Nutrient Management and the Environment

Adrian M. Johnston, P.Ag., CCA
Western Canada Director, Potash & Phosphate Institute of Canada
Saskatoon, SK

Nutrients in the Environment

The sustainability of agricultural systems focuses on how agricultural operations impact on social, economic and environmental factors. These components have received varying levels of attention based on where federal and provincial granting agencies see opportunities for progress. For the most part it is the environmental impacts that have been regulated by various levels of government, and as such command the most attention in research support. In western Canada, and particularly Saskatchewan, the large scale adoption of direct seeding could be considered the most significant environmental impact on agriculture since farming started. Given that untilled fields have little or no soil erosion by wind or water, this farming practice has overcome one of the most serious soil degradation processes facing semiarid agriculture. This significant environmental contribution is something all conservation farmers should be proud of.

By reducing soil loss by erosion, direct seeding has also minimized the movement of nutrients off of fields into environmentally sensitive areas. Soil in ditches, moving streams and still water bodies has always been a serious source of environmental degradation. Whether this degradation came about as a result of an erosion event, tillage erosion (soil movement by cultivation), or the activities of livestock, correction of the problem can go a long way to minimizing potentially negative environmental impacts.

Potential Nutrient Challenges

From an environmental impact point of view, nitrogen (N) and phosphorus (P) are the two agricultural nutrients of greatest concern. Potassium (K) is rather benign in the environment, with the very high levels found in a number of Saskatchewan soils having no apparent impact on the environment. From the standpoint of environmental impact, we are interested in how N and P influence soil, water and air quality.

Excessive levels of N in soil have a negative impact on crop growth, through lodging of crop stands and accumulated nitrates in livestock feed. There are no reported negative impacts from high soil P levels on crop production. Transport of N and P enriched soil off of fields and into water courses leads to elevated nitrate-N and P levels in the water, accelerating the process of eutrophication. Eutrophication is the process by which waters enriched with dissolved nitrate-N and P enhance the growth of phytoplankton (algae). This increased algae growth eventually dies, sinks to the bottom of the water body, and is decomposed by microorganisms there. The problem arises during decomposition, which is an oxygen demanding process, leading to reduced oxygen levels in the water. Reduced oxygen in the water limits aquatic life, including fish, insects and other organisms.

In the atmosphere, only N has detrimental effects. As most are aware, nitrous oxide N_2O is a potent greenhouse gas, with each molecule having 310 times the global warming potential as carbon dioxide (CO_2). The main source of N_2O comes from accumulated nitrate-N (NO_3) in soils that are saturated with water. The soil microorganisms use some of the oxygen in NO_3 to survive under the water logged conditions, converting NO_3 to N_2O, a volatile gas which enters the atmosphere. So, to minimize N_2O emissions the Best Management Practice (BMP) is to keep soil residual nitrate-N levels low. This is generally not a problem for most Saskatchewan farmers, unless they use fallow or allow nitrate-N to accumulate in their soil from excessive manure or fertilizer N application. Through no fault of their own, soil nitrate-N can also become elevated in soils where extended dry periods are followed by rainfall, similar to many areas of Saskatchewan in 2002. However, the greatest frequency of excessive soil N and P occurs after heavy manure application and for N alone after breaking legume forage crops.

Why Nutrient Management Planning?

Provincial nutrient management planning (NMP) legislation has come about as a result of soil nutrient accumulation where nutrients from manure application are in excess of crop removal. The problem is that most manure has been applied to meet crop N requirements, resulting in excessive P accumulation. Most plants use these nutrients in a ratio of approximately 10 N: 1 P. While liquid swine manure can have an N:P ratio ranging from 4:1 to 10:1, solid manures usually have a ratio of 3-4:1. Given the "slow release" nature of manure (especially solid manures), considerable amounts of the nutrients can be released during the non-growing season, leading to potential losses.

How high can soil nutrient levels become? While working at the Melfort Research Farm I encountered problems with severe crop lodging on some old manured pastures which were converted to annual crop production. Soil test samples collected from these fields revealed that surface 6 inch soil test P levels were in excess of 1,000 lb/A, and nitrate-N in excess of 120 lb/A in the spring of the year. This type of soil P loading is extreme, however, not uncommon in areas close to cattle feeding operations.

In an attempt to minimize the impact of soils heavily laden with nutrients, provincial regulators have implemented guidelines for maximum suggested soil N levels. In so doing, the regulators are attempting to provide farmers with a "measuring stick" with which to guide their on-farm manure management. The current guidelines used in Manitoba and Alberta are shown in Table 1. Currently, no soil nutrient level guidelines have been developed for Saskatchewan. Both Alberta and Manitoba are currently (2002-2003) evaluating the science-based information available to help them move from N-based to P-based soil nutrient management recommendations.

