MIGRATION AND FATE OF ALDICARB IN THE SANDSTONE AQUIFER OF PRINCE EDWARD ISLAND

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Executive Summary

The research presented in this paper was conducted in cooperation with IWD, Atlantic Region and the PEI Government. A 1983-84 study revealed that the potato pesticide, Temik (active ingredient - aldicarb) was present in a number of drinking water wells on PEI. This posed a health threat to these residents because of the extreme toxicity of aldicarb. It was felt that an investigation into the migration and fate of aldicarb in the groundwaters of PEI was necessary. Reasons for the persistence of aldicarb in the aquifer of PEI are presented in this paper. Furthermore, changes to agricultural practices that would lessen its persistence in the groundwater are proposed.

Résumé-gestion

Les recherches présentées dans ce document ont été effectuées

en coopérati on avec la DGE, région de l'Atlantique, ainsi que le

gouvernement de l'I.-P.-E. Une étude de 1983-84 indiquait qu'un

pesticide utilisé pour la culture de la pomme de terre, le Temik

(ingrédient actif : aldicarbe) était présent dans un certain nombre de

puits d'eau potable de l'I.-P.-E. Ceci présentait un danger pour

la santé des résidents à cause de l'extrême toxicité de l'aldicarbe.

On a cru qu'il était nécessaire de faire une étude sur la

migration et le devenir de l'aldicarbe dans les eaux souterraines

de l'I.-P.-E. Les raisons de la persistence de l'aldicarbe dans

la nappe aquifère de l'I.-P.-E. sont présentées dans ce document.

En outre, on y propose des modifications des pratiques agricoles

qui réduiraient sa persistence dans les eaux souterraines.

MIGRATION DE L'ALDICARBE DANS L'AQUIFÈRE
DE GRÈS A L'ÎLE-DU-PRINCE-EDOUARD

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RÉSUMÉ

La persistance de l'aldicarbe dans l'eau souterraine de l'aquifère fracturée de grès de l'Île-du-Prince-Édouard, Canada, est examinée. On a disposé des faisceaux de piézomètres pour les tests hydrauliques et chimiques de l'aquifère. L'eau souterraine a été échantillonnée; on a mesuré le pH, le E_H, la teneur en oxygène dissous et en ammoniac, ainsi que la concentration des ions les plus importants et des espèces toxiques de l'albicarbe, soient l'aldicarbe, les sulfoxydes d'aldicarbe et les sulfones d'aldicarbe. La persistance de l'aldicarbe semble liée à 1) son application au moment de la plantation alors que l'eau souterraine est froide ($<10^{\circ}$C), et 2) l'effet inhibiteur par modification du pH que l'oxydation des engrais à base d'ammoniac ont sur la décomposition de l'aldicarbe. Il est recommandé que l'aldicarbe (c.-à-d. Temik) soit appliqué au moment de l'émergence des plantes plutôt qu'à l'ensemencement et seulement dans les endroits où la nappe phréatique est profonde de 5 mètres ou plus.

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OF PRINCE EDWARD ISLAND

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ABSTRACT

The persistence of aldicarb in groundwater of the fractured, sandstone aquifer of Prince Edward Island, Canada is assessed. Two potato fields were instrumented with nests of piezometers which were used in the hydraulic and chemical testing of the sandstone aquifer. Groundwaters were sampled and analysed for pH, E_H, dissolved oxygen and ammonia, major ions and the toxic aldicarb species - aldicarb, aldicarb sulfoxide and aldicarb sulfone. Aldicarb persistence appears related to (1) its application at time of planting when soil water temperatures are low ($<10°C$) and (2) the inhibiting pH effect that the oxidation of ammonia-based fertilizers has on aldicarb degradation. It is recommended that aldicarb (i.e. Temik) be applied at the time of plant emergence rather than seeding, and only where the depth to the water table is 5 metres or more.

INTRODUCTION

Pesticide contamination of groundwater is an environmental and public health concern throughout Canada, particularly in the Maritime provinces where groundwater is a major source of water for all uses, e.g. food processing, drinking, etc. Surveys of farm wells on Prince Edward Island (PEI) in 1983/84 indicated that low levels (1-6 µg/L) of the toxic insecticide aldicarb were present in 18% of high-risk wells around potato fields (Matheson et al., 1987). Aldicarb residues have also been found in drinking water wells as a result of application to potatoes in the Northeastern United States (especially Long Island, N.Y.) and Wisconsin (Jones, 1986b).

