Preliminary risk assessment of common-use pesticides using PRIMET and PERPEST pesticide risk models in a semi-arid subtropical region

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ABSTRACT

The pesticide risk in agriculture in developing countries has not been adequately studied due to the extent and fate of pesticides in the environment often being unknown. South Africa is a country that has significant pressure on its freshwater and agricultural resources, which increases the possibility of pesticide effects. Thus, the aim of this study was to evaluate the use of the PRIMET (Pesticide Risks in the Tropics to Man, Environment and Trade) and PERPEST (Predicting the Ecological Risk of PESTicides) models to predict pesticide exposure and effects on aquatic ecosystems due to spray drift. Vaalharts Irrigation Scheme is situated in the Northern Cape Province and receives water from the Vaal River for 43 000 ha of agricultural land. Crops in the area mostly consist of wheat, maize and groundnuts. Data gathered through household surveys with farmers were used in PRIMET as a first-tier estimate of the potential risk of the pesticides. The Predicted Effect Concentrations (PEC) calculated for the pesticides indicating a possible to definite risk were then used as input for PERPEST. PERPEST is a higher-tier model that predicts the potential effects of a pesticide on various grouped endpoints in the aquatic environment. The PRIMET results indicated most pesticides posed no risk to the environment, except the pyrethroid, deltamethrin. The ETR for deltamethrin indicated a possible to definite risk to the aquatic environment. The PERPEST results for deltamethrin indicated a high probability of clear effects on insects, micro- and macro-crustacean communities, with a lower probability for rotifers, algae, macrophytes and fish. PRIMET and PERPEST provided valid estimates of risk for pesticides and could be used effectively in South Africa.

Keywords: pesticides, PRIMET, PERPEST, Vaalharts

INTRODUCTION

In most countries the use of pesticides in agriculture is an accepted practice as it ensures a reliable yield of good quality produce. However, the extensive use of pesticides in developing countries quite often goes along with improper use (Ecobichon, 2001; Damalas and Eleftherohorinos, 2011). The pesticides can enter the aquatic ecosystem through various routes such as spray drift or runoff (Raschke and Burger, 1997; Schulz, 2004). This may then pose risks to various non-target organisms in the aquatic ecosystem that can cause effects at population, community and ecosystem levels. Pesticides potentially affect human health through the consumption of fish, water and macrophytes from affected surface water (Van den Brink et al., 2005). Therefore it is important to assess the risk posed by the multitude of different pesticides that are used within the agricultural communities at this point in time.

There are various models being used to predict ecological risk of pesticides, including population, food-web and ecological models (Koelmans et al., 2001; Traas et al., 1998; Van den Brink et al., 2007). However, these models are quite often intricate and complex with a large number of input parameters required. Quite often the detailed data needed for these models are not available, and the models often focus only on certain risk aspects, making their applicability limited. The resulting outcome of this is complex simulation models that are inaccurate due to the primary input data being insufficient (Van den Brink et al., 2006). This is amplified in developing countries due to a lack of resources, thus restricting widespread use of the models (London et al., 2005).

To overcome the limitations of the various pesticide models that are currently available the PRIMET (Pesticide Risks in the Tropics to Man, Environment and Trade) and PERPEST (Predicting the Ecological Risk of PESTicides) models were created. The aim was to create models that have a wider scope for application, need a limited number of input parameters and are cost effective (Ansara-Ross et al., 2008). The resultant models are also easy to use making it possible for people without specialist training to use and predict the risk of pesticides to the environment.

The PRIMET Decision Support System was created to predict the risk of pesticide application to aquatic life, terrestrial life, use of groundwater for drinking water as well as dietary exposure (Van den Brink et al., 2005). PRIMET estimates the risk at household level, using actual pesticide application data gathered from a situation analysis, and only the risk of pesticides to surface water (due to spray drift) is taken into account. PRIMET was developed and applied in developing countries in south-east Asia (Thailand and Sri Lanka). The PRIMET version 1.0 model that was implemented in these countries yielded a relatively worst-case scenario risk assessment that required limited input data (Satapornvanit et al., 2004). It is important to note that PRIMET only accounts for risk due to spray drift and therefore the risk might be an underestimation as runoff processes are not incorporated.

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