference scenario

4. Comparison

Table 1 illustrates the life-cycle analysis result for the 9 environmental categories under consideration.

Table 1 Analysis of results

Category Values printed per tonne ISA	**Knowaste scenario 1**	**Knowaste scenario 2**	**Knowaste scenario 3**	**WIP best practice**
Energy consumption (MJ)	-5,994.5	-6,664.9	-7,335.3	-5,5576.1
Consumption of energy-carrying raw material (kg)	-424.7	-435.9	-447.2	-140.7
Consumption of non energy-carrying raw material (kg)	1.1	0.8	0.5	-
Water consumption (m³)	-6.6	-7.4	-8.2	1.1
Refuse (kg)	0.5	-1.0	-2.6	2.0
Processable waste (kg)	10.5	10.2	9.8	2.0
Eutrophication potential (g PO_4)	-148.8	-202.7	-256.6	65.4
Acidification potential (g SO_4)	-2.6	-26.4	-50.2	12.7
Greenhouse gas potential (kg CO_2)	284	195.5	107	33.7

**the energy consumption for an average WIP is –4731 MJ*

Negative values in the table represent *environmental protection*; positive values represent *environmental pollution*.

Energy consumption
The energy savings in the three Knowaste scenarios are brought about by avoiding the production of primary paper pulp and by saving on the creation of thermal energy with fossil fuels. In scenarios 2 and 3 the saving on the production of primary plastic contributes to the reduced energy consumption. When plastic is recycled to produce substances more energy is saved than can be gained by incineration.

The energy saving with the WIP is brought about by the production of steam. This saving is lower than that in the three Knowaste scenarios.

Consumption of energy-carrying raw materials
This category is directly linked to the category of energy consumption. However, the greater difference between the three Knowaste scenarios and the WIP for the use of energy-carrying raw materials is due to the relatively low incineration value of wood in relation to fossil fuels.

Consumption of non energy-carrying raw materials
The value of this category is not specified for the WIP. Whilst it will be higher in reality, a value of zero is assumed in the study.

The positive values for the Knowaste scenarios result from raw materials required for water purification. The saving on the production of primary plastic provides a negative contribution, on account of which scenarios 2 and 3 in this category have lower values than scenario 1.

Water consumption
Knowaste uses water for the separation process itself and mainly cooling water to dry the paper sludge. A much larger volume of water, however, is saved by economising on the production of primary paper sludge and primary plastic.

The WIP uses water for flue gas cleaning.

Refuse
In the ISA incineration processes, sludge and plastic, and in the water purification installation, waste remains that is extracted from the economic cycle. In scenarios 2 and 3 of Knowaste, however, the saving of refuse is the dominant feature through the avoided production of primary plastic.

Processable waste
In the WIP, boiler and filtering materials that can be re-used to produce substances or energy are left behind.

At Knowaste the waste from the water purification installations remains as processable waste.

Eutrophication potential
The emissions of oxides of nitrogen in the WIP are higher than the saved emissions through the avoided production of thermal energy.

At Knowaste the saved emissions are the decisive factor because of the avoided production of primary paper pulp and plastic.

Acidification potential
Here too the saved emissions through the avoided production of thermal energy cannot counterbalance the emissions from the WIP.

At Knowaste, the saved emissions through the avoided production of primary paper pulp and plastic are once again the determining factor.

Greenhouse gas potential
The carbon dioxide emissions have had the greatest influence on the greenhouse effect. To determine greenhouse gas potential only the CO_2 emissions that are released when fossil fuels are incinerated are included. Paper pulp, for example, originates from the so-called "sustainable raw material" wood and is not counted, while plastic originates from the fossil raw material oil and does count. In scenario 1 all fossil fuels are incinerated in the ISA and the CO_2 emission is equal to that of the WIP. The complete incineration in the WIP does, however, provide more energy (even the paper pulp is incinerated), on account of which the avoided production of thermal energy and the associated CO_2 emission is greater in the WIP.

In the production of paper pulp, wood is practically the only fossil fuel to be used. The avoided production of primary pulp provides a slight contribution towards CO_2 saving.

The use of electrical energy and the more unfavourable logistical position of Knowaste also contribute towards the large difference from the WIP.

In scenarios 2 and 3 a part of the plastic is no longer incinerated, and this results in lower CO_2 emissions. On top of this, savings in CO_2 emissions are made by the avoided production of primary plastic.

The results for greenhouse gas potential very much depend on the selected boundaries. Within these system boundaries, avoiding primary pulp production does not cut down CO_2 emissions, since the wood is used as fuel for the production. However, if we broaden the system boundaries further then the amount of wood saved can be used elsewhere to replace a fossil fuel. The avoidance of primary paper pulp production would then result in a fall in CO_2. In table 2 the figures for greenhouse gas potential are recalculated for the situation where the amount of wood saved is used for the production of electricity. The wood, in turn, replaces natural gas, pit coal and the power mix used in Germany.