Aldicarb is an extremely toxic carbamate insecticide (Oral LD_{50} (rats) = 0.9 mg/kg) with a solubility of 0.6% and a hydrolysis half-life ranging from a few weeks to years (Lightfoot et al., 1987). Because of its toxicity, aldicarb is applied in granular form (as Temik - 10% aldicarb) during spring planting of potatoes, along with urea or ammonium nitrate fertilizer. The granules dissolve and the insecticide undergoes rapid microbially-catalyzed oxidation to the sulfoxide, which may undergo either hydrolysis to relatively non-toxic oximes and nitriles or further oxidation to the sulfone and then similar hydrolytic degradation. Health and Welfare Canada has issued an interim guideline value for total aldicarb (aldicarb, aldicarb sulfoxide and aldicarb sulfone) in drinking water of 9 µg/L (Toft, 1986).

The migration and fate of aldicarb in groundwater has been extensively studied at various sites under a wide variety of conditions (e.g., Jones, 1986b; Harkin et al., 1986). The objective of this study is to gain an understanding of the transport and transformations of aldicarb under the particular conditions of the fractured sandstone aquifer of Prince Edward Island, which is the sole source supply of water for the Island (Francis, 1981). From this study information will be gained in order to refine guidelines on the use of aldicarb in Canada.

A detailed examination of the groundwater and aquifer conditions beneath two fields on PEI is being undertaken. In this paper the chemical and hydrogeological conditions are described and the factors leading to aldicarb persistence in the subsurface are discussed.

FIELD SITES

Two sites on PEI were chosen to conduct field assessments of aldicarb persistence. These sites were selected because there had been accurate documentation of pesticide and fertilizer use over the last few years and evidence of aldicarb residues in nearby farm wells. Both of these fields are located in the main potato growing area of eastern Prince County, PEI (see Fig. 1). The hydrostratigraphy consists of 2-3 m of silty fine sand till underlain mainly by fractured fine-grained sandstone redbeds of the Permo-Carboniferous age (van de Poll, 1983). The bedrock properties vary considerably but Carr (1971) calculated an average bulk hydraulic conductivity (K) of 1.86×10^{-6} m/s from the results of 32 pump tests throughout the Island. The sandstone aquifer is basically unconfined and, due to the decreasing number of fractures and their decreasing aperture, the permeability decreases with depth. Therefore the most productive zones are the most easily contaminated (Francis, 1981). Groundwater flow and contaminant transport are controlled by the degree, orientation and continuity of fracturing.
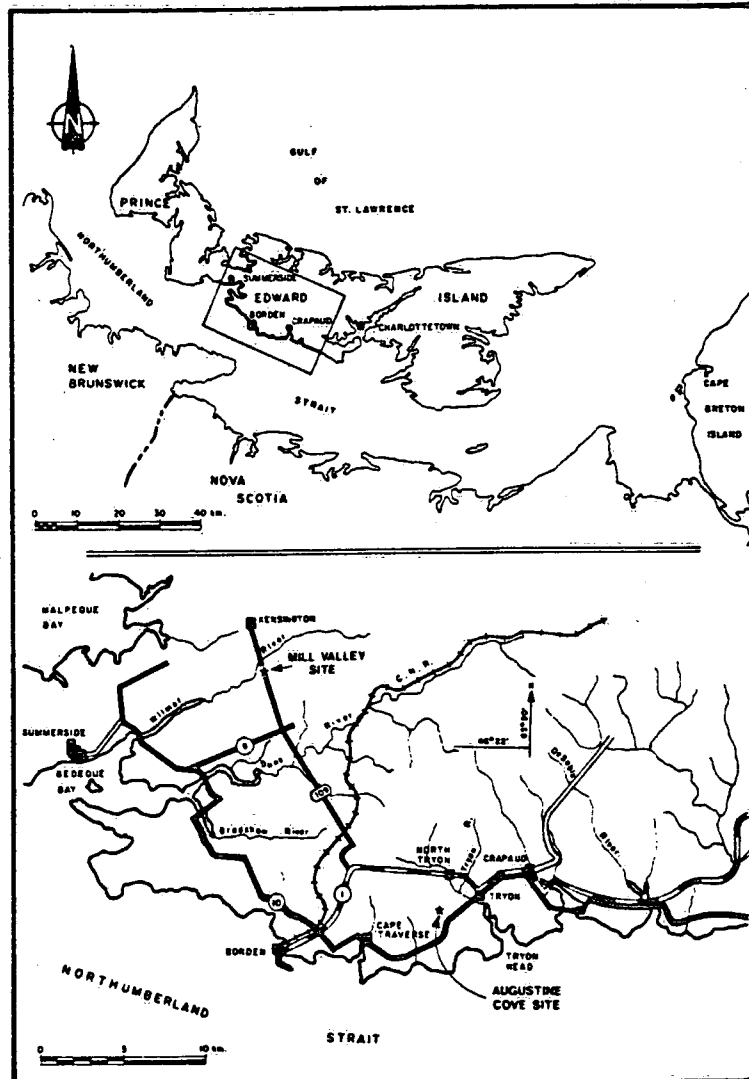

