Atmospheric dispersion of pesticides

an ecological risk evaluation

Gezondheidsraad **President**
Health Council of the Netherlands

To the Minister of Public Health, Welfare and Sport

Subject	: presentation of advisory report on pesticides
Your reference	: GZB/C&O/971542
Our reference	: -1738/97/HvD/HB/446/4-B3
Enclosure(s)	: 2
Date	: January 27, 2000

Dear Minister,

On February 13, 1996, you requested, in your own name, and on behalf of the Ministers of Housing, Spatial Planning and the Environment, of Transport, Public Works and Water Management, of Agriculture, Nature Management and Fisheries, and the State Secretary for Social Affairs and Employment, that the Health Council of the Netherlands report on problem areas in the risk assessment for the authorisation of pesticides. You stated that you would establish priorities regarding the questions that have to be answered. Subsequently, on April 14, 1997, you asked the Health Council to produce an advisory report on the necessity of, and possibilities for, accounting for atmospheric dispersion op agricultural pesticides when assessing the risks. A committee I established for this purpose has addressed the problem. Having consulted the Standing Committee on Ecotoxicology, I hereby present you the result of its deliberations.

The committee leaned heavily on the results of an international workshop on atmospheric dispersion of pesticides that it convened in spring 1998. This workshop was made possible by a grant from the Ministry of Housing, Spatial Planning and the Environment. The proceedings have been enclosed as a separate annex.

The dispersion of pesticides via the air is a cross-border problem. Moreover, legislation regarding these substances is increasingly being enacted on an international level. I hope that this advisory report will stimulate further international co-operation in order to curb atmospheric dispersion of pesticides.

Today, I have presented the report to all ministers involved.

(signed)
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Preferred citation:
Health Council of the Netherlands: Committee on Atmospheric dispersion of pesticides. Atmospheric dispersion of pesticides; an ecological risk evaluation. The Hague: Health Council of the Netherlands, 2000: publication no. 2000/03.

ISBN: 90-5549-304-X

Contents

Executive Summary

The present authorisation procedure for agricultural pesticides includes an evaluation of the risks pesticide use poses to non-target organisms living on and immediately adjacent to the treated fields. In recent years, it has become increasingly apparent that airborne dispersion is also resulting in these pesticides finding their way into surface waters and nature reserves a long way from the areas of use. Consequently, the Minister of Health, Welfare and Sport, also on behalf of other members of the government, has requested the Health Council of the Netherlands to review the current level of knowledge about the atmospheric dispersion of agricultural pesticides and to make recommendations about both the necessity of including such dispersion in the risk evaluation and the possibilities that exist for doing so. The Health Council's Committee that was established for this purpose presents its findings in this advisory report. It does so on the basis of the results of an international workshop the Committee organised on the subject.

Extent and significance of atmospheric dispersion

The extensive use of chemical pesticides results in these substances being ubiquitous in air and rainwater and in their dispersion through the atmosphere across large areas. The resulting atmospheric deposition also affects areas outside the immediate surroundings of the areas of use. It is several orders of magnitude lower than the deposition on the treated fields and at least one or two orders of magnitude lower than that on adjacent verges, ditches and so forth. There is still a lot of uncertainty about the

ecological significance of this atmospheric input. However, rainwater quality does not meet the standards based on toxicity data for the quality of surface water. The Committee does not, therefore, exclude the possibility of ecological damage outside the immediate surroundings of the treated fields. Also considering the large scale of the problem, the Committee believes a reduction of the risks of atmospheric dispersion is required to guarantee that wildlife is conserved. The most effective way is to reduce the use of chemical pesticides, but the authorisation policy also needs to be tightened. The policy is currently only concerned with limiting environmental damage on and around the treated fields that is caused by direct application and by drops of sprayed liquid landing in adjacent ditches. However, the Committee does not believe this is sufficient to prevent damage occurring at greater distances as a result of atmospheric dispersion. The fact that the resulting deposition is relatively small does not alter the situation. The exposure pattern that results from atmospheric transport differs considerably from that caused by direct application or spray drift. It is characterised by a chronic exposure to possibly a whole range of pesticides. Moreover, in nature reserves, situations may prevail that affect the behaviour (transformation, mobility) of pesticides (low pH, low availability of nutrients, low temperature and, consequently, little microbial activity) and occurring populations and communities of organisms may also be relatively more vulnerable.

Emission into the atmosphere

The Committee subscribes to the workshop’s conclusion that it is preferable to make the additional risk assessment according to a tiered procedure. The first tier of the procedure involves a simple classification of pesticides into, on the one hand, substances for which atmospheric dispersion most probably presents no problem and, on the other hand, substances for which this needs to be further evaluated. The first sifting should be based on the degree to which the pesticide may enter the atmosphere during or after application. The percentage of the applied amount that is permitted to enter the air should be subject to a limit, preferably based on the substance’s toxicity, persistence, bio-accumulation and (anticipated) application volume.

Risks of medium-range atmospheric transport

Pesticides that are identified as problem substances in the first tier must be evaluated in a second tier to determine the risks that arise from medium-range atmospheric dispersion (up to a few dozen kilometres from the area of use). This must be based on a comparison between the anticipated exposure of organisms and their anticipated sensitivity. Models are available for estimating the atmospheric transport of pesticides to nature reserves. Soil- and water-quality models can then be used for estimating exposure in various environmental compartments. However, there is a lack of data on pesticide behaviour (e.g. transformation rate, attachment to organic matter) under the conditions that prevail in nature reserves. There is also a lack of toxicity data, at least for representative species. The Committee therefore calls for the evaluation to be based on information - to be supplied by the manufacturer in accordance with the present procedure - that relates to conditions in agricultural areas and to standard test organisms. In order to compensate for the uncertainty about the validity of the data for nature reserves and for exposure to several substances simultaneously, more stringent provisional requirements can be set for the ratio between exposure and sensitivity than for the evaluation of the risks to organisms on and nearby the fields. The Committee calls for research into how the conditions that prevail in nature reserves affect the behaviour of pesticides and into the sensitivity and recovery capability of the organisms and populations that live there. Such research should show the degree to which more stringent requirements for the aforementioned ratio would be appropriate. If a pesticide fails to satisfy the ratio criterion, the manufacturer could be given the opportunity to demonstrate by providing additional research data that unacceptable impacts would not occur in practice.

