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Review of agrochemical contamination of waterways within agricultural areas of Victoria

Summary

Victoria
The Place To Be

Review of agrochemical contamination of waterways within agricultural areas of Victoria

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Funding for this review was provided by the Department of Primary Industries' Agricultural Development Division, Program 1 – Integrating farming systems into landscapes.

Published by:
Department of Primary Industries
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Introduction

Victoria has a diverse range of agricultural landscapes, all of which rely on the use of agrochemicals (including insecticides, fungicides, and herbicides). It is known that agricultural chemicals can be transported off-site via air, soil, and water to surface and groundwater in turn potentially causing adverse impacts on aquatic ecosystems as a result of toxic effects, both lethal and sub-lethal, to aquatic species[1,2]. The migration of agrochemicals to aquatic environments and effects on water quality has been studied in many regions of the world. However, despite the potential risks, in comparison there have been relatively few studies in Australia, in particular Victoria[2].

The need to protect Victoria's water resources and to address emerging water quality issues is highlighted in various Victorian government documents[3,-5] including the White Paper "Securing our water future together", the "Victorian River Health Strategy" and the policy "Water: Growing Sustainable Primary Industries". Amongst other issues, DPI has highlighted a need for further research to understand the risks that agrochemicals pose to water quality in Victoria.

As such in 2006/07 DPI's Agriculture Development Division program 1 "Integrating farming systems into landscapes" funding a project entitled "Agrochemical residues in waterways: assessing and managing ecosystem risk in Victoria's catchment". Broadly, this project aims to provide strategic research direction and to facilitate a more coordinated approach to understand the risks that agrochemicals pose to water quality in Victoria. Fundamental to this effort is an understanding of existing information on pesticide residues in waterways within agricultural areas of Victoria. Accordingly, a major activity in 2006/07 was to complete a review of agrochemical contamination in Victoria waterways.
The specific objectives of the review were to:

- Identify and review previous studies relating to agrochemical residues in waterways within key agricultural areas of Victoria.
- Identify knowledge gaps for future research.
- Compile background information for use in understand the threats posed by agrochemicals and to assist future risk assessments

This document provides a summary of the review completed.



DPI projects are investigating ways to improve the integration of farming systems into landscapes, including understanding threats to water quality such as from agrochemical use

Agricultural land use in Victoria

Agricultural land use in Victoria covers approximately 13.9 million ha of land accounting for ~ 61% of Victoria. Over 95% of agricultural land devoted to dryland agriculture (ie cropping and pastures). Whilst representing a relatively small area, irrigated agriculture is intensive, accounting for >50% of Victoria's water consumption and >30% of the total value of agricultural commodity production[5]. Irrigated areas also contain surface and/or sub-surface drainage systems many of which discharge into natural rivers and water bodies potentially accelerating the transportation of pesticides to these aquatic environments.

The key irrigation areas in Victoria are:

- Bacchus-Marsh (~1,182 ha)
- Kerang (~239,313 ha)
- Macalister (~54,700 ha)
- Shepparton (~321,396 ha)
- Sunraysia (~53,640 ha)
- Werribee (~2,857 ha)
- Wimmera-Mallee (~668 ha)

Agrochemical use

Nationally there are >2000 active constituents registered for use through the Australian Pesticides and Veterinary Medicines Authority (APVMA). However there is only limited information available on the volumes of individual agrochemicals used[2]. Information on agrochemical usage within defined areas is needed to assist with region risk assessments. The number of types of chemicals registered for use in Victoria varies according to crop type (summarised in Figure 1). The review details the specific chemicals registered for use by each crop type.

Some localised chemical use information is available from farmer and re-seller surveys previously conducted in the Goulburn-Murray, Barwon and Sunraysia regions which have assisted with agrochemical risk rankings and assessments[6,7].

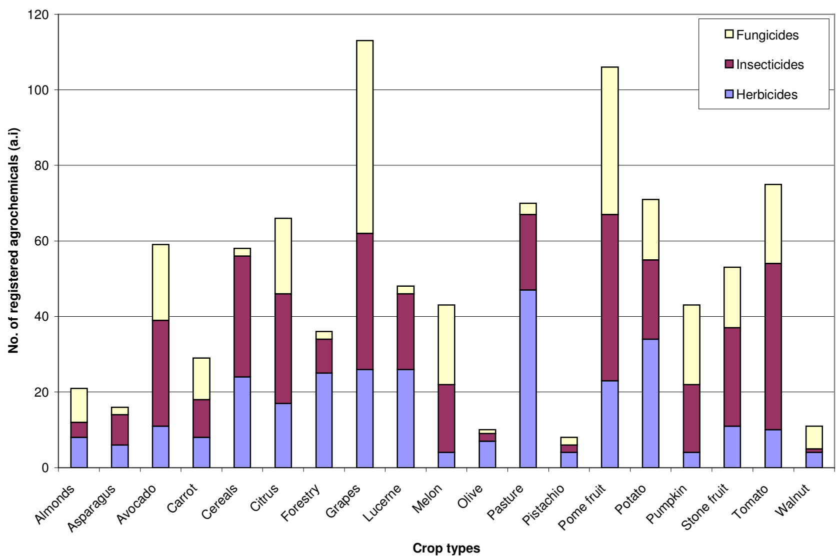

Figure 1 *Number and type of agrochemicals registered for use in Victoria by crop type*

