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Comparison between the incineration and the co-combustion in cement plants of industrial wastes using a life cycle approach

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Abstract

The possibility of using different industrial wastes (tyres, plastics and sewage sludge) as combustible has been studied for two industrial processes: the incineration and the co-combustion in cement plants (they correspond to a production of electricity and clinker respectively). This study has mainly been achieved to illustrate the Eco-indicator 95 methodology, but also to demonstrate that both industrial processes are complementary. The uncertainty due to choices has been taken into account through different valuation methods leading to different weightings of the environmental impacts considered (greenhouse effect, heavy metals, etc.), while a Monte Carlo simulation has been used to translate the parameters uncertainty. One of the main conclusions of this study is that most of the wastes with a high heavy metals, sulphur and halogens content and also with a low calorific value should rather be incinerated than burned in a cement kiln. These results are particularly interesting for the authorities desirous of following a coherent environmental policy in the area of industrial wastes.

Introduction

Waste management in Belgium

In Belgium, the use of typical industrial wastes such as tyres, plastics and resofuel (solid fuel residue) in rotary cement kilns has appeared at the end of the eighties. Since then, the cement producers have increased the substitution of classical combustibles in an important way, mainly for economical reasons. A direct consequence of this policy is the introduction of a better global waste management.

Methodology chosen for the comparison

The LCA methodology has been chosen to compare the co-combustion in cement kilns with the incineration on the basis of a global environmental load attributed to each process respectively. The purpose of this study was to simplify the problem by aggregating the different environmental impacts resulting from the activity of a given process for 1 ton of waste (chosen as functional unit). This has been achieved thanks to Eco-indicator 95 (Goedkoop, 1995). Two other weighting sets (the Questionnaire and the Iso-preference approach) have also been used at the valuation step in order to check the robustness of the final results.

Working plan

Not less than 27 different cases have been studied. They come as the combination of all the following possibilities :

Three industrial wastes: tyres, plastics and sewage sludge.

Three different hypothesis:
- the differential system: which consists in differential emissions (sometimes negative ones) resulting from the difference between a situation with wastes and a situation without).
  In this way, there is an "economy" of environmental load due to the fact that less “classical" combustible had to be used thanks to the combustion of industrial wastes.
- the incinerator cannot produce a sufficient amount of electricity to be considered as an electricity producer. In this case, the differential system is only applied to the co-combustion in cement plants.
- the only function considered for both processes is the elimination of industrial wastes. Therefore, the differential system is not applied.

Three valuation weighting sets: Eco-indicator 95, Questionnaire and Iso-preference approach.

Example of case study

Application of the first hypothesis (differential system for both processes) and of the Eco-indicator 95 valuation step to the case of the thermal treatment of used tyres.

Inventory

As it is very difficult to measure emission data which correspond to the same industrial waste for both processes, emission factors have been calculated and then applied to the particular waste chosen.
All these emission factors are shown in table 1. Each of them correspond to the fraction of pollutant released in the environment. For example, if an industrial waste containing 1 kg of Pb was incinerated, then 1 x $9,0.10^{-4}$ = $9,0.10^{-4}$ kg of Pb would be emitted at the chimney.

	Cd_{water}	Hg_{water}	Pb_{water}	Mn_{water}	As_{water}	Cu_{water}	Cd_{air}	Hg_{air}	Pb_{air}
Incineration	0	$1,7.10^{-3}$	$3,0.10^{-4}$	$3,6.10^{-3}$	0	$1,0.10^{-4}$	$1,0.10^{-4}$	$2,2.10^{-3}$	$9,0.10^{-4}$
Co-combustion	0	0	0	0	0	0	$3,0.10^{-4}$	$2,7.10^{-1}$	$6,0.10^{-4}$

	Mn_{air}	As_{air}	Ni_{air}	Cr_{air}	HCl_{air}	HF_{air}	$SO_{2\ air}$	$CO_{2\ air}$
Incineration	$5,0.10^{-5}$	$2,0.10^{-4}$	$8,0.10^{-4}$	$5,0.10^{-5}$	$5,0.10^{-5}$	$5,0.10^{-5}$	$2,0.10^{-3}$	3,63
Co-combustion	$1,5.10^{-4}$	$2,0.10^{-4}$	$3,0.10^{-4}$	$2,0.10^{-4}$	$3,4.10^{-2}$	$6,6.10^{-3}$	$6,2.10^{-2}$	3,63

Table 1 - Emission factors (kg_{output}/kg_{input}) for the incineration and the co-combustion.