Risks of long-range atmospheric transport

The second tier should also include making an estimate of the substance’s potential for long-range dispersal (more than one thousand kilometres). This can be estimated by calculating an atmospheric transport potential. The potential quantifies either the time it takes for half of the emitted substance to disappear from the atmosphere, or the distance the substance travels in that time, given a postulated, constant wind speed. The transformation of the pesticide in air has to be known for the calculation. The best measure of this is the reaction rate constant for the reaction of a substance with OH radicals in air, k_{OH}. The Committee calls for manufacturers to be obliged to provide this figure for risk assessment. This should be determined in accordance with an internationally accepted protocol, which has yet to be drafted. The Committee recommends that the figure for the atmospheric transport potential above which a further risk evaluation owing to long-range transport is required should be made dependent on the substance’s toxicity, persistence, bioaccumulation and the (anticipated) volume used.

The risk evaluation for long-range transport may depend on the ratio between anticipated exposure and the sensitivity of the living organisms in the remote areas. The Committee recommends also basing this calculation on the information the manufacturer already has to supply. However, the limiting value for this ratio should be made more stringent than that for the evaluation of the risks of medium-range transport, because there is more uncertainty about the validity of the data used. Further research should show the degree to which the conditions and the vulnerability of organisms in remote areas necessitate a more stringent limiting value.

In general, the uncertainties in the calculation of the anticipated exposure at a given distance from the area of use increase as the transport distance increases. Consequently, the calculation of the ratio between exposure and sensitivity for organisms in distant nature reserves will be subject to greater uncertainty. This may be an argument for the advance prohibition of substances with a large atmospheric transport potential. Given the cross-border character of the long-range atmospheric transport of pesticides, this would require international agreement.

Operationalisation

The Committee believes it ought to be possible to have the outlined procedure operational within approximately five years. To be able to determine whether such a modified acceptance procedure would be adequate to limit the risks of atmospheric dispersion of pesticides, the Committee believes it will be necessary to monitor air and precipitation quality. This applies all the more so because only the risks of individual pesticides are considered in the acceptance procedure. The monitoring data may show that problems occur (e.g. excessive concentrations in rainwater), owing to the authorisation of several pesticides with the same active ingredients or with the same working mechanism. In those cases, it will be necessary to examine whether this need have consequences for the entire group of pesticides or only for specific ones, for example, those that can be most readily missed. The monitoring results can also be used for further validation and improvement of the models used. Finally, the Committee points out that modification of the authorisation procedure is only possible at the international level, in the first place at the level of the European Union.

Hoofdstuk 1

Introduction

1.1 Background

The authorisation of pesticides in the Netherlands is regulated by the Pesticides Act (Stb98). This Act ensures that only reliable pesticides are registered (i.e. pesticides that have the intended effect) which, when used according to the instructions, do not damage the crop or human health. Their impacts on organisms other than the target organisms and on the quality of the environment must also remain within acceptable limits. The ‘environmental requirements’ for agricultural pesticides have been worked out in greater detail in an Order in Council, the ‘Pesticides Environmental Authorisation Requirements Decree’ (Stb95). The Board for the Authorisation of Pesticides (CTB) decides on the government’s behalf about the approval of pesticides. The assessment of a pesticide entails applicants submitting a great deal of information about its method of application, its physico-chemical properties and its toxicity to all kinds of test organisms.

Many countries have an authorisation procedure of this kind, but each country’s procedure is different. Several years ago, to achieve harmonisation, the European Union issued the Authorisations Directive (91/414/EEC). The Uniform Principles (97/57/EG) (EU97) provided in an appendix to the directive indicate the environmental requirements for pesticides. All pesticides used in the European Union will have to comply with community regulations in a few years time. The Netherlands environmental requirements have already been extensively altered to bring them into line with those of the EU.

The present environmental requirements in the national and community regulations are mainly intended to prevent damage on and near to the areas of application. However, it has become increasingly clear in recent years that pesticides may be carried from those areas by water and air currents. This means they enter areas where they are not wanted, such as surface waters and nature reserves. It emerged from an interim evaluation of the Multi-year Crop Protection Plan, which is concerned with reducing the use of these substances, that the atmospheric route plays an overpowering role: more than 90% of pesticide emissions from the areas of use into the environment occur through the air. Volumes may be as much as several dozen percent of the volume applied (Hor96).

1.2 Request for advisory report

In connection with the above, the Minister of Health, Welfare and Sport, also on behalf of the Minister of Housing, Spatial Planning and the Environment, the Minister of Agriculture, Nature Management and Fisheries, the Minister of Transport, Public Works and Water Management, and the State Secretary for Social Affairs and Employment, has requested the President of the Health Council of the Netherlands to produce an advisory report on the atmospheric dispersion of agricultural pesticides, the necessity of including such dispersion in the risk assessment for their authorisation, and the possibilities that exist for doing so. The complete text of the request for the advisory report is provided in annex A.

1.3 Committee and method of working

To address the request for an advisory report, the President of the Health Council of the Netherlands established the ‘Atmospheric Dispersion of Pesticides’ Committee. The Committee’s composition is shown in annex B. The Committee organised an international workshop to address the minister’s specific request for the advisory report to be based on knowledge available in other countries. The workshop was held on 22, 23 and 24 April 1998, in Driebergen, the Netherlands. The focus was mainly on the physical and chemical processes of atmospheric dispersion and far less on the possible ecological and health impacts of pesticides, because the issue of possible impacts is largely separate from the issue of the conveyance route. In many cases, the nature of an impact will scarcely depend on how the pesticides entered an ecosystem. The findings and recommendations of the approximately forty experts that participated have been published in a book entitled ‘Fate of Pesticides in the Atmosphere; Implications for Environmental Risk Assessment’ (Dij99a), which is included with this advisory report as annex C.

1.4 Organisation of the advisory report

In this advisory report, the Committee elaborates on the results of the workshop with a discussion of the necessity of the authorisation of agricultural pesticides taking into account atmospheric dispersion (chapter 2) and the possibilities that exist for doing so (chapter 3).

