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# Management of Pesticide Residues in Sustainable Agriculture

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## Abstract

Sustainable agriculture requires the maintenance of the natural resource base and the economic viability of agricultural production. The use of pesticides may contribute to sustainability provided the pre-registration risk assessments pass the hurdles of safety for public health, the environment and trade. Post-registration monitoring should confirm the pre-registration assessment, but we should be alert for unanticipated residues or impacts.

The management of agricultural and animal industries needs special attention where land has been contaminated by previous uses of organochlorine pesticides. Production systems should be organised to minimise the extraneous residues occurring in food and to reduce dietary exposure and risks to trade.

## Key words

Pesticide residues, risk assessment, public health, environment, trade.

## Introduction

The pesticide registration system provides the opportunity to evaluate risks from the use of pesticides before they are registered and used. Pesticide companies are required to generate extensive data packages designed to satisfy questions about safety. Questions about the impact of the pesticide on the sustainability of agricultural production systems and the impact on ecosystems can often be dealt with in the pre-registration evaluation.

Sustainability of production may be threatened in some instances by soil contaminated with persistent organochlorine pesticides from previous uses. Organochlorine residues in soil can threaten the viability of animal industries because of the resulting residues in meat, milk or eggs.

In this paper I shall discuss:

- definitions of sustainable agriculture
- pesticide specifications
- uses of pesticides and the risks posed by pesticide residues
    - public health risks of residues in food
    - environmental risks posed by residues in soil and water
    - trade risks posed by residues
- residues from previous uses of organochlorine pesticides
- future

## Definitions of sustainable agriculture

Clarke and Wylie (1997) drew attention to the variety of definitions of sustainable agriculture. In simple terms, "A sustainable farming system is one which allows the production of food and fibre on a given land area to be sustained at the current level indefinitely." They quoted the Standing Committee on Agriculture Working Party definition (SCA 1991), which elaborates implications and supporting principles of sustainable agriculture.

The SCA Working Party defined sustainable agriculture as: the use of farming practices and systems which maintain or enhance:

- the economic viability of agricultural production,
- the natural resource base, and
- other ecosystems which are influenced by agricultural activities.

The definition was further elaborated with five supporting principles:

1. Farm productivity is sustained or enhanced over the long term.
2. Adverse impacts on the natural resource base of agriculture and associated ecosystems are ameliorated, minimised or avoided.
3. Residues resulting from the use of chemicals in agriculture are minimised.
4. The net social benefit derived from agriculture is maximised.
5. Farming systems are sufficiently flexible to manage risks associated with the vagaries of climate and markets.

We should note that residues are specifically mentioned and that economic viability is part of sustainability.

## Pesticide specifications - risks posed by environmental contaminants

Technical grade pesticides usually contain impurities structurally related to the starting materials, reaction products and the pesticide itself. In some cases the manufacturing impurities are environmental contaminants, the levels of which need to be controlled.

FAO defines relevant impurities as those by-products of the manufacture or storage of a pesticide which, compared with the active ingredient, are toxicologically significant to health or the environment, are phytotoxic to treated plants, cause taint in food crops, affect the stability of the pesticide, or cause any other adverse effect (FAO, 2002).

Our interest here is in those impurities that are toxicologically significant to health or the environment. Users may be inadvertently contaminating the farm environment if the pesticide product is formulated from an out-of-specification technical material. Examples of environmental contaminants occurring in pesticides are shown in Table 1.

Table 1. Examples of contaminants occurring in pesticides (Ambrus *et al.*, 2003).

| Pesticide | Contaminant |
|---|---|
| chlorthal-dimethyl | hexachlorobenzene |
| copper oxychloride | arsenic, lead, cadmium |
| dicofol | DDT and related compounds |
| quintozene | hexachlorobenzene |
| zineb | cadmium |

Pesticides evaluated by registration authorities should only be approved for use if they comply with the specifications. Out-of-patent pesticides from various sources need to be checked to ensure they do not contain excessive contaminant levels.

## The uses of pesticides and the risks posed by pesticide residues

Before a pesticide is registered or approved for use the authorities must be satisfied that the risks are either minimal or are acceptable with proper management.

The following risks are subject to assessment prior to registration:

–occupational health, i.e. the risks to the user or applicator of the pesticide;

–public health, risks to the consumer of residues in food;

–environmental, risks to non-target organisms of residues in soil and water; and
–trade, risks that residues in raw and processed commodities will be illegal.

The occupational health risk is not generally related to residues, but public health, environment and trade risks are often residue issues.

