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The Flux-Pulse problem in LCA

Due to N.T. de Oude's request for co-operation of experts to arrive at a sound classification and characterisation method, a platform for discussion between experts and counter-experts is emerging. We are glad that our previous contribution [1] is under critical review. this provides an excellent way for scientific progress. We would like to respond to Mr. Assies's comments [2].

Assies acknowledges the problem of assessing emission pulses. However, he does not agree with our solution of dividing the unknown emission time period by the same unknown time period of a reference emission. Instead, he proposes to choose a functional unit in accordance with the real emission flux, so that the steady-state environmental models can be applied directly. Below, we will present a new argument to demonstrate the correctness of our proposal, and emphasise the impossibility of Assies's approach.

The sentence "The factor time is introduced in the definitions, namely the life-time of the substance under consideration" is wrong. The time we introduce in equation (3) in reference [3] is "the time period during which the emission takes place". We just call it t without knowing its actual value. The lifetime of the substance is fully incorporated in the modelling constant K. The example of PCB and phenol given by Assies is, therefore, inappropriate. If one studies the life-cycle of, say, surfactants, the functional unit will usually be 1 kg of surfactant or 5 kg of clean clothes. Assies's proposal to abandon pulses and study actual fluxes would amount to defining a functional unit of e.g., 24 Mton surfactant/year or 500 Mton of clean clothes/year. In that case, the emission flux of surfactant to the waste water treatment plant is larger, as it also contains surfactants from shampoos and soaps. The actual emission flux of the power plant is also larger, as only a small part of the electricity is generated for the life-cycle of surfactants. In general, one can normalise the functional unit such that only one of the processes in the life-cycle is included to the actual extent. The other processes will not fit. It is, thus, impossible to predict exposure concentrations in LCA, even when the functional unit is expressed as the annual consumption value of a product. We already discussed this problem in [1] with an example on shaving.

Assies may be right in stating that "there is no reason to introduce a reference substance. ..... The normalisation to a reference substance in the ODP-, GWP-, and POCP-concepts is just a matter of presentation". In our proposal, the introduction is not needed *per se*, but is just one way of solving the flux-pulse problem. We assumed that presentation in terms of an amount of reference substance is more conceivable than in terms of some weird dimension. Another solution is to employ Mackay's level IV model and integrate over an infinite time horizon to arrive at an expression in which a reference substance is not needed. One can prove, however, that this gives the same results as using a level III model with a reference substance. The proof is too lengthy to include here, but has been submitted for publication elsewhere [4].

As discussed in the last paragraph of [3], the implementation of our proposal needs further work. This work is not an exclusive issue for LCA-experts, but should include other experts (chemical engineers, toxicologists, modelling experts, ...) as well. This is what we hope will be undertaken in The Netherlands this year. A critical review of the basic principles of multi-media models and toxicity potentials remains necessary, however.

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[1] Heijungs, R. and J.B. Guinée. CML on actual versus potential risks. *SETAC-Europe News* 3 (4) 4 (1993).
[2] Assies, J. Experts need ..... experts (II). *SETAC-Europe News* 4 (1) 5-6 (1994).
[3] Guinée, J.B. and R. Heijungs. A proposal for the classification of toxic substances within the framework of life-cycle assessment of products. *Chemosphere* 26, 1925-1944 (1993).

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