

LIFE CYCLE ASSESSMENT OF PHOSPHOROUS RECOVERY FROM SEWAGE SLUDGE

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ABSTRACT

The Danish waste treatment plant for hazardous waste “Nordgroup a/s” plans to recover phosphorus from waste water sludge. The presented LCA-study indicates that environmental impacts by phosphorous recovery in an energy efficient process are at the same level or lower than through the re-use of sewage sludge applied directly on farmland.

The recovery method is based on drying and thermal gasification of activated sewage sludge followed by extraction of phosphorous from the ashes. The obtained product can be used as a fertilizer replacing similar products on the market.

The conclusion is that the general rule according to waste hierarchy, where re-use is preferable to material and energy recovery, is wrong in this case.

INTRODUCTION

Until now sludge waste treatment in Denmark has followed the general waste hierarchy where reuse is preferred instead of incineration. This means that sludge most commonly has been spread on farm land as fertilizer and soil improver. Only when the sludge did not meet the threshold values for hazardous compounds has incineration been approved. The Danish EPA has initiated an LCA-study to verify how different treatment options performs if several environmental and resource parameters are included (Kirkeby et al, 2012). As a contribution to this study, the University of Southern Denmark has assisted Nordgroup a/s to deliver LCA-data for a planned treatment process for sewage sludge with focus on phosphorous recovery by efficient use of energy in all process steps (Sørensen and Dall, 2012).

THE TREATMENT PROCESS AND METHODS FOR THE LCA STUDY

The treatment consist of 4 steps as shown in figure 1, and the data sources are mentioned for each step:

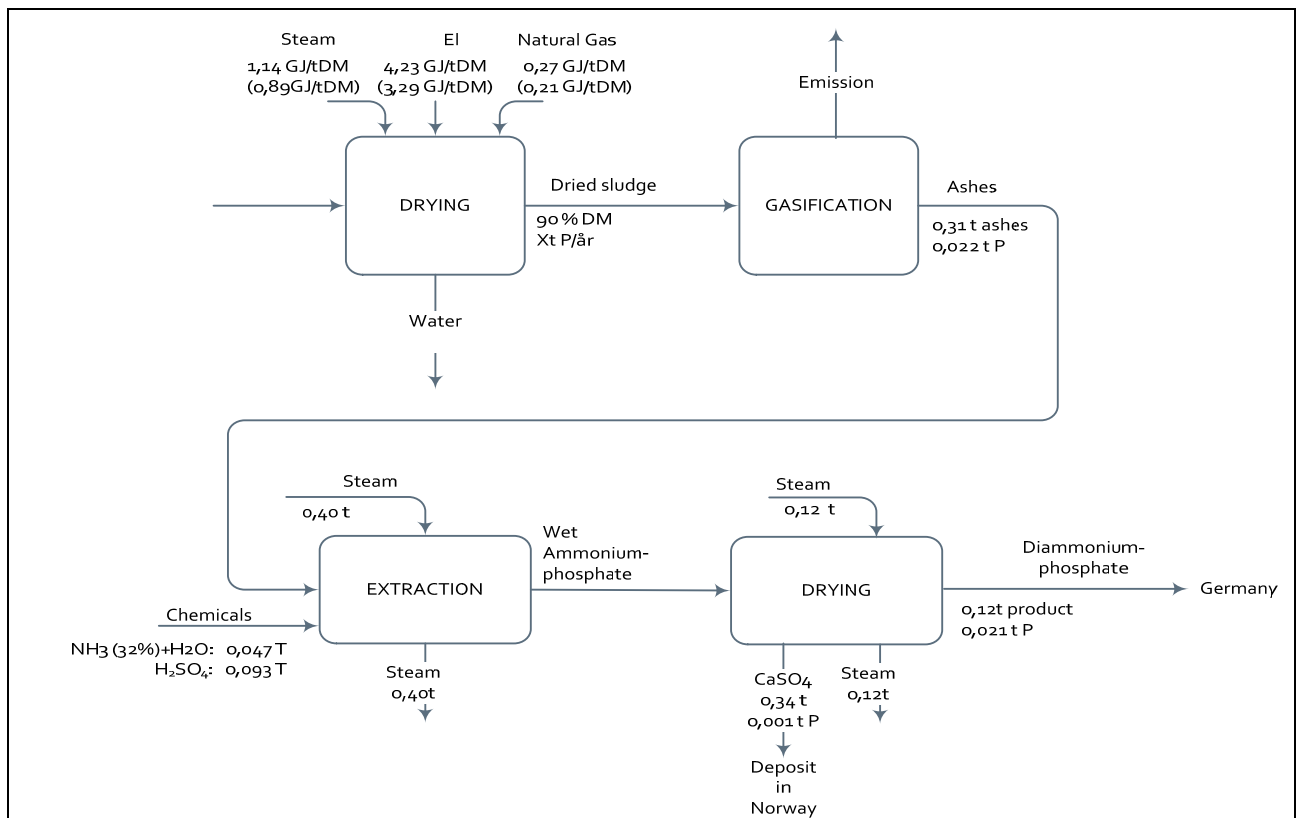
- Drying of sewage sludge by use of heat (Dall, Ole et al. 2009),
- Gasification dried sludge and use of gas (DONG, 2012),
- Chemical Phosphorous extraction (Nordgroup, 2012)
- Drying of final fertilizer product (Dall, Ole et al. 2009),

