

Persistent pesticides: the need for criteria to control atmospheric transport

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INTRODUCTION

In the fifties persistence was originally seen as a very useful intrinsic property for the efficacy of pesticides. It took almost two decades, however, to realize that adverse effects from the health and environment perspective outweigh the advantages of persistence in most applications.

Another decade was needed to implement adequate measures. Nowadays, persistence is most of the time evaluated at the moment of pesticides registration. Criteria have been developed to assess persistence in relation to biomagnification, accumulation in soil or sediment and leaching to groundwater (geoconcentration). Until recently little or no attention was paid to the evaluation of persistence in relation to long range atmospheric transport. The question is: Have we really learned from the lessons of the past and are we now prepared to anticipate in an early stage to prevent widespread consequences of persistence-related problems.

Accumulating evidence is pointing out that pesticides are found in sites far away from application areas due to medium and long range atmospheric transport [1,2,3]. Concentrations regularly exceed the levels of concern in both water and soil. In order to identify potentially hazardous compounds for atmospheric transport further research is needed and criteria have to be developed to restrict the use or reject registration of such

pesticides. These criteria could prevent the introduction to the market of new compounds with hazardous properties, and trigger the need for additional data.

1. A KEY ISSUE IN HEALTH AND ENVIRONMENTAL EFFECTS ASSESSMENT

1.1. Persistence: an intrinsic hazard or a conditional risk?

Persistence as an intrinsic property of a molecule can be quite harmless to the environment if the molecule in question can be recovered and destructed in a controllable way after use. The use of persistent molecules is controllable only in well defined situations, when small volumes are applied. However, crop-protection practice often implies the use of large volumes of an agent in an open situation and diffusion to soil, water, groundwater and air will inevitably happen. In these situations, persistence could lead to bio- or geoconcentration of a molecule or its degradation products and forms a potential environmental threat.

Persistence has been a key issue in environmental effects assessment since the impact on wildlife of very persistent organochlorine pesticides as DDT and drins became evident. Ever since, policy development was triggered by the discovery of new side effects of persistent pesticides on an unexpected target (figure 1), such as potential effects in follow-up crops (bio- magnification), contamination of drinking water sources due leaching into groundwater (several herbicides) and threatening of the ozone layer (methyl bromide). Most of the time the measures taken consisted of restricting the application or eventually banning the use of a specific active substance. Those incidents also gradually led to setting criteria for the registration of pesticides that take into account persistence in direct relation to the target involved.

