



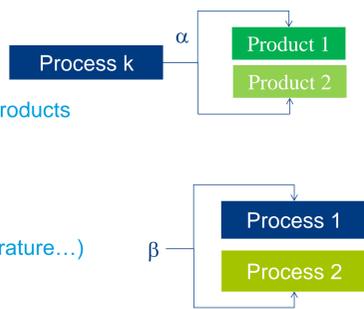
Allocating an environmental load to wastewater sludge when sludge status moves from “waste” to “product”, a methodological challenge

When sludge status moves from “waste” to “product”, the wastewater treatment plant can be seen as a joint production system generating two indivisible coproducts : the sludge and the clean water (Pradel et al., 2015). Assessing the environmental impacts of the two coproducts implies to allocate the environmental burden of the system to each of them. This is a methodological challenge that we propose to solve with the use of generic and specific allocation factors.

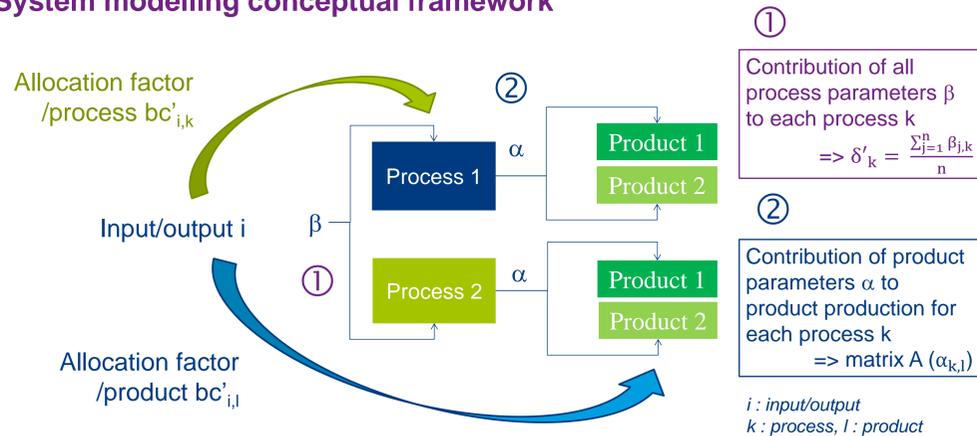
Conceptual framework for allocating an environmental burden to coproducts of an indivisible system

System modelling depends on

- Product parameters α
 - Physical, chemical, stoichiometric properties
 - Flux/flow properties
 - Used as main allocation properties between coproducts
 - « Product-related burden »
- Process parameters β
 - Process operation parameters (pressure, temperature...)
 - Associated to process functioning
 - « Process-related burden »



System modelling conceptual framework

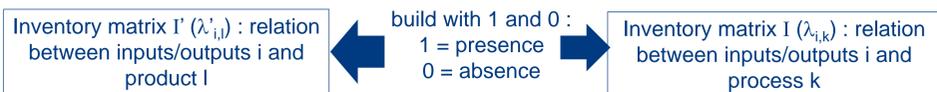


Environmental burden calculation

$$B'_{process} = i b c'_{i,k} \quad \text{or} \quad B'_{product} = i b c'_{i,l}$$

Where $B'_{process} / B'_{product}$ = environmental burden allocated to process k or product l ; i = input/output value
 $b c'_{i,k} / b c'_{i,l}$ = allocation factor per process k or product l ($b c$: burden coefficient) ; $b c'_{i,k} / b c'_{i,l} = f(\delta'_k, \alpha_{k,l})$

Calculation of generic and specific allocation factors



Specific allocation factor

Need to specify if input/output i is related to the production of each product l : inventory matrix I' x generic allocation factor

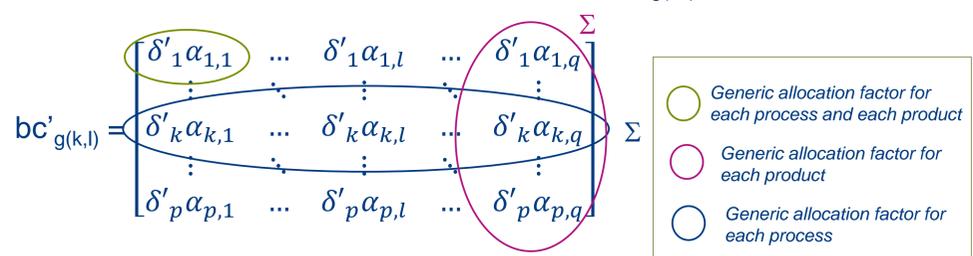
Need to specify if input/output i is specific to each process k : inventory coefficient $\lambda_{i,k}$ multiplied with previous result

$$b c'_{i,k} \quad \times \quad \text{matrix A} \quad \Rightarrow \quad b c'_{i,l}$$

Specific allocation factor / process Specific allocation factor / product

Generic allocation factor

Product ① x ② \Rightarrow generic allocation factor $b c'_{g(k,l)}$ with matrix shape



Allocation factors

- Generic allocation factor to be used for generic inputs/outputs
 - To be used for common inputs/outputs to all the process (infrastructures...)
 - To be used when inputs/outputs cannot be specified to one or several process
- Specific allocation factor to be used for specific inputs/outputs
 - To be used for specific inputs/outputs
 - Can also be used as generic allocation factor

Challenge for sludge-based products

Identify product and process parameters

- Product parameters can be based on stoichiometric equations for Carbon, Nitrogen (nitrification + denitrification) and Phosphorus treatments
- Process parameters can be based on process treatment functioning (oxygenation rate and aeration duration)

Need of an environmental burden to the production of sludge-based products to allow system comparison

Waste as raw material	Sludge-based product	Manufactured product
Use	Production	Production
End-of-life	Use	Use
	End-of-life	End-of-life

Conclusion

- A methodological framework has been developed to allocate an environmental load to several product in a joint-production system.
- Generic and specific allocation factors are based on product and process parameters and inventory matrices.
- Sludge-based products can therefore be compared with fossil-based products as their production is charged with an environmental burden.

PRADEL, M., AISSANI, L., VILLOT, J., BAUDEZ, J.C., LAFOREST, V., 2015. From waste to product: a paradigm shift in LCA applied to wastewater sewage sludge. SETAC Europe 25th Annual Meeting, Barcelona, Spain, 3-7 May 2015.

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