The LCA study has one ton of dry matter sewage sludge as functional unit. The study is based on consequential LCA, using as far as possible marginal data sets and system expansions.

The LCA study includes all 4 process steps, but also the avoided production of fertilizer (diammoniumphosphate) and all necessary transportation to make the study fully compliant to the studies in the Danish EPA report.

Besides the above mentioned data sources, we have used LCA data for production of chemicals, transportation and energy based on the EcoInvent database, 2012). The LCA-calculations presented in this article are based on the EDIP 2003 methodology (Laurent, A. et al 2011) and updated according to (USGS, 2010) for all resource parameters. The biogenic C emissions are added to complete the picture of all processes.

Figure 1: Treatment steps in the recovery process.



RESULTS

The results for selected LCA-impacts and resources consumption/savings are shown in figure 2 and 3 as PE (person equivalents) per ton (dry matter) sewage sludge. There are both reduced impacts (negative values) and increased impacts for each parameter.

For fossil global warming contribution and acidification there is a small (both values are minus 0,015 PE) reduction in the total process which is due to the avoided marginal energy production and replacement of fossil energy with biogenic fuel originating from the sewage sludge. This is also reflected in the increased emission of biogenic C, which in this case

should be considered as neutral to global warming, since the biogenic materials in sewage sludge typically are grown in a timespan of a few years before being discarded.

The only impact that has a relatively small increase (0,0016 PE) is photochemical ozone formation.

Resource use and savings are calculated as PE/ton dry matter. The normalization reference is the global use of fossil energy resources and phosphorous in 2010 (USGS, 2010).

The results show a total resource reduction for energy resources and for phosphorous, which means that 1 ton of dried matter in sewage sludge replaces almost (0,9 PE) the use of phosphorous per person globally. On the other hand, the total content of phosphorous in sewage sludge only accounts for a small percentage of the use in Denmark.

Figure 2: LCA-results for all process steps in PE/ton dry matter, negative values are reductions and positive increased – the total is the sum of both.

