O.51 - Multicriteria comparison of RA and LCA ecotoxicity methods with focus on pesticide application strategies

Kägi, T.[1], Bockstaller, C.[2], Gaillard, G.[1], Hayer, F.[1], Mamy, L.[3], Strassemeyer, J.[4]

[1] Agroscope Reckenholz-Tänikon Research Station ART, CH-8046 Zurich, Switzerland,
[2] INRA Agronomie et Environnement Nancy-Colmar, FR-68021 Colmar Cedex, France
[3] INRA UR 251 PESSAC, FR-78026 Versailles Cedex, France
[4] Julius Kühn-Institut (JKI) Bundesforschungsinstitut für Kulturpflanzen, DE-14532 Kleinmachnow
Contact: : frank.hayer@art.admin.ch

Abstract

Over the last years many life cycle assessment (LCA) models have been developed in order to analyse the toxic effect of chemical substances to the environment and to human health. At the same time, risk assessment (RA) models were developed to allow thorough assessment of the fate and effects of substances in the environment. Experience shows substantial variation between the models, especially when looking at pesticides in agricultural production systems. For these reasons we have chosen, within the framework of the European network of competence on pesticides (ENDURE), to compare RA models SYNOPS (JKI), IPHY (INRA) and PRZM-USES (INRA) and the LCA toxicity models EDIP, USES, IMPACT2002+ and EI99 using a multicriteria analysis. The criteria list is derived from the work of Gaillard et al. (2005). It considers the criteria groups' scientific soundness (11 criteria sets), practical feasibility (9 criteria sets) and stakeholder utility (6 criteria sets). This study is focused on scientific soundness. First results on scientific soundness show higher scores of RA compared with LCA methods in coverage of agricultural production and coverage of production factors. However, the LCA methods also show their strength considering the criteria sets environmental issues, coverage of human health, and the ones that deal with the quality of the indicator in terms of results and implementation. Therefore, further tests on different case studies are foreseen to better document the ability of each method for an application in agricultural LCA.

Over the last years, many life cycle assessment (LCA) models have been developed in order to analyse the toxic effect of chemical substances to environmental and human health. Experience shows substantial variation between the models, especially when looking at pesticides in agricultural production systems (Nemecek et al., 2005). The main problems are the high number of pesticides applied and the modelling of the fate and effect of the pesticides. Current LCA methods can consider only a few pesticides. Furthermore, the fate analysis of the methods is often rather simple in order to be able to assess chemicals with only few properties. The recent announcement of the newly developed USETox method (Rosenbaum et al., 2007) should improve the situation in LCA. But so far it is not known whether the improvements in USETox will be sufficient enough for pesticide applications in agriculture. Risk assessment models, as for them, were developed to allow thorough assessment of the fate and effects of pesticides in the environment. For these reasons, a closer collaboration between LCA and risk assessment (RA) modelling approaches is necessary.

Within the ENDURE Network, one goal of the subactivity RA3.4 "Life cycle assessment" is to compare the RA toxicity models SYNOPS (Gutsche and Strassemeyer, 2007), IPHY (Bockstaller et al., 2007) and PRZM-USES (Mamy et al., 2007) and the LCA toxicity models EDIP (Hauschild and Wenzel, 1998), USES (Guinée et al. 2001), IMPACT2002+ (Jolliet et al., 2003) and EI99 (Goedkoop and Spreinsma, 1999) using a multicriteria analysis.

The criteria list is derived from the work of Gaillard et al. (2005) and was established by the three research institutions represented in RA3.4 (ART, JKI and INRA). The criteria are adapted to the evaluation of indicator methods assessing the impacts of pesticides in an LCA framework. Adaptations were discussed based on inputs of the method developers. Each author of the method or researcher supporting an indicator first evaluated its own method according to the criteria. The method developers not represented in the ENDURE Network were consulted separately. A cross-validation of the evaluation of each method has been completed in order to avoid evaluation discrepancies. The criteria list considers the following three groups:

- Scientific soundness (Tab. 1): Among the 11 criteria sets, three criteria sets refer to the coverage of the environmental issues (output), the production branches (domain of application) and the production factors (input). Two criteria sets tackle the construction of the indicators, the indicator type and the degree of integration of processes. The three last ones deal with the quality of the indicator in terms of result ('avoidance of incorrect conclusions') and implementation (transparency).
- Practical feasibility: The 9 criteria sets consider the practical feasibility for extension services, authorities and scientists, the accessibility of the data, the qualification requirements, the necessity for external services, the user friendliness, the support and time needed.
- Stakeholder utility: The 6 criteria sets refer to the utility of the methods for extension services, authorities and scientists, the coverage of needs, the unambiguousness and communication of the results.

The assessment of the seven methods showed the following results for the criteria group scientific soundness (see also Tab. 1) on which this study was focused: Considering the environmental issues, all methods cover the aquatic risk satisfactorily. Looking at the terrestrial risk, the methods EDIP and IPHY only partially cover this environmental issue because only one target species and only the chronic or acute risk potential is calculated for single products. On the other hand, IPHY is the only method, which considers the risk assessment for beneficial organisms.

Considering human toxicity, the methods SYNOPS, IPHY and EDIP do not cover it sufficiently. SYNOPS does not consider human toxicity at all, IPHY does not consider the risk for farmers and consumers and EDIP does not consider the pesticide uptake through water. On the contrary, the methods USES, IMPACT2002+, EI99 and USES-PRZM face this aspect almost entirely.

In view of the exposition pathways, EDIP only roughly estimates the fate factors to water, air and soil and therefore shows the lowest value. On the other hand, the methods SYNOPS, EI99, USES and USES-PRZM have the highest value, calculation of the exposition pathways being well founded.