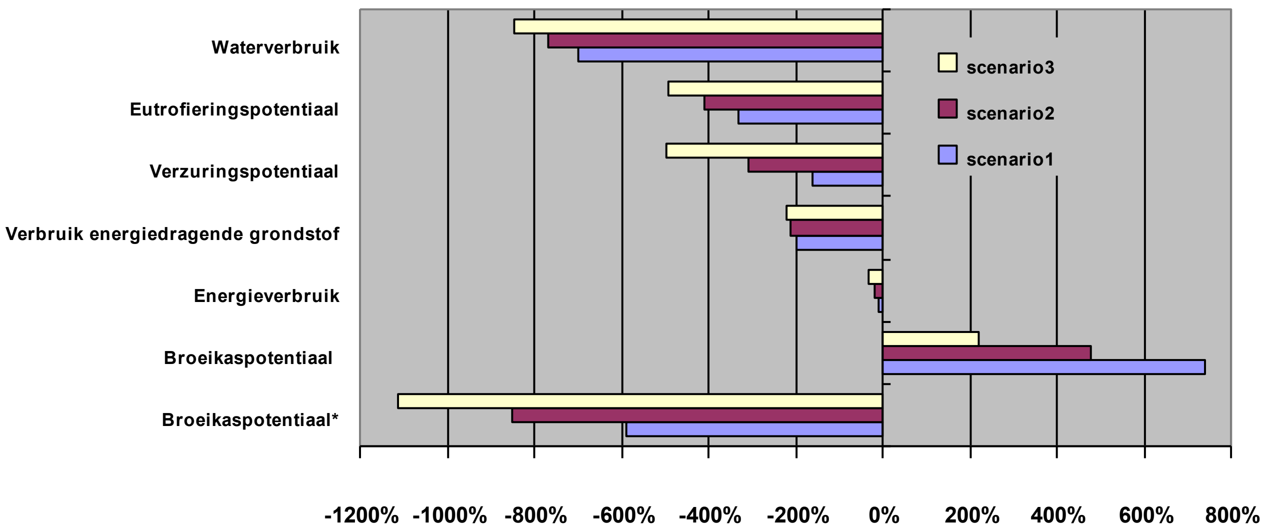
Greenhouse gas potential in broader system boundaries (kg CO2)	Knowaste scenario 1	Knowaste scenario 2	Knowaste scenario 3	WIP scenario
Old system boundary	284	195.5	107	33.7
Electricity generation by means of natural gas	-77.0	-165.5	-254.0	33.7
Electricity generation by means of coal	-253.7	-342.2	-430.7	33.7
Electricity generation by means of electricity mix Dld	-164	-252.5	-341.0	33.7

Table 2: The category of greenhouse gas effect for a wider system limit

The Federal Office for the Environment in Germany gives the highest priority to greenhouse gas potential, a very high priority to energy consumption, the consumption of energy-carrying raw materials and the acidification and eutrophication potential, and a low priority to water consumption. In figure 5 these six relevant categories are portrayed in the form of a T diagram. For each category the additional impact of the three Knowaste scenarios compared to the reference process of disposal is depicted as a bar.

Water consumption	Scenario 3
Eutrophication potential	Scenario 2
Acidification potential	Scenario 1
Consumption of energy-carrying raw material	
Energy consumption	
Greenhouse gas potential	
Greenhouse gas potential*	
*greenhouse gas potential in broader system boundaries	

Figure 5: Comparison of the additional environmental impact



*broeikaspotentiaal bij bredere systeemgrenzen

5. Conclusions

In six of the nine categories the Knowaste process is clearly better for the environment than the reference process of disposal. If we consider only the most relevant categories

1. *Greenhouse gas potential*
2. *Consumption of energy-carrying raw materials*
3. *Eutrophication potential*
4. *Acidification potential*
5. *Energy consumption*

then it is only for greenhouse gas potential that Knowaste has a greater environmental impact than disposal. The results of the CO_2 analysis, however, depend on the choice of system boundary. A sensitivity analysis has demonstrated that by shifting the system boundaries even Knowaste's greenhouse gas potential is better than that of the reference process.

According to the authors of the Fraunhofer report, on the basis of the analysis performed the recycling of ISA by Knowaste proved to be *ecologically worthwhile* and *better for the environment* than the disposal of ISA.

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Appendix

		Possible to avoid?	yes	Avoid
		no		
		Is processing technically/ economically sensible?	no	Definitive disposal
		yes		
		Is disposal more environmentally friendly than processing?	yes	Option to process lapses
		no / neutral		
		Is a processing method prescribed?	yes	Process in accordance with instruction
		no		
		Designate processing method		
	Processing to produce substances		Processing to recover energy	
Main aim substance recycling?	no	No processing in accordance with KrW-/AbfG	no	Main aim processing to recover energy?
	yes		yes	
		Selection of the most environmentally friendly processing method		
		If equal, preference is given to highest-value method		
		Processing in accordance with KrW-/AbfG		

Structure of the Closed Substance Cycle Waste Management Act, the basis of German policy on waste