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APPLICATION OF 1,4-DICHLOROBENZENE AS A REFERENCE SUBSTANCE IN THE LCA METHODOLOGY (LIFE CYCLE ASSESSMENT)

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Abstract: *The characterization model CML2001 for Life Cycle Impact Assessment (LCIA) in a Life Cycle Assessment analysis (LCA) uses 1,4-dichlorobenzene as a reference substance for characterization of ecotoxicicological impacts of elementary flows. The damage of Ecotoxicity as an specific impact category is quantified in kg of 1,4-dichlorobenzene. In this work, the combination of experimental method of ecotoxicology tests and the LCA methodology leading to a simplification of waste (mixture substances) characterization in the LCA methodology, was studied. 1,4-dichlorobenzene is a chemical commonly used in industry. The ecotoxicological data of this substance for aquatic environment can be found in the literature. Unfortunately there is an absence of the toxicological data of this substance for the terrestrial environment. This study is focused on the evaluation of 1,4-dichlorobenzene toxicity on soil organisms using soil toxicity tests. The toxicity was determined by using a set of four terrestrial tests: determination of effects on reproduction and survival of Enchytraeidae (Enchytraeus crypticus), inhibition of reproduction of Collembola (Folsomia candida) by soil pollutants and the determination of the effect of pollutants on lettuce seedlings (Lactuca sativa L.).*

Keywords: 1,4-dichlorobenzene, soil organisms, toxicity tests, LCA, LCIA.

INTRODUCTION

1,4-dichlorbenzene (1,4-DCB) is an environmentally hazardous substance. This substance is used as raw material for production of insecticides, deodorants, pigments and solvents in industry. Its widespread usage necessarily leads to an increasing concentration in the environment. 1,4-DCB is one of the reference substances used in the Life Cycle Assessment methodology (LCA) in the part called Life Cycle Impact Assessment (LCIA). Experimental values of toxicity tests for individual types of solid waste can be used in LCIA. We would like to test the hypothesis, if in laboratory conducted bioassays can offer data for LCIA characterization of mixed wastes in Ecotoxicity impact category.

METHODOLOGY

The toxicological data of 1,4-DCB are available for the aquatic environment but the information for terrestrial environment are missing. The dichlorobenzenes are lipophilic organic compounds which can transfer to all environment media where they can be converted or decomposed through abiotic and biotic mechanisms. Three basic terrestrial toxicity tests were used: the determination of effects on reproduction and survival of *Enchytraeidae* (*Enchytraeus crypticus*) (ISO 16387, 2004), the inhibition of reproduction of Collembola (*Folsomia candida*) by soil pollutants (ISO 11267, 1999)0 and the determination of effect of pollutants on lettuce seedlings (*Lactuca sativa* L.) (ISO 11269-1, 1993).

The acetone (propan-2-on), a volatile dissolution reagent, was used for the preparation of the tested concentrations, considering low solubility of this substance. The concentration range of 1,4-DCB was 125, 250, 500, 750 and 1000 $mg.kg^{-1}$ in all of used tests. Artificial soil according to EN 14735 (EN 14735, 2005) was used as a dilution medium.

The main idea of the LCA analysis is the quantification of emissions flowing from life cycle of products or services into natural ecosystems. The LCA method is defined by guidelines ISO 14040 (2006) and ISO 14044 (2006). The connection of the experimental method of ecotoxicology and LCA analysis is possible in LCIA phase of LCA. Calculation of environmental impacts from inventory analysis is conducted in classification and characterization step of LCIA. For our work the most important is the characterization step. Evaluation of impact of elementary flows (including mixture wastes) is realized using characterization factors (CFs) determined for every single elementary flow. CFs are determined in a characterization model CML2001 considering the reference substance which is in our case the 1,4-DCB.(Kočí 2009; Guinée et al. 2002)

RESULTS

All methods of individual tests were carried out according to the ISO cited guidelines. The results of toxicity tests – the EC50 values – were evaluated with the GraphPad Prism 4 software (GrafPad Software, 2003) by methods of nonlinear regression. The results are shown in the following tables along with the corresponding 95 % confidence intervals.