Hoofdstuk 2

The necessity of an additional risk assessment

2.1 Extent of atmospheric dispersion

The extensive use of pesticides results in these substances being ubiquitous in the atmosphere (Dij99b). For the old organochlorine pesticides this was known as early as the nineteen-sixties, but for currently used pesticides this only became clear around ten years ago. In Europe, more than 80 currently used pesticides have been detected in rainwater and 30 have been detected in air. Comparable findings have been made in North America. The most frequently detected pesticides are the insecticide lindane and herbicides of the triazine group, particularly atrazine. However, other pesticides, such as anilides, chlorophenoxy herbicides and organophosphate insecticides are regularly detected in rainwater and air. The concentrations in air vary from a few picograms to many nanograms per cubic metre and those in rainwater from a few nanograms to several micrograms per litre. Concentrations are generally higher in fog. Atmospheric deposition probably ranges from a few milligrams to more than 1 gram per hectare per year. However, these estimates are largely based on the collection and analysis of precipitation. They do not include the dry deposition of gases and particles. Model calculations, analyses of plant material and initial attempts to measure dry deposition directly, all indicate that total atmospheric deposition will usually remain below a few grams per hectare, per year, per compound. Little information is available about the presence of pesticide transformation products in the atmosphere, with the exception of those of triazine herbicides, which are frequently detected in air and rainwater.

Current pesticides are generally only detected in increased concentrations during the application season. The less volatile and more persistent compounds, such as lindane and, to a lesser degree, also triazines, are also present in the atmosphere in low concentrations throughout the rest of the year. The presence of pesticides in the atmosphere is not limited to agricultural areas. They are also detected in air and rainwater outside the areas of application, and sometimes even in remote places. Concentrations in the atmosphere outside agricultural areas are generally significantly lower. Measurement data indicate that today's pesticides can be dispersed by the air across distances ranging from a few dozen to hundreds of kilometres, and in some cases more than a thousand kilometres. The relative importance of atmospheric transport vis-à-vis other transport routes differs from place to place. In mountainous areas and around remote lakes, the atmosphere is often the only conveyance route. In coastal waters conveyance by rivers may be the predominating factor.

2.2 The ecological significance of atmospheric transport

The ecological damage that results from the worldwide dispersion of organochlorine pesticides has been extensively documented in the international literature (see for example AMAP97). It depends mainly on the persistence of these substances and the degree to which they accumulate in food chains. There is a lack of any specific indications that also the more modern pesticides cause damage beyond the immediate surroundings of the areas of use (Str99). However, the Committee adds that damage caused in, for example, nature reserves by atmospheric dispersion of pesticides is usually difficult to demonstrate in the field through measurements. Changes as a result of low but more or less chronic exposure are generally subtle and occur gradually. Countless other stress factors may also have an effect and obscure the relationship to exposure to a particular pesticide. Finally, there are no suitable reference areas that are not subject to atmospheric input.

Views about possible ecological consequences of atmospheric dispersion of pesticides therefore have to be based on a comparison of measured or calculated exposure concentrations with data obtained from toxicity tests on the sensitivity (NOEC or LC_{50} values) of organisms, or standards based on these. Direct toxic impacts on organisms as a result of pesticides present in the air seem unlikely outside the immediate proximity of the areas of use because LC_{50} values determined in the laboratory are in the order of milligrams per cubic metre and are considerably higher than the concentrations measured in air (Str99). However, the highest pesticide concentrations measured in rainwater appear to closely approach and sometimes exceed laboratory test figures for the lowest NOEC or LC_{50} values relating to aquatic organisms (Zab93, Poo97). Rainwater quality also generally fails to meet the standards based on toxicity data of this kind for the quality of surface water (Maj95, Poo97). An additional problem is that the analytical methods are rather insensitive: the detection limits are relatively high, especially with regard to the standards for surface water quality. However, dilution and adsorption can usually be expected if rain falls on the surface water or soil, and this will often reduce the final exposure of organisms. Nevertheless, the Committee believes that the possibility of direct toxic impacts of pesticides present in rainwater cannot be excluded in advance.

De Jong *et al.* concluded on the basis of estimated deposition figures and data on the sensitivity of vascular plants and fungi that most impacts of the pesticides they considered probably occur in the immediate proximity of the areas of use (Jon95). However, their calculations show that volatile, persistent substances may also cause damage on a regional scale (tens of kilometres from the place of application).

The above opinions are based on the effect of individual substances. However, atmospheric dispersion results in organisms and communities being exposed to small volumes of several pesticides. Klepper *et al.* therefore calculated what the combined impact of atmospheric dispersion is of a large number of herbicides on natural vegetations in the Netherlands (Kle98). They found that the average, annual atmospheric input of herbicides in nature reserves corresponds with 2% of the recommended volume applied in a single spraying of an agricultural of field. The model calculations predict that approximately 2% of all plant species will be exposed to concentrations in excess of their no-observed-effect concentration. The spatial distribution of this percentage is considerable: lower values near the coast, higher values in central and eastern parts of the Netherlands and the highest values in areas where agriculture and horticulture are concentrated. The authors admit that the calculations are subject to a great deal of uncertainty and that the results have to be regarded as being indicative of a possible problem.

The Committee concludes on the basis of the above that the ecological significance of the atmospheric dispersion of pesticides is uncertain, but that the possibility of harmful impacts outside the immediate surroundings of the areas of use cannot be excluded in advance. Also considering the large spatial range over which the problem occurs, the Committee believes the risks of atmospheric dispersion of pesticides need to be limited in order to guarantee the conservation of wildlife. The most effective way is to limit the use of pesticides as far as possible. This is also the Dutch government’s aim, as expressed in the Multi-year Crop Protection Plan (TK91). Tightening the authorisation procedure by means of an extra environmental criterion for atmospheric dispersion (see chapter 3) would offer additional possibilities.

