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Surface water risk assessment of pesticides in Ethiopia

Berhan M. Teklu^{a,b}, Paulien I. Adriaanse^c, Mechteld M.S. Ter Horst^c, John W. Deneer^c, Paul J. Van den Brink^{a,c,*}^a Department of Aquatic Ecology and Water Quality Management, Wageningen University, Wageningen University and Research Centre, P.O. Box 47, 6700 AA Wageningen, The Netherlands^b The College of Natural Sciences, University of Addis Ababa, 4 Kiklo Campus, Addis Ababa, Ethiopia^c Alterra, Wageningen University and Research centre, P.O. Box 47, 6700 AA Wageningen, The Netherlands

HIGHLIGHTS

- Scenarios for pesticide registration procedure in Ethiopia have been designed.
- Only a few pesticides resulted in medium to high risk to aquatic species.
- The risk assessment methodology developed is ready for implementation in Ethiopia.

GRAPHICAL ABSTRACT



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ABSTRACT

Scenarios for future use in the pesticide registration procedure in Ethiopia were designed for 3 separate Ethiopian locations, which are aimed to be protective for the whole of Ethiopia. The scenarios estimate concentrations in surface water resulting from agricultural use of pesticides for a small stream and for two types of small ponds. Seven selected pesticides were selected since they were estimated to bear the highest risk to humans on the basis of volume of use, application rate and acute and chronic human toxicity, assuming exposure as a result of the consumption of surface water. Potential ecotoxicological risks were not considered as a selection criterion at this stage. Estimates of exposure concentrations in surface water were established using modelling software also applied in the EU registration procedure (PRZM and TOXSWA). Input variables included physico-chemical properties, and data such as crop calendars, irrigation schedules, meteorological information and detailed application data which were specifically tailored to the Ethiopian situation.

The results indicate that for all the pesticides investigated the acute human risk resulting from the consumption of surface water is low to negligible, whereas agricultural use of chlorothalonil, deltamethrin, endosulfan and malathion in some crops may result in medium to high risk to aquatic species.

The predicted environmental concentration estimates are based on procedures similar to procedures used at the EU level and in the USA. Addition of aquatic macrophytes as an ecotoxicological endpoint may constitute a welcome future addition to the risk assessment procedure. Implementation of the methods used for risk characterization constitutes a good step forward in the pesticide registration procedure in Ethiopia.

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1. Introduction

Agriculture is often referred to as the backbone of the Ethiopian economy. Over 80% of the people living in the rural areas are dependent on agriculture. Recent developments in the country brought about intensification of farming activities, both in acreage and in the use of

* Corresponding author at: Department of Aquatic Ecology and Water Quality Management, Wageningen University, Wageningen University and Research centre, P.O. Box 47, 6700 AA Wageningen, The Netherlands.

E-mail address: paul.vandenbrink@wur.nl (P.J. Van den Brink).

extrinsic inputs like pesticides and fertilisers (Ethiopia Investment Agency, 2012). This is evidenced by the latest increase in intensive commercial agricultural activities, including large scale flower farming in the country. The pesticide consumption of small-scale farmers is also increasing at a high rate despite the poor knowledge about the (eco-) toxicological properties of pesticides and inappropriate handling of agrochemicals (Taddese and Asferachew, 2008).

Ethiopia has 11 fresh and 9 saline lakes of major importance, 4 crater lakes, over 12 major swamps or wetlands and more than 96 rivers, and is for that reason sometimes referred to as the water tower of Africa. The majority of the lakes are found in the Rift Valley Basin. The total surface area of these natural and artificial lakes in Ethiopia is about 7500 km², and most of Ethiopian lakes are rich in fish (Awulachew et al., 2007). Besides these larger water bodies many small rivers and (temporary) ponds exist. Because small water bodies are more vulnerable for pesticide contamination than larger water bodies, the risk assessment focusses on these smaller water bodies.

In view of the current intensification of agricultural activities and increased intensity of pesticide use, in combination with the abundance of surface water bodies in the country, the risk posed to humans and the environment from application of pesticides may be increasing. Hence there is a growing need for the adoption of a scientifically sound pesticide registration procedure that filters out pesticides causing damage to humans and the environment. So, a sound risk assessment tool for quantifying risks is essential. In this light the Pesticide Risk Reduction Programme – Ethiopia (PRRP-Ethiopia), a joint collaborative project on pesticide registration and post-registration aiming to develop a sound tool for quantitative risk assessment, was initiated in 2010 (www.prrp-ethiopia.org).

