Policy Research Initiative | Projet de recherche sur les politiques

SUSTAINABLE DEVELOPMENT
BRIEFING NOTE

Water Quality Trading I: Scientific Considerations for Agricultural Pollutants

Highlights

- Water quality trading (WQT) and similar policy tools can be used to manage pollution from non-point sources including agriculture.
- WQT requires a basic scientific understanding of:
  - the problem to be solved;
  - how the pollutant of concern contributes to the problem;
  - the sources of the pollutant;
  - the fate of the pollutant in the environment;
  - the management practices that can reduce pollutant load; and
  - the affected watershed.
- Phosphorous, nitrogen, and sediment are the most suitable agricultural candidates for WQT in Canada.

Background

The water quality in Canadian watersheds is often compromised by pollution associated with a number of human activities. While point source (PS) pollution, such as that from municipal sewage treatment plants, can be addressed through a variety of policy instruments, pollution from non-point sources (NPSs), such as agriculture, has often been more difficult to manage. Crop and livestock production can be a source of pollution when agricultural inputs (e.g., pesticides and manure) and/or unintentional by-products (e.g., bacteria and sediment) make their way into the environment. Water quality trading (WQT) may be one way of addressing NPS pollution in general and agricultural sources in particular. Not all pollutants will be equally manageable through WQT or related policy tools. A recent science policy workshop concluded that sediment and nutrients, specifically phosphorous (P), and to a lesser extent nitrogen

Table 1
Main Agricultural Pollutants, Potential Trading Partners, and Major Science Considerations

Agricultural Pollutants	Potential Trading Partners						Science Considerations	
	Municipal wastewater	Industry	Septic systems	Forestry	Mining	Urban storm run-off	Behaviour known	Quantifiable reductions from NPSs
Phosphorous	•	•	•			•	•	•
Nitrogen	•	•	•			•	•	•
Sediment	•	•		•	•	•	•	•
Bacteria			•			•	*	
Pesticides				•		•	*	
Trace Elements					•			
Salts**		•			•	•	•	•

Notes:

* Depends on the type of bacteria or pesticide.
** Not typically a problem in Canada.

Canada

(N), are the most suitable agricultural candidates.[1] This briefing note discusses a number of science considerations for developing WQT programs. A second briefing note will discuss the concept of trading ratios for addressing scientific uncertainties and other issues.

What Is Water Quality Trading?

Water quality trading is a market-based instrument for managing water pollution that involves the trading of water quality credits between different polluters within a geographically defined region, typically a watershed. For many polluters that are subject to pollution standards as part of their permit agreement, the purchase of water quality credits may be an attractive means of compliance when compared to alternative options (e.g., costly system upgrades). The credits, which represent quantifiable reductions of a given pollutant, could be supplied by NPSs that reduce their emissions by implementing pollution abatement measures, such as agricultural best management practices (BMPs). This scenario may be suitable for addressing a number of water pollution problems (e.g., eutrophication, contaminated fish), if certain conditions are met.

Agricultural Pollutants

Agriculture can be a source of a variety of pollutants, including nutrients, sediment, pesticides, pathogens, salts and trace elements, and other pollutants of emerging concern like endocrine disrupting chemicals (EDCs), veterinary pharmaceuticals, and heavy metals. These pollutants enter the environment from different sources and through different pathways, and may or may not be associated with all types of agricultural production. Each pollutant is linked to a unique series of adverse effects when present at sufficient concentrations or amounts in the environment. Some effects are toxic and possibly lethal to humans and wildlife, whereas others could disrupt economic or recreational activities, such as fishing or boating.[2] For WQT to be a successful management tool for minimizing the effects associated with agricultural pollutants, there must be a sufficient understanding of where the pollutants come from; how these pollutants behave; and how these pollutants can be abated and by how much.

Pollutant Sources and Potential Trading Partners

Water quality trading would only be suitable for pollutants for which there is a potential to create a market (supply and demand) for water quality credits within the affected watershed. With respect to the main agricultural pollutants, there are several potential trading partners for agricultural P, N, and sediment, and fewer for bacteria and pesticides.

P, N, and sediment can enter a waterway from several sources and, thus, there could be a number of potential trading partners with which agricultural producers could trade credits. Of particular interest are the sources that are likely to be regulated and monitored, including the municipal wastewater and industrial facilities. The need for these facilities to meet pollution standards creates a driver, which can, in turn, generate demand for water quality credits. Furthermore, the possibility of nutrient loading exists with almost any type of agricultural activity, since most involve fertilizer, manure, or both and, thus, the *potential* for nutrient-related surface and ground water pollution in Canada's agricultural regions is widespread. The release of sediment into waterways is also a common problem in agricultural areas due to soil erosion (See text box, “Sediment and Water Quality”). The ubiquity of nutrient and sediment sources, both agricultural and non-agricultural, contributes to their suitability as candidates for WQT.

1 This workshop was a PRI - Agriculture and Agri-Food Canada collaboration. A more complete review of the workshop results and scientific considerations for WQT in general is provided in the PRI Working Paper, “Biogeochemical Considerations of Water Quality Trading in Canada,” available by following the publication link at <www.policyresearch.gc.ca>.

2 For more information on agricultural pollutants and their environmental impacts, see Coote and Gregorich (2000) and Chambers et al. (2001).

Bacteria can be associated with septic systems and urban storm water sources that are not often measured and may be unpredictable in terms of the effluent composition and volume of discharges. Pesticides are widely used, but the type of pesticide varies depending on the system (e.g., residential, forest, crop) and the pest being managed (e.g., fungus, weeds, insect). Within a given watershed, pesticide use could be quite diverse and opportunities for trading may be minimal unless there is a sufficient scientific understanding of the pollutants and their behaviour to establish inter-pollutant trading for different types of pesticides. For these reasons, it may be more difficult to implement WQT for these pollutants than for nutrients and sediment.

