

# Towards the development of a salinity impact category for South African life cycle assessments: Part 3 – Salinity potentials

Tony Leske\* and Chris Buckley

Pollution Research Group, School of Chemical Engineering, University of Natal, Durban 4041, South Africa

## Abstract

In Part 2 of this series of papers, a conceptual characterisation model was proposed for the inclusion of salinity impacts into environmental life cycle assessments. In this, the final part of the series, the results of a detailed characterisation model are presented. The methodologies used to define the “unit South African catchment” are discussed, as are the methods used to predict salt concentrations in the various compartments, from which fate factors are derived. The effect factors used in the study are presented, and in combination with the fate factors, salinity potentials are derived for emissions into the various initial release compartments. The total salinity potentials for emissions into the various initial release compartments are as follows:

| Initial release compartment | Total salinity potential<br>(kg TDS equ./kg) |
|-----------------------------|----------------------------------------------|
| Atmosphere                  | 0.013                                        |
| Surface water               | 0.165                                        |
| Natural surfaces            | 0.031                                        |
| Agricultural surfaces       | 1.000                                        |

An additional impact category for salinity effects is therefore proposed, and the derived salinity potentials (also known as characterisation factors or equivalency factors) can be used in the classification and characterisation steps of conducting an environmental life cycle assessment to calculate the score for the impact category. The salinity potentials are only relevant to South African conditions, and their use in LCA in other countries may not be applicable. When applying the salinity potentials, the LCA practitioner should take care to prevent double accounting for certain impacts. Currently, this is simple because no equivalency factors exist for common ions, or for total dissolved salts as a lumped parameter.

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

## Introduction

The work presented in this paper stemmed out of the apparent lack of a method for incorporating salinity effects into environmental life cycle assessments, and was done to fulfil the academic requirements for the degree of doctor of philosophy at the School of Chemical Engineering, University of Natal. The reader is referred to the thesis (Leske, 2003) for detail that is too lengthy to be included in this paper.

Salination of the water resources is a well-known problem in South Africa, and is of strategic concern. Any environmental decision support tool that does not allow the evaluation of salinity effects therefore has limited applicability in the South African context. The starting point for the study was to evaluate existing impact categories, and the characterisation models used to calculate equivalency factors for these impact categories, in an attempt to incorporate salinity effects into existing categories and/or characterisation models. The types of effects of elevated (above normal background levels) dissolved salt concentrations on the natural and man-made environment were evaluated, and it was concluded that, although there was some overlap with existing impact categories, some of the salinity effects could not be described by existing impact categories. It was also concluded that there are clear and

quantifiable causal relationships between interventions and salinity effects. A separate salinity impact category was therefore recommended that includes all salinity effects, including; aquatic ecotoxicity effects, damage to man-made environment, loss of agricultural production (livestock and crops), aesthetic effects and effects to natural fauna and flora (Leske and Buckley, 2003).

Once a conceptual model for a separate salinity impact category had been formulated, existing characterisation models were evaluated to determine their applicability for modelling salinity effects. Salination is a local or regional problem, and to characterise salinity effects, an environmental fate model would be required to estimate salt concentrations in the various compartments, particularly surface and subsurface water. The USES-LCA model (based on the USES 2.0 model) was evaluated because it is a well developed and accepted environmental fate model that has been adapted to calculate toxicity potentials for LCA, and would intuitively seem to be suited to be used for calculating salinity effects, some of which are toxicological in nature. It was, however, concluded that the USES-LCA model was not suitable for the calculation of salinity potentials (Leske and Buckley, 2004).

It was therefore decided to develop an environmental fate model that would overcome the limitations of The USES-LCA model, in terms of modelling the movement of salts in the environment. In terms of spatial differentiation, the same approach adopted in the USES-LCA model was adopted in developing an environmental fate model for South African conditions. This was done by defining a “unit South African catchment” (including the air volume above the catchment), which consists of an urban surface,

\* 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](mailto:Tony.Leske@sappi.com)  
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