
Impact of Agricultural Land Management on Water Quality

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Introduction

Water quality can be defined as the suitability of water for a variety of uses which include drinking, livestock watering, irrigation, recreation use and support of aquatic life. When contaminants are added to water its use may be impaired and its quality deteriorates. Most agricultural land management activities can impact water quality by either altering the way that water moves through or over soil (transport) or by altering the potential contaminants that water may come in contact with (source). Some contaminants that may have agricultural sources include sediments, excessive nutrients, pesticides, pathogens and pharmaceuticals. However, not all agricultural impacts on water quality are negative, and positive impacts can be used to develop beneficial management practices for water quality protection.

Sediments

While excessive tillage can lead to soil erosion and sediment transport to surface waters, conservation tillage systems have been shown to protect the soil surface and reduce erosion by wind and water. The reduction in water erosion reduces direct transport of sediment to surface water. By reducing wind erosion, direct deposition of wind-blown sediments into surface waters is reduced along with indirect transport through the deposition of wind-blown sediments into the snow-pack.

Nutrient Management

Nutrients can accumulate in soil through over-application of fertilizers or manures. When nutrients accumulate in the surface soil they become available for transport in surface runoff impacting surface water. Soluble nutrients such as nitrate may leach through the soil and impact groundwater. Since phosphorus is a relatively immobile nutrient its primary impact is on surface waters but when a soil becomes saturated with phosphorus, phosphorus mobility increases and leaching may occur. By balancing nutrient applications to crop requirements, long term nutrient accumulation can be avoided and the potential for water contamination is decreased.

Placement and timing of fertilizer applications are also important. Fertilizer nutrients that are broadcast in the fall (or applied to the snow-pack) present a far greater risk for transport in surface runoff and surface water contamination than nutrients that are spring-applied or banded into the soil. In zero-till systems, nutrients (especially phosphorus)

from fertilizer applications and residues may accumulate near the soil surface due to the lack of mixing. In these soils the agronomic soil test of 0-15 cm or 0-30 cm may not indicate an accumulation of phosphorus while an accumulation would be indicated by an environmental soil test taken from 0-5 cm (the soil that interacts with surface runoff).

Manure Management

The principles of nutrient management also apply to manure management but in addition to nutrients, manures may also contain pathogens and pharmaceuticals (mostly antibiotics) that are often fed to confined livestock. Studies of snowmelt runoff from manured fields in Saskatchewan have detected antibiotics.

Since manures are normally fall-applied, they often contribute nutrients to snowmelt runoff. Manure applications should be managed to avoid long term accumulation and should be injected below the soil surface or incorporated soon after surface application. A study of snowmelt runoff from land where hog manure had been injected in the fall showed that contributions of nutrients to surface water were minimal when the manure applications were carefully managed. However, when the fall application was made just prior to freeze-up, nutrient loadings in snowmelt runoff increased to unacceptable levels and were comparable to loadings observed after an emergency winter application onto the snow-pack. The freshly applied manure was frozen in the injection slots and was available for transport in snowmelt.

Pesticides

On the prairies, pesticide contamination from agricultural application is more likely in surface waters than groundwater. Most reports of groundwater contamination by pesticides are the result of spills but pesticide leaching can occur under irrigation, through recharge zones and during wet conditions. Pesticides can reach surface water through long range atmospheric transport (where volatilized applications are transported many hundreds of kilometers and re-deposited), spray drift, over-spraying and surface runoff. The first three represent application problems but in the case of surface runoff, the pesticide has been effectively applied to the target soil or crop and has later been transported to water. Pesticides were detected in more than 60 % of snowmelt runoff samples in recent Saskatchewan study. Although many of these detections were very low concentrations, some samples exceeded guidelines for protection of aquatic life and for irrigation use. As with manure applications, when pesticide applications were made late in the fall, little degradation took place over-winter and concentrations in snowmelt runoff were much greater than those for applications made earlier in the fall.

Irrigated Agriculture

Production of high value crops under irrigation has the potential for leaching of nitrate and pesticides unless water applications are carefully balanced to retain water in the soil profile. Potatoes have a high demand for water but their root system is fairly ineffective and shallow, and is not able to effectively utilize applied water. This, coupled with the need for high rates of nitrogen fertilizer and multiple pesticide applications makes some leaching of nitrates and pesticides likely. In a study of irrigated potato production at the Canada-Saskatchewan Irrigation Diversification Centre, the water table rose and

groundwater nitrate concentrations increased when potatoes were grown while under canola the water table fell and groundwater nitrate remained stable. Some applied pesticides were detected in shallow groundwater at the site.

Beneficial Management Practices

A range of beneficial management practices can be used to protect surface and groundwater quality. Conservation tillage practices decrease sediment transport. The timing, placement and rate of fertilizer and manure applications can be managed to reduce nutrient accumulation and transport. Low drift nozzles and setbacks from sensitive areas may protect water resources from contamination by pesticides. On irrigated lands, water efficient irrigation practices should be used to minimize leaching. Vegetated buffer strips have been shown to effectively reduce transport of sediments and particulate nutrients to surface waters but they appear to be less effective in reducing transport of soluble nutrients.

Conclusions

Agricultural land management impacts surface water quality in many ways. There are some well-understood and easily applied beneficial management practices that can be used to protect surface water quality. However, in some cases there are complex interactions and practices may have impacts that were not expected. Further research should be conducted to ensure that contaminant sources and transport processes are well-understood to allow the development of effective management practices.

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