Effect of Field-Scale Soil and Crop Management on Surface and Groundwater Quality Across the Canadian Prairies*

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ABSTRACT

The potential for field-scale (nonpoint) soil and crop management activities to have a negative effect on water quality within the Canadian prairies is apparent, but results are by no means certain Individual attitudes towards concepts such as : relative risk; the implications of zero tolerance; and the strengths and limitations behind water quality guidelines will have a great bearing on how we interpret water quality information. The implication that prairie waters are widely, unacceptably affected by agriculture cannot be substantiated. Within the context of the Canadian Water Quality Guidelines, we find no clear evidence of the wide-spread contamination of surface and groundwaters from nonpoint agricultural activities on the prairies For example, relatively few pesticides are consistently detected in surface and groundwaters, and these rarely exceed current guidelines. This does not mean there are no problems nor the potential for them to occur. But current problems are generally neither wide-spread nor excessive in magnitude. There is need for a prairie-wide coordination of water quality activities to assure a unified approach towards common water quality objectives.

NONPOINT-SOURCE WATER QUALITY

Concerns over water quality issues on the prairies are increasing the wide-spread nature of agricultural soil and crop management activities clearly creates a risk that surface and groundwaters may become contaminated (Reynolds et al. 1995). Runoff, leachate and airborne deposition from agricultural lands may be contributing unacceptable levels of sediment and agrichemicals to surface and groundwater supplies. This could adversely affect water use and safety for human life and the entire ecosystem.

The extent and severity of a possible water quality problem on the prairies are not clear. It is certain that "hot spots" occur. It is uncertain how representative these isolated findings are of nonpoint-source contamination by prairie agriculture.

BACKGROUND CONSIDERATIONS

PUBLIC RELATIONS

There is a public perception of increasing water quality problems. An Angus Reid opinion poll showed that many Canadians see water pollution as "the most serious environmental danger facing the world today." On the other hand, most urban residents in Saskatchewan and Manitoba do not consider agriculture to be among the greatest threats to the environment (The Advisory Group 1994).

Conflicting Messages The public receives conflicting messages as to the role of agriculture in degraded water quality. Experts say that agriculture is a "major contributor" (Offutt 1990), or that there is "very little evidence"

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of such a condition (Lindwall 1992). Colgan (1992) has expressed the concern that negative "generalizations" about water quality are being used in school curricula in spite of the extent and severity of the problem not being adequately documented.

Critics warn that increasing regulation is imminent and action is needed now (Offutt 1990). Landowners must demonstrate that responsibility for land use and accountability for water quality go hand-in-hand with property rights. The most sensible, cost-effective approach to addressing water quality degradation may well be a reliance on the farm community to devise and implement codes of practice for pollution control.

RELATIVE RISK

The concept of relative risk is central to our understanding of water quality issues. Even among experts there is great disagreement as to the meaning of water quality findings. This is because risk assessment is at best an imprecise science, and we must be careful not to ask more of risk assessment than it can deliver (Finkel 1996).

Scherer maintains that "risk assessment is a complex discipline not fully understood by experts, much less by the public" (1990). He says that public reaction to risk assessment is based on a different set of criteria, that technical and scientific problems are ultimately social problems, and these require both social and technical solutions.

Dose And Concentration. Risk assessment must consider both dose and concentration. This is because risk involves time/dose relationships, wherein the concentration of the substance involved must be related to the time period of exposure to determine the dose or total amount encountered. Others caution, however, that while any one substance may not be considered harmful in trace amounts, no one knows the effect of long term exposure to a "cocktail" of multiple trace contaminants (J-G. Zakrevsky 1996, pers. commun., Envt. Canada, Regina, SK.).

Zero Tolerance. The concept of *Zero Tolerance* in water quality holds that even trace amounts of an unnatural substance are deemed to be unacceptable. Scherer (1990) is of the opinion that public demand for zero risk is unreasonable. But he acknowledges the need for experts and policy makers to provide a better understanding of why such an objective may be unattainable.

Hrudey and Krewski (1995) question the validity of a zero tolerance point of view. To test this position, they calculated the hazard of exposure to the smallest conceivable dose of a carcinogen. Conservative USEPA assumptions were used to determine the risk from "lifetime exposure to one molecule a day of the most potent known carcinogen (TCDD)". Results indicated that exposing the entire world population to such a dose would not yield a single case of cancer. Therefore, "within a realistic concept of safety, there is a safe level of exposure" to even the most toxic of carcinogens.

