



Generating LCA partitioning factors for sewage sludge management using a Delphi procedure

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What is the problem?

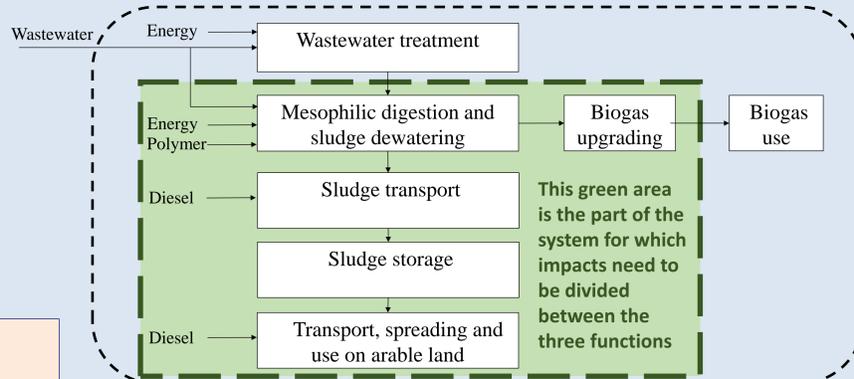
In **attributorial life cycle assessment (ALCA)**, the goal is to map the environmental impact from the system under study in such a way that it reveals what share of the total global environmental impact that belongs to the product or service investigated. Any process performing multiple functions then gives rise to an **allocation problem**: the environmental impact related to the process needs to be partitioned between the functions. As **wastewater and sludge management systems are increasingly multifunctional**, they increasingly present such allocation problems when any of their products or services are to be part of a life cycle assessment (LCA).

What is our solution?

It has been recommended that **the partitioning in ALCA studies should be based on the drivers of the system**. The drivers of present wastewater and sludge management systems, however, is most often a mix of various ideas and concerns relating to environmental protection, resource recovery, economy, and other interests, that seem to vary among stakeholders, over time and across regions. **We developed and tested a two-stage Delphi procedure for finding partitioning factors** for use in ALCA studies where multiple drivers and stakeholders are present in relation to multifunctional systems.

The studied system

We applied the process for a wastewater and sludge management system for which the sludge management simultaneously provides three functions: **(1) management of the sludge from the wastewater treatment, (2) biogas production for use in vehicles, and (3) fertilization of agricultural soil.**



The Delphi procedure

Various actors with a strong connection to sludge management in Sweden were involved in the procedure. Consensus was more or less achieved for the ranking of the functions as drivers for the system but not for the exact partitioning factors. Many different types of arguments were provided.

Electronic voting: 70 participants at sludge event

“How strong reasons to the existence and operation of the system are each of the three functions? Distribute 10p among the three functions”



Function	All (n=26)			Municipal organisations (n=18)			Private companies (n=5)			Consultancies and institutes (n=3)		
	Ave	Low	High	Ave	Low	High	Ave	Low	High	Ave	Low	High
Wastewater treatment and sludge management	6.8	5	10	6.9	6	10	7.2	6	6	6.0		
Production and use of biogas in vehicles	1.3	0	3	1.2	0	2	1.0	1	3	2.0		
Fertilisation of agricultural soil	1.9	0	5	1.9	0	3	1.8	1	3	2.0		

Two-stage Delphi procedure: questionnaire with 26 respondents

We want to achieve a circular economy

There are political targets to generate biogas

There are clear benefits related to sludge application on soil

My organization has the responsibility to protect the local environment, not to produce fertilizer or a vehicle fuel

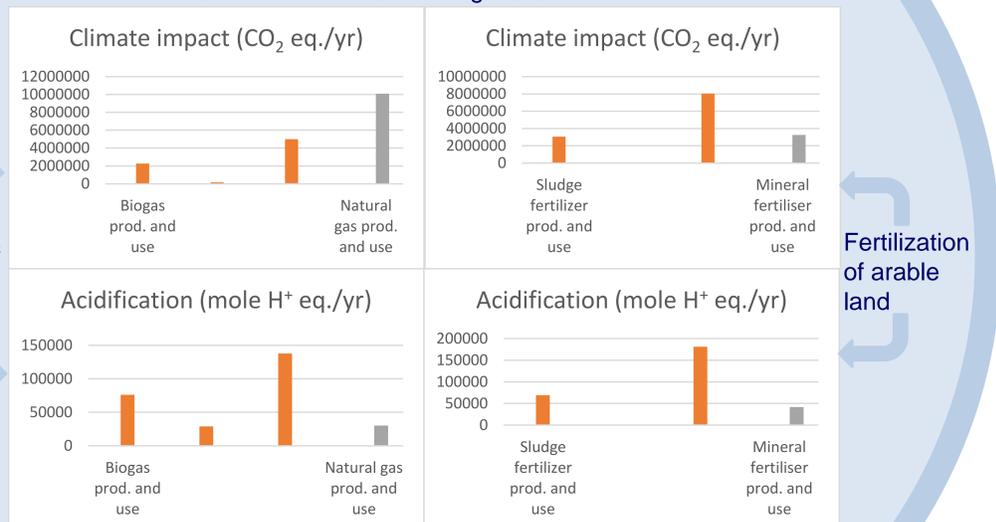
P is a critical resource

Implications for practice

For an ALCA that focuses on either of these three functions, only the share of the total that is allocated to that function by means of the partitioning factor is counted. When applying these partitioning factors in an LCA of the system above, this **will have a large impact on the outcome of a comparison to other ways of achieving similar functions**, see graph below. The suggested Delphi procedure can be useful in many different situations where expert or stakeholder judgments could be a way to meaningfully describe the drivers of a system.

LCA results

for the system above using partitioning factors from the two stage Delphi procedure (average, low, high). Comparison to alternative means of fulfilling the same function.



- Get relevant experts involved and committed
- Describe the task and the system in an understandable way
- Generate relevant feedback that will trigger reconsideration
- Interpreting results when consensus is not achieved

Challenges