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Reducing environmental exposure to biocides through drift during application

Summary of two research projects on machinery for the application of biocides

Jahre Umweltbundesamt 1974–2024

Content

1 Introduction

From an environmental point of view, drift of biocidal products to non-target areas should be minimised as far as possible to reduce environmental exposure. Machinery used for the application of biocides has a big influence on the potential drift. Starting in 2016, two research projects were commissioned by the German Environment Agency (Umweltbundesamt; UBA) to elaborate on possibilities to reduce drift to non-target areas during outdoor applications of biocidal products and to derive drift values for the exposure assessment of biocidal applications. Both projects were conducted by the Institute for Application Techniques in Plant Protection at the Julius Kühn-Insitute (Germany). This factsheet compiles the conclusions of UBA based on the work of the contractors. For further reading, links to the final reports and publications are provided at the end of the document.

2 Methods

The first research project[1] compiled existing knowledge on biocidal product types and their potential of direct environmental exposure by drift, equipment with high drift potential, guidelines to measure drift and an overview of existing drift values for exposure assessments. In field studies, the researches determined the drift potential of various techniques to control oak processionary moths in solitary oaks, avenues and at a forest edge. Drift measurements were conducted by applying a non-biocidal liquid containing water with the fluorescent dye Pyranine using the technique in question. Drift was collected using Petri dishes placed in different distances from the application areas. For the analysis, the Pyranine was extracted from the Petri dishes and analyzed in a fluorometer. Drift values for the use in environmental exposure assessments of the uses included in the project were derived.

The second project[2] compiled information on factors influencing drift, measures to reduce drift, techniques for drift measurements and on Ultra Low Volume (ULV) application techniques to control mosquitos. In field studies, the drift potential of further techniques to control oak processionary moths in solitary oaks, avenues and at a forest edge was investigated using the same experimental set-up as the first project. Further on, the researches determined the drift potential of the application of insecticides against flying or crawling insects on house walls and of the application of algaecides on horizontal surfaces. Drift values for the use in environmental exposure assessments of these uses were derived. Run-off during applications on vertical surfaces was also investigated, as well as laboratory tests on nozzles.

In general, to obtain meaningful and comparable reference values in field studies for the comparison of nozzles and techniques and for environmental risk assessment, it is recommended to use as least 5 distances for drift measurement (as recommended also in the JKI Guideline 7-1.5 used as the methodological basis of the trials[3]). Considering only one distance can lead to significant misunderstandings especially if rebound effects may impact the results. Large droplets have a greater kinetic energy and can therefore rebound more strongly, e.g. from

[1] Langkamp-Wedde et al. (2020): Reduction of drift in spray application/ nebulization of biocides - Derivation of risk reduction measures and device requirements. UBA-Texte 55/2020. Available online at https://www.umweltbundesamt.de/publikationen/reduction-of-drift-in-spray-application

[2] Langkamp-Wedde et al. (2024): Reduction of environmental impact of biocides. UBA-Texte 11/2025. Available online at *https://www.umweltbundesamt.de/publikationen/reduction-of-environmental-impact-of-biocides*

[3] JKI (2013): Richtlinie für die Prüfung von Pflanzenschutzgeräten - 7-1.5 Messung der direkten Abdrift beim Ausbringen von flüssigen Pflanzenschutzmitteln im Freiland (Guideline for the testing of plant protection equipment - 7-1.5 Measurement of direct drift when applying liquid plant protection products in the field). Available online at https://wissen.julius-kuehn.de/mediaPublic/AT-Dokumente/01-Antraege-Richtlinien/Richtlinien/7-1.5-Messung-der-direkten-Abdrift-beim-Ausbringen-von-fluessigen-Pflanzenschutzmitteln-im-Freiland.pdf.

treated areas like walls, even though the actual drift potential is lower due to the faster sedimentation.

3 Relevant biocidal uses

Based on the evaluation of the contractors, the most relevant application areas from an environmental point of view related to drift are presented in Table 1. Their choice is based on the use of spraying equipment for the application and potential outdoor applications.

Table 1 Applications most prone to drift to outdoor non-target areas[4] and their consideration in the projects

Product type	Application	Covered in our experiments?
2	Control of green growth on paths, terraces and masonry	Yes
3	Disinfection of vehicles used for animal transport	No
7/10	Façade protection	No, but results from studies on control of flying and crawling insects might be transferable
18	Control of oak processionary moth	Yes
18	Control of flying and crawling insects in the surrounding of buildings	Yes
18	Control of mosquitoes	No, but literature research on ULV devices was conducted
18	Control of wasps	No
19	Repellents for the control of horsefly	No

The research projects were not able to cover all biocidal uses mentioned in Table 1. Further research is necessary to elaborate on potential drift and possible drift mitigation measures for these applications.