Figure 1 Location of field sites on Prince Edward Island

Groundwater monitoring was conducted using 5.04 cm, schedule 40, PVC piezometers that were installed using an air-rotary drilling rig. Screens (#6 slot) were either 1 or 1.5 m long and a sand-pack (one to two metres of #2 silica sand) was used with a one metre bentonite seal placed above it. The hole was backfilled with native material produced during the drilling of the borehole.

In June of 1985, ten piezometers were installed in a 13 ha field near Augustine Cove. Five pairs (one deep, one shallow) were arranged in a pattern resembling a "T" which had its base at the topographic high point of the field. This arrangement will allow a tracer test to be conducted at a later date. In June of 1986, 15 more piezometers were installed at various locations throughout the field. Three nests of three piezometers were placed at the outer edges of the field. The other six were single water table wells placed alongside the nests installed the previous year.

Figure 2 shows a plan view of the site with water table contours. Figure 3 is the cross section ABCD showing the stratigraphy and the lines of equal hydraulic head in the aquifer. Note the difference in water table between 1985 and 1986. In mapping the water table from the 1986 data it seemed that water was recharging the aquifer from the stream and being discharged through a fracture zone (out of the plane of the paper in Fig. 3) in the vicinity of piezometers 5 and 6.
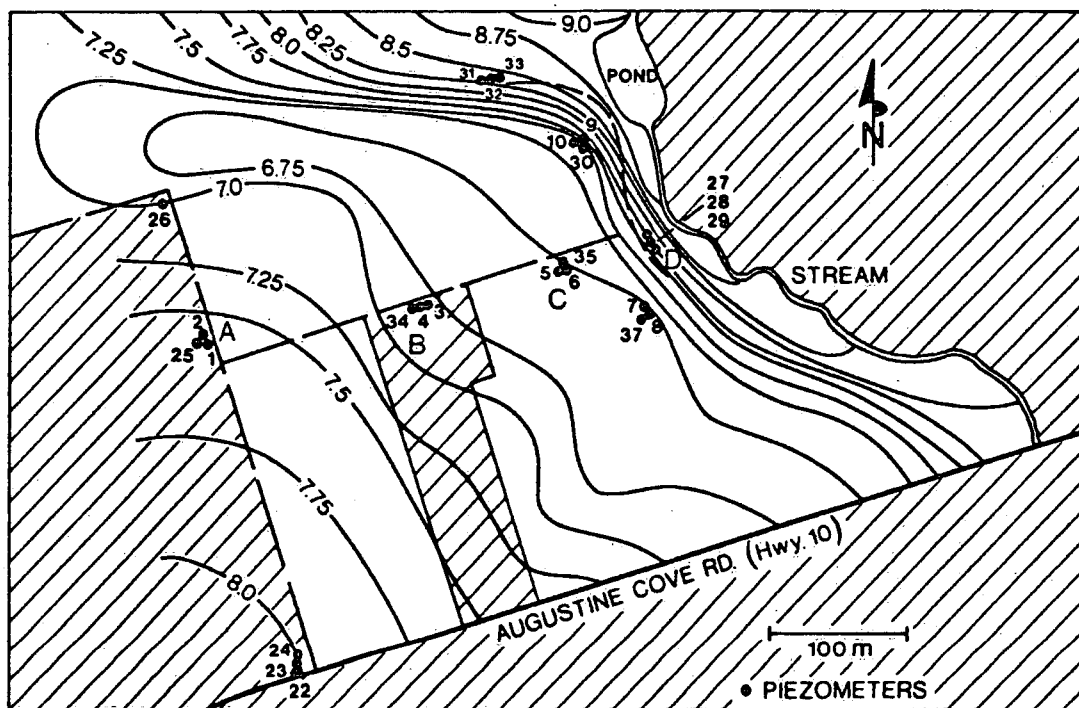

