Reduction of water contamination from pesticides through the application of the Best Management Practices defined by the TOPPS project

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Abstract
Point sources are considered the most relevant entry route of PPP into surface and ground water. To focus on them is important in order to prevent contamination risks and to avoid exceeding the admitted threshold for PPP residues in drinkable water (0.1 µg/l), stated by European Water Directive. TOPPS (training of Operators to prevent Pollution from Point Sources) is a European Life project aimed at identifying Best Management Practices to prevent point sources taking into account farmers' behaviour, equipment and infrastructure. Dissemination of TOPPS BMP through advice, training and demonstrations at a larger co-ordinated scale in Europe is the final project goal, which should lead to a consistent reduction of water contamination from pesticides.

Keywords: point sources, sprayer, remnants management.

Introduction
Several studies carried out in Northern Europe (Seel et al., 1996; Kreuger, 1998; Mason et al., 1999; Muller et al., 2002; Maillet-Mazeray et al., 2004; Bach et al., 2005; Neal et al., 2006) have pointed out that from 50% and up to 90% of water contamination from plant protection products (PPP) originates from point sources. Especially the phases of PPP mixture preparation and loading into the sprayer, as well as the management of the spray mixture residue at the end of the application and the cleaning of the spraying equipment are considered mainly responsible for PPP point sources.

As in 2000 the European Water Directive was adopted, stating that the maximum allowable threshold of PPP concentration in drinkable water is 0.1 µg/l, prevention of water contamination from pesticides came into particular focus. Exceeding the admitted threshold, in fact, could mean a ban for some pesticides from the market, hence reducing the range of available crop protection solutions for farmers.

In November 2005, a EU Life Project named "TOPPS" (acronym of Training the Operators to prevent Pollution from Point Sources) started. This project aimed at defining Best Management Practises to prevent water contamination from point sources and its final objective is to disseminate these BMP among European farmers, through advice, training and demonstrations.

PPP point sources
During the management of PPP in the farm, there are different phases that can be particularly at risk for water contamination. According to a TOPPS survey carried out among European farmers in 2007, especially the management of left over spray

solutions at the end of the application, the cleaning of the spraying equipment and the filling of the sprayer are considered significant for the generation of PPP point sources. Typically, filling and cleaning of the sprayer are carried out always in the same area of the farmyard, close to the water source (well or water network). In most cases, as the TOPPS survey carried out in 2007 showed (Fig. 1), any precaution is taken to avoid that liquids containing pesticides - originating from spills, accidental overflows occurring during the sprayer filling process (Fig. 2) or from rinsing of the spraying equipment at the end of the application - percolate through the soil towards ground water table or run off towards surface water. As these operations of filling and cleaning sprayers are repeated several times during the season, there is a risk that a not negligible amount of pesticides is let in a reduced soil surface, originating water pollution phenomena.

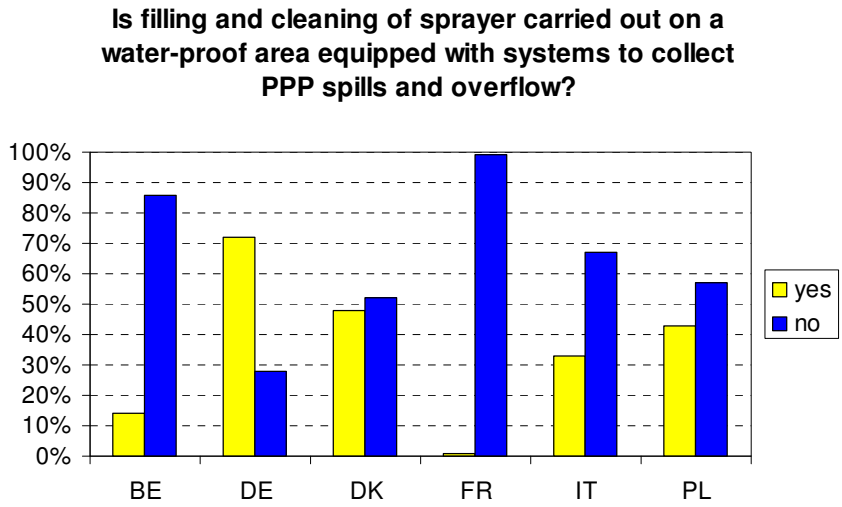

Figure 1. Use of an equipped sprayer filling/cleaning area in Europe (TOPPS survey, 2007).

Figure 2. Example of accidental sprayer overfilling.

