

Volumes of residual of sprayers and their International Standards: impact on farm water treatment systems.

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Summary

On farm water treatment systems are helpful in reducing risk of point source contamination of surface water by pesticides. However, their effectiveness is governed by potential loads on treatment systems, which will vary with type and range of crops, spray schedules, operating and cleaning procedures, operator behaviour and – especially - the type of sprayer(s) used. The Standard EN 12761 sets the maximum volume of total residual in a crop sprayer. Measurements of total residual volumes of sprayers - conducted by ENTAM testing stations – suggest that all tested sprayers comply with the requirement. In many cases in fact, their total residual volume is 50% less than the stated requirement. This paper therefore proposes that the existing performance limits are further reduced to the level of the better quartile of sprayers tested; a step that is needed in order not to restrict the further uptake and better use of farm treatment systems.

Key words: total volume of residual, European Standard, point source contamination, pesticides, internal rinsing of spray tank, orchard sprayers, boom sprayers

Introduction

One of the side-effects of the use of pesticides is the contamination of ground and surface waters, which is a major environmental issue in Europe. Over the past ten years, several field surveys and measurement campaigns tried to quantify the relative importance of various practices and actions in the contamination of water by pesticides: Nil, Belgium (Bernaerts *et al.*, 2003); Cherwell, UK (Mason *et al.*, 1999); Vemmenhög, Sweden (Krueger & Nilsson, 2001); Fontaine du Theil, France (Decoin, 2003; Maillet-Mezeray *et al.*, 2004); Stever, Germany (Peterwitz & Rodeck, 2004). An overview of the risk of water contamination by plant protection products during pre- and post treatment operations is given by Jaeken & Debaer (2005). These studies show that 40 to 90% of surface water contamination is attributed to direct losses. These point sources are mainly linked to the filling and cleaning area on the farm.

Apart from various solution in the field and systems that work on physical and/or chemical principles, there are those that rely on biodegradation of pesticides (De Wilde *et al.*, 2007), like the unlined and semipermeable biobeds (Thorstensson, 1997, 2000), the impermeable biobeds (Basford *et al.*, 2004), and the biofilters (Pussemier, 2004; Debaer *et al.*, 2006). In Belgium, various bio-purification systems are operated under a range of conditions. One of the critical factors for dimensioning and optimising systems to treat waste water from filling and cleaning of sprayers, is the hydraulic and the pesticide load. The potential load is influenced by several farm specific factors. The number of different crops cultivated by a farmer, and the spray schedule, will determine how many times the sprayer must be cleaned to prevent damage and residues to the next crop. Next to operating procedures and operator behaviour, it is especially the type of sprayer(s) that will have a major impact on the potential load. Sprayer characteristics, dimensions and design, such as the spray tank and rinse water tank and boom length, will determine the quantity of pesticides in and on the sprayer after spraying. The internal spray leftovers contribute largely to the potential load on treatment systems.

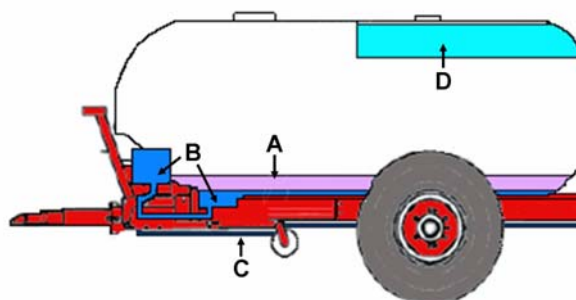


Fig.1: A) spray mixture leftover, B) residual in the tank or dilutable volume, C) dead volume or non dilutable volume, D) rinsing water tank.

The European Standard EN 12761 sets minimum requirements for crop protection equipment. An important factor is the maximum volume of total residual of a sprayer as defined by ISO 13440. The volume of total residual is the volume of spray mixture remaining in the sprayer which cannot be delivered with the intended application rate and/or pressure, equal to the sum of the volume of residual tank and the dead volume (fig. 1). The volume of residual in the tank or dilutable volume is defined as the part of the total residual that remains in the tank or that can flow back to the tank during normal sprayer operation. The dead volume, or non dilutable volume is in turn the part of the total residual that cannot flow back to the tank during normal operation of the sprayer. The European Standard EN 12761-2 for field crop sprayers states that the volume of total residual shall not exceed 0.5% of the nominal tank volume plus 2 litres per metre of the boom. EN 12761-3 for air-assisted tree crop sprayers states the volume of total residual shall not exceed 4% of the nominal tank volume for a tank volume of less than 400 litres, 3% of the nominal tank volume for a tank volume between 400 litres (included) and 1000 litres (included), and 2% of the nominal tank volume for a tank volume more than 1000 litres. Another minimum requirement specified by the European Standard concerns a water tank for rinsing the spraying equipment, which must be provided except for mounted sprayers of capacity less than or equal to 400 litres. The rinsing water tank shall have a volume of at least 10% of the nominal tank volume or at least 10 times the volume of residual which can be diluted.