Figure 2   Water table in metres above mean sea level at Augustine Cove,PEI. Average of three water level measurements in September, 1986.
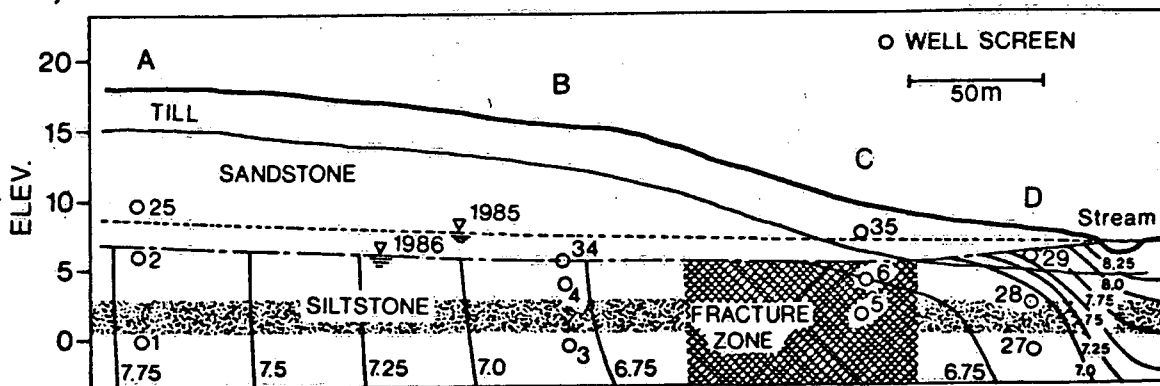

Figure 3   Equipotential map of hydraulic head in metres above mean sea level at Augustine Cove, PEI (cross section ABCD). Average of three water level measurements in September, 1986.

Seven piezometers at Augustine Cove were slug-tested to determine hydraulic conductivity (K) by the method of Patterson and Devlin (1985). A pressure transducer was used instead of an electric sonde to monitor the decrease in water level. The resulting curves were analysed by both the Hvorslev (1951) and Cooper et al. (1967) methods (see Table 1). From the borehole logs and the approximate storativity values, semi-confined conditions were noted in piezometers 1, 3 and 27. This is possibly due to the semi-confining siltstone bed shown in Figure 3 or a result of fewer vertical fractures at this depth.

TABLE 1   Hydraulic conductivity (K) values by the methods of Hvorslev (1951) -H and Cooper et al. (1967) -C

Piezometer	Depth to Mid-Screen (metres)	K (m/s)	
		H	C
1	18.8	3.3×10^{-5}	9.8×10^{-6}
2	12.7	5.2×10^{-5}	8.9×10^{-5}
3	16.7	5.3×10^{-6}	1.5×10^{-5}
4	12.7	2.8×10^{-5}	2.2×10^{-5}
5	9.6	9.3×10^{-5}	8.0×10^{-5}
27	9.5	1.4×10^{-4}	3.2×10^{-4}
28	6.6	1.9×10^{-4}	

Ten piezometers were installed in June of 1985 in a similar pattern at a site near Mill Valley. The field is somewhat larger and thus the "T" is more spread out. Again the base of the "T" is located at the topographic high point of the field. Due to access problems only three more piezometers were installed in the spring of 1986. Figure 4 shows a plan view of the site with water table contours. Figure 5 is the cross section JLM showing the lines of equal head in the aquifer.
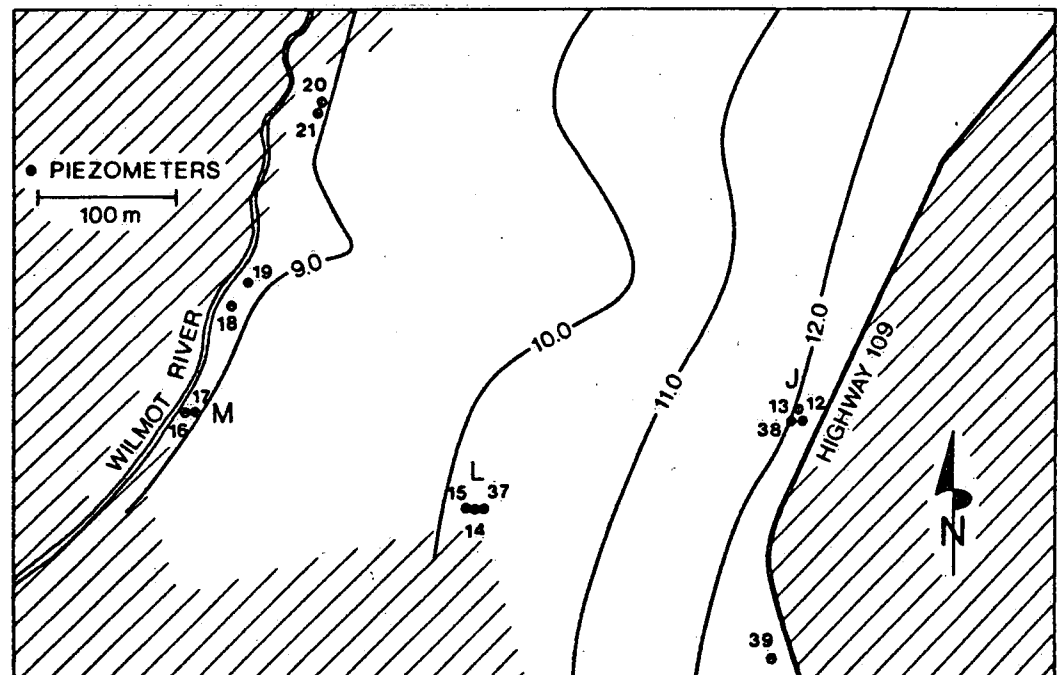