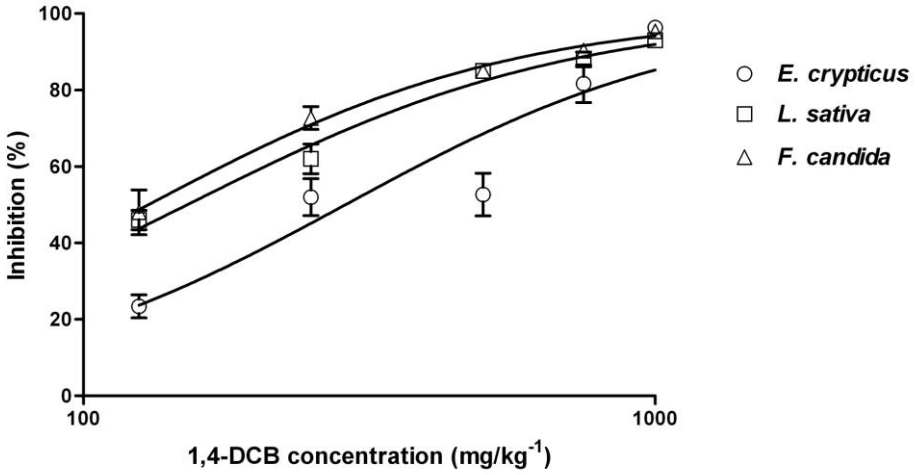

Fig. 1: Effects of 1,4-DCB on reproduction of *E. crypticus* and *F. candida* and on elongation of root *L. sativa*.

Tab. 1: Summary of results for the toxicity of 1,4-DCB: 50 % effects on reproduction or elongation of root with 95 % confidence intervals.

Species	Test duration	Endpoint	EC50 ($mg.kg^{-1}$)	95 % CI
Folsomia candida	28 days	Reproduction	129.9	110.7 to 152.3
Enchytraeus crypticus	28 days	Reproduction	287.3	233.3 to 353.6
***Lactuca sativa* L.**	120 ± 2 hours	Elongation of root	151.9	131.7 to 175.2

DISCUSSION

F. candida appeared to be more sensitive than other tested species (Tab. 1). For the concentration of 500 $mg.kg^{-1}$, the inhibition exceeded 80 % for *F. candida* and *L. sativa*. The toxicity trend is the same for all organisms (Fig. 1). However, *E. crypticus* are less sensitive to 1,4-DCB than the other tested species. The 80 % inhibition is exceeded at the highest concentration of 1000 $mg.kg^{-1}$. These variations can be explained by different ways of exposure or specific or non-specific mode of action (Bezchlebová et al. 2007). The characterization factor of value 1 will be assigned to the toxicological indexes EC50 for 1,4-DCB. CFs of other wastes will be derived from the CF for 1,4-DCB.

CONCLUSION

The main aim of this study was the connection of analytical instruments LCA methodology with experimental ecotoxicology. The characterization of the waste will be simplified by using a new way of derivation of the CFs. Terrestrial tests include the effect of all pollutants in the tested sample. This fact is really important because the target group for which this methodology is suggested is a waste contaminated by metals.

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REFERENCES

Bezchlebová J., Černohlávková J., Lána J., Sochová I., Kobetičová K., Hofman J. 2007. Effects of toxaphene on soil organisms. *Ecotoxicology and Environmental Safety* 68, pp. 326–334.

EN 14735 Characterization of waste – Preparation of waste samples for ecotoxicity tests, European Standard EN 14735, 2005.

GrafPad. 2003. Prism 4 for Windows. GrafPad Software, Inc., San Diego CA.

Guinée J. B., Gorrée M., Heijungs R., Huppes G., Kleijn R., De Koning A., Van Oers L., Wegener-Sleeswijk A., Suh S., Udo De Haes H. A., De Bruijn J. A., Van Duin R., Huijbregts M. A. J. 2002. Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards. Kluwer Academic Publishers.

ISO 11267 Soil quality – Inhibition of reproduction of Collembola (*Folsomia candida*) by soil pollutants. International standard ISO 11267, 1999.

ISO 11269-1 Soil quality: Determination of the Effects of Pollutants on Soil Flora – Method for the Measurement of Inhibition of Root Growth, International standard ISO 11269-1, 1993.

ISO 14040 Environmental management – Life cycle assessment – Principles and framework. International standard ISO 14040, 2006.

ISO 14044 Environmental management – Life cycle assessment–Requirements and guidelines. International standard ISO 14044, 2006.

ISO 16387 Soil quality – Effects of pollutants on Enchytraeidae (*Enchytraeus* sp.) – Determination of effects on reproduction and survival, International standard ISO, 2004.

Kočí V. 2009. Posuzování životního cyklu Life Cycle Assessment – LCA. Vodní zdroje Ekomonitor spol. s. r. o., Chrudim.