Towards the development of a salinity impact category for South African life cycle assessments: Part 2 – A conceptual multimedia environmental fate and effect model

Tony Leske* and Chris Buckley
Pollution Research Group, School of Chemical Engineering, University of Natal, Durban 4041, South Africa

Abstract

In Part 1 of the series, it was shown that there is sufficient justification for the creation of a separate salinity impact category. In this paper, the fundamental basis of environmental life cycle assessments (LCA) is examined. The generalised model, and model simplifications on which the life cycle assessment methodology is based is examined. The formulation of a characterisation model for salinity, which is a local or regional problem, requires the development of environmental fate models. An environmental fate model currently in use to calculate equivalency factors for toxicity effects is evaluated in terms of its applicability for use as is, or in some modified form, to calculate equivalency factors for salinity. It is concluded that this model cannot be used, and a conceptual environmental fate model for salinity is proposed. The proposed conceptual model follows the same approach as models currently in use. It is proposed that a "unit South African catchment" be defined, and that non-steady state hydrological models currently in use in the country be used to predict the fate of salts in the various compartments defined for the "unit catchment".

Keywords: environmental life cycle assessment, salinity, characterisation model, environmental fate and effect model, equivalency factors

Introduction

There are two fundamentally different methodologies for developing methods for LCA. On the one hand, there is the methodology in which comparison of theoretical predictions and actual phenomena provides the benchmark for the adequacy of the LCA theory. A usual approach in this methodology is to analyse the complicated structure in a number of simpler steps. These steps correspond to portions of accepted models, disciplines and causal relationships, such as multi-media fate models. This approach is suitable to change-oriented LCA, where the environmental consequences of different options for fulfilling a certain function are compiled and evaluated. On the other hand, there is descriptive LCA, which is not based on scientific method and cannot be tested empirically. Although there is one ultimate benchmark for testing the predictions of change-oriented LCA, it is clear that this benchmark is useless in practice due to the complicated autonomous developments in society, economy and the environment. The comparison of the predictions of LCA with reality is therefore practically unattainable (Guinee et al., 2000). The predictions made with change-oriented LCA are based on model calculations, and a model is a simplified representation of real mechanisms and phenomena. The choices in modelling are not fully subjective however. Depending on the questions asked, some models are more appropriate than others. It would be best to be as explicit as possible in the assumptions and simplifications that are introduced in modelling the environmental consequences of change.

A general model for LCA

When studying the change in environmental interventions or effects, it is necessary to specify the time pattern and reference situation, as shown in Fig. 1.

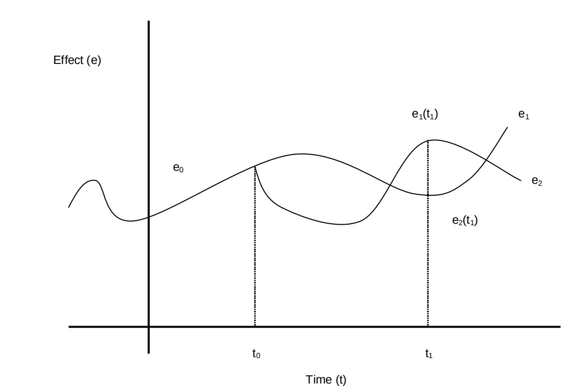

Figure 1
Time pattern of effect (e) before a choice (e_0 to the left of t_0), after the choice not implemented (e_1, to the right of t_0) and after the choice is implemented (e_2, to the right of t_0) (adapted from Guinee et al., 2000)

The LCA analysis is between two parallel systems (e_1 being the predicted future state without the environmental intervention – or reference situation, and e_2 being the predicted future state with the environmental intervention); not a before-after comparison, but a with-and-without comparison.

A general equation for describing the change in environmental effects would include not only time, but also space, as shown in Eq. (1) below:

$$\Delta_{s,t} = \int_{t_0}^{\infty} \iiint_{world} [e_2(x,y,z,t) - e_1(x,y,z,t)]dxdydzdt \qquad (1)$$

Choosing one point in time (e.g. time t_1 in Fig. 1) will discard many effects from the life cycle. If all effects over time are required, it is necessary to integrate these over time. In the spatial domain, it is

* To whom all correspondence should be addressed.
Present address: Postnet Suite 5, Private Bag X4, Kloof 3610, South Africa
☎+2783 6470015; fax: +2731 764 1025; e-mail: Tony.Leske@sappi.com
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