**Public health risks of residues in food**

The data requirements and the methods of risk evaluation are more highly developed in this area than in any other (Figure 1).

In risk analysis terminology we may regard the toxicity of the pesticide as the hazard.

The dose response of the pesticide is the hazard characterization.

Consumer exposure is the dose of residue, which is equal to the residue concentration in the food multiplied by the amount of the food consumed.

The risk is then assessed by examining consumer exposure against the hazard characterization.

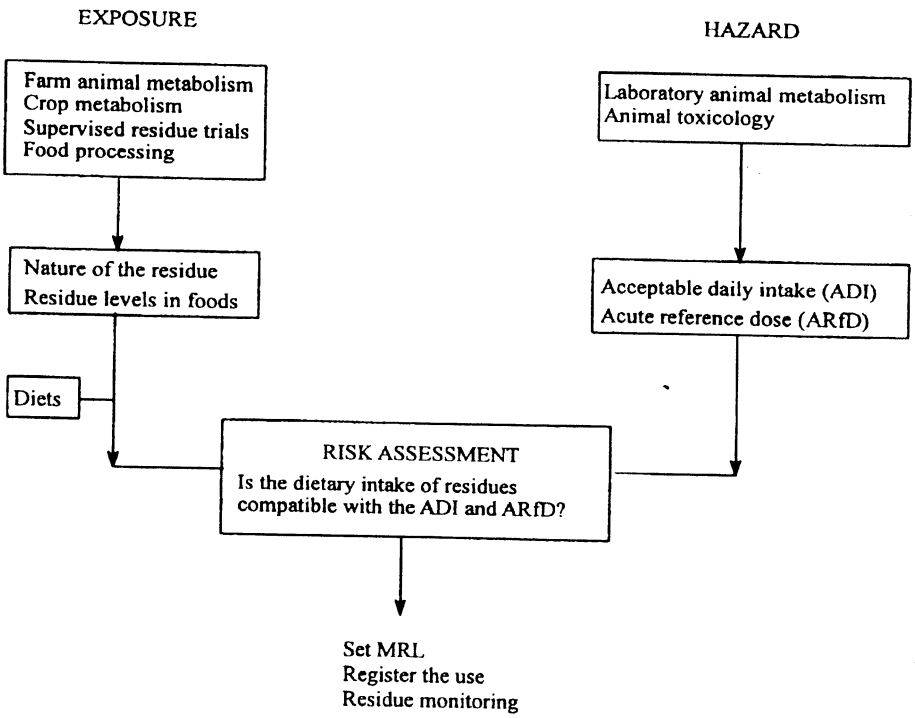


Figure 1. Risk assessment for pesticide residues in food.

Prior to registration extensive data on metabolism and toxicity testing of the pesticide allow the authorities to establish an ADI (acceptable daily intake) and an ARfD (acute reference dose) needed for assessing the acceptability of chronic and short term exposures respectively. (Exposure in this context means

the same as intake).

The no-observable-effect-levels (NOELs) from animal toxicity testing are divided by suitable safety factors (usually 100) to obtain the ADI and acute RfD.

Data on animal and plant metabolism, supervised residue trials and food processing studies provide the information on the residues likely to occur in food when the pesticide is used according to label directions. The residue level in a food multiplied by its consumption gives us the consumer intake or exposure for the residue.

Chronic or long-term consumer intake is compared with the ADI. Short-term intake is compared with the acute RfD. Registration will not proceed if the best estimates of intake exceed the ADI or acute RfD.

**Environmental risks posed by residues in soil and water**

Registrants provide copious data that allow registration authorities to evaluate risks to the environment (Figure 2)