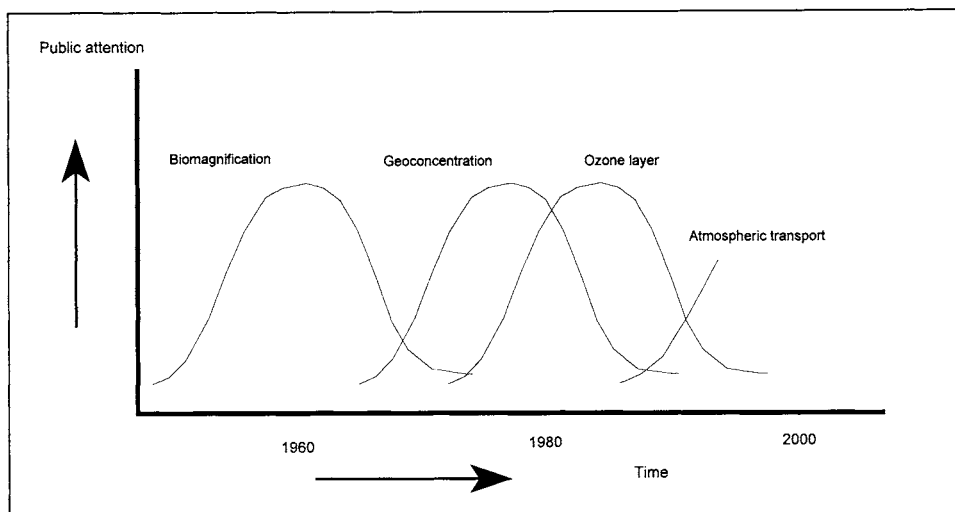


Figure 1: Public attention on the effects of persistent pesticides triggers policy measures. Studies and discussions on persistence of pesticides drew major public attention over the past decades. As the evidence on severe effects on predator populations due to biomagnification, grew to a consensus, the public attention increased, leading to restriction or banning of the use of organochlorine pesticides in many countries. Similar cycles occurred in the eighties in relation to persistence in soil and in ground water and in the early nineties when the effects of methyl bromide on the ozone layer became known. As evidence is building up on the impact of atmospheric transport, it will be necessary to formulate adequate control policies on this issue in the coming years.

1.2. Policies developed to cope with persistence in soil and ground water

Persistence in soil has been a matter of concern for numerous years before legislation was adopted in The Netherlands on this issue [4]. Not only environmental concerns, but also potential effects on follow-up crops of herbicide residues in the soil triggered discussions on persistence and persistence criteria were set in the European plant protection legislation [5]. Active ingredients with a half life time over 90 days have to be screened on the potential effect of their long lasting residues. The residues concentration in a field should be lower than the maximum tolerable risk concentration two years after the last pesticides application. In addition, very persistent agents, with half lives over 180 days

will not be registered or will be subjected to very strict use restrictions.

Active ingredients leaching into groundwater at concentrations over 0.1 µg/l (potable water quality standard) are not registered. If leaching of ingredients into the shallow ground water is probable, authorization will only be granted if sufficient degradation will occur in the saturated zone during the travelling time that is necessary to reach the shallowest ground water wells. Only degradation processes that actually happen in these groundwater layers are considered for registration. Ecological effects on deeper groundwater ecosystem are not considered at the moment, although a recent study from the Health Council of The Netherlands [6] indicated that this should be taken into account. The Health Council suggested that the same ecological quality criteria e.g. 0.1 µg/l should apply for both groundwater- and surface water systems.

2. PERSISTENCE AND ATMOSPHERIC TRANSPORT

Persistence in the atmosphere is linked to other time scales than those in the other environmental compartments with a slower transport velocity. Residence times of a few days in the atmosphere may be sufficient to transport a molecule over long distances. The persistence property of a pesticide during transport in the atmosphere, together with its persistence at a potential sink location of geological, biological or tropospheric origin will determine whether dissipation into the atmosphere presents a risk. However, persistence in the atmosphere itself may not be the most critical parameter due to the rapid rate of transport, up to hundreds of kilometers a day [7].

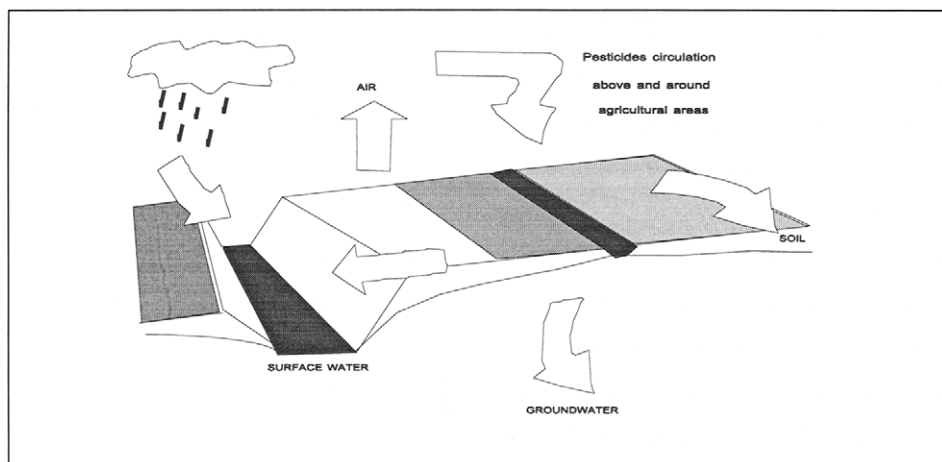


Figure 2: Spray drift is the main cause for atmospheric transport of pesticides over short distances. Medium and long range transport are mainly determined by volatilization, transport of particles and deposition cycles.