Probabilities. Risk analysis comes down to a matter of probabilities. These are usually based on historical data, assume average conditions, and project that past trends will continue. When it comes to extrapolating the probable effects of trace amounts of water-borne agrichemicals on human life, we really have very little historical data. As well, toxicology findings from average laboratory rats may be far removed from average people.

THE PRAIRIE SETTING

Pesticide use is one example of the risk of nonpoint agricultural practices contaminating surface and groundwaters on the prairies. On a rate basis, average prairie use of pesticides (0.6 kg/ha) is only 1/4 of that applied in Ontario (Paterson 1992), less than 1/3 of the active ingredient applied in the United States (2 kg/ha), and only about 12% of that applied on average in France (5.2 kg/ha) (PFRA 1995).

Urban and Non-Farm Chemicals A portion of pesticide application is for urban use. US figures for 1982 indicate that urban pesticide use was almost 27% (Brown et al. 1989 in Burland and Byrtus 1992), but only a small portion of the prairie landscape and population is urban. In Alberta, limited data on 1993 homeowner applied pesticide sales indicates that only about 1% of sales are for domestic purposes (Gary Byrtus 1996, pers. commun., Alberta Environment Protection, Edmonton, AB.). Nonetheless, prairie cities may be urban islands of concentrated application. Recent studies along the Red River in Manitoba show increased concentrations of two herbicides (2,4-D and dicamba) downstream of the city of Winnipeg (Currie and Williamson 1995).

A Low Risk Zone? Some consider the prairies to be a relatively low risk zone for contamination from pesticides, because the drier weather and lower intensity of agricultural inputs likely result in lower total leaching and runoff (McNaughton and Crowe 1995). Others contend that the dry, cold climate may lead to short-term, high-impact consequences as a result of slower pesticide degradation and seasonally concentrated leachate and runoff (B. McConkey 1996, pers. commun., AAFC Research Br., Swift Current, SK.).

Prairie Pothole Topography. One landscape feature that differentiates much of the prairies from other regions, is its prairie pothole topography. For much of the landscape the drainage is internal, with potential contaminants moving relativeiy short distances to surface sloughs or by interflow or recharge to groundwater areas (Anderson and Knapik 1984. in Environment Canada 1990). As little as 5% of prairie agricultural lands are estimated to drain into water courses (Do Acton 1996, pers. commun., CSALE, University of Saskatchewan, Saskatoon, SK.). Prairie potholes may act much like stormwater retention ponds in cities, filtering out silt and other erosion products before they have a chance to reach rivers and streams. Through this process, potholes may be collecting agrichemicals for focused recharge to the groundwater system

KEY INTERPRETATION CONCEPTS

An understanding of a few key concepts is central to the effective interpretation of water quality data

Biopbyrical Interactiona. Chemical characteristics such as solubility, adsorbtion, and persistence, can significantly affect the way a pesticide or nutrient reacts to biophysical condition (Yarish 1992). Farming practices influence the transportation and transformation of pesticides and nutrients by the way they affect the soil micro-environment. Choice of tillage practice, cropping system, residue management, and related decisions determine “unique combinations of aeration, water availability, temperature distribution and availability of substrates” (Power 1994).

Sampling and Analysis Protocol. Given the small concentrations often detected sampling and analysis protocol plays a major role in whether or not a residue is found-and at what level. For example, Chang and Entz (1966) identified the need to sample shallow groundwater weekly during the growing season, otherwise peak nitrate levels will be missed. Some pesticides may be absorbed by the PVC casing of sampling wells, or by the plastic bottles used to store samples (Hill 1995).

Water Quality Guidelines. The *Canadian Water Quality Guidelines* (1987 and updates) are an attempt to define acceptable water quality for drinking, recreation, irrigation, and other uses (CCREM 1987). They serve as a useful benchmark against which to assess relative water quality, and we assume that Water Quality Guidelines are a legitimate basis of evaluation.