Agrochemical transport from agricultural systems

Agrochemicals applied to crops and agricultural land do not necessarily remain in the location where they were intended and can find their way to off-site locations, such as waterways, via various physical and chemical pathways[8] (Figure 2). The three main pathways for agrochemical movement are:

1. Atmospheric transport (ie drift)
2. Leaching through the soil profile
3. Surface run-off

Once applied agrochemicals can change form and degrade influencing their fate, behaviour, and toxicity in the environment (ie some chemicals are more persistent than others), as influenced by abiotic and biotic processes including[8]:

- Hydrolysis
- Volatilisation
- Oxidation
- Photolysis
- Adsorption
- Ionisation
- Microbial degradation

The fate and behaviour of agrochemicals in the environment is influenced by and can be predicted using the physio-chemical properties of the individual chemical including:

- Vapour pressure (volatility)
- Water solubility
- Soil adsorption coefficient (K_{oc})
- Octanol-water partitioning coefficient (K_{ow})
- Half-life in soil and water

The physio-chemical properties of agrochemicals registered for use in Victoria have been tabulated in the review.

Fate and behaviour is also influenced by environmental and site conditions such as:

- Method of chemical application
- Agricultural farming system
- Presence of irrigation/drainage systems
- Soil types and characteristics
- Topography
- Rainfall

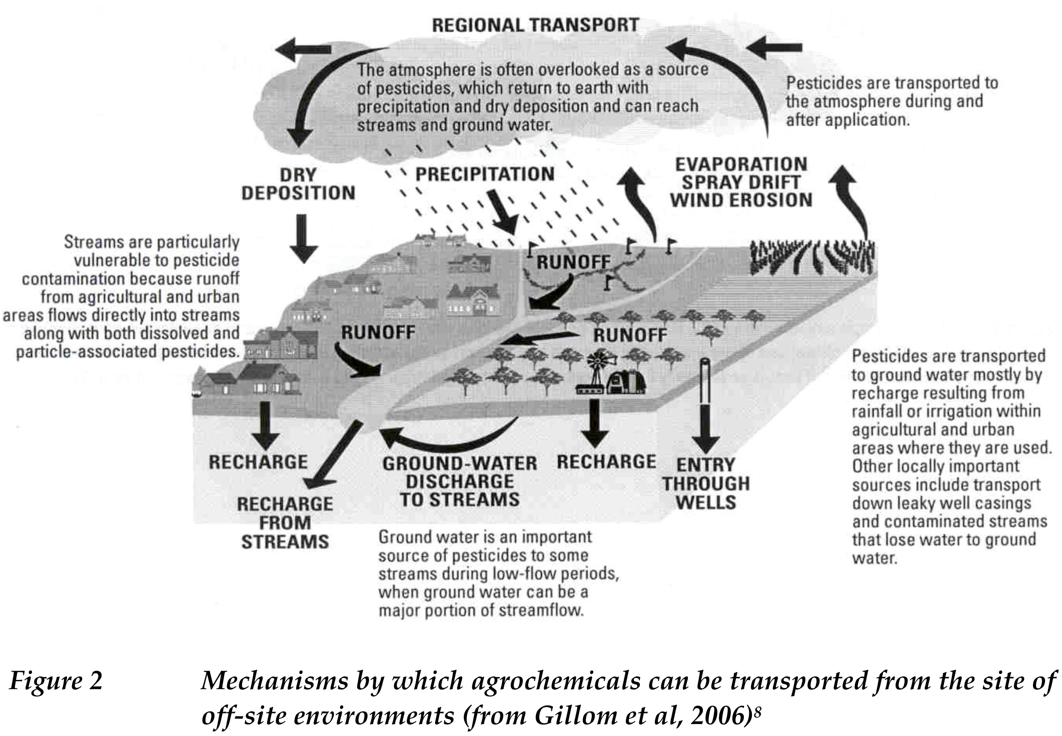

Figure 2 ***Mechanisms by which agrochemicals can be transported from the site of application to off-site environments (from Gillom et al, 2006)[8]***

Toxicity of agrochemicals

Agrochemicals can have varying toxicities to aquatic organisms, ranging from acute lethal effects to longer term chronic and sub-lethal effects (ie development/reproductive). The toxicity of individual agrochemicals is influenced by the structure and properties of the chemical and its mode of toxic action, with toxicity also being influenced by the type of organism (ie herbicides have lower toxicity to insects but higher toxicity to aquatic plants).

Ecotoxological data derived from laboratory experiments is used to describe the toxicity of individual chemicals – this data is generally expressed as an LC50 value (ie lethal concentration to 50% of organisms). There is much data available worldwide which can be accessed via databases[9] and used to characterise toxicity and assess risks. For many chemicals data is only available for a small number of species. Data relating specifically to Australian species and conditions is even more limited. Available ecotoxological data has been summarised in the review.