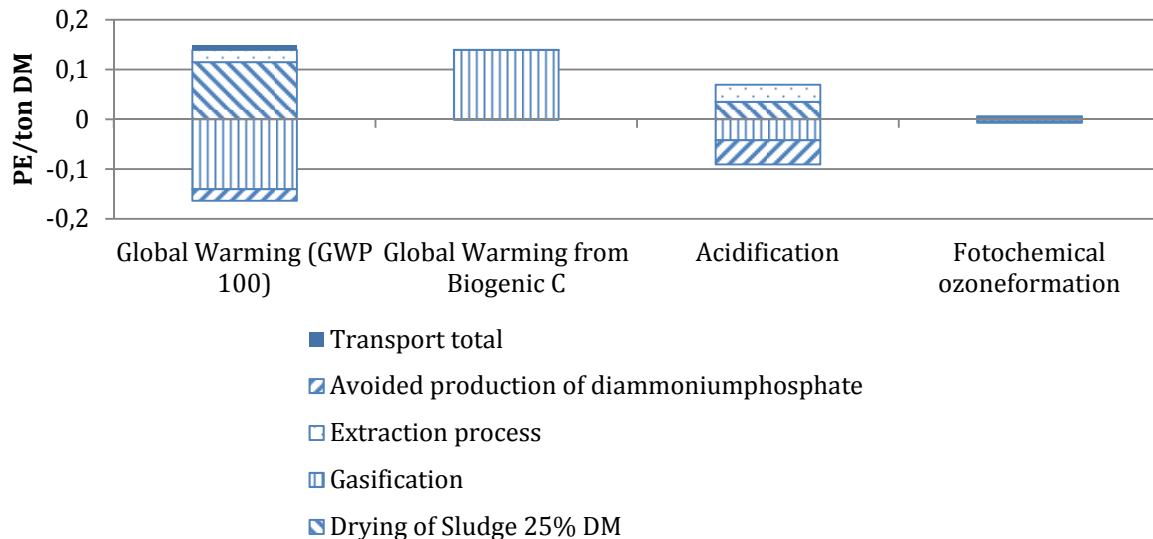
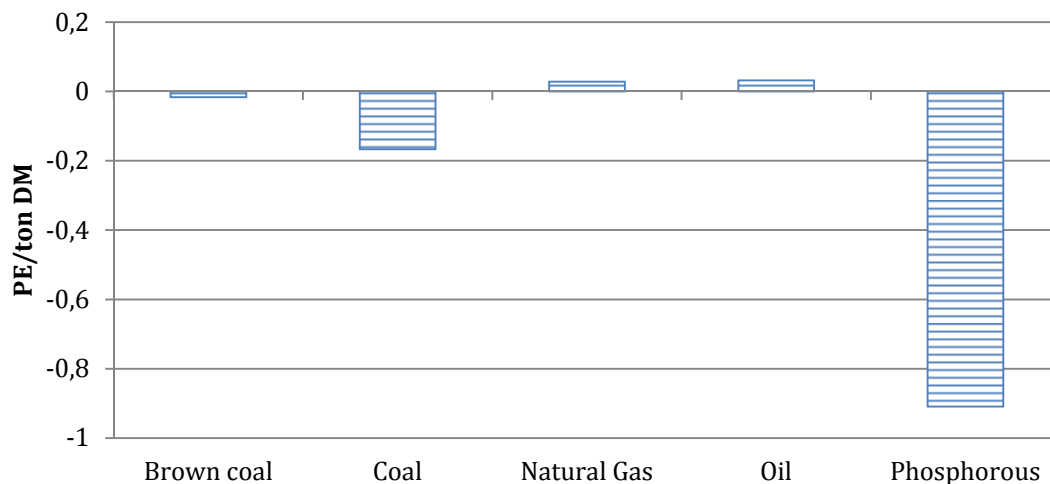


Figure 3: Shows resource and savings in PE/ton dry matter.



DISCUSSION

The impacts of phosphorous recovery from waste activated sludge are investigated on a specific waste treatment plant in Denmark but can be implemented elsewhere with similar conditions

The LCA is included in a study by the Danish EPA where other treatment options for sewage sludge are also analyzed. The comparison to other treatment options shows that the proposed process performs as good as direct use of sludge on farmland. Especially the reduction of fossil CO₂ emission is remarkable, due to the efficient drying and incineration processes and the replacement of fossil fuel by biogenic based fuel from sewage sludge.

The recycling of phosphorous resources is crucial due to its life threatening necessity, lack of substitution options and a forecast showing global scarcity. The optional direct use of sludge on farmland can provide similar phosphorous recycling over a long time span, but does not have the potential to avoid use of phosphorous fertilizers due to transportation costs.

CONCLUSIONS

The LCA-study shows that energy efficient processing has a positive environmental impact compared to production of other phosphorous fertilizer. If the process is compared to optional treatment methods it turns out to be just as good – but has an advantage to provide an easy distributable phosphorus fertilizer.

The conclusion is that the aim of the waste hierarchy is fulfilled by incineration with efficient energy use and phosphorous recovery.

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