Impact assessment

The table 2 shows the valuation results for both processes, according to the Eco-indicator 95 methodology. All these values are expressed in a same unit (inhabitant.year/ ton of tyres), which allows to add the different environmental impacts for each process.

	h. metals	carcin.	acidif.	greenh.	w.smog	s.smog	ozone	pesticid	eutroph.	global
Incineration	$4,0.10^{-2}$	$5,0.10^{-3}$	$-1,7.10^{-1}$	$4,1.10^{-1}$	$-9,7.10^{-2}$	0	0	0	0	0,188
Co-combustion	$2,5.10^{-2}$	$1,7.10^{-2}$	$2,5.10^{-2}$	$2,9.10^{-2}$	$1,6.10^{-2}$	0	0	0	0	0,112

Table 2 - Valuation results (inhabitant.year/ ton of tyres) according to Eco-indicator 95.

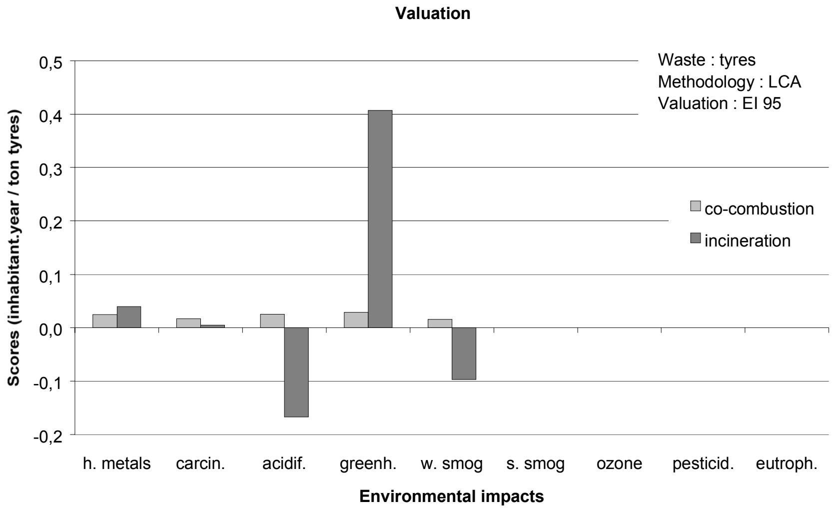

Fig. 1 - Valuation of the environmental impacts.

The figure 1 shows that all the environmental impacts resulting from the co-combustion of tyres have positive (but small) values, while the acidification and the winter smog resulting from the incineration of tyres have negative values and partially compensate for the positive ones. These negative values can be explained by the fact that the Belgian electricity producers emit more SO_2 than the incinerators do, considering the same amount of electricity produced.

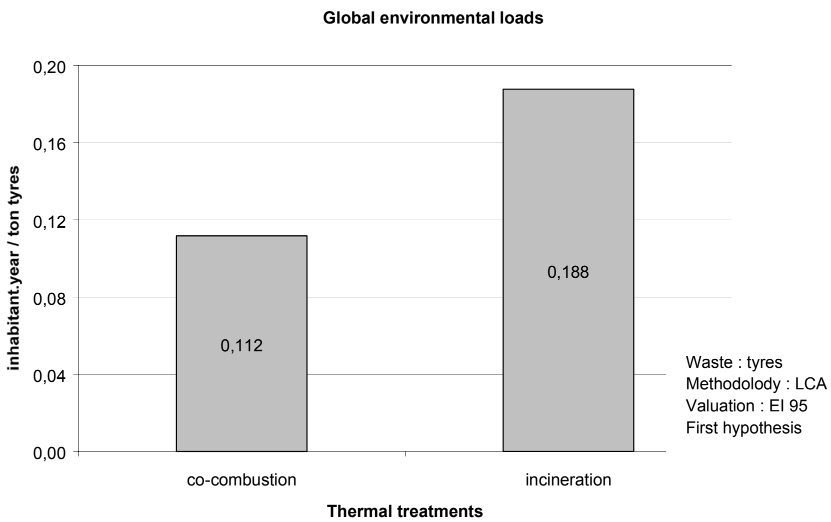

Fig. 2 - Global environmental loads.

The figure 2 shows that the used tyres should preferably be burned in cement kilns rather than incinerated. This choice is reinforced by the fact that the global environmental load is better distributed between the different environmental impacts for the co-combustion in cement plants.

Conclusion

By achieving the 27 case studies described above, we noticed that :

When the first hypothesis (the differential system for both processes) is considered, the global environmental load of the incineration is higher than the one of the co-combustion (the case of the thermal treatment of the sewage sludge with a valuation step according to Eco-indicator 95 is the only one for which these conclusions are reversed).

When the second hypothesis is considered, the global environmental load of the incineration is always the highest.

When the third hypothesis is considered, the global environmental load of the co-combustion in cement plants is always the highest.

The main conclusions resulting from these observations are:

- The choice of one the three hypothesis has much more influence on the final results than the valuation methodology has.
- The results obtained in this study can't be generalised. They depend on the industrial waste studied, but also on the hypothesis chosen.
- Finally, both processes are complementary for the problem of the thermal treatment of industrial wastes. Most of the wastes with a high heavy metals, sulphur and halogen content, but also with a low calorific value, should rather be incinerated than burned in a cement kiln.

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