Figure 4   Water table in metres above mean sea level at Mill Valley, PEI (September, 1986).
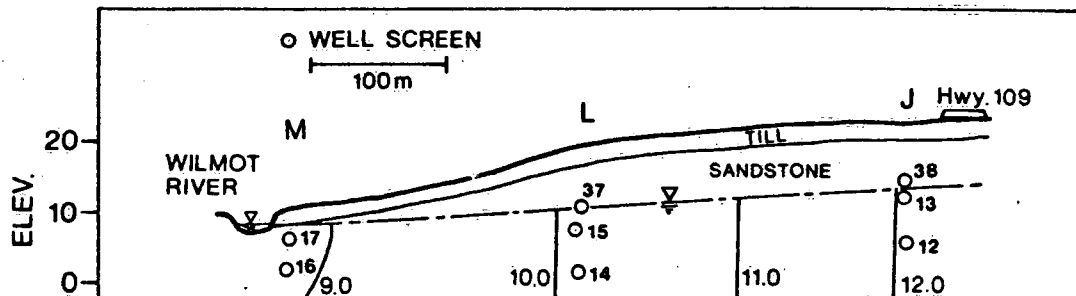
Figure 5   Equipotential map of hydraulic head in metres above mean sea level at Mill Valley, PEI (cross section JLM, September, 1986).

Because of its high solubility, the migration of aldicarb is influenced almost solely by the movement of water (Jones, 1986a). Zhong et al. (1986) demonstrated that the movement of aldicarb is unretarded in soils with low organic carbon content (<2%). Consequently, groundwater velocities and residence times should closely reflect aldicarb movement as well. At present, velocities have not been calculated at either of the field sites because the complex nature of the fractured sandstone aquifer has not been studied in detail.

FIELD CHEMICAL METHODS

As many water quality parameters as possible were measured in the field in order to define in situ conditions and avoid possible changes during sample shipment. E_H and pH measurements were made in a flow cell using combination platinum and pH electrodes, respectively (Orion Research Inc., Cambridge, Massachusetts, USA). Dissolved oxygen was measured using an Orbisphere Oxygen Indicator, Model 2606 (Orbisphere Labs., Geneva, Switzerland). Specific conductance (YSI Scientific meter, Yellow Springs, Ohio, USA), temperature and ammonia (Orion gas-sensing electrode) were also measured in the field.

After at least two well volumes had been purged, samples for aldicarb analysis were collected in 60 or 130 mL amber glass bottles using a Teflon bladder pump (Well Wizard, QED Systems, Ann Arbor, Michigan, USA). These samples were filtered, acidified to pH 5 and stored at 4°C prior to analysis. Samples for inorganic analysis were taken in 1 L plastic bottles and stored at 4°C. However only the nitrate and bicarbonate values are reported here.

LABORATORY CHEMICAL METHODS

Previous studies of aldicarb contamination of groundwater had indicated the desirability of developing an analytical method which would allow the chromatographic identification of all three toxic species - aldicarb, aldicarb sulfoxide, aldicarb sulfone - in a once-through analysis with minimum detection limits well below 1 ppb.

To achieve these ends, Chaput (1986) used high performance liquid chromatography and combined on-line trace enrichment with a very sensitive fluorescence detector. Increased sensitivity was achieved by loading 10 mL of groundwater onto an RP-8 concentrator column installed in the loop position of a six-port injection valve. Switching of the valves allowed the concentrated material to be backflushed onto the RP-8 analytical column using a methanol-water gradient elution. Separation is followed by post-column hydrolysis to yield methylamine, and the formation of a fluorophore with o-phthalaldehyde and 2-mercaptoethanol prior to fluorescence detection. The minimum detection limit, defined as five times baseline noise, is about 70 ng/L for each of the three compounds.