2.3 Why is the current risk-assessment procedure insufficient?

An important question is whether or not a good local risk assessment is sufficient for also preventing impacts at a greater distance. In other words, are pesticides that cause no damage to the flora and fauna on and adjacent to the field where these substances are applied not by definition also safe for nature reserves located further away? After all, deposition on a field where a pesticide is applied directly and deposition on adjacent strips of land, where input is caused by drifting droplets of sprayed liquids and possibly by run-off and leaching, will practically always be higher than in areas located further away. Dilution and transformation during atmospheric transport will also increase this difference. Roughly speaking, the deposition on strips of land adjacent to treated fields as a result of spray drift is usually one to two orders of magnitude lower than the deposition on the field itself. The deposition on more remote areas as a result of the atmospheric transport of evaporated or aerosol-bound pesticides is at least another one to two orders of magnitude lower. Although an effective authorisation policy aimed at preventing local impacts would help reduce possible damage at a greater distance from the areas of use, the Committee believes a separate evaluation of the risks resulting from atmospheric dispersion of pesticides is advisable. This opinion is based on the following considerations:

Nature of the exposure

The exposure resulting from spray drift differs from that caused by atmospheric transport of aerosols and vapours. In the first case, input is relatively high, but only for a short period of time and generally involves a single toxic substance. Besides the level of input being lower, there is no essential difference from the exposure on the treated field itself. It is a local problem. Solutions can be sought, for example by improving the application technique (Hui97), and establishing unsprayed field margins (Sno98). Measures of this kind have no effect on atmospheric dispersion of gaseous and aerosol-bound pesticides, as such dispersion is determined more by the physical and chemical properties of the substance concerned. Transport through the atmosphere results in relatively low but more chronic exposure. The latter is the result of many fields being involved, which are not all treated at the same time, the substance being released gradually from the field after application, and the substance’s long-range transport. Atmospheric dispersion is also more likely to result in a simultaneous exposure to several pesticides. It affects a much larger area and inputs need by no means be confined to the immediate proximity of treated fields.

Transformation and mobility

Specific conditions may prevail in nature reserves, such as low pH values, oligotrophy (low availability of nutrients) or low temperatures. These may hamper transformation processes considerably, partly due to their effect on microbial activity. For example, the transformation of phenoxy herbicide occurs relatively slowly in acid soils (Tor95) and that of atrazine only occurs slowly in lakes (Sch94, Mül97). The mobility of substances can also be affected: volatility, for example, reduces with falling temperatures. Low degradability and limited volatility at low temperatures together explain why certain organochlorine compounds accumulate at the poles (Wan96). This illustrates that exposure in nature reserves may, nevertheless, be higher or more persistent than in areas of application, in spite of low input levels.

Vulnerability of organisms

Populations of organisms and ecosystems in nature reserves may be more vulnerable than those found in and around areas of application (Str99). This may be because of a greater intrinsic sensitivity of species, or the more limited recovery capability of populations, as a result of slower reproduction, or it may be because of impeded recolonisation owing to the isolated location of nature reserves.

Hoofdstuk 3

Risk-assessment procedure

The workshop participants called for a tiered approach when assessing the risks involved in the atmospheric dispersion of pesticides (figure 1, Gui99). The Committee supports this recommendation. It is also the method of working adopted in the current risk-assessment procedure for pesticides, which focuses on the areas of use. The basic idea is that, using a minimum amount of data, a distinction can be made between pesticides that most probably present no problems with regard to atmospheric dispersion and pesticides for which additional research is required to obtain greater certainty.

3.1 The first tier

In the proposed scheme, the substance's ability to reach the air compartment is determined in the first tier. Emission into the air may occur during or after application. The emission during application depends mainly on the crop-growing situation (orchards, nursery trees, field crops or greenhouses) and the application technique (spraying rig, air-assistance, shielding, nozzle type, pesticide formulation). The Committee recommends classifying pesticides on the basis of these specifications and estimating for each class what percentage of the spray cloud, under standard conditions (weather conditions, size of field, amount applied), may reach remote areas (more than one kilometre). This can be achieved by modifying existing drift models (Ber99).

