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Catchment scale monitoring of pesticides in Sweden and the use of a toxicity index

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Introduction

Environmental monitoring of pesticides generates information that help researchers, industry and regulators to better understand the pesticide-environment relationship. Results generated can also be used to ensure that the environmental behaviour of pesticides is in accordance with regulatory intentions and applications done with the use of best management practices. This forms the basis for better communication of appropriate practices for minimising possible negative impacts from pesticide use on the environment.

Environmental monitoring of pesticides in Sweden started during the mid-80s as short term, research based investigations of possible occurrence of pesticides in streams and rivers. Today the programme is long-term and includes several monitoring sites with sampling in different matrixes such as surface water, ground water, sediments and precipitation. The aim of the Swedish pesticides monitoring programme is to quantify and follow variations of pesticides in time and space, both regarding concentrations and transported amounts. Results are used to document the outcome of national work on the sustainable use of pesticides, if actions taken result in required environmental improvements.

Material and methods

Selection of pesticides to be included into the present monitoring programme is based on a ranking system, including all pesticides registered in Sweden, as well as some superseded still of possible concern due to e.g. persistence in the environment. The ranking was based on the following six parameters: *i*) degradation rate in soil (DT_{50}), *ii*) soil sorption (K_{oc}), *iii*) WFD priority substance, *iv*) potential toxicity for aquatic organisms (EU EQS or national WQO), *v*) amount sold and *vi*) area treated. For each parameter the pesticide is given a number between 1 and 10, with 10 indicating the highest relative risk for the aquatic environment (in the case of WFD priority substances all pesticides listed in Annex X were assigned a value of 10). For each pesticide the given numbers were added forming an index enabling a ranking of those pesticides most important to include into the monitoring programme. According to this ranking system isoproturon was the top candidate for monitoring in Sweden, followed by MCPA, fluroxypyr, metazachlor and diflufenican.

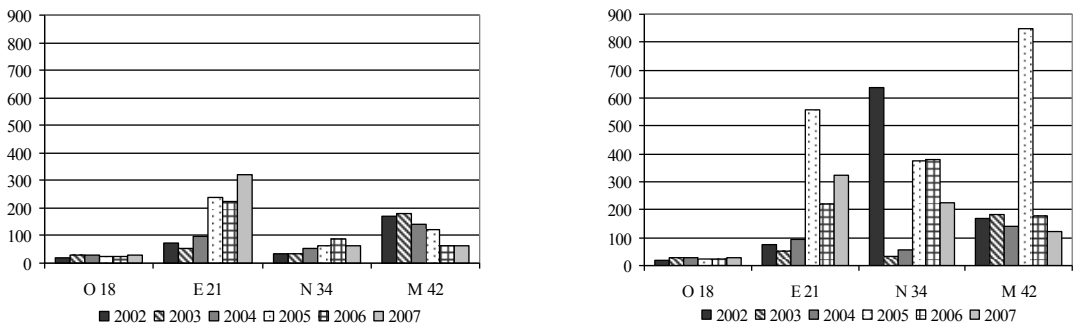
The monitoring programme on pesticides is mainly focused on four intensive study areas. The areas represent major agricultural regions in Sweden. Beside these, two rivers and two sites for precipitation sampling is included. The intensive study areas are catchments (8- 16 km^2) dominated by agriculture. Surface water samples are collected during the cropping season as weekly time-integrated samples, collected with refrigerated automatic water samplers. During later years year round sampling has been done in one of the catchments. Great emphasis is given to collecting information (through interviews with the farmers) on agricultural practices within the catchments, including detailed data on pesticide usage. Samples are today analysed for approximately 110 substances in surface waters and include almost 90% of the total volume applied in the catchments.

Results

Monitoring results demonstrate herbicides being the most frequently detected substances in surface waters, followed by fungicides and with more occasional findings of insecticides. Herbicides are normally used much more frequently, and in higher quantities, than both fungicides and insecticides. The 9 most commonly found compounds were all herbicides, and they were also among the most commonly used in the areas. Bentazone was the most frequently detected pesticide, followed by glyphosate. Glyphosate alone represents over a third of total Swedish sales of pesticides. The average transported loss of glyphosate during 2002-2007 was 0.1 % from the catchment areas, which was lower than for a number of other compounds, indicating that compound intrinsic properties contribute to overall losses of pesticides to the aquatic environment. The corresponding figure for bentazone was 0.3 %.

The concentration alone does not provide information on potential toxicity to aquatic organisms. Different pesticides are toxic at different concentration levels. The Swedish Chemicals Agency has developed surface water quality objectives (WQO) for a number of pesticides. The WQO gives the maximum concentration of each pesticide that is calculated not to cause negative effects on aquatic organisms. Dividing measured concentrations for a substance with its WQO and summarizing for each sample or season results gives an index describing potential toxicity (PTI = Pesticide Toxicity Index), modified from Munn et al. (2006). The index was calculated for the areas within the monitoring programme (Figure 1). Due to the fact that the detection limit was substantially above the WQO for insecticides belonging to the chemical group of pyrethroids during the initial years two separate calculations were made. There were differences between the areas, with O18 consistently having the lowest PTI value during all years. In area E21 the index value increased during the monitoring period, while the opposite tendency was being observed in area M 42. The herbicides diflufenican and isoproturon were the most frequently detected substances above their respective Swedish WQO.

Figure 1. Development of the Pesticide Toxicity Index (PTI) in the four monitoring catchments during 2002-2007. Analytical results of pyrethroids are included in the right hand figure.



Acknowledgment

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References

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