The aim of this paper is to evaluate the actual volume of total residual and of the rinsing tank in view of potential loading on systems to treat liquid remnants of the spray process.

Materials and Methods

Measurements of different requirements, such as the volume of total residual of sprayers, have been conducted by several testing stations in Europe, united as members of the European Network

for Testing of Agricultural Machines (ENTAM). Members of this network evaluated a total of 163 different sprayers in 72 available test reports, generated between 1995 and 2006 were evaluated. The test reports used are publicly available on the websites of ENAMA (www.enama.it), BBA (www.bba.de) and ENTAM (www.entam.org). Test reports of CMA (www.cma.es) were sent by email on request. Calculations of the potential load on a waste water treatment system were done according to minimum requirements of the European Standard for volume of total residual, and the actual volumes of residual of sprayers measured by the testing stations. For data analyses Unistat 5.6 (Unistat Ltd.) was used.

Results

Different types of tree and field crop sprayers are represented. The 52 tree crop sprayers are distributed in 22 axial or conventional, 12 cross flow or tower-shaped, 10 semi cross flow and 8 other air-assisted tree crop sprayers. Most tree cop sprayers are trailed (48), only 4 are mounted sprayers. The majority of the 111 studied field crop sprayers are trailed sprayers (59), 23 are mounted, and 29 are self-propelled sprayers.

All of the sprayer types tested comply with the present standard on volume of total residual (fig.2). The volume of total residual for tree crop sprayers ranges between 4 and 27 liter (average = 11.06 for 52 tree crop sprayers including the total dilutable volume of 25 sprayers; 10.06 for 27 tree crop sprayers excluding those 25 sprayers). For field crop sprayers the range is between 12.2 and 72.7 liter (average = 34.64). The wider span for field crop sprayers is linked with the range of boom lengths. The volume of total residual plays an important role in the potential load of on farm clean up systems. Especially in those cases where the operator does not clean in the field, but executes all rinsing operations in the farm yard.

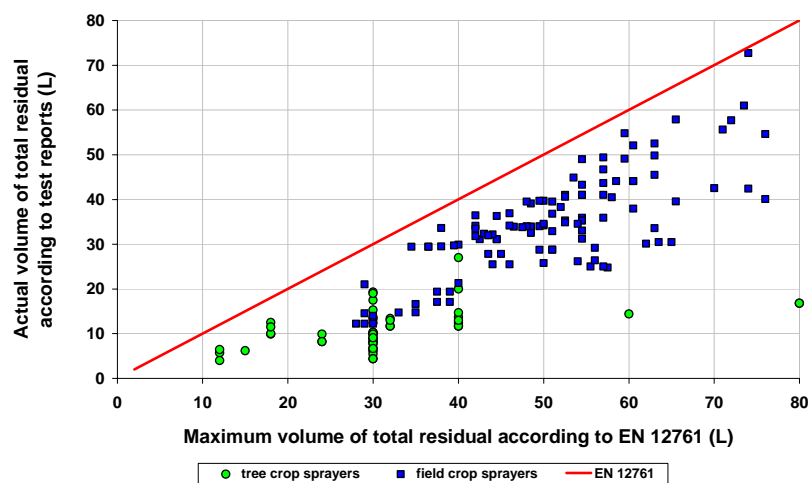


Fig. 2: Actual volume of total residual of 163 sprayers according to test reports compared with the maximum volume of residual stated by the European Standard EN 12761 (for 25 tree crop sprayers the total dilutable volume was used due to missing data for volume of total residual)

In other cases, the potential load on clean up systems is depending on the applied rinsing method and the rinsing location. The total rinsing volume applied in the field is often linked with the nominal content of the mounted rinse tank. The minimum total content of the rinse tank (in liters) is defined in EN 12761. Fig. 3 represents the scatter plots of the actual versus the required rinsing tank volumes for field and tree crop sprayers according to the two standard options. The dots on and above the equity line represents those sprayer types that comply with the indicated rinsing tank content requirements.