There are data gaps within the Guidelines and evaluations are urgently required for a number of currently used pesticides. According to Byrtus (1996 pers. commun.), over 500 active ingredients for pesticides are listed for sale in Canada. Of these, approximately 100 might be used on the prairies. Yet less than 50 pesticides have established national guidelines and several high-use products in Alberta have no guideline (Cotton and Byrtus 1995).

Water quality guidelines generally incorporate a safety factor at least 10-100 time greater than test results would indicate and there is no hard and fast line between good and poor water quality. The Guidelines for Canadian Drinking *Water Quality state only that continually exceeding them “may, in some instances, be* capable of inducing deleterious effects on health. ..." (Federal-Provinical Subcommittee 1987).

Despite their inherent limitations and the difficulty of applying them, the Canadian Water Quality Guidelines represent a middle ground between the extremes of zero tolerance and a lack of any standard.

SPECIFIC PRAIRIE FINDINGS

SEDIMENT

Sediment in surface waters can be a problem in terms of both turbidity and silt loading. In Canada, the wind and water erosion of soil is considered a serious threat to the sustainability of agriculture (PFRA 1983).

Natural Prairie Loadings. Sediment loading in major prairie rivers is generally not considered to be a problem and the "proportion of sediment from farmland erosion seems to be relatively insignificant" (Environment Canada 1990). There is an apparent disparity between projected high soil erosion rates and lower in-stream sediment yields..This may be because erosion models have over-predicted net erosion losses (de Jong 1983), or because sediment is trapped in prairie potholes or small rivers and streams before reaching major rivers (Gomez 1995).

Small Basin Studies. There is little information to indicate that sedimentation is a serious problem In the small watercourses of the Saskatchewan River Basin (Environment Canada 1990). The Cooks Creek watershed study in Manitoba found that sediment levels did not appear to impair water quality for most uses, including aquatic life (Hughes et al. 1994). In the Turtle River watershed of west central Manitoba (Williamson et al. 1992), a significant portion of sediment loading came from within Riding Mountain National Park

Secondary Loadings. The volume and rate of runoff to streams can increase as native lands are cleared and cultivated for agricultural purposes Despite the fact that this runoff may be low in silt, the higher stream flows created will cause increased channel scouring, resulting in a secondary increase in sediment loading and greater downstream deposition of silt (Fisheries and Oceans 1992) This indirect effect can have a localized, negative impact on fish spawning beds (Gaboury 1985) and on the aquatic environment in general.

A perceived need for downstream channel straightening may be due to increased flows from wide-spread, up-stream drainage activity. On an alluvial fan within Wilson Creek, Manitoba, head-cutting due to drainage construction caused extensive re-suspension and downstream deposition of alluvial silts (Wilson Creek 1983).

Cattle **Effect.** Concentrated grazing and watering sites for cattle adjacent to streams can have a negative effect on riparian and in-stream habitat (Adams and Fitch 1995) This effect does not automatically extend to range cattle **in general. Compared to natural sources,** the relative contribution of range cattle could be minimal A study in the Cypress Hills found that runoff from Police Point landslide resulted in "large volumes" (up to 438 ppm) of sediment in the flow of Battle Creek (Sauchyn and Lemmen 19%). In contrast, above the slide where range cattle were at large, sediment levels were only 2 ppm.

PESTICIDES

Relatively few pesticides are consistently detect& on the prairies and the great majority of these are well below Water Quality Guidelines.

Prairie Riven and Streams. A 20-yr summary of findings on the large rivers of Alberta reports that relatively few pesticides have been detected and concentrations were generauy low (Anderson et al. 1995). Guidelines were exceeded for aquatic life and irrigation in only a few cases.

In Manitoba, Currie and Williamson (1995) analysed results for approximately 3,000 samples collected from 100 surface water sites over a 25 year period. They found frequencies and concentrations similar to those observed elsewhere on the prairies Most guidelines (drinking water, etc.) were exceeded less than 1% of the time, by only 3 or 4 of the 65 pesticides tested.

During a 3-yr period, 7 of 28 pesticides tested for were detected in Cooks Creek (Hughes et al. 1994). None of the detected levels exceeded Manitoba ***Surface Water Quality Ojbectives. In*** a 3-yr study on the Red River and eight of its tributaries, the 23 pesticides tested are generally well below water quality guidelines for Canadian and European standards (Rawn et al. 1995).

