

# Integrating LCA and ERA in a single decision support tool for contaminated site management

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## Abstract

Life Cycle Assessment (LCA) and Environmental Risk Assessment (ERA) can be used in parallel for selecting the most appropriate land management strategy. Nevertheless, even if both approaches can now address impact on ecosystems and human health, the methodological background is very different and results can differ considerably. Furthermore, since both tools can not currently be applied in the same framework, some situation can occur where the environmental burden of the remediation can be higher than the impact of the site itself. It is the purpose of this work to identify the similarities and discrepancies of the methods and to propose a coherent common framework for applying LCA and ERA at the same time for selecting the most appropriate strategy in a contaminated land management perspective for terrestrial and aquatic ecosystems.

## Life Cycle Assessment and Environmental Risk Assessment

LCA was designed using comparative methods, ERA is based on conservative methods. Nevertheless, methods rely on models and the models of the two methods can be applied in parallel as soon as the underlying assumptions of models are coherent.

### Main discrepancies between LCIA and ERA:

- Space scale: ERA is designed for assessing hazard at a local scale while LCA deals mainly with continental scale.
- Time scale: ERA aims at estimating the hazard in a short term perspective, while LCA mainly addresses a long term perspective (100 to 1000 years).
- Biological indicator: while ERA is working on a small dataset of well known biological indicators, LCA estimates a percent of change of biodiversity in the ecosystem on the basis of laboratory test species.
- Reference value: ERA is based on the notion of an acceptable risk define by a threshold value (the target value) while LCA is based on the "less is better" method.

### Time scale

Years	10	100	1000	10000	60000-inf.
Persp.	Management	Human life	Civilisation	Ecosystem	Ecosystem
ERA	Yes	No	No	No	No
LCA	No	LCI Short term	No	No	LCI-LCIA

Developing a single decision support tool for LCA and ERA requires to work at an coherent time scale. It is possible to develop impact assessment methods for ecosystems working at 100, 1000 and 10000 years for LCA

### Space scale

Scale	Indic. km <sup>2</sup>	LCA	ERA
Local	0.0001	Site	Site
Regional	2500	Watershed	Intermediate
Continental	25000000	Generic	No

Generic LCA gives results at the continental or global scale while ERA mainly works at the site scale. Regionalization of LCA models gives a promising perspectives in assessing impact at a coherent scale with ERA.

## Key parameters for impact assessment modeling

### Fate model input for Cd, Cu, Pb, Zn

For LCIA, fate of metals in soil and water is determined by Kd values, while in ERA, measured values are used to determined the risk.

Kd Values in IMPACT 2002	Unit	Cd	Cu	Zn	Pb
Susp.solid :water	Lwater/kgSolid	5.1	4.7	5.0	5.8
Sediment:water	Lwater/kgSolid	4.9	4.5	4.9	5.6
Soil:water	Lwater/kgSolid	2.3	2.3	2.5	3.3

Table 1: Kd Values used in IMPACT 2002

Impact 2002 Kd values are coherent with median Kd values in the literature. Nevertheless, a literature review of numerous Kd experiments from US-EPA indicates a variability of +/- 1.5; 3 and 2.5 order of magnitude for suspended solid/water, sediment/water, and soil/water respectively.

### Toxicological reference concentrations

ERA and LCA are using reference toxicity concentration for comparing relative hazard associated with substances presents

Soil	Cd	Cu	Pb	Zn
Target value	0.8	36.0	85.0	140.0
Intervention value	13.0	190.0	530.0	720.0
Targ. Values (20% clay, 50% OM)	1.6	57.0	120.0	185.0
Int. Values (20% clay, 50% OM)	24.0	301.0	748.0	951.0
HC50 Generic	169.8	346.7	1349.0	380.2

Table 2: Reference toxicological values for soil for ERA (Target & intervention Values) and LCA (HC50) expressed in mg/kg dry soil

Water	Cd	Cu	Pb	Zn
Target value	0.05	3	4	9
Intervention value	0.2	3	25	30
HC50 Generic	0.43	0.18	1.88	1.05

Table 3: Reference toxicological values for water for ERA (Target & intervention Values) and LCA (HC50) expressed in mg/l

## Conclusions and perspectives

The project MuSA highlight some clear discrepancies between LCA and ERA at the conceptual level and also in terms of input data. Nevertheless, both decision support tools address similar targets and shall give coherent results. The development of regional model in LCIA is a promising perspective. Nevertheless, the uncertainty on the data input in the model are important and measured (or observed) data from the site itself should be compared with model output in order to ensure a reliable modeling at least for the first results obtained with regional models.

In terms of perspectives, the priority issues are (1) the variability of the soil composition shall be addressed for developing more accurate soil model and (2) target organisms and biodiversity indicators used in LCA must be consider in parallel with organisms diversity from the site or this area to ensure a coherent assessment at the local, regional and continental scale.

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