The rinsing tank content requirement of 10x the dilutable volume is the most relevant in terms of rinsing level achievement. Sufficient rinsing is critical in terms of crop damage and residue. Linking the rinsing volume with the dilutable residual volume, gives the best guarantee to the operator that the rinsing can be executed properly without carrying excessive rinsing water. In addition, the total residual volume is an important sprayer characteristic that determines to a large extent the rinsing water needed to dilute it to an acceptable level. Hence it is also important to minimise this to reduce hydraulic loading on clean up systems or to reduce labour required to spray out rinsates in the field and minimise risk on MRL exceedance.

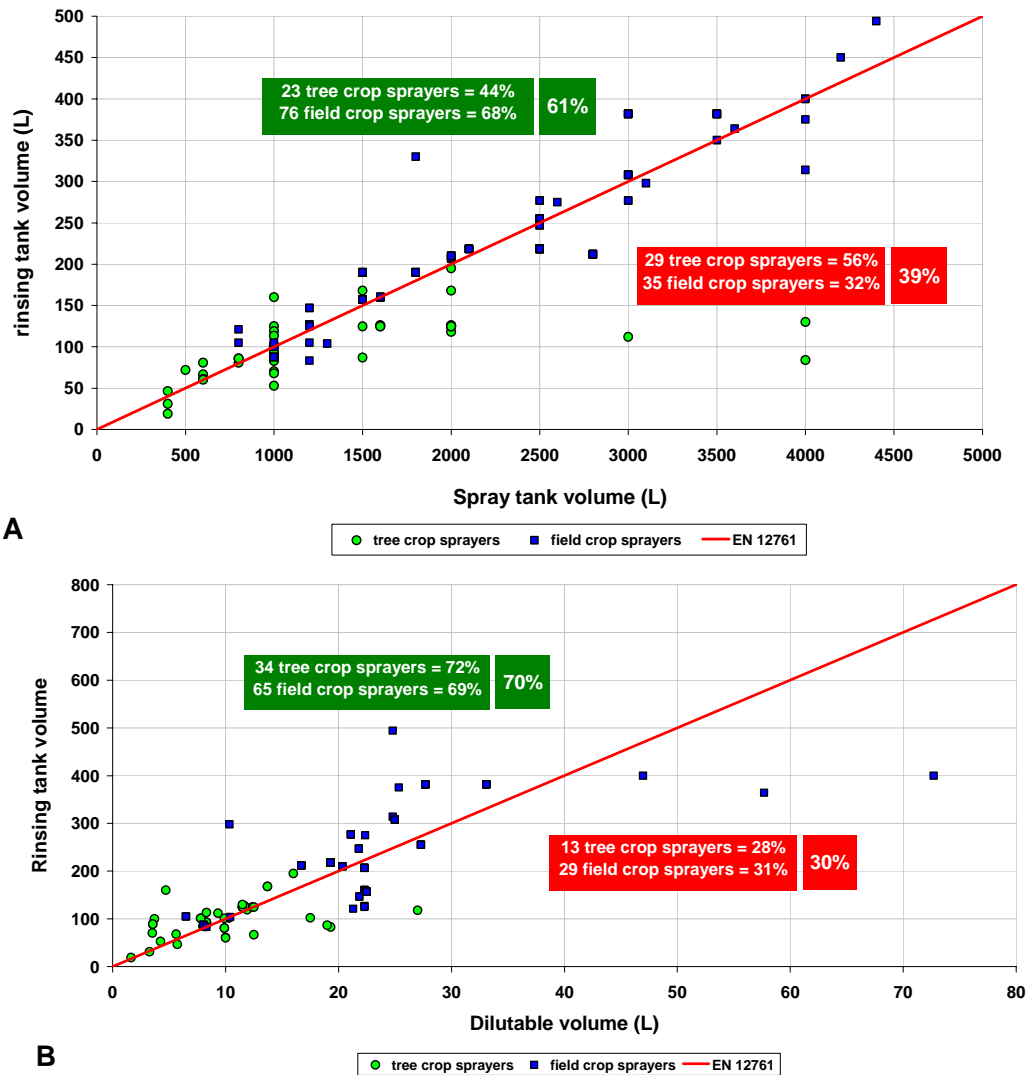


Fig. 3: A) Actual rinsing tank volume of 163 sprayers compared with the minimum rinsing tank volume (10% of spray tank volume) stated by the European Standard EN 12761; B) Actual rinsing tank volume of 141 sprayers compared with the minimum rinsing tank volume (10 times dilutable volume) stated by the European Standard EN 12761

Fig. 4 shows the theoretical cleaning potential calculated for the different sprayer types and three different rinsing protocols. It is clear that the rinsing method is the most relevant parameter if the cleaning water volume is restricted to the rinsing tank content, when rinsing nozzle efficiency is not considered. Nevertheless, the variability in theoretical rinsing efficiency among sprayer types is still considerable, due to a wide variety in volumes of total residual, dilutable residual volumes and rinsing water tank capacities.

