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Pesticide Residues in Drinking Water in the North Coast Region of New South Wales, Australia, 1986–87

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The New South Wales North Coast region of Australia is characterised by a warm and humid to sub-humid climate, and high rainfall with the dominant agricultural activities being dairying, plantation fruit such as bananas, beef production and sugar cane growing. The area is divided into local government regions with five regions - Byron, Ballina, Coffs Harbour, Lismore and Tweed - being centres of high population. (see Figure 1). Together these regions comprise 24% of the states rural population.

The combination of relatively high rural population density with intensive agricultural activities means that the usage of pesticides and agricultural chemicals has a potentially high environmental impact. Attention has been directed to the quality of local drinking water supplies and the risk of contamination by pesticides, particularly the organochlorine group.

Although there have been a number of studies conducted in other countries (Wegman and Greve, Netherlands, 1978; Achari et al, USA, 1975; McCarthy, USA, 1976) and other Australian states (Fuller et al, 1981; Brodie et al, 1984; Sutherland et al, 1982) there has been no recent comprehensive survey of pesticide residues in drinking water undertaken in rural New South Wales.

In view of the significant usage of pesticides in the area, the North Coast was chosen as the site for a survey which aimed to evaluate the extent of pesticide and herbicide residues in drinking water supplies. This paper reports the results of the survey which was conducted from November 1986, to June 1987, in five local government areas - Coffs Harbour, Byron, Ballina, Lismore and Tweed.

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MATERIALS AND METHODS

In each local government area samples were taken from the reticulated or public water supply system and from twenty private supplies. Sites were selected to cover a range of exposure to pesticide usage and a variety of water source types including bores, dams and roof water tanks. It was planned to test each site six times over the survey period. The water was conveyed to the laboratory, in a cooled state, by overnight courier. The samples were protected from light by storage in amber glass bottles and, on arrival at the laboratory, were stored in a 0°C cold room.

Each sample was analysed for a range of herbicides and organochlorine and organophosphate pesticides. In addition, analyses were conducted for the broad spectrum systemic fungicide, propiconazole. Marketed as "Tilt", propiconazole is extensively applied to banana plantations in the region using aerial spraying techniques.

The specific herbicides, fungicides and pesticides covered by the screening program, together with detection limits, are provided in Table 1.

Water samples were extracted as follows:

a) Organochlorine and organophosphate pesticides and propiconazole: 480 mL of the water sample was adjusted to pH 9 using 1N NaOH and then extracted with 4 mL nanograde hexane using a 'Ystral' high speed blender. A 500 mL narrow neck, round flask was used for the extraction. Centrifugation of the hexane layer was required in some instances. The hexane extract was dried over Na_2SO_4.

b) Herbicides: 40 mL of the water sample was adjusted to pH 1-2 using 1N HCl and then extracted with 4 mL nanograde toluene using a 'Ystral' high speed blender. A 50 mL measuring cylinder was used for the extraction. Centrifugation of the toluene layer was required in some instances. The extract was then derivatised with diazomethane and dried over Na_2SO_4.

Extracts were then analysed by gas chromatography. Herbicide and pesticide standards were obtained from EPA and were of greater than 99% purity. Detection limits are listed in Table 1.

Organophosphate pesticides were analysed using a flame photometric (phosphorus mode) detector on a Hewlett Packard (HP) 5730A gas chromatograph with a HP 3350 Laboratory Automation System. Residues were separated using a 4% SE 30 plus 6% OV 210 on 100-200# Chromosorb WHP 2m x 2mm glass column at an oven temperature of 195°C, injection port temperature of 250°C and detector temperature of 200°C. The gas flow was 25mL/min nitrogen.