2.1. Transport mechanisms of pesticides through the air

During pesticide applications, fine droplets can be carried away on airstreams as spraydrift. Studies of Van Haasteren et al. [8] estimated that about 25 to 40% of the applied dose entered the atmosphere as spraydrift or evaporated from the cropsurface or soil. Due to rapid atmospheric transport, pesticides can have a negative environmental impact on both direct surroundings of application areas as well as further away from their source when they are deposited again (figure 2). Atmospheric transport and deposition of persistent pesticides (or compounds) are determined by molecule characteristics and meteorological circumstances. Deposition and re-entry processes in the atmosphere can be repeated several times until a compound reaches its 'sink'. These processes can lead to migration of persistent compounds from warm climatic regions towards the poles and can be considered as transboundary problems. The residence time in the atmosphere could serve as a valuable screening parameter for possible environmental impact of emitted substances. A second screening parameter could be the persistence after deposition, this is in particular important at the poles where degradation processes are slow due low temperatures.

2.2. A major part of the applied dose of pesticides dissipates into the atmosphere

Recently, the mid-term evaluation of The Netherlands multi-annual crop protection plan estimated that 95% of the total pesticides emission to the environment dissipates into the atmosphere and can be transported over long distances (table 1). This illustrates the importance of persistent pesticides in the atmosphere and the need to control this major pathway for dissipation into the environment.

The presence of pesticides in the air itself can present a potential health risk for workers and for the environment close to the application point. For very toxic and volatile agents as for instance methyl bromide, The Netherlands regulations therefore stipulate a safety zone of 100 m around the object where it is applied. Workers are only allowed to carry out activities for a limited period of time within this area.

Potential threats for locations at medium or long distance from the application areas are more difficult to cope with and no regulations exist. An exception, however, is methyl bromide due to its ozone-depleting potential [9]. The following section outlines different studies on residence time and spatial extent of atmospheric transport of pesticides substances.

Table 1: Estimates of emission of crop-protection agents to water, soil, groundwater and atmosphere [10]. The largest part of the applied dose enters the atmosphere and can be transported rapidly over long distances. The impact of this transport depends on persistence of these agents in the atmosphere and the sinks where they will concentrate.

	Emission in 1995 (in kg/year)	Reduction achieved since 1984/88 (%)	Aimed reduction 1984/88-1995 (%)
Surface water	46.000	72	> 70
Soil/Groundwater	67.000	80	40-45
Air	3.110.000	43	30-35

2.3. Evidence of the impact of atmospheric transport at medium range

Evidence of negative effects of agricultural pesticides at medium range from the application point is growing. Several recent studies in The Netherlands demonstrated contamination of rainwater, leading to concentration levels higher than the ecological

target values in natural reserves at significant distance from agricultural areas [11,12,13]. Boom et al [14,15] monitored organostannic compounds in the Flevoland province and studied the impact of intensive pesticides use on atmospheric deposition and concentrations in surface waters. Crop protection agents were detected in the natural reserve of the Oostvaarders Plassen, located in the western area of the province, upwind of the agricultural areas. Pesticides application from planes on potato crops were considered to be the major source for atmospheric transport and environmental threats.

Pruissen et al [15] measured the occurrence of forty pesticides in rainwater at different sites around application areas in the province of Zuid-Holland. High concentrations of fifteen pesticides originated from four main sources: bulb-flowers cultivation (38%), intensive greenhouse farming (31%), regional transport (18%) and long distance transport (13%) of the total detected amount.

The reported levels lead only in incidental cases to exceedance of maximum tolerable risk levels, however, ecotoxicological target values were often exceeded. Non-target areas sometimes located kilometers away from the application area were contaminated with significant amounts of pesticides, leading to concentration that are not acceptable when a high level of environmental protection is required.