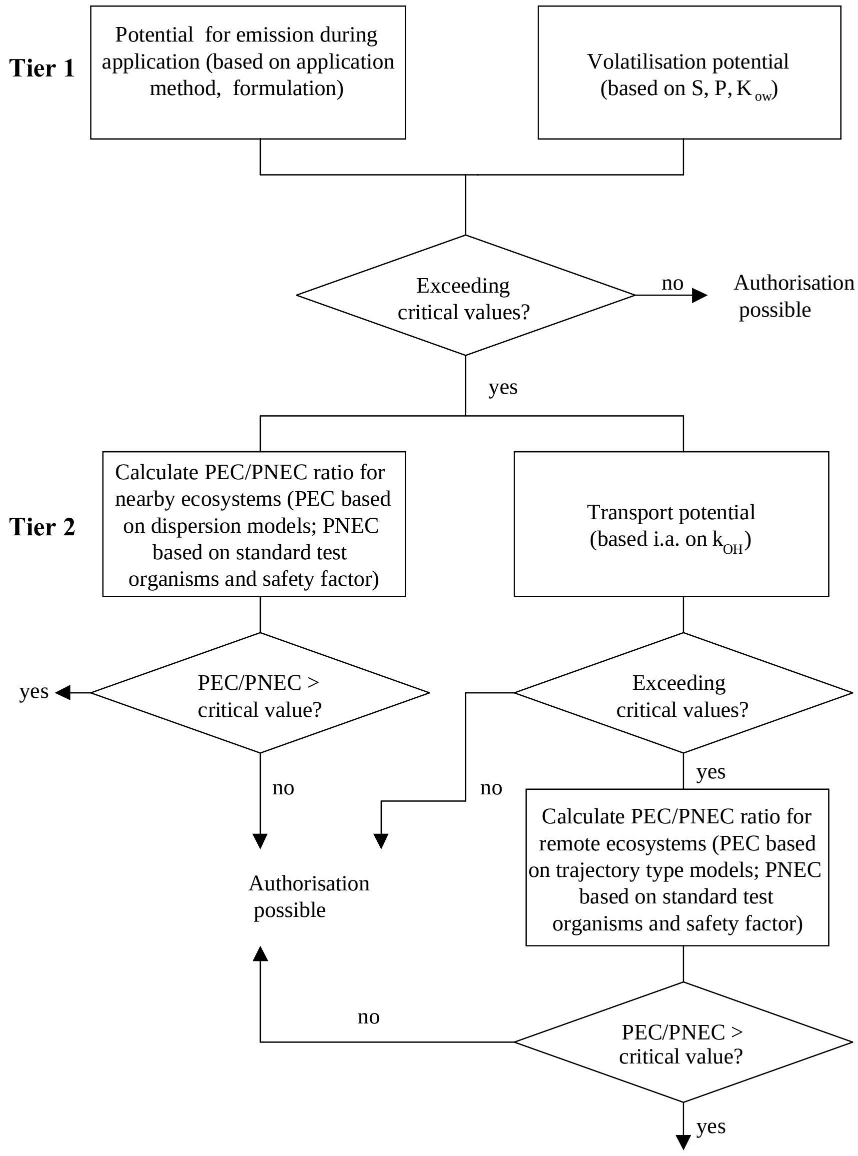

Figure 1 Decision making scheme for assessing the risks of atmospheric dispersion of pesticides, as proposed during the workshop on atmospheric dispersion of pesticides, held on 22-24 April 1998, in Driebergen, the Netherlands (Gui99).

Emission into the air after application occurs through volatilisation from the crop or from the soil. Simple calculation methods have been developed for calculating this, which are based on the physico-chemical properties of the pesticides (Ber99). These methods need to be modified to enable estimates of volatilisation under unfavourable, i.e. emission-promoting conditions (compare EPPO93).

Both emission fractions are expressed as a percentage of the amount applied. These percentages will have to be subject to limits, to enable a decision to be made about the necessity of a further risk evaluation in a second tier. The Committee recommends adding both percentages and setting a limit for their sum. An addition of this kind may not take into account the time difference between emission during and after application (minutes to hours versus days to weeks), however, the Committee considers this acceptable for the sake of simplicity.

The German BBA* adopts a figure of 20% within 24 hours as the limit for the sum of the percentages (Got90). The Committee sees a parallel with the risk assessment for pesticide transformation products: it has been decided in the European Union to only subject these products to a risk assessment, if they are formed in volumes of at least 10% of the original substance. These choices are mainly based on practical considerations; they are not well-founded from the scientific point of view. After all, low emission percentages can also cause damage in nature reserves, if extremely toxic pesticides are used that are also persistent and bioaccumulating. The extent of use also plays a role. Therefore, according to the Committee, in the first tier it would be better from the scientific point of view to only ascertain whether a substance would be able to enter the atmosphere, given the method of application. However, the disadvantage of this is that the first tier becomes much less selective, which means expensive and time-consuming further investigation is required for more substances. The Committee recommends as a compromise that the aforementioned limiting value should be made dependent on the substance’s toxicity, persistence, bioaccumulation and the (anticipated) volume used.

3.2 The second tier

3.2.1 Risks of medium-range atmospheric dispersion (up to around 50 km)

Pesticides identified in the first tier of the assessment procedure as having the potential to enter the atmosphere in substantial volumes must undergo the second tier of the assessment. It must be established in the second tier whether their use presents a risk to nature reserves within a particular radius of the sites of application (the Committee

* Biologische Bundesanstalt für Land- und Forstwirtschaft

envisages a radius of approximately 50 km). To this end, the participants in the workshop recommended determining the ratio between the anticipated exposure (predicted environmental concentration or PEC) and the anticipated sensitivity (predicted no-effect concentration, PNEC) of organisms in those areas. A limit would then have to be set for the PEC/PNEC ratio above which use of a pesticide would not be permitted.

To determine the anticipated exposure, the concentration of a pesticide in the air above an imaginary nature reserve, or the atmospheric deposition on that area, can be calculated using models. A summary was provided during the workshop of the current level of knowledge about the processes involved in emission, transport and deposition (Ber99, Bid99, Pul99). An explanation was also provided of what is currently possible in terms of modelling these processes (Ber99, Jaa99). It was proposed that the input in a nature reserve as a result of emissions from agricultural fields within a radius of 50 km (scenario approach) should be calculated. It would also be necessary to take into account emissions from sources outside this area (background input). However, the spatial dispersion of these emissions need not be known in detail. Modelling of this kind has already been in use for many years. However, there has only been limited validation of the models owing to a lack of measurement data.

Proposals were also made during the workshop for new, simpler transport models, such as the unit-surface-area approach (Bak99, Str99). However, with current computer facilities, quick calculations can also readily be made using the more complex and accurate models that are already available. Simplified versions of these models could be used, if necessary.

To derive exposure concentrations in the other environmental compartments (soil, water, sediment) of a nature reserve from the calculated air concentration or atmospheric deposition, it is necessary to make additional calculations using water- and soil-quality models. It is essential for these calculations to be made using data (for example DT_{50} and K_{om} values*) that is typical of the prevailing conditions in nature reserves. However, the standard information manufacturers have to provide with their applications does not include such data. The same applies to toxicity data for the representative species of nature reserves. According to the Committee, a practical solution to this problem could be to perform the PEC/PNEC calculation using the standard data the manufacturer has to supply for the local risk assessment. Provisionally imposing more stringent requirements for the critical value of this ratio would compensate for the uncertainty about the validity of the data for nature reserves.

* DT_{50}: the time in which 50% of the amount of a substance in an environmental compartment has been removed from that compartment by transformation or transport.
K_{om}: partition coefficient, which gives the distribution of a substance over water and organic matter in a state of equilibrium

This was also proposed during the workshop (Str99). Further research into the effect of conditions on the fate of pesticides deposited in nature reserves and into the vulnerability of populations of representative species should indicate which requirements are appropriate for the PEC/PNEC ratio.

Simultaneous exposure to several pesticides is another argument for being more stringent in establishing the critical value. This is in line with current environmental policy in the Netherlands, in which, besides the maximum permissible concentration (MPC) a target value, based on the hundred times lower negligible risk level, is adopted to compensate for multiple exposure (TK89, TK98).

If a pesticide fails to meet the PEC/PNEC criterion, the applicant can be given the opportunity to demonstrate by providing additional research data (data on the behaviour of the substance under relevant environmental conditions in order to provide a better calculation of the exposure, toxicity data for more representative species, and information on the impact-bearing capacity and recovery of ecosystems) that the unacceptable impacts would not occur in practice. Manufacturers already have this possibility in the present local risk assessment.