Farm Dugouts. As small scale water bodies in the midst of prairie agriculture, farm dugouts may represent a "worst case" scenario for potential pesticide contamination. Grover and Cessna (1996) reviewed the work of a number of prairie studies on dugout water quality. They conclude that even after long-term pesticide use on the prairies : median residue levels continue to be at or near quantifiable detection limits; concentrations are generally well below Canadian drinking guidelines and "near or below the most stringent (European) guidelines...;" and maximum residues are usually seasonal and short lived.

Groundwater, **Irrigated Lands.** Pesticide detections in prairie groundwaters are generally of limited extent **and well below water quality guidelines. A one-time sampling of farmstead** wells in three areas of Alberta showed no detection of the seven herbicides tested (Fikgerald 1995).

Irrigated lands represent zones of intensive agriculture and water movement, where herbicides have been found, though usually at low concentrations In a 1-yr Alberta study on short, gravity-irrigated runs (Miller et al. 1995), [redacted] was detected in 50% of surface runoff samples, but found in less than 1/3 of local groundwater samples. In a different gravity-irrigated study on long runs, Miller et al. (1995) failed to find any phenoxy herbicides in surface runoff but residue occurred in 1/2 of local groundwater samples. In both cases, concentrations were generally well below guideline levels. Within the Assiniboine Delta Aquifer of southern Manitoba, single samples representing 26 irrigation wells were tested for 16 pesticides during late summer/early fall (Buth et al. 1992). One sample contained a single pesticide residue. In a 3-yr fall irrigation study at the Saskatchewan Irrigation Development Centre (SIDC), only those herbicides not incorporated into the soil, leached into lysimeters and tile drains (Elliott et al. 1995).

NITRATE

The term "nitrate" refers to the concentration of nitrogen (N) present as nitrate (NO,), ie., nitrate-nitrogen (NO_3-N). A concentration of 2 10 ppm nitrate may be hazardous to the health of infants.

Multiple Sources. Not all nitrate levels in surface and groundwaters can be attributed to local or recent activities, or to agriculture alone (Reynolds and Edwards 1995). Seasonal effects can have a large influence on the variability on nitrate concentrations in streams. Atmospheric inputs have increased greatly since pre-industrial times, and can be a major source of N to upland catchments. As well, the natural, background level of nitrate may be so high that it is difficult to track small agricultural additions. In southern Alberta, high groundwater nitrate from natural sources (100-500 ppm) has been commonly detected in oxidized till and some shallow bedrock (Rodvang et al. **1995).**

Prairie Surface Waters. The net effect of agriculture on nitrate conentrations in surface waters is uncertain. On Cooks Creek in Manitoba, no significnt difference in N was found between upstream and downstream reaches (Hughes et al. 1994). In west-central Manitoba, it was unclear how much of the in-stream nitrate increase after rainfall was from land-use vs. natural causes (Williamson et al. 1992). In Alberta, the sampling of delivery and spill waters from two irrigation districts found N consistently below guidelines for human and stock use (Greenlee and Lund 1995).

Groundwater. Groundwater studies show varied findings that may or may not be agriculturally related. A literature review of nitrate in groundwater on the prairies reports that as early as the 1940s, levels of greater than 10 ppm were found in as many as 20% of wells (Henry 1995). Frequencies today are generally no higher. In southern Alberta, a 3-yr study of 20 tile drainage sites found mean nitrate levels of 9 ppm (Harker 1982). In Saskatchewan, 117 shallow, domestic wells having "an extremely high potential for contamination" averaged 33% of wells exceeding guidelines (Volgesang et al. 19%). Near Carberry, Manitoba, in a one-time sampling of 26 irrigation wells, nitrate ranged from <1 to 8 ppm (Buth et al. 1992).

Soil Accumulation & Losses. There is some evidence of nitrogen build-up in annually cropped soils-an indication of possible leaching hazard_ In Manitoba, this is particularly true of soils that are heavity fertilized for specialty crops, or for manured fields (Ewanek 1995). In semi-arid Saskatchewan, one year of above-normal precipitation (23%) was estimated to have leached at least 123 kg/ha ofnitrate from a fallow soil (Campbell et al. 1984). Estimates by the same authors also indicate that 20% of the soil organic N present at the breaking of the prairies may have since been lost to leaching.