Pesticide risk assessment is typically based on a framework as depicted in Fig. 1, comparing estimated exposure to toxicologically relevant values of a compound. Generally, application scenarios and pesticide properties, as well as data on pesticide use and data obtained through toxicological studies, are used as input for models. Despite the many challenges faced in the implementation and acceptance in risk assessment, adoption of this framework is essential to make a scientific informed decision on the admittance of a pesticide on the market (Brock et al., 2006; Van den Brink, 2013).

Aquatic risk assessment in Ethiopia has until now not included such tools. Some of the few monitoring studies undertaken (Prabu, 2009;

Prabu et al., 2011) concentrate on heavy metal pollution and assessment of the physico-chemical characteristics of the Awash tributary rivers Akaki (Small and Greater) in Addis Ababa and Huluka and Aleltu Rivers of Ambo. These studies indicated an increased heavy metal pollution downstream the rivers Huluka and Aleltu and increased concentration of heavy metals in waters of Akaki rivers and residues in vegetables produced using these rivers as a source of irrigation. Investigation by Jansen and Harmsen (2011) on samples taken from surface waters around agricultural fields and effluent waters from commercial farms showed concentrations of pesticides above 0.1 µg/L, hence not meeting the European standards for drinking water (URL: <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31998L0083&from=EN>).

This study presents results on risk assessment for humans and aquatic life for 7 pesticides currently in use in Ethiopia. The risk assessment is based on principles underlying the EU aquatic risk assessment and is presently being implemented in the registration procedure for pesticides in Ethiopia.

The objectives of this study are (i) to assess the suitability of the proposed protection goals and scenario locations for risk assessment procedures under development in Ethiopia, (ii) to evaluate the applicability of the combination of PRZM and TOXSWA exposure models for assessing the exposure concentration in a realistic worst-case acute surface water risk assessment of agricultural chemicals in Ethiopia, (iii) to evaluate the risk posed by a few of the already registered pesticides to surface water organisms and humans, based on Exposure Toxicity Ratios (ETR) calculations and (iv) to gain a preliminary perspective on the feasibility of pre-registration risk assessment, using the outlined principles, in Ethiopia.

2. Materials and methods

2.1. Selection of protection goals and scenario locations

The selection of protection goals was discussed in workshops with Ethiopian experts of the Animal and Plant Health Regulatory Directorate (APHRD), Addis Ababa University (AAU), Institute of Biodiversity Conservation (IBC) and Ethiopian Institute of Agricultural Research (EIAR) (www.prrp-ethiopia.org). The selected protection goals were humans directly using surface water as drinking water (especially in surface water that is used for consumption without prior purification) and aquatic organisms living in surface water. Highest priority was given

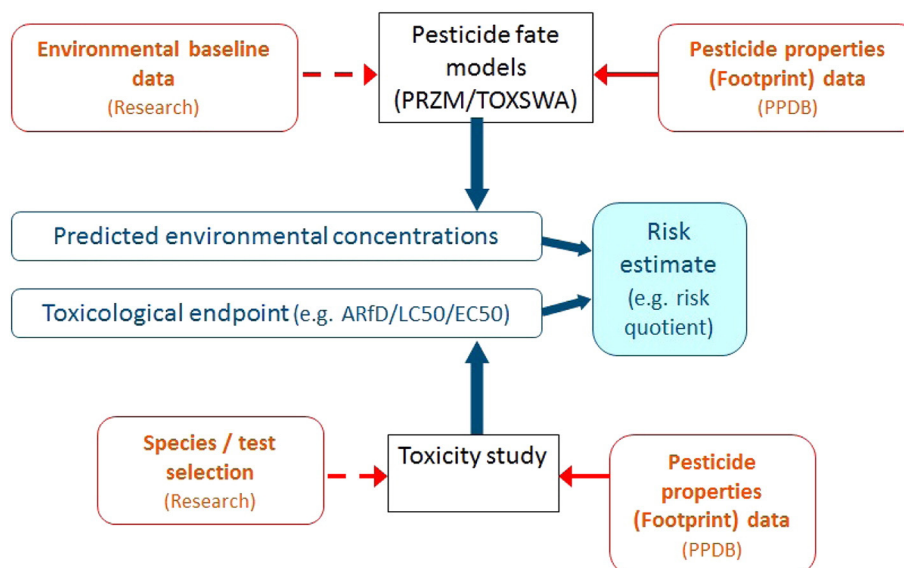


Fig. 1. General approach of the proposed risk estimation (Source: Adriaanse et al., 2014).

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