3.2.2 *Risks of long-range atmospheric dispersion (more than 1000 km)*

Atmospheric transport potential

The workshop participants recommended that the second tier should also include an evaluation of the risk of long-range transport (more than 1000 km). In the first place, it would be necessary to determine to this end whether it is plausible that substantial amounts of a pesticide would be capable of covering such a distance. This would be possible by calculating an ‘atmospheric transport potential’. This is defined as either the time it takes for half of the emitted substance to disappear from the atmosphere through transformation or deposition, or the distance the substance travels in that half-life period, given a postulated, constant wind speed. An unfavourable situation is generally assumed when calculating the transport distance, as a straight transport route is postulated. Long residence times in the atmosphere make the assumption of a straight trajectory too unrealistic and corrections are required.

Various methods have been developed for calculating this potential (Mee99). In essence, the various methods only differ in the number of environmental compartments included in the calculation. Scheringer (Sch96, Sch97) and Bennett *et al.* (Ben99) calculated the residence time in the various compartments using environmental fate models of the fugacity type (Mac91). The exchange between the air compartment and soil, surface water, sediment and vegetation is taken into account in these models. In a simple calculation method of Van Pul *et al.* (Pul98) for determining the residence time of a substance in the atmospheric boundary layer* only exchange with the soil is taken into account.

The pesticide's transformation rate in air is required information in every method of calculating the atmospheric transport potential. In the workshop, a review was provided of the current level of knowledge on the chemical transformation of pesticides in air (Atk99). This showed that the reaction rate constant k_{OH}** is the best measure of the transformation rate. The Committee is of the opinion that manufacturers should be obliged to specify the k_{OH} value and believes it is important for an internationally acceptable measurement protocol to be established as soon as possible for determining this quantity's value.

The calculation of the atmospheric transport potential also requires meteorological data and data on the properties of the substances. Weather conditions vary widely in both space and time. Considerable uncertainties about the substance's physico-chemical properties further reduce the level of accuracy (Pul98). The Committee therefore calls for a sensitivity analysis to be conducted, to clarify which variables contribute most to the uncertainty. The Committee also calls for a comparison of the results of various models for calculating the transport potential. In the event of major differences, the cause would have to be analysed. This should take place before the models are actually used in the authorisation of pesticides.

It is difficult to say at which value of the atmospheric transport potential a further risk evaluation (PEC/PNEC calculation for remote areas) is required. Here too, for practical reasons it would be possible to choose a percentage of the original amount of pesticide emitted into the air that is still permitted to be in the atmosphere a certain distance away. For example, if a maximum of 10% of the substance was still permitted to be found in the atmosphere at a distance of 1000 km from the place of application, this would imply a limit on the atmospheric transport potential of either 17 hours or approximately 300 km at a wind speed of 5 m/s. Rounded off, this means that a 24-hour period could be adopted as the limiting value. The limit adopted in Germany is a $DT_{50,air}$ of less than four days (Got90). However, they only take into account removal from the air by transformation and not by deposition. The UN-ECE and the UNEP adopt a two-day limit for persistent organic pollutants (POPs), which is likewise only based on transformation.

The Committee points out that choosing a specific percentage involves a failure to take into account the substance's toxicity, its persistence in the recipient nature reserve, bioaccumulation and the volume applied. The Committee therefore calls for the limiting value for the atmospheric transport potential to be made dependent on the

* atmospheric boundary layer: the lower layer of the troposphere, in which air currents are affected by the earth's surface

** k_{OH}: reaction rate constant of the reaction of a substance with OH radicals aforementioned parameters, as is the case with the emission percentage in the first tier of the risk assessment (see section 3.1).

Risk assessment on the basis of the PEC/PNEC ratio

The workshop participants recommended carrying out an additional risk evaluation for long-range transport in respect of pesticides with an atmospheric transport potential in excess of the chosen limiting value. The decision to define ‘long-range’ as at least 1000 km was relatively arbitrary. It was based on the idea that the characteristics of the conditions and communities at that distance could have changed to such a degree that a separate risk evaluation would be necessary, besides the one carried out for areas located at medium distances. After all, an even greater substance persistence or even higher level of vulnerability of the populations and communities in remote areas could lead to unacceptable impacts. Consider, for example, the extremely low temperatures that prevail in polar regions. Such temperatures would not only affect the fate of a pesticide in the environment but also the likelihood of recovery of any populations or organisms that were affected. It was proposed during the workshop that this risk assessment should, likewise, be based on a comparison of the anticipated exposure (PEC) with the anticipated sensitivity (PNEC).

Here too, the Committee calls for the PEC/PNEC ratio to be calculated from the data the applicant has to submit for the local risk assessment. The limiting value for the ratio should be more stringent than that adopted for the evaluation of the risks of medium-range transport, because there is more uncertainty about the validity of the data used. Further research should show the degree to which the conditions and the vulnerability of organisms in remote areas necessitate a lower critical value for the quotient.

In general, the uncertainties in the quantification of the various processes (emission into, transformation in and transport through the atmosphere, and deposition in a remote area) increase as the transport distance increases. Consequently, the PEC calculation for nature reserves at large distances from the areas of use will unavoidably be subject to greater uncertainty than the calculation for areas close by. The Committee is of the opinion that this may be an argument for the advance prohibition of substances with a large atmospheric transport potential. Given the cross-border character of the long-range atmospheric transport of pesticides, this would require an international approach. By way of comparison, the Committee refers to the recently established protocol on persistent organic pollutants (POPs), under the UN-ECE convention on long-range and cross-border transport of air pollution.

3.3 Operationalisation

There are still many gaps in the knowledge about the processes that play a role in the atmospheric dispersion of pesticides, especially with regard to their emission into and transformation in the atmosphere (Atk99, Ber99, Pul99). There is also still a lack of precise knowledge about the physico-chemical properties of many substances. Nevertheless, in view of the pace at which knowledge is advancing and the modelling instruments that are already available, the Committee believes it ought to be possible to have the outlined procedure operational within approximately five years. However, it makes an exception with regard to the calculation of the ratio between exposure and the sensitivity of organisms in remote areas, as it believes this will be more difficult to put into operation.