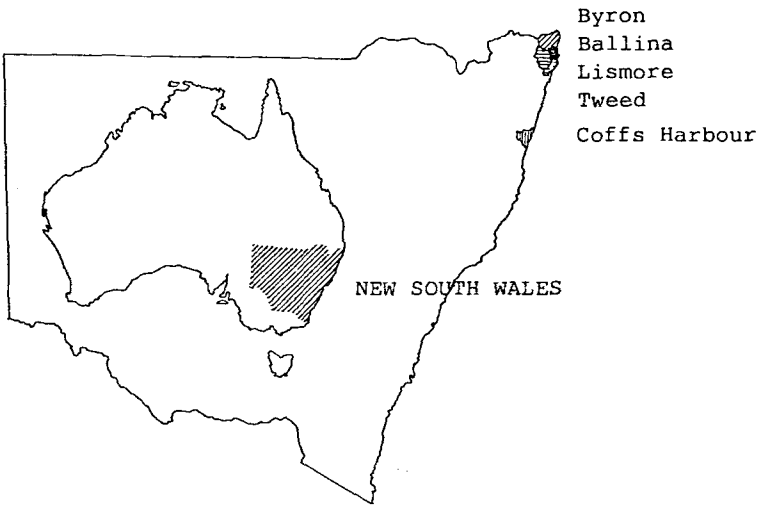

Figure 1. Location of the Survey.

Organochlorine pesticides, propiconazole and the herbicides were determined using electron capture detection on two HP 5880A gas chromatographs with a HP 3350 Laboratory Automation System. Residues were separated on both systems at a 250°C injection port temperature and 320°C detector temperature. System 1 employed a DB17, 30m x 0.53mm ID (J and W) column at an oven temperature of 170°C (1 min) to 210°C at 80°/min and a gas flow of 20mL/min 10% methane in argon. System 2 employed a 5% SP2401 on 100-200# Supelcoport, 2m x 4mm ID glass column at an oven temperature of 190°C and gas flow rate of 25mL/min 10% methane in argon.

All results for organochlorine pesticides, propiconazole and the herbicides were confirmed using these two systems. All positive results (those above detection limits) for organophosphate pesticides were confirmed using alternate column gas chromatography. In some instances the identity of the pesticide was also confirmed using gas chromatography-mass spectrometry. Throughout the survey, spiked water samples were submitted to the laboratory as part of an ongoing quality assurance program.

RESULTS AND DISCUSSION

A total of 659 water samples were analysed between November, 1986 and June, 1987. The results, separated according to local government area and source type, are detailed in Table 2. Residues were not detected in 482 samples (73.1%). Trace level residues were found in 147 samples (22.3%) and residues above trace levels were detected in 30 samples (4.6%). The above trace results are detailed in Table 3 and are compared to maximum residue levels (MRL's) recommended by the Australian National Health and Medical Research Council (NH&MRC). There is no MRL for propiconazole.

Table 1. Pesticides monitored during the survey

Pesticide Group	Pesticides	Detection Limit µg/L (nd)	Trace Level µg/L (tr)
Organochlorines	Hexachlorobenzene (HCB) α-Hexachlorocyclohexane (αBHC) β-Hexachlorocyclohexane (βBHC) Lindane, Aldrin, Dieldrin DDE, DDD, DDT Heptachlor epoxide Endrin, Chlordane, OH - Chlordene Heptachlor, Dicofol Endosulfan, Propiconazole	0.005	0.05
Organophosphates	Phorate, Diazinon Chlorpyrifos, Ethion Ethyl Parathion, Fenthion	0.05	0.5
Herbicides	2,4-dichlorophenoxyacetic acid (2,4-D) 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) Pentachlorophenol (PCP) Triclopyr, Dicamba	0.05	0.5

nd - none detected tr - trace level

Dieldrin was the residue most frequently detected in waters comprising 63% of results above trace levels. Dieldrin was detected at or above trace levels (greater than 0.005 µg/L) in 151 samples (22.9%); of these 89% were tank supplies. In three samples the level of dieldrin was above the MRL. All three samples were from the same private tank supply at Coffs Harbour. Further investigation of this supply including the analysis of followup samples has not pinpointed the source of the contamination. Residue levels continue to exceed the MRL.

The high frequency of low levels of dieldrin detected in private water supplies is consistent with the extent of prior use of the chemical in the area. Post-survey investigation of rural properties with water supplies found to contain dieldrin revealed in a number of cases a prior history of spraying for termite and spider control using the chemical.

Dieldrin has also been used extensively for agricultural purposes in the North Coast region and its use has only been banned in recent times. Recent work (McDougall et al, 1987) has shown that dieldrin persists in soils in the region. These factors are consistent with the results obtained for the survey.