4 Drift mitigation measures

Minimizing drift leads to reduced emissions to non-target areas, reducing risks for the environment. As drift mitigation has been practiced in plant protection for long time, the experiences in agriculture have been the starting point for a compilation of factors that could be varied to reduce drift. These measures can aim at different points, the most important ones are explained in the following sections. This is a summary of a more extensive elaboration in the final report[5].

[4] Adapted from Langkamp-Wedde et al. (2020): Reduction of drift in spray application/ nebulization of biocides - Derivation of risk reduction measures and device requirements. UBA-Texte 55/2020. Available online at https://www.umweltbundesamt.de/publikationen/reduction-of-drift-in-spray-application

[5] Adapted from Langkamp-Wedde et al. (2024): Reduction of environmental impact of biocides. UBA-Texte 11/2025. Available online at *https://www.umweltbundesamt.de/publikationen/reduction-of-environmental-impact-of-biocides*

Application factors

The term application factor includes the parameters nozzle type and size, spray pressure, application height, sprayer type and angle. When choosing the parameters for a specific application, all requirements of the application need to be considered. Next to reducing spray drift to non-target areas, ensuring an efficacious application is important for a sustainable use of biocides. However, the evaluation of these aspects has not been the focus of the research projects and needs to be investigated further in the future.

Drift risk is closely related to droplet size and also to the composition of the droplet spectrum. This is closely related to the used **nozzle type**. Generally, full-cone nozzles produce larger droplets than flat fan nozzles and hollow-cone nozzles produce smaller droplets than flat fan nozzles.

The **nozzle orifice** and **spray pressure** also have a major influence on droplet size. While small nozzle orifices produce small droplets, large nozzle orifices produce larger droplets. The spray pressure has an even greater influence on the droplet size than the orifice. A high spray pressure produces a larger number of small droplets.

In addition, nozzles with larger **spray angles** produce smaller spray droplets than a nozzle with the same application rate but a narrower spray angle. However, wide-angle nozzles have the advantage of being placed closer to the target than narrow-angle nozzles so the advantages of lower nozzle placement can outweigh the disadvantage of slightly smaller droplets in some applications.

Selecting suitable nozzles and switching to **low-drift nozzles** are important factors in reducing drift. This is currently only in the responsibility of the user. Conventional nozzles are normally supplied as standard when new sprayers are first fitted. Economic considerations can influence users' decisions, as standard nozzles are cheaper than purchasing drift-reducing types. To simplify the selection of suitable low-drift nozzles for the application of plant protection products in Germany, nozzles are tested and approved by the Julius Kühn-Institute. On request, nozzles can be classified in drift mitigation classes of 50 %, 75 %, 90 % and 95 %. Approved flat spray nozzles are included in the "Descriptive List" and published in the Federal Gazette. A system like this would be suitable for nozzles used for biocides applications as well. However, the results of the already existing lists for the application of plant protection products cannot be directly transferred as the testing is conducted using specific agricultural equipment.

Other technologies that can be used to reduce drift of plant protection products include shielded sprayers, boom height control systems and constant flow systems. **Shielded spray booms**, protective cones with a sprayer or completely covered spray booms, can reduce drift by 50 % or more. Especially with knapsack sprayers, the use of a drift shield can significantly reduce drift. This measure could be transferred to biocides applications using knapsack sprayers. **Boom height control systems** are widely used on modern field sprayers. It is known that drift increases with the height of the boom. An active height control system on a passively suspended boom can reduce this problem. As automation is not as widespread in biocides applications, the transferability of this measure is limited at the moment. **Pressure control** is standard equipment in an agricultural field sprayer. An electronic pump can provide constant pressure. Most knapsack sprayers are not equipped with a pressure regulator, as the purchase of a conventional pressure regulator is far too expensive. An alternative is to use constant flow valves called pressure relief valves. These valves are attached to a lance or boom line, usually just before the nozzle. They only open when their rated pressure is reached. As soon as the valve opens, the overpressure is reduced to the current pressure. If the pressure drops below the current pressure, the valve shuts off the flow to the nozzle. This would also be applicable for biocidal applications with knapsack sprayers.

