

Data structure in MFA and its effects on results: a comparison of P in Denmark and Austria

Manfred Klinglmair¹, Ottavia Zoboli², David Laner², Helmut Rechberger², Thomas Astrup¹, Charlotte Scheutz¹

¹ Technical University of Denmark
² Vienna University of Technology



1) Background & aim

A considerable range of recent Material Flow Analyses (MFA) of phosphorus on a country scale have been published.

While these may differ due to the region examined, authors' choices in building MFA models are a different set of factors often disregarded in direct comparison of regional resource households.

In terms of system boundaries, and external trade and national accounts, country or multi-country level MFA studies are quite consistent across substances and countries (Fischer-Kowalski et al. 2011), although there is considerable freedom in the layout of the respective models and selection of data behind the model.

In comparisons of MFA studies, differences resulting from system layout and data structure (sources, aggregation/disaggregation) tend to get little attention, but are taken at face value (see e.g. Chowdhury et al. (2013) for the case of phosphorus). Metadata are rarely discussed; this work aims to shed some light on the influence of modelling choices and the underlying data structure of MFA studies on their outcome.

2) Materials & methods

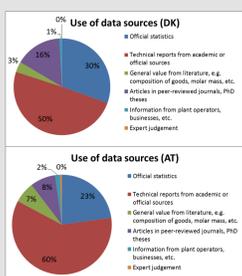
Building upon MFA studies of phosphorus in Denmark and Austria, we examine the effect of the layout of an MFA system and its underlying data structure on the outcome of regional MFAs.

The research (Klinglmair et al. 2015; Zoboli et al. 2014) we draw upon for this case study share a similar geographical (country) scale, with good data availability in both countries examined. We use 2011 as a reference year for comparison.

The models are comparable in complexity (AT: 56 processes, 122 flows, DK: 52 processes, 156 flows). Both studies use the STAN 2.0 software (Cencic & Rechberger 2008) for handling of uncertainties, data reconciliation, and visualization.

In particular, the following characteristics of MFA models are of interest here: **1)** system boundaries, **2)** aggregation/disaggregation of processes, i.e. which processes are shown as discrete entities, **3)** aggregation/disaggregation of flows, **4)** choice of data sources, **5)** uncertainty assessment.

3) Results



Data sources

An obvious first step is a run-down of data sources used in studies to be compared; both cases are comparable here, with a preponderance of technical reports published by official or academic sources (for a more detailed discussion of data characterization in MFA, see Schwab et al. (2014)).

Fig. 1 Relative importance of data sources used in P balances for Austria (AT) and Denmark (DK), % of citations in documentation of flow values entered in STAN.

Consistency

"Consistency" here means consistency of the input data with the constraints imposed by the model. The effect of the data reconciliation process can be quantified as the change of individual flow values after data reconciliation in STAN (which uses the method of least squares) in % of input value; the mean of these deviations gives a measure of the extent of data reconciliation, with \bar{D} being the mean deviation, m the total number of flows, x the entered flow value, and \hat{x}_n the reconciled flow value. \bar{D} was found to be **6%** in the Austrian case, **10%** in the Danish case; this value can serve as a proxy of model "quality".

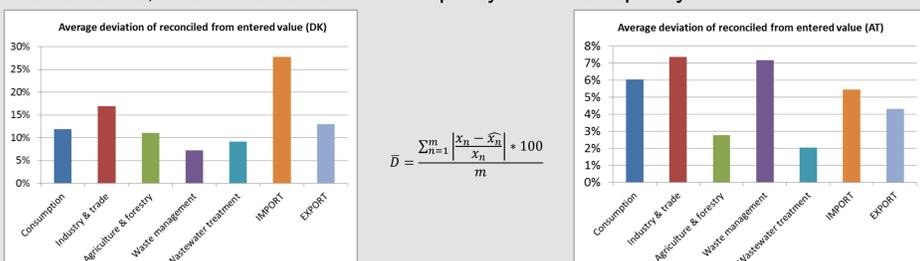


Fig. 2 Model consistency (mean deviation of reconciled from entered value), by process/process group, not including sub-processes.

Handling of uncertainties

Data reconciliation in STAN results in the reduction of the uncertainties associated with reconciled values. Ideally, all uncertainty ranges should be smaller in the balanced system than entered; ideally, uncertainty ranges ought to be adjusted iteratively.

