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ERI: Environmental risk index. A simple proposal to select agrochemicals for agricultural use

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Abstract

Agricultural production must respond to high-quality and improved environmental requirements. To choose adequate pest control strategies, it is necessary that there is knowledge to enable management of many agrochemicals parameters that offer sufficient information to take correct decisions. However, information about leaching, persistence, chronic and acute toxicology parameters, bioconcentration and others are hard to perform and analyze for persons without knowledge related with agrochemicals. The Environmental Risk Index (*ERI*) reported here permits the usage of available parameters of each different agrochemical. These include persistence (DT_{50}), leaching, volatility, octanol-water coefficient (K_{ow}), reference dose (*Rfd*), lethal dose (LD_{50}) for non-target organism (mammals, birds, aquatic animals and insects). These can be compared in a simple way for many agrochemicals and ranked according to environmental risk. To assess the use of this index, *ERI* values were calculated for several agrochemicals used in USA and Europe and related to their detection in ground and surface water. These showed good correlations. This result allows consideration of the *ERI* as a useful screening tool to incorporate the environment into local or regional regulations and change criteria for individual agrochemical use according to soil, weather or crop management condition.

Keywords: Environment; Risk index; Leaching; Toxicology; Agrochemical

1. Introduction

Agrochemicals play a fundamental role in food and fiber production in addition to protecting animal and human health. During recent years, there has been increasing interest in the fate of agrochemicals in the environment and their impact on ground and surface water quality. Drinking water quality and the need to ensure that there are no unacceptable effects on non-target aquatic organisms are the fundamental issues of concern.

Agricultural practice like Integrated Pest Management (IPM), Integrated Farm Management (IFM), Integrated Crop Management (ICM), and Good Agricultural Practice (GAP) provide to farmers a decision-making framework to optimize the use of plant protection products and encourage management practices which ultimately protect the environment and the human health.

Nevertheless, if they are used carelessly or improperly, then they can be a threat to farmers, consumers, drinking water supplies and wildlife. To avoid these unpleasant effects, it is necessary to have a better understanding of how agrochemicals behave in the environment. To achieve that goal, interdisciplinary interactions are required among chemists, toxicologists, hydrologists, soil and water scientists, biologists and agronomists.

Many factors determine whether an agrochemical can have a human acceptable toxicological and environmental profile. Several deterministic models have been

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generated to predict agrochemical behavior in the environment, to assess leaching, water contamination, movement into the atmosphere and through the various food chain levels. However, these models require precise information, which is sometimes relatively complex, and results are often difficult to interpret because environmental phenomena are complex and hard to model.

The ability to detect and determine the amount of an agrochemical present in all compartments of the environment and to determine its eco-toxicological significance is fundamental to reducing the environmental impact.

Today, specialized research reported in the literature offers enough scientific information about agrochemicals which can be classified and processed. For this reason the aim of this simple environmental risk index (*ERI*) is to offer a screening tool to take quick and technically supported decisions that could be useful for agrochemical local registration which can result in a reduction in the environmental risk.

2. Methods

The meaning of risk, namely hazard x exposure, implies the possibility that something adverse could happen. Thus, environmental hazard depends to a large extent on molecular structure and on physicochemical properties (Seiber, 1987). In order to compare the potential risk from different agrochemicals, it is necessary to consider the characteristics of those and the relevant environment for different soil and weather conditions that are available in the literature. The factors to consider could be soil persistence, adsorption, volatilization, solubility in water and organic solvent and toxicological profile (*TP*) of the agrochemicals

2.1. Environmental risk index

Considering the basic parameters that characterize each agrochemical and their *TP*s, it maybe possible to evaluate and compare relatively the environmental risk that each agrochemical could exhibit. A simple lineal equation for *ERI*, for any agrochemical, is proposed by the authors below:

$$ERI = (P + L + V + TP)D, \quad (1)$$

where P is the soil persistence, L the leaching, V the volatility, TP the toxicological profile and D the dose.

To calculate TP we suggested the following:

$$TP = K_{ow} + Rfd + LD_{50} + AT, \quad (2)$$

where K_{ow} is the partition coefficient (octanol-water), Rfd the reference dose, LD_{50} the human acute dermal lethal dose and AT the animal toxicology.

Each term from Eqs. (1) and (2), will have four levels or intervals: low, medium, high and very high, with assigned numerical values of 1, 2, 3 and 4, respectively (Tables 1 and 2). In order to better use and understand the equations mentioned above, it is necessary to briefly describe the herbicide parameters that were considered to estimate *ERI*.

Table 1
The degree of severity and assigned values and intervals proposed for each term of *ERI*

Severity degree and assigned values		Intervals ranking				
		Persistence (P) (DT_{50}, days)	Dose (D) (kg ia ha^{-1})	Leaching (L) *LIX Index*	Volatility (V) (mm Hg)	Toxicological profile (TP)
Low	1	$\leqslant 30$	$\leqslant 1$	$\leqslant 0.09$	$\leqslant 10^{-6}$	$\leqslant 8$
Medium	2	$30 \leqslant 60$	$1 \leqslant 2$	$0.09 \leqslant 0.25$	$10^{-6} \leqslant 10^{-5}$	$8 \leqslant 14$
High	3	$60 < 90$	$2 < 3$	$0.25 < 0.5$	$10^{-5} < 10^{-4}$	$14 < 20$
Very high	4	$\geqslant 90$	$\geqslant 3$	$\geqslant 0.5$	$\geqslant 10^{-4}$	$\geqslant 20$

Table 2
The degree of severity and assigned values and intervals proposed for each term of *TP*

Severity degree and assigned values		Intervals ranking			*AT*		
		K_{ow} (Log K_{ow})	Rfd (mg kg^{-1} day^{-1})	LD_{50} (mg kg^{-1})	Mallard Duck LD_{50} (mg kg^{-1})	Rainbow trout LC_{50} (mg L^{-1})	Honey bee LD_{50} (mg kg^{-1})
Low	1	$\leqslant 1$	$\geqslant 0.1$	$\geqslant 4000$	$\geqslant 5000$	$\geqslant 100$	$\geqslant 100$
Medium	2	$1 \leqslant 2$	$0.1 \geqslant 0.01$	$4000 \geqslant 400$	$5000 \geqslant 500$	$100 \geqslant 50$	$100 \geqslant 50$
High	3	$2 < 3$	$0.01 > 0.001$	$400 > 40$	$500 > 50$	$50 > 10$	$50 > 25$
Very high	4	$\geqslant 3$	$\leqslant 0.001$	$\leqslant 40$	$\leqslant 50$	$\leqslant 10$	$\leqslant 25$