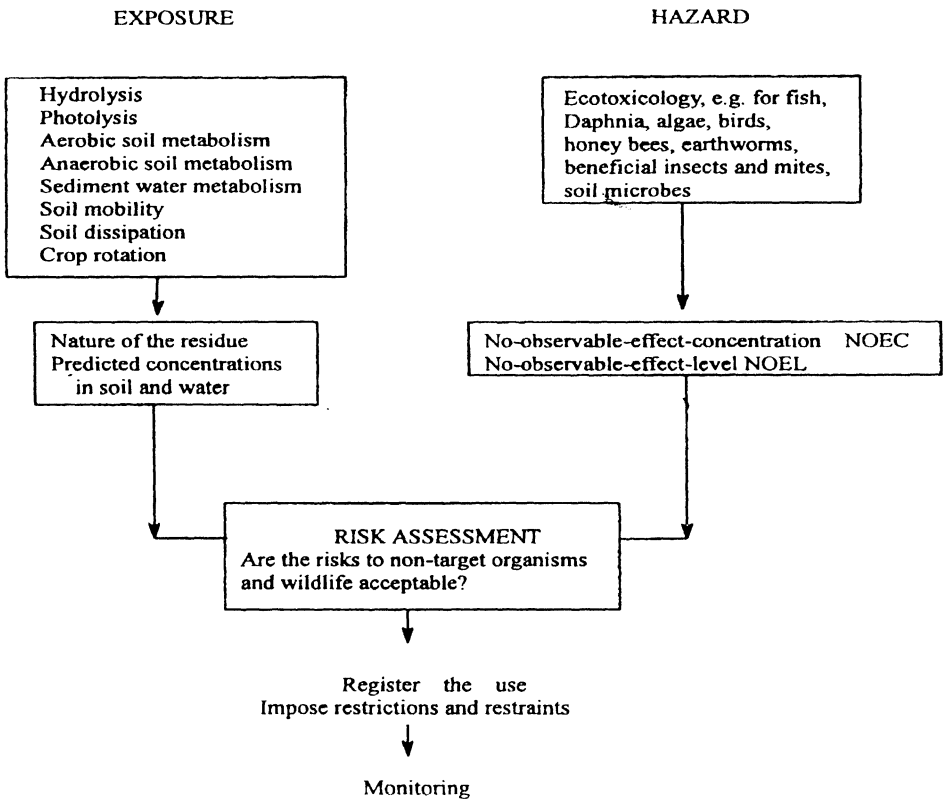


Figure 2. Assessment of risks to the environment resulting from pesticide uses.

We are interested in the persistence and fate of the pesticide and relevant transformation products (metabolites and hydrolysis and photolysis products) in

soil and water and their potential to move off target in run-off or down the soil profile to ground water.

We should be alert for environmental properties that would raise concerns for sustainable agriculture:

- a combination of soil persistence and high leaching mobility increases the risk of ground water contamination.
- a combination of soil persistence and fat solubility increases the risk of residues occurring in farm animals.
- a combination of environmental persistence and high ecotoxicity for a particular species, e.g. Daphnia, suggests a risk to aquatic organisms from runoff.

Registration should proceed only where environmental risks are acceptable.

A particular method of usage that minimises exposure of the environment might allow the use of some compounds that would otherwise be of concern. For example, rodenticides may be used in bait stations that minimise soil contamination and restrict access by other wildlife.

After registration, monitoring should be introduced to check the validity of pre-registration assessments. Ideally the monitoring should target those areas or situations where residues or effects, if they occur at all, are most likely to be seen. But we should also be alert for residues or impacts that might occur but were not anticipated.

**Trade risks posed by residues**

Trade risk is different from public health and environmental risk because it generally applies only to exports. Trade risk caused by pesticide residues is a serious threat to sustainable agriculture and should be evaluated prior to registration. The nature of the hazards and exposures to trade risks is summarised in Figure 3.