Fertilizer & Irrigation. There is evidence that the amount of manure or chemical fertilizer applied and the irrigation management used, can significantly affect nitrate leaching on the prairies. In an 11 -yr Lethbridge study **where manure application was up to three times the recommended rate (Chang and Entz** 19%). nitrate was leached beyond the 150 cm soil depth Groundwater concentration was as high as 500 ppm. Similar results were not observed for dryland

PHOSPHORUS IN SURFACE WATERS

Phosphorus (P) can enter surface waters as part of the sediment load attached to soil particles or in a purely water soluble form. There is no Canadian Water Quality Guideline for P concentrations. The USEPA suggests a maximum desirable concentration of 0.10 ppm for flowing water.

Large Rivers. The mainstream rivers and reservoirs of the prairies have P concentrations close to what Environment Canada (1990) calls "background" levels. Occasional eutrophication is said to be largely a summer **phenomenon, downstream of sewage treatment** plants. Most of the flow in these rivers originates in the mountains and the great majority of sediment load (and its accompanying P) comes from stream-bed erosion and not from agricultural lands.

Smaller Streams & Lakes. Smaller streams and lakes that are tributary to the Saskatchewan River receive most of their water from prairie sources, and are generally regarded as being more eutrophic. Although some people perceive water quality in prairie lakes to be deteriorating, and believe that agriculture is largely to blame, Mitchell and Trew (1992) caution that it is simply not known whether many prairie lakes were already eutrophic prior to agricultural development.

It cannot be assumed that P eroded from agricultural lands is **necessarily** fertilizer P (Environment Canada 1990). Indeed this is unlikely to be so, as the amount of P applied in chemical fertilizers is minimal compared to the P that is indigenous to the soil (although not immediately available for plant use). Near cattle operations, stream concentraions of P are often the highest_ since as cattle numbers and associated **manure volumes increase,** P loading tends to increase.

On Cooks Creek in Manitoba (Hughes et al. 1994), P was relatively abundant, with concentrations averaging 0.26 ppm. However, no significant differences were seen in P levels between upstream and downstream waters flowing through agricultural lands. In the Turtle River of Manitoba, P loadings sometimes increased in response to rainfall, yet it was unclear how much of the increase was due to land use as **opposed to natural sources (Williamson et al.** 1992).

Irrigation In Alberta, Greenlee and Lund (1995) found that P concentrations in the delivery and spill waters of two irrigation districts were generally below maximum EPA limits for flowing water. Oosterveld and Carefoot found average total P in the spill drains of an irrigation district to be up to six times the *Alberta Wafer Quality Objective* of 0.05 ppm (1979, in Environment Canada 1990). Most P was deemed to have come from drain erosion In another study, Oosterveld and McMullin (1979) observed that total P in field runoff from a 3,000 ha flood irrigated basin averaged 0.18 ppm. P levels in dram waters where particulate P was deemed to have settled out were significantly lower.

Uncertain Net Effect. Estimating the net effect of agricultural P contributions on overall water quality can be difficult o fnecessity, when estimating P loadings, calculations are often based on isolated water samples and stream As well, lake bottom sediments alone can release the quivalent of 1/2 to several times the annual supply of P from external sources (Mitchell 1985).

Export coefficients from agricultural lands can be 2-5 times that from forested areas. Yet P exports from agricultural lands near Pine Lake, Alberta were as little as1/10 of those elsewhere in the province, perhaps due to limited rainfall and hummocky topography (Mitchell and Trew 1992). Although overall export coefficients were low, P loadings were fairly high from 4 relatively small agricultural sites.

Clearing and cultivation can increase P loadings in runoff. In Alberta, clearing only 2 1% of the Baptiste Lake **watershed increased the annual P load by as much as 88% (Trew et al.** 1987). **Yet on Pine Lake, where the largest** external loading (36%) is from agricultural and sewage sources, the greatest portion of annual P loading (61%) is from the internal cycling of P, historically deposited to lake sediments (Sosiak 1995). As well, loading estimates must take into account that **only SO??** of agricultural P may be biologically available (Mitchell and Trew 1992).