The Committee recommends setting a provisional figure for the various limiting values and testing the procedure against the pesticides that have already been accepted. That way, it can be ascertained, amongst other things, whether the emission estimate in the first tier and the calculation of the atmospheric transport potential in the second tier provide a sufficient level of sifting and therefore reduce the amount of work required.

To be able to determine whether such a modified acceptance procedure would be adequate to limit the risks of atmospheric dispersion of pesticides, the Committee believes it will be necessary to monitor air and precipitation quality. This is mainly important because only the risks of individual pesticides are considered in the authorisation procedure. The monitoring data may show that certain substances possibly lead to problems (e.g. excessive concentrations in rainwater). This could result from the authorisation of several pesticides with the same active ingredients or with the same working mechanism (e.g. cholinesterase inhibition). In such cases, the Board for the Authorisation of Pesticides (CTB), possibly in consultation with interested parties from agriculture and the industry, would have to examine whether the findings need have consequences for the whole group of pesticides concerned or only for specific ones, for example, those that can be most readily missed.

The monitoring results can also be used for further validation and improvement of the models used. Finally, the Committee points out that modification of the authorisation procedure is only possible at the international level, in the first place at the level of the European Union.

The Hague, 27 January 2000,
for the Committee
(Signed)
dr HFG van Dijk, scientific secretary, dr R Guicherit, chair

Literature

AMAP97 Arctic Monitoring and Assessment Programme. The AMAP Assessment Report: Arctic pollution issues. Tromso: AMAP, 1997.

Atk99 Atkinson R, Guicherit R, Hites RA, e.a. Transformation of pesticides in the atmosphere: a state of the art. Water Air Soil Pollut 1999; 115: 219-43.

Bak99 Bakker DJ, Gilbert AJ, Gottschild D, e.a. Implementing atmospheric fate in regulatory risk assessment of pesticides: (how) can it be done? Water Air Soil Pollut 1999; 115: 257-66.

Ben99 Bennett DH, McKone TE, Matthies M, e.a. General formulation of characteristic distance for persistent chemicals in a multimedia environment. Environ Sci Technol 1999; in press.

Ber99 van den Berg, F, Kubiak R, Benjey WG, e.a. Emission of pesticides into the air. Water Air Soil Pollut 1999; 115: 195-218.

Bid99 Bidleman TF. Atmospheric transport and air-surface exchange of pesticides. Water Air Soil Pollut 1999; 115: 115-66.

Dij99a van Dijk HFG, van Pul WAJ, de Voogt, P, red. Fate of pesticides in the atmosphere; implications for environmental risk assessment. Water Air Soil Pollut 1999; 115: 1-276. (Tevens als boek uitgegeven door Kluwer Academic Publishers, Dordrecht, 1999.)

Dij99b van Dijk HFG, Guicherit R. Atmospheric dispersion of current-use pesticides: a review of the evidence from monitoring studies. Water Air Soil Pollut 1999; 115: 21-70.

EPPO93 European and Mediterranean Plant Protection Organisation / Council of Europe (EPPO/CoE) decision making schemes for the environmental risk assessment of plant protection products (with additional Air sub-scheme). Parijs: EPPO, 1993.

EU97 Europese Gemeenschappen. Richtlijn 97/57/EG van de Raad van 22 september 1997 tot vaststelling van bijlage VI bij richtlijn 91/414/EEG betreffende het op de markt brengen van gewasbeschermingsmiddelen. Publicatieblad van de Europese Gemeenschappen 1997; nr L265:87-108.

Got90 Gottschild D, Siebers J, Nolting HG. Richtlinien für die Prüfung von Pflanzenschutzmitteln im Zulassungsverfahren. Teil IV, 6-1, Prüfung des Verflüchtigungsverhaltens und des Verbleibs von Pflanzenschutzmitteln in der Luft. Biologische Bundesanstalt für Land- und Forstwirtschaft (BBA). Ribbesbüttel: Saphir Verlag, 1990.

Gui99 Guicherit R, Bakker DJ, de Voogt P, e.a. Environmental risk assessment of pesticides in the atmosphere; the results of an international workshop. Water Air Soil Pollut 1999; 115: 5-19.

Hor96 Horeman GH, red. MJP-G Emissie-evaluatie 1995; Einddocument. Ede: Commissie van deskundigen emissie-evaluatie MJP-G, IKC-landbouw, 1996.

Hui97 Huijsmans JFM, Porskamp HAJ, van de Zande JC. Drift(beperking) bij de toediening van gewasbeschermingsmiddelen. Wageningen: IMAG-DLO, 1997; (publicatie nr 97-04).

Jaa99 van Jaarsveld JA, van Pul, WAJ. Modelling of atmospheric transport and deposition of pesticides. Water Air Soil Pollut 1999; 115: 167-82.

Jon95 de Jong FMW, van der Voet E, Canters KJ. Possible side effects of airborne pesticides on fungi and vascular plants in The Netherlands. Ecotoxicol Environ Safety 1995; 30: 77-84.

Kle98 Klepper O, Jager T, van der Linden T, Smit R. An assessment of the effect on natural vegetations of atmospheric emissions and transport of herbicides in the Netherlands. Intern rapport Laboratorium voor Ecotoxicologie. Bilthoven: RIVM, 1998; (98/05).

Mac91 Mackay D, Paterson S. Evaluating the multimedia fate of organic chemicals - a level-III fugacity model. Environ Sci Technol 1991; 25: 427-36.

Maj95 Majewski MS, Capel PD. Pesticides in the atmosphere. Chelsea, Michigan: Ann Arbor Press, Inc., 1995.

Mee99 van de Meent D, McKone T, Pakerton T, e.a. Persistence and transport potential of chemicals in a multimedia environment. Verslag van een workshop gehouden in Fairmont, Canada, July 1998; in voorbereiding.

Mül97 Müller SR, Berg M, Ulrich MM, Schwarzenbach RP. Atrazine and its primary metabolites in Swiss lakes: input characteristics and long-term behavior in the water column. Environ Sci Technol 1997; 31: 2104-13.