Also the not correct management of remnants after the treatment, as the discharge of the PPP mixture residue still present in the tank at the end of spraying on a small surface area in the farmyard or close to a water course can originate point sources.

The TOPPS Project and the genesis of Best Management Practises

TOPPS is a three-year multi-stakeholder project funded by the European Union and by the European Crop Protection Association (ECPA) and involves 15 European countries structured in 4 Clusters (North, Midwest, South and East). DEIAFA - University of Turin is the Italian Partner in the project and co-ordinates the work within the South Cluster that includes Italy, Southern France, Spain and Portugal.

The first task of the project was to collect all existing materials (brochures, booklets, videos, articles, etc.) in the different European countries about the subject of PPP water contamination and about its prevention. These materials have been uploaded in a database available also on the project website (**www.topps-life.org**), and have constituted a basis for the development of Best Management Practices (BMP) guidelines. In a first phase, in each country BMP have been proposed and discussed with local stakeholders (representing farmers associations, environmental agencies, agricultural boards, sprayers manufacturers, crop protection industry), then the national proposals have been discussed at European level between Partners in order to find a "European BMP core" agreed. On February 7, 2007 the official presentation of TOPPS BMP guidelines agreed at European level took place in Bruxelles, in front of the main stakeholders delegated by each European country.

TOPPS BMP guidelines are structured on the basis of defined processes, which represent a sequence of steps in the use of plant protection products.
There are 6 main processes defined:

- Transport
- Storage
- Before spraying
- During spraying
- After spraying
- Remnant management

In the ambit of each main process, further sub-processes are then taken into account in order to better explain the different phases of PPP management in the farm: for instance, the main process of PPP transport is divided in four sub-processes: planning, loading/unloading, during and emergencies.

Based on these definitions the BMP guidelines have been developed in a two step approach (Table 1):
Statements = What to do
Specifications = How to do

Key elements that can improve the prevention of PPP point sources are based on farmer behaviour, on equipment and on infrastructure.

Table 1. Example of the structure of a TOPPS BMP guidelines.

Process	Sub-process	Statement	Specification
Transport	Planning	DO transport PPPs in their original containers with intact, readable label	Type approved [UN] packaging used by most manufacturers. Note: Individual containers taken from 'packs' (split-offs) may not conform; original approved containers and original label instructions.

The European TOPPS BMP guidelines are a selection of about 100 out of more than 400 statements which, during the development process, achieved a good level of consensus in the various discussions. The specifications given in the TOPPS BMP are to be considered as a proposal for the operators / advisors when no local regulations exist. Statements and specifications have been translated in the different languages of the European countries involved in the TOPPS project in order to facilitate their dissemination.

In Italy, two illustrated BMP booklets have been issued: one contains only the statements and is addressed to farmers (Fig. 3A), the second contains both statements and specifications and is addressed to advisors and experts. (Fig. 3B).

A B

Figure 4. Booklets in Italian language edited by DEIAFA concerning BMP guidelines: A) booklet addressed to farmers; B) booklet addressed to advisors.

Dissemination of TOPPS BMP is in course through training courses and demonstrations organised in the demofarms installed in some of the countries involved in TOPPS Project (in Italy the demofarm has been installed in Fontanafredda, Piemonte region), publications, and participations to fairs and exhibitions with TOPPS stands.

Main contents of TOPPS Best Management Practises

Transport

Guidelines concerning the transport of pesticides from the dealer to the farm concern recommendations about the use of adequate vehicles and boxes for transporting pesticides (e.g. van with driver cabin separated from loading area, or boxes for safe transport of PPP cans in the car, Fig. 5), checking of PPP packages integrity, the use of appropriate tools for loading and unloading pallets, the availability of emergency numbers and safety instructions to be used in case of accidents.

Figure 5. Example of safety box used for PPP transport in a car.

Storage

PPP have to be stored preferably in a dedicated room, locked and clearly identified with pictograms; the floor of the storage room has to be waterproof and equipped with a system to separately collect accidental chemical losses. If it is not possible to have a dedicated storage room, pesticides at least must be placed in appropriate metallic cupboards (Fig. 6), displacing powders on the top shelves and liquids on the low shelves in order to minimise risks of accidental spills. Absorbent material shall be always available in the storage room, to contain accidental leakages, and a clearly identified tank or can must be present to store PPP contaminated material (e.g. broken cans, absorbent material, etc.).

Figure 6. Example of cupboard to store pesticides, with powder displaced over liquids.