The previous figures show that minimising the total volume of residual, and thus the dilutable residual volume is key to keep needed rinsing water amounts at acceptable levels. The present

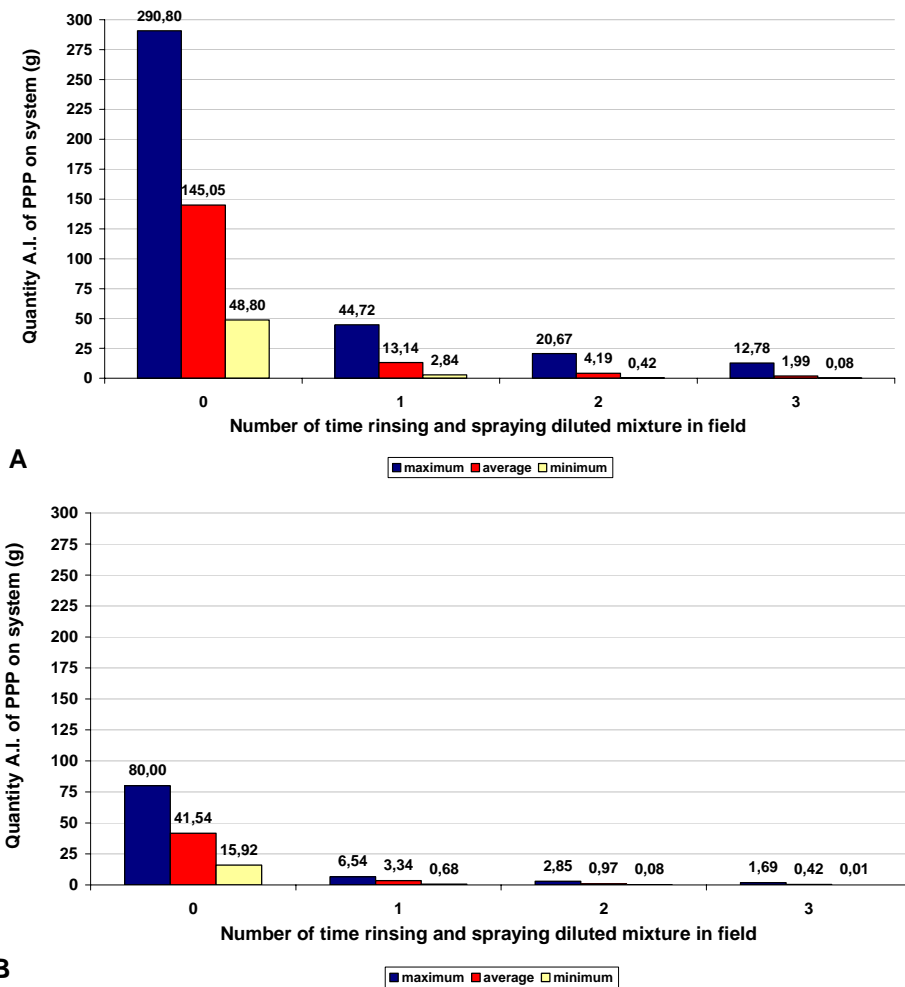


Fig. 4: Estimated load of active ingredient (A.I.) of pesticides on waste water treatment systems based on volumes of residual of 94 field crop sprayers (A), 23 tree crop sprayers (B) and a standard tank mixture of 1000 g A.I. in 250 L per ha.