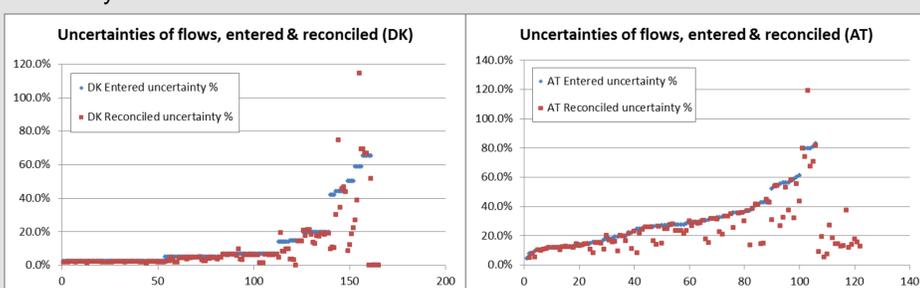


Fig. 3 Entered and reconciled uncertainties (coefficients of variance) of flow values.

4) Conclusions

This is a work in progress; here, we aimed at showing several characteristics (or metrics for the evaluation) of MFA studies, including such beyond phosphorus.

Metadata matter; it is only to be expected to find differences resulting from the different nature of the systems examined, we will identify the instances in which such variation is due to different approaches to data collection by the modeller(s), different modelling choices, and/or the data used due to different degrees of availability.

A central question to be clarified is to which extent the MFA models are shaped by their underlying data structure (as opposed to the modeller/their goal and scope).

We expect to identify best practice with regard to data quantity and quality, and give recommendations as to future provision of data to aid the establishment of accurate MFA models for regional resource efficiency objectives (i.e., how should the data structure for systematic and consistent, e.g. annual, P monitoring on the basis of MFA look like?).

References

- Baccini, Peter, and Paul H. Brunner. 2012. *Metabolism of the Anthroposphere*. 2nd ed. Cambridge (MA): MIT Press.
- Cencic, Oliver, and Helmut Rechberger. 2008. "Material Flow Analysis with Software STAN." *Journal of Environmental Engineering & Management* 18 (1): 3-7. http://ser.cienve.org.tw/download/18-1/jeem18-1_3-7.pdf.
- Chowdhury, Rubel Biswas, Graham A. Moore, Anthony J. Weatherley, and Meenakshi Arora. 2013. "A Review of Recent Substance Flow Analyses of Phosphorus to Identify Priority Management Areas at Different Geographical Scales." *Resources, Conservation and Recycling* (December). doi:10.1016/j.resconrec.2013.10.014. <http://linkinghub.elsevier.com/retrieve/pii/S0921344913002218>.
- Fischer-Kowalski, Marina, Fridolin Krausmann, Stefan Giljum, Stephan Lutter, Andreas Mayer, Stefan Bringezu, Yuichi Moriguchi, Helmut Schütz, Heinz Schandl, and Helga Weisz. 2011. "Methodology and Indicators of Economy-Wide Material Flow Accounting." *Journal of Industrial Ecology* 15 (6) (December 31): 855-876. doi:10.1111/j.1530-9290.2011.00366.x. <http://doi.wiley.com/10.1111/j.1530-9290.2011.00366.x>.
- Klinglmair, Manfred, Camilla Lemming, Lars Stoumann Jensen, Helmut Rechberger, Charlotte Scheutz, and Thomas Fruergaard Astrup. 2015. "Phosphorus in Denmark: National and Regional Anthropogenic Flows." *Resources, Conservation and Recycling* (submitted).
- Schwab, Oliver, Ottavia Zoboli, and Helmut Rechberger. 2014. "A Data Characterization Framework for Material Flow Analysis." *Journal of Industrial Ecology* (submitted).
- Zoboli, Ottavia, Matthias Zessner, and Helmut Rechberger. 2014. "Added Values of Time Series in MFA: The Austrian Phosphorus Budget from 1990 to 2011." *Journal of Industrial Ecology* (submitted).

Contact

Funded by:



www.IRMAR.dk
www.env.dtu.dk

Contact:

Manfred Klinglmair

Miljøvej, Building 113
2800 Kongens Lyngby
IRMAR@env.dtu.dk

mank@env.dtu.dk