Before spraying

Before starting any spray application, a planning should be made in order to consider all sensitive areas within the treated area (wells, ponds, ditches, etc.) and then to define appropriate buffer zones to avoid direct contamination of surface water.

Preparation of spray mixture and filling of sprayer should be carried out on a paved area, waterproof and enabling to separately collect PPP spills and accidental overflows, in order to guarantee their proper disposal. The filling area should be placed close to the PPP storage room and far away from surface water and areas sensitive to pollution.

To facilitate the introduction of chemicals into the sprayer tank, the use of an induction hopper is recommended. This auxiliary device, which allows to make a first mixing of the concentrated PPP with some water and then to transfer the concentrated mixture directly into the main sprayer tank can be installed independent from the sprayer in the filling area and connected to the water network (Fig. 7). This solution enables to use the same induction hopper to fill different machines, avoiding the uncomfortable and risky practise to pre-mix chemicals in a pail and then to pour the concentrated solution from the bucket into the main tank opening.

Moreover, inside the induction hoppers there are rotating nozzles which for cleaning empty PPP cans, allowing to transfer the rinsing water directly in the sprayer tank.

Figure 7. Dedicated paved area for loading and cleaning of sprayers, equipped with a collecting system for PPP contaminated liquids and with an independent induction hopper for loading sprayers.

During spraying

TOPPS Best Management Practises concerning the phase of spray distribution in the field are focussed on recommendations to avoid the aspects which could originate point sources, such as the dripping of PPP mixture from hoses or nozzles (for example when the antidrip devices do not properly work), the dispersion of spray mixture when turns at the end of rows are made without stopping spraying, or the accumulation of spray mixture on a restricted area when priming is made with the static sprayer (Fig. 8).

Figure 8. Point source originating from priming operations carried out with the static sprayer.

After spraying

A key aspect to minimise risks of point sources is, first of all, to avoid high volumes of spray mixture residues in the sprayer tank at the end of the application; this goal can be reached assessing precisely the quantity of PPP mixture to apply on the crop surface and therefore filling the tank just with the exact volume necessary. Moreover, it is important to use certified sprayers whose design enable the sprayer pump to suck nearly completely the content of the main tank.

At the end of the application it is important to rinse the sprayer, internally and externally: if the sprayer is equipped with a clear water tank, these operations can be carried out directly in the field. Internal cleaning allows to dilute the residual spray volume still present in the main tank and the diluted mixture can be sprayed on the crop (Fig. 9A); the external cleaning is aimed at removing the amount of spray deposited on the outer parts of the machine and can be done also in the field, changing the cleaning place from treatment to treatment, just connecting a spray lance to the clear water tank (Fig. 9B).

Even if the clear water tank is not originally available on the sprayer, it can be easily added, simply connecting a plastic auxiliary tank to the sprayer circuit (Fig. 10).

Cleaning of sprayer in the farm has to be made on a equipped area (Fig. 11), analogue to the one used for filling, enabling to collect rinsing water separately, in order to allow its subsequent correct disposal and/or treatment.

A

B

Figure 9. A) Application in the field of the diluted mixture obtained after the internal sprayer cleaning; B) external cleaning carried out in the field.

Figure 10. Sprayer equipped with an added auxiliary clear water tank.

Figure 11. Sprayer cleaning made in the farm on equipped area.

Remnant management

Solid and liquid wastes produced at the end of spray applications must be properly managed in order to avoid environmental contamination. For example, empty PPP cans should be collected in dedicated boxes and then delivered to specialised companies for their disposal. The PPP contaminated liquid (originating from spills, overflows, sprayers rinsing procedures, etc.) can be stored in appropriate tanks for delivery to specialised disposal companies or can be treated directly in the farm, for instance using biofilter systems. In this latter case, liquids containing pesticides are poured on farm soil layers (Fig. 12), where the microbial activity degrades PPP active ingredients, allowing to obtain as a final result a "purified" water that can be reused for subsequent treatments.

Figure 12. Biofilter installed in Fontanafredda demo farm

Conclusions

There are several devices and technical solutions able to prevent water contamination from PPP originated from point sources. Most of them have been well defined by the European Life Project TOPPS through the TOPPS BMP guidelines. It is now necessary to promote and to spread the use of these Best Management Practises all around Europe by means of specific training courses and economical subsides to increase the use of the necessary adequate equipment. In this sense, useful information can be downloaded from the TOPPS website: www.topps-life.org

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