The **design of the application area** can also significantly reduce spray drift. A spray-free buffer zone of 3 m during the application of plant protection products can reduce drift in an adjacent ditch by 95 %[6]. In addition, a crop-free zone with tall and dense vegetation is more effective in reducing drift than bare soil. The transferability of this measure seems questionable for biocidal applications as users' of biocidal products mostly do not have the same possibilities to shape the environment they are working in.

Specifically, for the **control of oak processionary moths**, the results of the field trials in the two research projects have shown that the general choice of machinery has a high influence on drift. Choosing a pneumatic cannon sprayer with drift reducing nozzles can reduce the drift by 75 % compared to a hydraulic cannon sprayer[7]. Also, the application via helicopter showed 50 % less drift compared to a hydraulic cannon sprayer[8].

Weather

The drift potential can be influenced by weather conditions, especially wind speed, temperature, relative humidity and atmospheric stability. As the droplet sizes are an important factor for drift, the weather conditions influencing droplet sizes are especially relevant. They have a significantly higher influence on droplets smaller than 100 µm compared to larger droplets. The evaporation and movement of droplets smaller than 100 µm is significantly influenced by air temperature, relative humidity and other climatic conditions. Wind speed also is an important factor for the distribution of droplets.

According to good agricultural practice, plant protection products should not be applied at wind speeds above 5 m s^{-1}, air temperatures above 25 °C or relative humidity below 30 % in order to reduce drift[9]. There is currently no guideline for the application of biocidal products, but there is no reason why the same limits should not be relevant for their application. For some biocidal products, weather conditions already have been defined that need to be complied with during application.

Operator skills

The skills of the operator are very important to adjust and use the machinery appropriately. For some biocidal products, specific knowledge of users already has been required during product authorisations. Especially for knapsack sprayers, however, targeted spraying of the product is difficult due to a lack of mechanization options. This leads to difficulties in applying the correct application rate by setting a specific pressure and adapting walking speed accordingly.

5 Refinement of environmental exposure assessments

Next to general findings on drift reduction, the two projects also worked on defining drift values for some applications of biocidal products to refine environmental risk assessments. Until then, no drift values specific for biocidal applications have been available. For large scale outdoor applications of insecticides, a **general default value** was defined (WG ENV II 2022) which is still based on results determined for plant protection products but represents an overall worst-case value. However, in both research projects, it became clear that it is necessary to determine

[6] de Snoo, G. R.; de Wit, P. J. (1998): Buffer Zones for Reducing Pesticide Drift to Ditches and Risks to Aquatic Organisms. Ecotoxicology and Environmental Safety. 41: 112-118. doi: https://doi.org/10.1006/eesa.1998.1678.

[7] Langkamp-Wedde et al. (2023): Possibilities to reduce drift by 75 percent in biocidal applications of insecticides with cannon sprayers. Environmental Sciences Europe. Volume 35. Issue 1. doi: 10.1186/s12302-023-00729-0

[8] Adapted from Langkamp-Wedde et al. (2024): Reduction of environmental impact of biocides. UBA-Texte 11/2025. Available online at *https://www.umweltbundesamt.de/publikationen/reduction-of-environmental-impact-of-biocides*

[9] BMELV (2010): Gute fachliche Praxis im Pflanzenschutz - Grundsätze für die Durchführung (Good professional practice in crop protection - principles for implementation). Available online at https://www.nap-pflanzenschutz.de/fileadmin/SITE_MASTER/content/Service/GutePraxisPflanzenschutz2010.pdf, 07.08.2024.

specific drift values for biocidal applications as the differences in the applications are too high to simply transfer the values derived for the application of plant protection products. Therefore, at the WG ENV II 2022, also drift values for the biocidal treatment against the oak processionary moth (OPM) in dependence of the application technique based on the aforementioned research project[10] were agreed and subsequently published in the Technical Agreements on Biocides[11]. Thus, for the treatment against the OPM specific drift values are now available for single applications

a) on solitary trees (pneumatic cannon sprayer and motorized sprayer),

b) in avenues (hydraulic and pneumatic cannon sprayer as well as helicopter) and

c) in forest edges (pneumatic cannon sprayer).

Further drift values for repeated applications were established in the final report of the second research project[12]. These are drift values for

d) treatment of forest edges against OPM with helicopters and

e) drift values for biocidal treatments against flying and crawling insects on foundation or the entire house wall.