There is evidence of a relationship between changes to extemal loadings and internal cycling, but the relative time frames for seeing these changes are uncertain. There is a critical need to refine phosphorus models and to calii them to local conditions Until this is done, the view exists that a "healthy scepticism" of the validity of such models may be warranted (Daniel et al. 1994).

CATLZ&,BA~XERL~,SAUNITY, HEAvYMETAls

Other risks to water quality include the effect of range livestock increases in coliform and other bacteria, the salinity content of irrigation and drainage waters, and possible heavy metal problems.

Range Livestock Range livestock production is said to be “an environmentally sound water management practice (Sweeten 1984, in Buchanan 1992). The effects of range cattle on a watershed are often indistinguishable from the effects of wildlife and where effects have been reported, these are often discernable for only short distances downstream (Dixon 1983a, Dixon 1983b; in Buchanan 1992).

At concentrated feeding and watering sites, allowing cattle to have direct access to streams and water bodies **can result in local and possibly downstream increases** in bacteria and sediment (Sweeten 1984 in Buchanan 1992). Concentrations in winter **feeding** areas could be similar to that **from feedlots.** Where cattle are allowed direct **access** to farm dugouts, significant increases in sediment and bacteria levels might adversely affect water quality and subsequent cattle performance (Willms 1995).

Fecal Coliform Bacteria. The presence of fecal coliform bacteria in surface and well waters can pose a health risktohumans. **This may be due to the bacteria themselves or because they indicate that other, more harmful** pathogens might be present

In Alberta, Greenlee and Lund (1995) monitored spill drain waters weekly within two irrigation districcts. Bacterial counts were consistently above those in irrigation delivery water and public health standards were usually exceeded. In Manitoba, **fecal** counts in Cooks Creek were slightly above surface water quality guidelines in upstream reaches, but within guidelines downstream (Hughes et al. 1994). Contamination sources may have included direct cattle access, runoff from feedlots or manured fields, or beaver presence in upstream reaches. On the Turtle River, coliform bacteria increased in response to rainfall but it was not clear how much of the increase was from natural (wildlife) sources as opposed to land-use causes (Williamson et al. 1992).

In groundwater, Rodvang (1995 pers. comm.) found fecal coliform bacteria in a few very shallow wells, within an intensive livestock area of Alberta In a one-time sampling of 192 farmstead dugouts and wells in Alberta, 93% of wells but only 47% of dugouts met microbiological standards for drinking water (Fitzgerald 1995).

Irrigation Salinity. In western Canada, surface water for irrigation is generally low in salinity (reported as EC) and does not appear to adversely affect most soils, but may affect the groundwaters beneath them Long-term irrigation in Alberta did not salinize 12 of 13 test sites deemed to represent typical soils (Chang and Oosterveld 1981). Yet water tables monitored beneath irrigated lands for up to 20 years showed a significant increase in groundwater EC at 3 of 9 sites (Beke et al. 1992, in Miller et al. 1992).

Water quality downstream of irrigation projects is an issue in many places, though not generally so in western Canada, in Alberta, salinity in 38 irrigation return-flow channels was similar to diversion-water quality (Bolseng 1991 in Paterson 1992). The salinity of tile drainage effluent can be high but typical drainage flows are low, and the net effect on water quality is expected to be negligible at normal river flow (Harker 1983). Subsurface (groundwater) return flow from irrigated lands to rivers has had minimal impact on river water quality (Robertson 1988).

Trace Elements & Heavy Metals. Certain trace elements, alone or in agrichemical combinations, can also affect water quality. In the mainstream rivers of the Saskatchewan River Basin, concentrations are ususally comparable to natural levels (Environment Canada 1990).

Green and Beck (1995) report on 14 years of monitoring the Assiniboine river of Manitoba to assess the potential for seven trace metals to biomagnify in fish muscle. Residues of arsenic, cadmium, chromium, copper, nickel, zinc and selenium "appeared to be in the range of normal background concentrations." Mercury may be the exception, there being no clear evidence that historically high levels are declining. It is, however, often difficult to discern between natural and man-made sources for trace elements.