The Australian and New Zealand Guidelines for Marine and Freshwater Quality have interpreted available ecotoxological data and provide guideline trigger values[10]. These trigger values indicate the concentration at which adverse ecological effects may occur and are based on the most sensitive species. Trigger values are currently only available for 28 agrochemicals (Table 1).

Table 1 ANZECC water quality trigger values for agrochemicals[10]

Chemical	Trigger value for protection of 95% of species (µg/L)*
Insecticides	
Azinphos-methyl	0.02
Carbofuran	1.2
Chlordane	0.08
Chlorpyrifos	0.01
DDT	0.01
Diazinon	0.01
Dimethoate	0.15
Endosulfan	0.2
Endrin	0.02
Esfenvalerate	0.001
Fenitrothion	0.2
Heptachlor	0.09
Lindane	0.2
Toxaphene	0.2
Malathion	0.05
Methomyl	3.5
Parathion	0.004
Herbicides	
2,4-D	280
2,4,5-T	36
Atrazine	13
Diquat	1.4
Glyphosate	1200
Molinate	3.4
Simazine	3.2
Tebuthiuron	2.2
Thiobencarb	2.8
Trifluralin	4.4
Fungicides	
Thiram	0.2

Water fleas (Daphnia) are a sensitive species commonly used in aquatic toxological testing

Agrochemical contamination of waterways in Victoria

There have been a number of studies investigating agrochemical contamination of waterways within Victoria. We have reviewed these past studies in light of their contribution towards assessing the risks posed to aquatic environments in Victoria. For the purpose of this review we have focussed on the studies conducted since 1990 as they are of more relevance to current agriculture practices within Victoria. The agrochemicals detected and concentrations found are detailed in the Review. The concentrations found have been referred back to the current ANZECC trigger values (where available) to indicate their significance. A summary of the key findings from the past studies is provided hereafter.

Ground water

- Most studies have been in the Goulburn-Murray region and vegetable growing areas of southern Victoria.

- The now deregistered organo-chlorines (ie DDT) have been detected (legacy of the past).

- The triazine herbicides simazine and atrazine have been the chemicals most frequently detected in groundwater (in the Goulburn-Murray). Other herbicides detected include amitrole, hexazinone, terbutryn, metribuzin, diuron, and bromacil, and metolachlor.

- Organophosphate insecticides detected include chlorpyrfos, fenitrothion, dichlorvos, parathion, ethion, diazinon, mevinphos, tetrachlorfenvinphos, and fenchlorvos.

- The concentrations of agrochemicals detected have generally been very low, but atrazine, amitrole, chlorpyrifos, dieldrin, DDT have been detected above guideline values

- No agrochemicals detected in the Ballarat, Wimmera-Mallee, and Sunraysia regions, but studies were small.

Surface water

- There has been very little monitoring of agrochemicals in surface waters in Victoria

- Organochlorines found in a number of areas, particularly in the Ovens catchment.

- Atrazine, metribuzin, endosulfan, dimethoate, and chlorpyrifos detected in Gippsland surface waters (concentrations low and below guideline values).

- Monitoring in the Melbourne metropolitan area has indicated agrochemical contamination from urban sources.

Off-site agrochemical movement may pose a risk to surface waters receiving run-off and drainage water from agricultural land

Sub-surface drains

- A number of drainage outfalls monitored for agrochemicals

- Reports are not publicly available but suggest that further investigations to assess the ecological risks are warranted.

Surface drains

- DDT and 2,4-D detected in sediments of surface drains in the Goulburn-Murray region

- In Gippsland, atrazine, metribuzin, simazine, diuron, and methamidophos detected in surface drains

Irrigation Supply channels

- Irrigation supply channels in the Goulburn-Murray region have been extensively surveyed.

- Atrazine, endosulfan, chlorpyrifos, and parathion-methyl were the agrochemicals most frequently detected.

- The concentrations detected were generally low, but chlorpyrifos and endosulfan were detected above guideline values.

Irrigation supply channels in the Goulburn-Murray region have been monitored for agrochemical residues

Conclusions

- The review has provided background information to assist in understanding the fate of agrochemicals in the environment

- There is limited information available on agrochemical use in Victoria for which to feed into risk assessments.

- There is limited ecotoxological data related to Australian species and conditions.

- There is very limited information on the concentrations of individual agrochemicals in Victorian streams and rivers, and of that information available much is now outdated due to changes in chemical and land use.

- The concentrations of agrochemicals detected in past studies have generally been relatively low, however some agrochemicals have been found in exceedance of guideline values thus indicating a risk.

- Due to the limited and largely outdated nature of the past studies it is difficult to draw any conclusions regarding the risks of agrochemicals to aquatic ecosystems in Victoria.

- Further more comprehensive studies are needed to reflect the current situation. These studies need to be conducted in a more strategic coordinated manner and within a risk assessment framework.

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