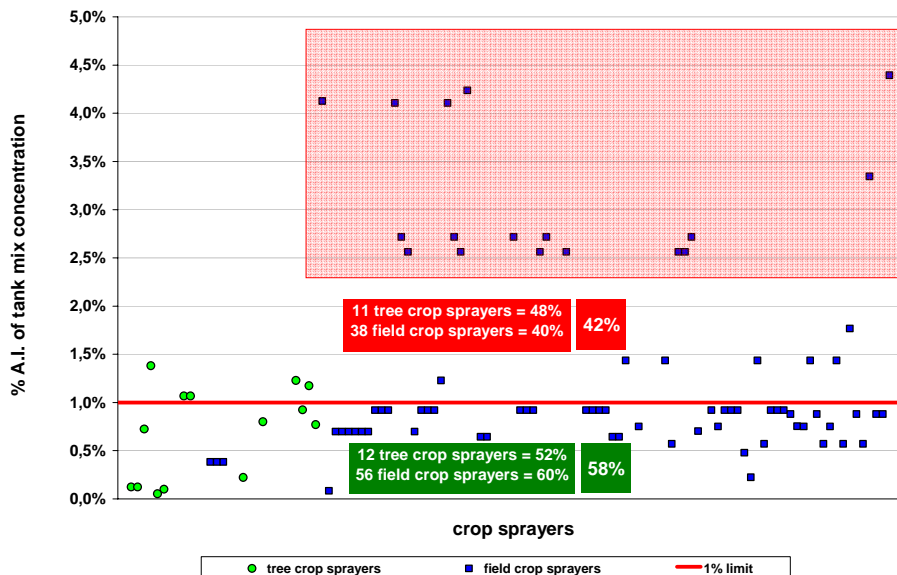


Fig. 5: Percentage of active ingredient of tank mix concentration remaining in the sprayer after 3 times rinsing for volume of total residual – rinse tank combinations.

calculation method for volumes of total residual is mainly linked to input parameters (tank content for orchard sprayers and tank content and boom length for field crop sprayers). Other options are possible.

Discussion

The prime aim of this study was to estimate the variability in chemical load on bio-purification systems based on the technical residual volumes left in the sprayers. Though the approach has some drawbacks such as its inadequacy to include on farm external cleaning input (Balsari 2006, Wehmann 2006), the zero rinsing situation in graph 3 clearly shows the impact of the sprayer type on the chemical and hydraulic load on bio-purification systems. The span is close to factor 20 in potential chemical load. Being restrictive to a similar sprayer category, the span can still be considerable. To achieve a same dilution also means a similar span in hydraulic load. The present acceptable volume of total residual according to EN 12761 shows large variations for similar applications. For similar boom lengths, the total residual volume can vary from 22.8 l to 54.8 l in the case of a 21 m boom length within the population of tested sprayer types. There is no apparent explanation for this under the present standard. The present standard is focussing on input parameters (nominal tank content) and boom length, but does not take into account hydraulic requirements essential in achieving a homogenous distribution. Often pipes and hoses are over dimensioned, especially with air assisted sprayers, resulting in a higher volume of total residual. The current standard can not cope with technical improvements related to increased performance and reliability such as recirculating booms. The overall question can be set whether this standard is ambitious enough to solve the problem of dealing with the residual spray volume in a practical way by the farmers. On farm clean up systems such as bio-purification systems can only cope with a limited hydraulic and chemical load. Limiting the total residual to a minimum is key to minimise both. Also in field solutions strongly rely on minimal total residual volumes in the sprayer. To achieve a reliable dilution of residual volume with an economically acceptable rinsing tank volume, the volume of total residual of a sprayer should be minimised. The higher the total residual volume, the higher the dilution volumes needed, the more labour and/ or area required for over spraying and the higher the potential risk on bad after spraying protocols. Such bad in field cleaning practices might lead to washing down previous spray deposits, increased risk on exceeding MRL and creating puddles of spray rinsates in the field.

Linking the rinsing tank volume to the dilutable volume of residual, and thus part of the volume of total residual, can improve the situation. In general the volume of total residual should be mentioned in the sprayers manual to be able to calculate a dedicated surface of land for managing the total residual spray in an acceptable way. To minimise the volume of total residual, a more ambitious single formula to set maximum volumes of total residual for both orchard and field sprayers is suggested by Debaer *et al* (in press). The hydraulic requirements for orchard and boom sprayers are similar and are seldom influenced by presence of the air support and guidance system. The suggested formula includes hydraulic requirements and gives allowance to include application wise improvements such as recirculation booms.

Minimising the volume of total residual of a sprayer without affecting its functionality is key to offer a sustainable solution in dealing with this source of spray remnants and its potential consequences. Dimensioning of an on farm bio-purification system for dealing with diluted spray remnants should include volumes of total residual as a calculation parameter if internal cleaning is exclusively done on a single dedicated site, such as on the farm.

Acknowledgements

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