As the ESD PT 18 No. 18 is currently under revision, the drift values already published in the TAB (see above) are also implemented in the updated ESD version. However, for the drift values derived in the trials investigating treatments against crawling and flying insects and, in general, all new trials determining application specific drift values, discussion at WG ENV level and subsequent publication in the TAB in its current version is still needed. The picklist with the drift values should therefore be regarded as 'living document' that can be adapted to a growing data situation.

In addition to the trials on the determination of drift values, **run-off behaviour** of the test substance at different application rates was investigated for treatments against crawling and flying insects to derive first estimates. It was shown that, independent from the nozzle type, run-off of up to 50 % of the sprayed product was observed at full application rate. Decreasing the application rate to 50 % lead to a decrease of run-off to less than 1 %.

Moreover, the second report contains initial information on experiments to derive drift values for the use of biocidal products that are applied on **horizontal areas** like paved paths for algae removal. A significant drift mitigation when treating algae on paved paths can be achieved with the choice of the nozzle which also influences the accuracy of the application. As the trials investigated several small distances from the application area that have never been considered in drift tests for plant protection products, further discussion on the conclusions is needed.

[10] Langkamp-Wedde et al. (2020): Reduction of drift in spray application/ nebulization of biocides - Derivation of risk reduction measures and device requirements. UBA-Texte 55/2020. Available online at https://www.umweltbundesamt.de/publikationen/reduction-of-drift-in-spray-application

[11] Technical Agreements on Biocides (TAB) in its version from 10/22; entry ENV 248: https://webgate.ec.europa.eu/s-circabc/w/browse/20a938d6-b2c6-4876-840f-be4878ce8869

[12] Langkamp-Wedde et al. (2024): Reduction of environmental impact of biocides. UBA-Texte 11/2025. Available online at *https://www.umweltbundesamt.de/publikationen/reduction-of-environmental-impact-of-biocides*

6 Possibilities to implement the new knowledge

The results need to be considered in the future to reduce drift of biocidal products to non-target areas and thus to reduce risks for non-target organisms. We propose the following measures:

- **Adapt environmental exposure assessment**: The inclusion of the newly derived drift values into environmental exposure assessments ensures the consideration of realistic worst-case scenarios during active substance approval and product authorisation.
- **Define machinery requirements in product authorisation**: The knowledge on the parameters influencing drift can be the basis to define general requirements for machinery in product authorisations to mitigate environmental risks (example: only use 90 % drift reduction nozzles).
- **Consider drift reduction in public tenders**: Including requirements to use machinery less prone to drift in public tenders would lead to better equipment being used (example: only use pneumatic spray cannons with drift reduction nozzles).
- **Implement findings in legislation**: Machinery for the application of biocidal products should be obliged to fulfil requirements related to the protection of the environment comparable to Directive 2006/42/EC on machinery – Annex I Point 2.4, with an emphasis on Point 2.4.5. Furthermore, to better differentiate between conventional and more progressive machinery, standards should be defined for this progressive (e.g. drift-reducing) equipment, comparable to machinery for the application of plant protection products. Based on these standards, mandatory use of drift-reducing machinery could be implemented in legislation.

7 Further reading

- Final report of the first project: Langkamp-Wedde et al. (2020): Reduction of drift in spray application/ nebulization of biocides - Derivation of risk reduction measures and device requirements. UBA-Texte 55/2020. Available online at https://www.umweltbundesamt.de/publikationen/reduction-of-drift-in-spray-application
- Final report of the second project: Langkamp-Wedde et al. (2024): Reduction of environmental impact of biocides. UBA-Texte 11/2025. Available online at https://www.umweltbundesamt.de/publikationen/reduction-of-environmental-impact-of-biocides
- Langkamp-Wedde et al. (2020): Comparison of the drift potential of two application methods for the control of oak processionary moths with biocidal products in an oak avenue. Science of the Total Environment. Volume 704. doi: 10.1016/j.scitotenv.2019.135313
- Langkamp-Wedde et al. (2023): Possibilities to reduce drift by 75 percent in biocidal applications of insecticides with cannon sprayers. Environmental Sciences Europe. Volume 35. Issue 1. doi: 10.1186/s12302-023-00729-0

► Langkamp-Wedde at al. (2024): Drift when applying biocides to control crawling and flying insects on walls. Environmental Sciences Europe. Volume 36. Article number: 166. doi: https://doi.org/10.1186/s12302-024-00993-8

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