Probabilistic risk assessment of pesticides under present and future agricultural and climate scenarios using a Bayesian Network

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1. Introduction

Future environmental changes driven by predicted climate and population trends need to be accounted for better in environmental risk assessment. Increases in precipitation and temperature may cause higher occurance of plant disease and insect pests. Together with changes in production demand, agricultural practices are expacted to change for example crop types and pesticide use and application.

Current probabilistic risk assessment typically takes into account the variability of species sensitivity to pollution with Species sensitivity distributions, though lacks consideration of the variability and magnitude of exposure to hazardous chemicals and other factors that influence the exposure to or effects of these chemicals. Probabilistic approaches to risk assessment are recommended to account for uncertainty in pesticide exposure under future scenarios [1]. We developed a Bayesian Network to assess the environmental risk of pesticides under future scenarios, that incorporates various types of information climate projections, pesticide exposure models and toxicity tests. One of the main benefits of Bayesian Network models are that uncertainty of all components can be quantified and thus that a probabilistic risk calculation can be carried out.

2. Materials and methods

To predict the exposure for the selected representative study site (Heia and Syverud in the south east of Norway) a WISPE (World Integrated System for Pesticide Exposure) model is run, that predicts and evaluates the potential impacts of pesticides on the environment. It was configured with scenarios containing data on crops, soild, application and weather conditions and uses transport models including PRZM, EXAMS, and ADAM [2].
The Bayesian Network is used as it can serve as a meta-model that links the output from other models - in this case the WISPE model - with an probabilistic approach to risk estimation. It offers a tranparent way of showing uncertainties related to each of the components of the model [3].

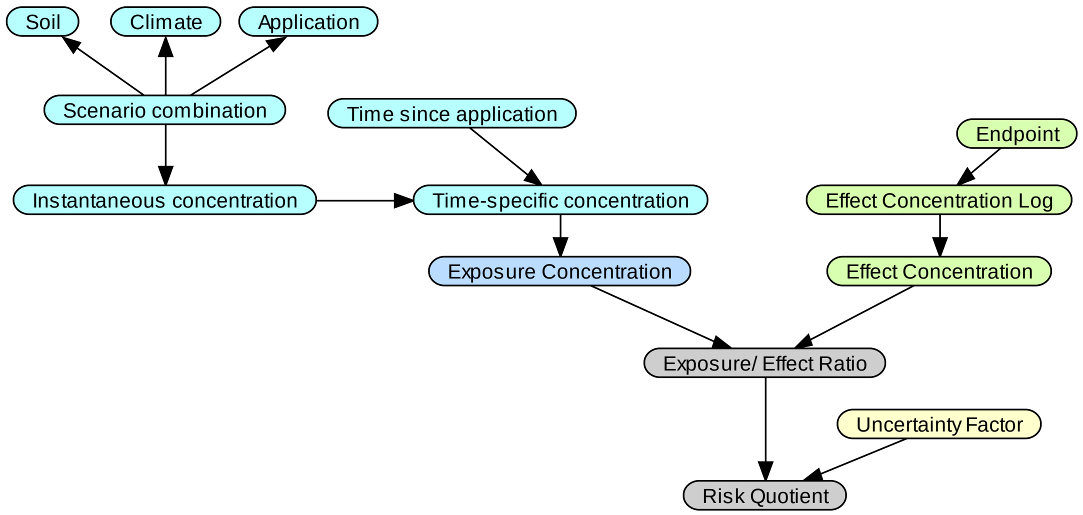

Figure 1: Conceptual model of the Bayesian network for probabilistic risk assessment of pesticides also incorporating future land-use, soil and climate scenarios.

The developed Bayesian Network contains an exposure prediction which is the output of the WISPE model (Figure 1). Meanwhile, the effect prediction has input from distributions derived from toxicity tests. Presently, we run the model for different application scenarios, and plan later to also add climate and soil scenarios. The preliminary effect distribution used so far is based on acute toxicity data (EC50 values). If multiple EC50 values for the same species existed the mean was used. Overall, only three taxonomic groups, and 13 species were used. The toxicity tests used only included adverse effect endpoints.
Within the model, the instantaneous concentration together with time since application determine the time-specific concentration. The effect concentration is determined by the node «endpoint» which differentiates between acute and chronic toxicity data. Exposure and effect together determine that exposure/ effect ratio node, that together with an uncertainty factor, derives the risk quotient.

3. Results and discussion

The finalized Bayesian Network model was run by selecting a set of scenarios as evidence. Given this evidence, probability distributions were updated throughout the Bayesian Network. The Table 1 displays the output for the risk quotient for all three application scenarios, for the time since application of 1 day and an AF of 10. For these "events" the differences between the the risk quotients to be in a certain interval is very small. Though the risk is higher for a scneario with higher application. It also displays the output for the risk quotient for the highest application scenario, the time since application of 1 days and an uncertainty factor of 1, 10 and 100, applied to demonstrate how the alternatives affect the risk quotient.

	Application scenario	APSC -25	APSC	APSC +25	APSC +25	APSC +25	APSC +25	APSC +25	APSC +25
	Assessment Factor	10	10	10	10	10	1	10	100
	time since application	1	1	1	1	5	1	1	1
Risk quotient intervals	0 to 1e-5	42.70	40.30	34.70	0.00	0.00	34.70	0.00	0
	1e-5 to 1e-4	48.20	49.30	51.80	0.00	34.70	51.80	34.70	0
	1e-4 to 0.001	8.78	10.00	13.00	73.20	42.10	13.00	51.80	34.70
	0.001 to 0.01	0.26	0.34	0.53	18.30	22.70	0.53	13.00	51.80
	0.01 to 0.1	0.00	0.00	0.00	8.51	0.50	0.00	0.53	13.00
	0.1 to 1	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.53
	1 to 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.003

Table 1: Preliminary output of the Bayesian network Risk quotient node for each of the intervals under several events

4. Conclusions

This approach has the potential to assess the environmental risk of pesticides under future scenarios. It integrates different types of information from e.g. climate, pesticide exposure models and toxicity testing. Also, it gives a transparent way to display the risk quotient. Further plans are to incorporate other crops such as vegetables or potatoes, and find a suitable pesticide exposure prediction model to use its output for another representative study site in Europe.

5. References

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