TABLE 2   Groundwater quality data, Augustine Cove, PEI, showing pH, E_H (measured Pt electrode potential vs. normal hydrogen electrode), dissolved oxygen, nitrate-nitrogen, bicarbonate, total aldicarb (sum of aldicarb, aldicarb sulfoxide and aldicarb sulfone), and the sulfone:sulfoxide mole ratio.

Piezometer	pH	E_H (V)	O_2 (mg/L)	NO_3-N (mg/L)	HCO_3 (mg/L)	Tot.Ald. (µg/L)	Sulfone/ Sulfoxide
				July 1985			
1	8.0	0.66	8.0	9.2		0.8	1.43
2	7.2	0.69	9.8	9.2		3.6	0.74
3	7.9	0.47	8.9	4.3		1.0	1.86
4	7.5	0.47	9.0	7.6	-	4.0	1.55
5	6.8	0.20	0.3	<0.2		3.0	0.93
6	6.3	0.54	2.8	14.0		12.0	2.78
7	6.4	0.49	9.0	12.0		10.8	2.20
8	5.9	0.50	9.0	13.0		7.6	2.28
9				14.0		14.2	2.14
10				16.0		16.4	2.24
				September 1985			
1				22.0	<1	0.9	1.30
2				14.0	18	1.0	1.32
3				15.0	36	n.d.	-
4				2.8	104	0.2	1.33
5				<0.2	122	n.d.	-
6				5.0	31	3.9	2.38
7				11.0	91	5.9	2.98
8						12.3	2.33
9				12.0	109		
				September 1986			
22	7.3	0.38				0.1	1.2
1	7.6	0.43	8.7	8.4	104	0.4	1.66
2	7.0	0.49	9.2	8.1	70	0.7	1.40
26	7.0	0.44				4.3	2.40
3	8.2	0.39	7.8	1.9	109	n.d.	-
4	7.0	0.43	8.7	7.6	101	3.6	2.11
34	7.0	0.43	8.1	8.4	101	4.2	2.07
5	6.9	0.14	0.2	<0.05	120	n.d.	-
6	6.4	0.42	5.7	8.4	49	7.1	3.19
27	6.8	0.13	0.3	<0.05	207	n.d.	-
28	6.3	0.33	0.4	1.2	124	1.0	10.0
7	5.6	0.48		8.0	50	4.7	3.43
9	6.6	0.48		13.6	94	12.8	2.57
30						0.1	1.50
31						n.d.	-
32						n.d.	-
33						n.d.	-

n.d.   - not detectable (<0.1 µg/L)

BLANK - parameter not measured

"-"   - ratio not calculated because sulfone and/or sulfoxide not detectable.

TABLE 3   Groundwater quality data, Mill Valley, PEI (see Table 2 for explanation of terms).

Piezometer	pH	E_H (V)	O_2 (mg/L)	NO_3-N (mg/L)	HCO_3 (mg/L)	Tot.Ald. (µg/L)	Sulfone/ Sulfoxide
				July 1985			
12			3.5			n.d.	–
13	7.8	0.47	7.6			0.5	0.50
14			5.4			T	–
15			5.2			0.3	–
16	8.1	0.47	5.2			T	–
17	7.9	0.47	5.4			T	–
19			7.0			n.d.	–
20	8.1	0.47	1.6			n.d.	–
21	7.9	0.57	6.4			T	–
Spring						4.7	0.70
				September 1985			
12				4.3	65	n.d.	–
13				7.0	113	0.3	0.45
14				6.0	77	0.8	–
15				3.9	82	0.3	0.23
16				5.4	76	T	–
17				4.3	75		
18				<0.2	490		
19				7.0	88	T	–
20				2.3	84	n.d.	–
21						T	–
Spring				8.0	70	4.6	0.80
				September 1986			
12						n.d.	–
13						T	–
39						n.d.	–
14						n.d.	–
16						T	–
17						1.1	1.40
18						0.2	–
19						0.9	1.15
20						n.d.	–
21						T	–

T – trace ($\approx$ 0.1 µg/L)
n.d. – not detectable (<0.1 µg/L)
BLANK – parameter not measured
"–" – ratio not calculated because sulfone and/or sulfoxide not detectable.

This "age-dating" of aldicarb application works best if aldicarb is not used in consecutive years. Note from Table 4 that aldicarb was applied with potatoes every three years at Augustine Cove. The aldicarb detected in 1985 is most probably from the 1983 application.

At Mill Valley, with aldicarb applications in 1985 and 1986, the ratios were low for both 1985 and 1986 sampling periods. These trends are not conclusive because of the low total aldicarb values.