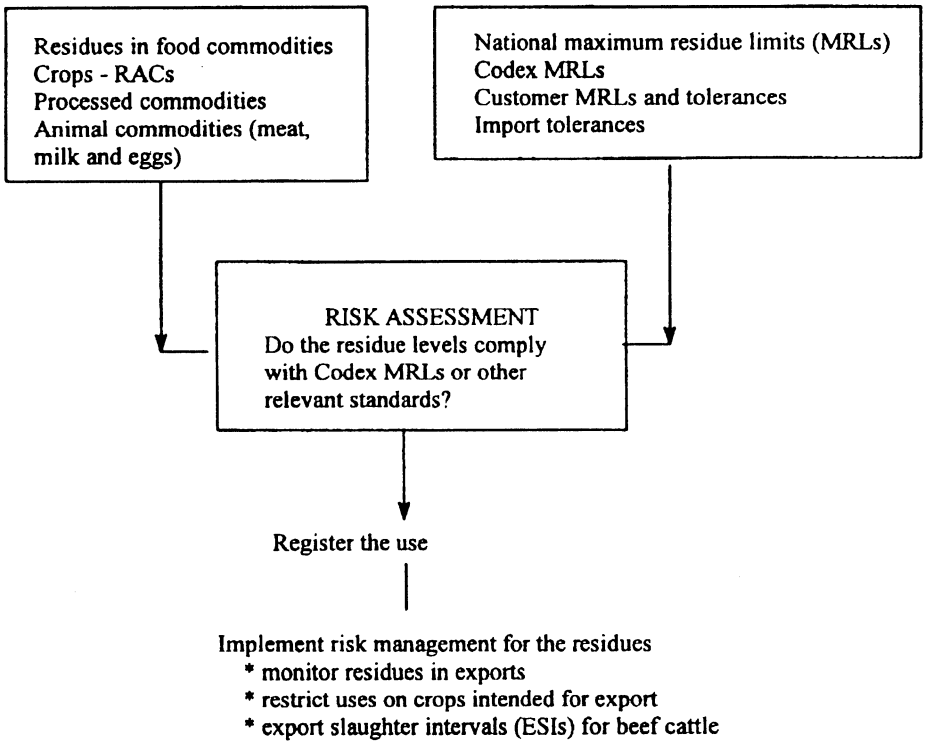


Figure 3. Assessment of risks to trade resulting from pesticide residues.

Some industries are particularly vulnerable to trade risks from residues. A pesticide used on only a small portion of the grape crop may result in residue contamination of a large volume of wine because of blending and mixing. This will impact on the trade if the residue is not permitted in the export market.

Beef cattle are also very susceptible to trade problems because their feed may sometimes be by-products of other industries, e.g. fruit, cereals, sugar cane, pulses and cotton, with the attendant residues from pesticide uses in those industries. Pastures may be inadvertently contaminated by spray drift from a neighbouring crop. Furthermore, considerable amounts of soil (1 kg per day) may be directly consumed by a grazing animal, thus exposing the animal directly to pesticide residues in the soil.

Pre-registration risk assessment is valuable for minimising some trade threats but it needs further development. Some trade risks resulting from residues are not amenable to control at registration and must be managed in other ways.

Risk management options for exports include residue monitoring. When

excessive or illegal residues are detected a traceback system should identify the causes. Animals intended for the export market may have to be put on a regime of controlled feed for an interval before slaughter to ensure that the meat complies with the standards of the importing country.

A pest or disease incursion can threaten the sustainability of an industry because of quarantine restrictions on the export of produce from the affected zone. For example, fruit from a fruit-fly infested zone may not be permitted to be sent elsewhere without inspection and pesticide treatment. Industries that cannot meet the requirements will no longer be sustainable. An example of such requirements is: (1) approved post-harvest insecticide treatment, (2) residues to be safe for the consumer and (3) residue levels complying with Codex or customer country standards.

## Residues from previous uses of organochlorine pesticides

Previous uses of persistent organochlorine compounds such as dieldrin and DDT have left residues in soil that pose risks to sustainable agriculture. Residues in the soil are likely to result in residues in some crops (e.g. root vegetables) and farm animals that have access to the contaminated area.

First is the risk that the dietary intake might approach or exceed the ADI for these compounds. Second is the risk to trade if the residues in produce exceed the extraneous maximum residue limits (EMRLs) allowed by Codex or training partners. These are both strong reasons to identify contaminated areas and to minimise the possibility of producing contaminated food. For example, farm animals should not be allowed access to old dip sites where organochlorine compounds were used.

The 1994 Australian Market Basket Survey (Marro, 1996) included DDT and dieldrin in the analytes surveyed and included tests on human milk in the diet of infants. The survey showed that infants were the critical population and that their intakes (on a body weight basis) were considerably higher than for other population groups (Table 2).

Table 2. Estimated daily intake of DDT (and DDE and related compounds) and dieldrin residues in μg/kg body weight (from Appendix 7, 1994 Australian Market Basket Survey).

| | Adult males | Adult females | Boys aged 12 | Girls aged 12 | Toddlers aged 2 | Infants, 9 months |
|---|---|---|---|---|---|---|
| DDT (total) | 0.0174 | 0.0121 | 0.0219 | 0.0195 | 0.0328 | 1.4552 |
| Dieldrin | 0.0041 | 0.0041 | 0.0048 | 0.0044 | 0.0070 | 0.1094 |

Substantial efforts by government and industry have been made to minimise and avoid organochlorine residues since the uses were deregistered in the 1980s. The incidence of organochlorine residue detections in Australian produce continues to decline. For example, there were only 2 detections of dieldrin (limit of reporting 0.02 mg/kg) in 616 cattle fat samples tested in the 2001-2002 National Residue Survey (NRS, 2002).

## Future

Risk assessment procedures and data requirements will be further refined in the light of experience to meet the needs of sustainable agriculture. There will be a wider understanding that pesticide uses will need to pass all the risk assessment hurdles before approval and registration.

New pesticides will be designed to pass the risk assessments posed by registration authorities. The process will encourage the development of "reduced risk" pesticides and withdrawal of support for some old pesticides.

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