On Cooks Creek in Manitoba, the content of six heavy metals does not apear to pose a hazard. Chromium, nickel, copper, zinc, lead and cadmium were generally just at or below detection limits (Hughes et al. 1994). In irrigation delivery and spill waters, Greenlee and Lund (1995) monitored arsenic, cadmium, copper, lead, and selenium. Most elements were very low or below detection limits (0.00 1 ppm). All were below guidelines for human, livestock and irrigation use. However, two years earlier, Greenlee et al. (1993) had sampled six trace elements in delivery and return flow sites within three irrigation districts. At that time, levels of cadmium, lead and mercury were found to exceed human guidelines at some time during the five month monitoring period, in all eight locations sampled Representing shallow groundwater, tile drainage waters in Alberta have been found to contain only traces of cadmium and selenium at or slightly above detection levels (Barker 1983; Paterson 1992).

PRIORITIES

RESEARCH AND MONITORING

There is wide spread recognition of the need to better understand how agrichemicals move in the environment, to establish universal field sampling and analysis protocols, and for research towards reducing application losses (Lindwall 1992, Lindwall 1996 pers. comm.). Importance is placed on a holistic watershed approach to water quality research and development Other topics less directly related to agricultural benefits include: the effect of pesticide residues on wetland invertebrates, and the influence of riparian zones on waterways (Nicholaichuk and Hendry 1992; Vermette 1995).

PUBLIC EDUCATION

Colgan (1992) says that current safe food levels, the status of water quality, and sustainable land management practices need to be clarified in the public mind He says we need to find a middle ground between the concepts of frontier economics and deep environmentalism.

There is a need to develop a long-tam urban awareness program to provide information to non-farm residents, as highlighted in a Saskatchewan survey of over 500 landowners and community leaders (Hass 1994). Educators polled during a survey of over 1,000 urbanites across Manitoba and Saskatchewan identified the need for school resource materials that: present a balanced viewpoint on the role of agriculture in the environment; are teacher-friendly; and will help them to stimulate informed debate on the topic (The Advisory Group 1994).

A COORDINATED APPROACH

There is room for a more Coordinated approach to the planning and monitoring of water resources on the prairies. This includes establishing a Central Steering Group -a water quality task force or lead agency to bring various water quality interests together (Bennett et al. 1992). Such a process should also include the creation of an integrated, long-term, strategic plan.

Lindwall (1996 Pers. commun., AAFC Research Br., Lethbridge, AB.) sees the need to assure that resources are specifically targeted to address research and policy requirements in water quality. Much recent water quality work initiated through Green ***Plan*** and other federal/provincial agreements is slated to end, with no obvious replacement program. Resources must somehow be reallocated if the water quality momentum achieved thus far is to be maintained in each of the provinces. A prairie-wide focus towards addressing water quality issues is required to assure the effective pursuit of common priorities and the efficient use of limited resources.

CONCLUSIONS

CONFLICTING MESSAGES

It IS clear that contamination of surface and groundwater by nonpoint-source agricultural contaminants occurs to some degree on the Canadian prairies. Yet the extent and severity Of a potential problem are by no means certain The public receive confusing messages as to the role of agriculture in water quality. The concept of relative risk is ill-defined and hard to understand. Even among professional researchers, and despite apparent standards, there is no clear demarcation as to when a problem is significant.

LIMITED CONTAMINATION

Within the context of the Canadian Water Quality Guidelines, we find no clear evidence of the ***wide-spread*** contamination of surface and groundwaters from nonpoint agricultural activities on the prairies. This does not mean there are no problems, or the potential for them to occur. But current problems are generally neither widespread nor excessive in magnitude:

- **Sediment.** Sediment loading on major rivers is, at most, a seasonal problem
- **Pesticides.** Relatively few pesticides are detected in prairie waters, and these rarely exceed current guidelines
- **Nitrate.** Nitrate contamination of ground-water is more likely, being a higherrisk under intensively fertilized and irrigated lands
- **Phosphorus.** Phosphorus contributions to surface waters are evident, but the net effect of agricultural loadings is uncertain
- **Other Risks. Risks** associated with range livestock, salinity, and heavy metals are generally limited and of local concern

PRIORITIES

Research needs to better understand how agrichemicals move in the environment, while taking a holistic, **watershed approach to water quality management and** assessment_ Educational activities should focus on the many things that agriculture is doing right We need a prairie-wide, coordinated approach to research and policy direction, to assure the optimum use of limited fiscal and technical resources.

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