TABLE 4   Fertilizer and aldicarb application (1983-1986)

Fertilizer or Pesticide	Year	Amount Applied (kg/ha)	
		Augustine Cove	Mill Valley
Aldicarb	1986	1.96	2.02
NH_4NO_3 (as N)		210	206
Urea (as N)			82
Aldicarb	1985		2.24
NH_4NO_3 (as N)			27
$CaCO_3$		2128	
$CaMg (CO_3)_2$		112	
NH_4NO_3 (as N)	1984		27
$(NH_4)_2HPO_4$		54	
Aldicarb	1983	1.96	
NH_4NO_3 (as N)		190	27
Urea		5.9	

NH_4NO_3 - ammonium nitrate
$(NH_4)_2HPO_4$ - diammonium phosphate
Urea - $CO(NH_2)_2$

Hydrolysis Reactions

Various workers have noted the conditions that favour the degradation of aldicarb to its relatively non-toxic hydrolysis products (Given and Dierberg, 1986; Lemley and Zhong, 1983).   Lightfoot et al. (1987) have demonstrated that aldicarb persists under conditions of low temperature and a pH of about 5, i.e. hydrolytic degradation is inhibited.

In the late 1970's problems of aldicarb contamination of domestic wells arose on Long Island, New York State (Pacenka and Porter, 1981).   The major contributing factors were heavy aldicarb application in consecutive years on sandy "acid" soils, shallow water tables, cool temperatures and heavy precipitation.   Despite a complete halt to aldicarb use on Long Island in 1980, residues are still being detected (Jones, 1986b).   Similar problems in Wisconsin and Maine soon became apparent.   These problems were addressed with changes to aldicarb application procedures (Jones, 1985; Wyman et al., 1985).   Most importantly the application of the aldicarb was delayed until plant emergence.   At this time the recharge rate is probably lower, therefore aldicarb is not leached as readily.   Also, soil temperatures are much higher, promoting aldicarb degradation.

On PEI, groundwater temperatures are generally in the range of 7 to 8°C.   The pH of precipitation and snowmelt is usually between 4 and 5.   These factors alone would suggest favourable conditions for aldicarb persistence. Furthermore, application of aldicarb occurs only at planting.   As noted, from experience in the northern States, this practice is conducive to aldicarb persistence.   Other agricultural practices discussed below also seem to be affecting the degradation of aldicarb in PEI groundwaters.

Table 2 shows that there is a correlation between total aldicarb and groundwater pH at the Augustine Cove site.   Total aldicarb tends to increase down the flow system while, in an anomalous manner for groundwater flow systems, pH is decreasing down the system.   The analyses also indicate that aldicarb concentrations are highest and pH values lowest where the water table is the shallowest.   In the upper region of the field where the unsaturated zone is the thickest (9 m) the infiltrating snowmelt and rainwater has more opportunity to be neutralized by the natural carbonate of the sandstone (1-2%) due to increased reaction time.   This neutralizing capacity is lower in the lowland area (piez. 6-10) because of the thin unsaturated zone which provides insufficient opportunity for neutralization to occur.   Hence groundwater pH remains fairly low (~6) and hydrolysis reactions are inhibited.

Lime ($CaCO_3$ and $CaMg(CO_3)_2$ was applied to the Augustine Cove field in 1985 because of soil acidity problems. This practice was intended to increase the soil pH, but in the lowland area the effect on groundwater seemed to be minimal.

The pH decrease down the flow system may also be a result of the oxidation of ammonia based fertilizers (see Table 4) in the oxygen-rich groundwaters of the aquifer. If the following reaction occurs in the hypothetical absence of neutralizing agents present in the soil:

$$O_2 + (1/2) NH_4^+ \rightarrow (1/2) NO_3^- + H^+ + (1/2) H_2O$$
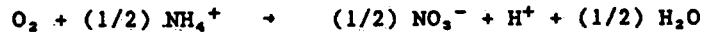
a pH of 3.6 will be obtained in consuming 8 mg O_2/L and only 10% of the applied ammonium. Since nitrogen uptake by first year potato crops is very low (Cameron et al., 1977) and NH_4 was detected (up to 0.3 mg/L) in the groundwater, suitable conditions for this reaction are present. This nitrification reaction has been studied in great detail. Kamprath and Foy (1971) noted that liming of fields actually increased nitrification because the optimal pH for nitrifying bacteria is about 6. Also the oxidation of ammonium occurs readily down to 0.3 mg O_2/L. Since O_2 values are generally in the 5-10 mg/L range throughout the aquifer there is sufficient dissolved oxygen for this reaction to occur.