Table 2. Summary of results - water supply samples

Source Type	Coffs Harbour				Tweed				Byron				Ballina				Lismore				Total
	*nd	tr	>tr	TOT	nd	tr	>tr	TOT	nd	tr	>tr	TOT	nd	tr	>tr	TOT	nd	tr	>tr	TOT	
Tank	31	45	12	88	29	26	8	63	34	30	2	66	48	19	2	69	5	5	-	10	296
Bore	11	1	-	12	17	1	-	18	-	-	-	-	22	3	-	25	3	-	-	3	58
Reticulated	18	-	-	18	20	1	-	22	22	-	-	22	17	-	1	18	27	-	-	27	107
Dam	15	-	-	5	-	-	-	-	6	1	-	7	3	-	-	3	20	-	-	20	35
Creek	-	-	-	-	17	-	-	17	11	7	-	18	18	1	-	19	34	-	-	34	88
Well	5	-	-	5	6	-	-	6	-	-	-	-	-	1	-	1	-	-	-	-	12
Spring	3	2	1	6	6	-	-	6	21	2	3	26	-	-	-	-	2	-	-	2	40
River	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	10	11
Canal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	1	5	5
Tank/bore mix	-	-	-	-	-	-	-	-	-	-	-	-	4	1	-	5	-	-	-	-	5
Tank/spring mix	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	1
Other	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	1
TOTAL				135				132				139				142				111	659

*For details see Table 1
nd - none detected tr - trace level >tr - exceed trace level TOT - Total

Table 3. Pesticide residues above trace levels.

Pesticide	Local Government Area	Water Source Type	Level µg/L	NHMRC[1] MRL µg/L
Dieldrin	Ballina	Tank	0.10	1.0
	Ballina	Tank	0.06	
	Byron	Tank	0.06	
	Byron	Tank	0.06	
	Byron	Spring	0.07	
	Coffs Harbour	Tank	0.06[2]	
	Coffs Harbour	Tank	0.20[2]	
		Tank	0.07	
		Tank	0.87	
		Tank	1.00	
		Tank	1.15	
		Tank	1.30	
		Tank	0.06	
		Tank	0.20	
		Tank	1.90	
	Tweed	Tank	0.07	
		Tank	0.06	
		Tank	0.07	
		Tank	0.09	
2,4,-D	Lismore	Canal	9.0	100
2,4,5-T	Byron	Spring	1.0	20
Lindane	Ballina	Reticulated	6.0	100
Propiconazole	Byron	Spring	0.6	NA[4]
	Coffs Harbour	Tank	5.0	
	Coffs Harbour	Tank	4.8	
	Coffs Harbour	Spring	5.5	
	Tweed	Tank	2.4	
Chlordane	Tweed	Tank	0.80[3]	6.0
	Tweed	Tank	0.13	
OH-Chlordene	Tweed	Tank	0.10	NA

1 NHMRC MRL - National Health and Medical Research Council Maximum Residue Limit
2 Also contained 0.06 µg/L aldrin
3 Also contained 0.5 µg/L OH-Chlordene
4 NA - not available

Post-survey monitoring of a sub-sample of the private water supplies examined during the 1986/87 North Coast Survey was carried out during November and December, 1987. The water supplies retested were those which contained consistent trace levels of pesticide, or those supplies which had been found to contain higher than trace levels. Twenty five samples were analysed from the Ballina, Byron, Coffs Harbour and Tweed local government areas. The results were found to be comparable with the trend shown for sites during the survey period. Sludges from seven roof water tanks were also analysed. The levels of pesticide detected were not found to differ significantly from water samples taken at the same site, discounting the sludge as the source of contamination.

Compared to the private supplies, samples from the public water supplies were relatively free from residues. Pesticide or herbicide residues were detected in only two (1.9%) of the 106 samples from reticulated supplies. Lindane was detected in one sample from Ballina and 2,4,5,T in one sample from Tweed. Levels were well below NH&MRC MRL's. No residues were detected in follow-up samples from the same supplies.

Although low-level residues were detected in 26.9% of samples, private and public water supplies in the North Coast region of New South Wales were generally found to be free from significant pesticide contamination. Levels above public health guideline values were detected in only one supply (three samples) with post-survey investigations indicating no obvious cause of the contamination.

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