2.4. Long range atmospheric transport

Significant accumulation of crop-protection products in remote areas has, until now, only been observed for a number of organochlorinated compounds that were world wide used in large volumes [17]. This fact demonstrates that the phenomenon of long range atmospheric transport can cause problems in regions that are located far away from the pesticide application point.

The process of transport and accumulation happens over a long time scale, and involves deposition that is no longer directly related to a specific use or application point. Due to dilution that occurs, concentrations will remain relatively low, but will steadily build up in areas with relatively vulnerable natural habitats. Possible implications for biodiversity in the long term cannot be excluded, as most ecotoxicologically accepted concentrations were derived for average ecosystems in regions where recovery and recolonization are possible.

3. MEASURES: A NEED FOR AN INTERNATIONAL APPROACH

3.1. Effects of medium and long range transport difficult to prove 'a priori'

In the past decades, regulatory measures were taken after a problem had been clearly identified. However, effects of persistent chemicals in the environment occur after a long period. This in particular is the case with atmospheric diffusion, while during transport dilution occurs and compounds are spread over large areas compared to transportation by rivers.

Once the effects are evident, it will take a long time before they disappear or decrease. The actual authorization practice in most countries is that restriction or total ban of a pesticide has to be based on *a priori* demonstration of no potential negative side-effects. The benefits of pesticide use to a farmer can be made quite clear, however, negative side-effects at close range of the application site can only be estimated with current registration procedures. Since the safety margins between effect-concentrations and trigger values that will dictate restrictions in applications or a ban of a product are small, restrictions or bans will be accepted in most cases. In this way, the effects of spray drift on the neighboring aquatic environment can be taken into account in the registration process.

Medium range transport leads to exposure of non-target areas. This exposure will vary according to meteorological conditions, but will show some consistency over the years. With appropriate models it should be possible to account also for this issue in the authorization procedures.

At long ranges, weighing risks and benefits is even more difficult. Long-range transport involves a long term accumulation process. The lag-phase between use and effects can be long. The built-up of significant concentrations will take a longer time. Persistent chemicals that are only mobile via the atmosphere and that are used in large volumes will potentially accumulate in non-target areas. A direct proof of effects will be difficult. Outside agricultural areas ecological target values are set to protect sensitive environments. These ecological target values are based on a precautionary principle, and the extrapolation factors from effect-concentration will consequently be greater. Discussion over these factors may delay necessary action.

Therefore pesticides that present a serious hazard for long range transport through the atmosphere should preferably be identified in the registration procedure on the basis of intrinsic properties regarding their persistence in the environment and their ability to be transported in the atmosphere. Compounds selected on these criteria should either not be registered or their use should be limited to well controlled applications.

3.2. Global effects require globally harmonized criteria

Because of the global character of atmospheric transport, effective measures can only be taken in an international setting. The UN-ECE working committee on persistent organic pollutants (POP's) is about to reach consensus on the intrinsic properties that determine the risks for long range transport. This consensus was reached over a number of pesticides that are now causing world wide background contamination. There is, however, a need to translate these criteria into triggers to recognize high risk compounds that would be submitted for registration.

An international forum will have to be found to take care of the specific aspects of setting trigger values aimed at preventing unrestricted registration of pesticides presenting a potential risk for long range atmospheric transport.

The current risk assessment procedures of the EU offer a number of possibilities to include atmospheric transport in the hazard and risk assessment for the registration of crop protection products. This includes both the option to include wet and dry atmospheric deposition as one of the inputs into surface waters [18] as well as the possibility to evaluate the risks of concentrations of the active substance or its metabolite in the air [19]. These criteria are not yet operational however.

The EPPO (European and Mediterranean Plant Protection Organization) is preparing a scheme as guidance for decisions on atmospheric transport [20]. Criteria for these decisions have not yet been set in the EU. Because of the often global implications, development of harmonized trigger criteria for atmospheric transport should happen in an international setting familiar with both atmospheric transport issues and pesticide legislation.

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