Another factor seems to be preventing the degradation of aldicarb in the groundwaters beneath the Augustine Cove field. From the hydraulic head data of September 1986 - at which time water levels on PEI were at a 15 year low (Francis, 1986) - it was determined that the creek at the bottom of the field was a losing stream (i.e. the creek recharges the aquifer). This suggested that the piezometers near the stream (i.e. 27 and 28) would reflect surface water quality conditions. After having passed through a marsh the stream waters would be high in dissolved organic carbon (DOC) and low in dissolved oxygen and also have a relatively low pH. An inspection of Table 2 does indeed show that piezometers 5, 27 and 28 reflect these conditions. The pH could further be lowered due to oxidation of DOC when the stream water mixes with the oxygenated waters of the aquifer and the following reaction occurs:

$$CH_2O(DOC) + O_2 \rightarrow H_2O + CO_2 \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$$
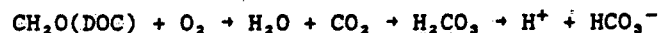
This may account for the high HCO_3 values in piezometers 27 and 28.

The site at Mill Valley showed no significant signs of contamination in the subsurface. The depth to the water table is much greater throughout, being at least 3 metres below ground surface. Infiltrating precipitation is well neutralized - as indicated by the higher groundwater pH (7.5-8); this higher pH range will result in faster degradation of aldicarb residues.

The one sampling point with a high level of aldicarb in 1985 was a spring that discharges at the bottom of the field into the Wilmot River. Most likely the fracture supplying this spring acts much like a tile drain and carries infiltrating water to the discharge zone much faster. It is likely that Mill Valley is a better example of conditions on PEI because of the anomalous hydrologic conditions (i.e. a losing stream) at Augustine Cove.

SUMMARY AND CONCLUSIONS

The sulfone:sulfoxide ratio appears to provide a "fingerprint" of annual aldicarb applications. In both the saturated and unsaturated zones the parent aldicarb undergoes rapid oxidation to the sulfoxide which is more slowly oxidized to the sulfone. Therefore, our data from PEI suggests that this ratio gradually increases with time after application.

The studies at Augustine Cove have disclosed a very complex set of agricultural, chemical and hydrological factors that lead to aldicarb persistence in the subsurface. The very conditions that inhibit aldicarb degradation to less toxic products are replicated in the groundwater beneath this field. In the soil, the primary factors that promote aldicarb degradation are increased soil water temperature and pH. However, aldicarb

is presently applied at seeding in the spring at which time soil waters exhibit the relatively low temperatures and pH of recent snowmelt. Furthermore, this is a period of high recharge to the water table as the soil moisture content approaches saturation. Consequently, downward transport of aldicarb is promoted.

In groundwater where the temperature is relatively constant, pH becomes the controlling factor in promoting hydrolytic degradation, which is enhanced in alkaline groundwaters. The sandstones of PEI are relatively low in natural carbonates (1-2%) consequently, their neutralizing effect is limited, especially in areas with a shallow water table where contact time is limited by an unsaturated zone of only one or two metres.

The application of ammonium and urea fertilizers may also compound the problem as there is sufficient oxygen in the groundwater for the oxidation of ammonium (nitrification) to produce a marked drop in pH. Finally the effect of a losing stream has also been to decrease the pH in parts of the aquifer by the oxidation of DOC from the stream water.

However, there is little groundwater contamination at Mill Valley because some of these conditions do not exist. The water table is much deeper providing more opportunity for neutralization and therefore a higher pH in the groundwater. There seems to be no anomalous influence from the adjacent stream.

On the basis of this study and numerous others, it would seem that the application of aldicarb at the time of plant emergence in June would remedy part of the problem of aldicarb persistence on PEI. The half-life of aldicarb sulfoxide drops from about 1800 days to less than 400 (at pH 6.5) with a change in temperature from 14 to 23°C (Lightfoot et al., in press). Emergence application on PEI should provide such a temperature increase that would stimulate aldicarb degradation.

Aldicarb-fertilizer interactions are not completely understood but the application of ammonia-based fertilizer one to two months before aldicarb application may allow better degradation conditions to develop. Finally, an important factor in preventing contamination of groundwaters from aldicarb is the thickness of the unsaturated zone. Aldicarb residues are more likely to enter groundwater when a shallow water table exists given the low neutralizing capacity of PEI soils and bedrock.

Studies involving sampling and analysis at commercial farms have proven useful. However, in order to more fully understand the migration and fate of aldicarb in the PEI aquifer, it would be advantageous to conduct a controlled field test. In such a case all the variables (fertilizer and aldicarb application rate, timing, etc.) can be regulated in order to determine precisely the effects of each. Furthermore, it is important to be able to detect all the degradation products (i.e. oximes and nitriles) so degradation pathways and mass balances can be determined. Consequently, analytical methods must be developed to allow their detection.

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