Sediment and Water Quality

Soil erosion resulting from activities like field run-off, stream bank damage from cows watering in streams, and vegetation loss, can result in high sediment loads to surface water, causing increased turbidity. Turbidity can reduce the transmission of sunlight needed for photosynthesis, interfere with sight-dependent animal behaviour, impede respiration and digestion in aquatic organisms, reduce oxygen in water, and degrade spawning habitat. Excessive deposition of sediment can fill valuable wetlands and compromise water storage facilities. Sediment is also a carrier of other pollutants to surface water, transporting potentially significant amounts of nutrients, pesticides, and bacteria.

Salinity trading occurs in other countries, such as Australia, but concerns regarding salts and trace elements are not widespread in Canada. EDCs are most likely emitted from several non-agricultural sources, but information is limited as such chemicals are not typically measured, and we are only beginning to explore their ecological and human health impacts.

Pollutant Fate and Transport

Pollutant fate and transport of a contaminant in the natural environment is important for determining the critical load, which is necessary for the design of a WQT program. Pollutant behaviour can be simulated using scientific models and requires knowledge of both pollutant and watershed characteristics. Important pollutant characteristics include how a chemical partitions between different media (water, air, soil) and under what conditions (e.g., temperature, pH, oxygen). The required watershed inputs will reflect ground and surface water interaction, hydrology (recharge, flow), topography, and soil types. Information on the biota will also be important for gauging biological uptake of the pollutants and the biological risk.

Critical Load

The maximum load that a given system can tolerate before failing.

Biota

Collectively, the plants, micro-organisms, and animals of a certain area or region.

The behaviours of P, N, and sediment are well understood. Nutrient cycling (a complex series of processes by which nutrients change into different chemical forms) largely dictates the behaviour of nutrients that occur naturally or are artificially added to the landscape. The nutrient cycles of P and N are well understood, including their chemical forms and transformations in the environment, which allows us to predict nutrient behaviour if the watershed itself is well understood.[3] Complications can arise, however, when pollutants become airborne (which may be an issue for N) and when deciding which form(s) of the nutrient to manage or trade.

Sediment in general is an important part of any aquatic ecosystem, but excessive amounts of sediment affect water quality. Unlike many other pollutants, the behaviour of sediment depends almost entirely on

3 Watersheds for which there is extensive scientific data and knowledge (as obtained through monitoring and research) are more likely to be considered candidates for WQT.

water flow and physical properties (particle size) that will determine if the particles settle or become suspended and at what point.

The scientific understanding of a number of pathogens and emerging pollutants is limited. If such pollutants become increasingly problematic (e.g., antibiotic-resistant bacteria or EDCs), a greater sense of urgency may force an increase in our level of understanding to a point where WQT may be viable for those pollutants.

Best Management Practices

For NPSs, the ability to reduce pollutant loadings through BMPs or other pollution abatement technologies is an important function of a WQT scheme as it creates a supply of water quality credits if the reductions can be quantified with an acceptable level of confidence.[4] Quantification is significant, as the likely range of pollution reduction achieved through the implementation of a BMP on a particular farm will be converted to water quality credits for trading purposes.

It is not practical to directly measure changes in the amount of pollutant that is emitted from most farms. Rather, the level of pollution reduction achieved by a given BMP can be calculated using methods derived from scientific research. Such methods are based on pollutant characteristics and will often require biogeochemical information of the site within the watershed, as the success of a specific BMP might vary depending on the type of farming system (e.g., tillage, crop) and the characteristics of the specific location (e.g. soil, slope, rain intensity) at which the BMP is being used.

A wide range of agricultural BMPs for managing sediment and nutrient loss have accepted methods for estimating pollution reduction. Other agricultural pollutants can be reduced using BMPs designed to manage nutrients and/or sediment. As an example, methods for reducing surface run-off and soil erosion may reduce the amount of any pollutant that is water soluble or sediment-bound, including certain pesticides and pathogens. Such positive side effects could only generate additional water quality credits if those reductions were quantifiable.

Conclusion

Based on the parameters discussed above, P, N, and sediment appear to be the most suitable agricultural candidates for WQT. This is not to say that other agricultural contaminants do not pose serious environmental threats, but rather that WQT may be difficult to implement for these pollutants due to a general lack of scientific understanding and/or potential trading partners. Policy, regulatory, and certain design issues have not been addressed here with respect to their effects on WQT feasibility. Such issues will be addressed in a final report of the WQT study to be released in the fall of 2005.

Further Reading

Chambers, P.A., M. Guy, E.S. Roberts, M.N. Charlton, R. Kent, C. Gagnon, G. Grove, and N. Foster. 2001. *Nutrients and Their Impact on the Canadian Environment.* Agriculture and Agri-Food Canada, Environment Canada, Fisheries and Oceans Canada, Health Canada and Natural Resources Canada. 241p.

Cross, P. and S. Cooke. 1996. *A Primer on Water Quality: Agricultural Impacts and Pollutant Pathways.* Alberta Agriculture, Food and Rural Development, Conservation and Development Branch. 27p.

Coote, D.R., and L. J. Gregorich (eds.) 2000. *The Health of Our Water - Toward Sustainable Agriculture in Canada.* Research Planning and Coordination Directorate, Research Branch, Agriculture and Agri-Food Canada, Ottawa.

4 Scientific uncertainty relating to pollution reduction and other aspects of WQT is discussed in a forthcoming briefing note.