Poo97 de Poorte J, van Leeuwen CJ. Hoe giftig is regenwater? H_2O 1997; 30(6): 168-71.

Pul98 van Pul WAJ, de Leeuw FAAM, van Jaarsveld JA, e.a. The potential for long-range transboundary atmospheric transport. Chemosphere 1998; 37: 113-41.

Pul99 van Pul WAJ, Bidleman TF, Brorström-Lundén E, e.a. Atmospheric transport and deposition of pesticides: an assessment of current knowledge. Water Air Soil Pollut 1999; 115: 245-56.

Sch94 Schottler SP, Eisenreich SJ. Herbicides in the Great Lakes. Environ Sci Technol 1994; 28: 2228-32.

Sch96 Scheringer M. Persistence and spatial range as endpoints of an exposure-based assessment of organic chemicals. Environ Sci Technol 1996; 30: 1652-9.

Sch97 Scheringer M. Characterization of the environmental distribution behavior of organic chemicals by means of persistence and spatial range. Environ Sci Technol 1997; 31: 2891-7.

Sno98 de Snoo GR, de Wit PJ. Buffer zones for reducing pesticide drift to ditches and risks to aquatic organisms. Ecotoxicol Environ Safety 1998; 41: 112-8.

Stb95 Besluit van 23 januari 1995, houdende regelen als bedoeld in artikel 3a, eerste lid, van de Bestrijdingsmiddelenwet 1962 (Besluit milieutoelatingseisen bestrijdingsmiddelen). Staatsblad 1995; nr 37. Den Haag: SDU uitgeverij, 1995.

Stb98 Wet van 12 juli 1962, Stb. 288, houdende vaststelling van nieuwe regelen met betrekking tot de handel in en het gebruik van bestrijdingsmiddelen (Bestrijdingsmiddelenwet). Staatsblad 1998; nr 690. Den Haag: SDU uitgeverij, 1998.

Str99 van Straalen NM, van Gestel CAM. Ecotoxicological risk assessment of pesticides subject to long-range transport. Water Air Soil Pollut 1999; 115: 71-81.

TK89 Omgaan met risico's. Handelingen Tweede Kamer, vergaderjaar 1988-1989, nr 21137-5. Den Haag: SDU, 1989.

TK91 Meerjarenplan Gewasbescherming. Regeringsbeslissing. Handelingen Tweede Kamer, vergaderjaar 1990-1991, nr 21677-3/4. Den Haag: SDU uitgeverij, 1991.

TK98 Derde Nationale Milieubeleidsplan. Handelingen Tweede Kamer, vergaderjaar 1997-1998, nr 25887-1. Den Haag: SDU uitgeverij, 1998.

Tor95 Torstensson L. Pesticides in precipitation. Consequences for the terrestrial environment. In: Helweg A, red. Pesticides in precipitation and surface water. Tema Nord 1995: 558. Kopenhagen: Nordic Coucil of Ministers; 84-93.

Wan96 Wania F, Mackay D. Tracking the distribution of persistent organic pollutants. Environ Sci Technol 1996; 30: A390-6.

Zab93 Zabik JM, Seiber JN. Atmospheric transport of organophosphate pesticides from California's Central Valley to the Sierra Nevada Mountains. J Environ Qual 1993; 22: 80-90.

Annexes

Annex **A**

Request for advisory report

On 14 April 1997, the Minister of Health, Welfare and Sport wrote to the President of the Health Council of the Netherlands as follows:

On 13 February 1996 (DGVgz/VVP/C951554) I, also on behalf of the Minister of Housing, Spatial Planning and the Environment, the Minister of Transport, Public Works and Water Management, the Minister of Agriculture, Nature Management and Fisheries, and the State Secretary for Social Affairs and Employment, requested you to report to me about the risk assessment of pesticides. In my letter, I indicated that the questions that have to be answered would be further prioritised during the course of this project.

Within the scope of the aforementioned risk assessment, you have meanwhile produced the first report on the ecological consequences of pesticides in groundwater.

I now request you to compile an advisory report on the necessity of including the atmospheric dispersion of pesticides in the risk assessment for their authorisation, and the possibilities that exist for doing so. This subject was already raised in my request of 13 February 1996 for advisory reports.

The current pesticides risk assessment is mainly concerned with local exposure and impacts. However, the use of a number of agricultural pesticides also involves medium- and long-range transport via the air, for example. The evaluation of the emission of pesticides conducted within the scope of the Multi-year Crop Protection Plan’s interim evaluation revealed that a larger percentage of the volume is dispersed via the air than had previously been assumed.

I request you to report to me on the current level of knowledge about the problem of the atmospheric dispersion of agricultural pesticides. In view of the international character of this dispersion route, I also hereby specifically request you to include in your report the knowledge and experience available in other countries about this problem.

The Minister of Health, Welfare and Sport,

Dr E. Borst-Eilers

Annex **B**

The Committee

- Dr R Guicherit, *chair*,
  atmospheric chemist; TNO Environment, Energy and Process Innovation, Apeldoorn
- Dr HE van de Baan, *adviser*,
  Ministry of Agriculture, Nature Management and Fisheries, The Hague
- Drs DJ Bakker,
  environmental chemist; Province of Flevoland, Lelystad
- Dr F van den Berg,
  environmental chemist; ALTERRA, Wageningen
- Drs DA Jonkers, *adviser*,
  Ministry of Housing, Spatial Planning and the Environment, The Hague
- Dr WAJ van Pul,
  air pollution expert; National Institute of Public Health and the Environment, Bilthoven
- Dr P de Voogt,
  environmental chemist; University of Amsterdam
- Dr HFG van Dijk, *scientific secretary,*
  Health Council of the Netherlands, The Hague

Annex **C**

Fate of Pesticides in the Atmosphere

Implications for Environmental Risk Assessment

HFG van Dijk, WAJ van Pul, P de Voogt, editors
Dordrecht: Kluwer Academic Publishers, 1999.
(Also appeared in Water, Air, and Soil Pollution 1999; 115(1-4): 3-276)*

Contents of the book

* While stocks last, the Health Council of the Netherlands will provide the book free of charge with the advisory report.