There is an apparent advantage of the RA methods over the LCA methods for the criteria sets coverage of agricultural applicability and coverage of production factor. The LCA methods can so far only handle a limited number of pesticides. Furthermore they are not detailed enough to consider production management aspects or processes on the field such as incorporation, etc… whereas the RA methods are especially designed for assessing pesticide applications.

Considering the coverage of geographical applicability, the method SYNOPS shows a clear advantage over the LCA methods, which do not cover this aspect satisfactorily.

Looking at the other criteria sets such as the depth of analysis, the integration of processes, the avoidance of incorrect conclusions and transparency, there is no difference between the methods. They all cover these aspects adequately.

Tab. 1: Overview of the provisional results for the criteria group scientific soundness for the considered toxicity methods. Scale goes from 1 (bad) to 5 (excellent). Each author first filled in the table for the method he supports

Tab	Criteria group scientific soundness	Score						
		SYNOPS	IPhy	PRZM -USES	EI99	USES	Imp02	EDIP
1	coverage of environmental issues	3.2	2.6	3.4	3.2	3.2	3.0	2.8
2	coverage of human health	1.0	1.7	3.8	4.5	4.8	4.2	2.8
3	coverage of exposition pathways	2.9	2.5	3.6	3.1	3.1	2.6	2.1
4	coverage of agricultural production branches	3.8	3.7	3.7	2.0	2.0	2.0	2.0
5	coverage of geographical applicability	4.2	2.0	1.5	1.2	1.2	1.2	1.0
6	coverage of production factor	3.4	2.6	1.9	1.5	1.5	1.5	1.5
7	indicator type, depth of environmental analysis	4.0	4.0	5.0	4.0	4.0	4.0	4.0
8	integration of processes	4.0	4.0	4.0	4.0	4.0	4.0	3.0
9	avoidance of incorrect conclusions linked to calculation method	4.0	4.0	4.0	4.0	4.0	4.0	3.0
10	avoidance of incorrect conclusions linked to outputs	4.0	4.0	4.0	4.0	4.0	4.0	3.0
11	Transparency	4.0	4.0	4.0	4.0	4.0	4.0	3.0

Although first results on scientific soundness shows higher scores of RA compared with LCA methods in coverage of agricultural production and coverage of production factors, the LCA methods also show their strength considering the criteria sets environmental issues, coverage of human health, and the ones which deal with the quality of the indicator in terms of result and implementation. Therefore, further tests on different case studies are foreseen to better document the ability of each method for an application in agriculture. Further results are discussed in Kägi et al, (2009).

References

Bockstaller C., J. Wohlfahrt J. Y. Chapot 2007. Presentation of I-PHY (former Ipest). ENDURE Meeting RA3, Tänikon, Switzerland

Gaillard, G., Baumgartner, D., Freiermuth Knuchel, R., Bockstaller, C., Reinsch, M., Brauner, R., 2005. Comparison of farm management tools. In F. C. Piqué, and J. R. Pons, (Eds.), Innovation by Life Cycle Management - International Conference, Barcelona, September 5-7, 2005, p. 360-364.

Goedkoop M & Spreinsma R. 1999. The eco-indicator 99, a damage orientated method for life cycle impact assessment. Pré consultants B.V., Amsford, downloaded from www.pre.nl

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, H., van Duin, R., Huijbregts, M.A.J., Lindeijer E., Roorda A.A.H., Weidema B.P., 2001: Life cycle assessment - an operational guide to the ISO standards. Ministry of Housing, Spatial Planning and Environment (VROM) and Centre of Environmental Science (CML), The Hague and Leiden.

Gutsche V. & Strassemeyer J (2007) SYNOPS - ein Modell zur Bewertung des Umwelt-Risikopotentials von chemischen Pflanzenschutzmitteln, Institut für Folgenabschätzung im Pflanzenschutz, Biologische Bundesanstalt für Land- und Forstwirtschaft.

Hauschild, M., Wenzel, H., 1998: Environmental assessment of products. Vol. 2: Scientific background. Chapman and Hall, London, 565 pages.

Kägi T., Bockstaller C., Gaillard G., Hayer F., Mamy L. & Strassemeyer J. (2009). Multicriteria comparison of RA and LCA toxicity methods with focus on pesticide application strategies. Proceedings 6th International Conference on Life Cycle Assessment in the Agri-Food Sector 2008, Zürich

Mamy, L., Gabrielle B. & Barriuso, E. 2007. Compared environmental balances of broad-spectrum and selective herbicides. In *Proceedings XIII Symposium in Pesticide Chemistry*, 3-6 Sept. 2007, Piacenza, pp 332-339.

Nemecek T., Huguenin-Elie O., Dubois D. & Gaillard G. 2005. Ökobilanzierung von Anbausystemen im schweizerischen Acker- und Futterbau. Agroscope FAL Reckenholz, Zürich; Schriftenreihe der FAL 58, 155 p.

Olivier J., Margni M., Charles R., Humbert S., Payet J., Rebitzer G. and Rosenbaum R. 2003. IMPACT 2002+: A New Life Cycle Impact Assessment Methodology, Int J LCA, 8 (6) 324 – 330 (2003)

Rosenbaum R.K., Hauschild M., Bachmann T., Huijbregts M., Jolliet O., Larsen H.F., Margni M., McKone T., van de Meent D., Schuhmacher M., Juraske R., Payet J., Köhler A. & MacLeod M. (2007). Towards a consensus model in chemical characterization modelling for LCA: comparison and harmonisation of models for human exposure and toxicity. Presentation at the SETAC Europe 17th Annual Meeting, Porto, downloaded from http://se.setac.org/files/setac-eu-0248-2007.pdf

Acknowledgment:

The work is supported by the European Network of Excellence for the Durable Exploitation of Crop Protection Strategies ENDURE.