Why use a P-based soil nutrient loading limit when dealing with nutrient application guidelines? This is in an effort to minimize the movement of soils heavily loaded with P into water, either streams or lakes. Remember, P precipitates mainly with calcium (Ca) in soils with neutral to alkaline pH (> 6.5), resulting in it binding with soil and organic particles. So, it is the movement of soil high in P that is the problem. Research in Oklahoma has shown that when soil erosion was slowed with the adoption of conservation tillage, so was the movement of P into local

watersheds. In the absence of soil erosion, having high soil P levels is not a problem. Soils have to become highly saturated with P before any P begins to leach below the crop rooting zone. While this has been recorded, it is usually only under conditions of extreme P loading. This leads to the recommendation that when high rates of manure are going to be applied to soils already high in P, application should be made only to those areas where soil loss by erosion can be prevented.

Table 1. Soil N limits used to guide manure application in Alberta and Manitoba.

Alberta Soil Zone	Sandy (<45% sand) Water table <4m	Sandy (>45% sand) Water table >4m	Medium and Fine textured soils
Brown	75	100	125
Dark Brown	100	125	150
Black	125	150	200
Gray Wooded	100	125	150
Irrigated	160	200	240

Manitoba recommendations are based on land use practices (crops grown)	Maximum allowable nitrate-N in to 24" of soil (lb N/A)
Alfalfa	275
Grasses	200
Alfalfa/grass mix	200
Annual crops:	
Medium to heavy soils (loams and clays)	140
Light soils (sands)	90

A P index has been developed to help in the evaluation of soil landscapes that have high soil P levels. The risk of such loss of P depends on both source (added fertilizer and manure, soil P) and transport factors (erosion and surface runoff). Fields at risk are those where areas of high P application or soil P coincide with zones of active surface runoff or erosion of soil. The P index has been developed to rank field vulnerability to P loss so that high risk fields may be identified for site-specific management. The index provides a framework that can be regionally adapted to prevailing topography, geology, and climatic conditions and only requires readily available data. Successful use and adaptation of the P index concept is being implemented in both Alberta and Manitoba. The Potash & Phosphate Institute has developed information and suggested guidelines on the P index which is available at http://www.ppi-ppic.org/, look under the menu item "site-specific management guidelines", and select "SSMG-1".

Environmental Farm Plans

An Environmental Farm Plan (EFP) has been described as a "check-up" on the impact of farm management on the soil, air and water resources in and around a farm. Rather than focusing on nutrients alone, as is common to a nutrient management plan, the goal of the EFP is to increase recognition amongst farmers of how they can minimize environmental impact.

Ontario has encouraged voluntary participation in Canada's largest EFP program. To date, there are over 20,000 farmers, representing half of the farmed acreage, who have voluntarily enrolled in the EFP. The program was established with the following philosophy: voluntary; self-directed; encompassing of all farming philosophies; relevant to all commodities; farmer to farmer delivery; risk reduction; financial incentives; awards/recognition for innovation; and confidentiality.

The EFP assessment involves 23 components, including:

1. Soil and Site Evaluation	2. Water Wells
3. Pesticide Storage and Handling	4. Fertilizer Storage and Handling
5. Storage of Petroleum Products	6. Disposal of Farm Wastes
7. Treatment of Household Wastewater	8. Storage of Agricultural Waste
9. Livestock Yards	10. Silage Storage
11. Milking Centre Washwater	12. Noise and Odour
13. Water Efficiency	14. Energy Efficiency
15. Soil Management	16. Nutrient Management in Growing Crops
17. Manure Use and Management	18. Horticultural Production
19. Field Crop Management	20. Pest Management
21. Stream, Ditch and Floodplain Mgt	22. Wetlands and Wildlife Ponds
23. Woodlands and Wildlife	

It will be obvious that not all of these assessment components apply to all farms. In fact, using the example above a Saskatchewan grain farm would likely only have to consider components 1-8, 13-16, 19-23. The fundamental principle of working through these EFP components as a means of evaluating an individual farm has proven effective in increasing awareness amongst farm operators on how their activities impact on the environment, and offers suggestions on how they may modify operations to minimize impact.

The Atlantic Provinces have a similar EFP program to Ontario, and Alberta Agriculture has just completed development of voluntary EFP program, with the first workshops being held in spring 2003. We can expect to see federal-provincial initiatives to develop a suitable EFP workbook for Saskatchewan in the near future.

Putting Nutrient Management Planning in Perspective for Saskatchewan Farms

There is little doubt that NMP and EFP programs are good for agriculture and society. With the intense scrutiny that agriculture finds itself under by the urban majority, anything that can properly position the impact and role of the industry will be of benefit. While the development of NMP's for existing and expanding livestock operations is easy to justify, there are real costs associated with the application of EFP's to all farm operations in Saskatchewan. However, provincial participation in the development of any EFP activities is critical to ensure that a proper balance between some form of standardization and regional specific issues evolves.

So, what can you do on your own farm to start the process of evaluating environmental impact? From a nutrient stand point we have a number of tools we can use to assess the impact of operations on soil nutrient status.

1. **Soil testing**. While only a small fraction of farmers soil test, it might be time to start using this as a means of understanding a) where your soils are as far as nutrient supply levels, and b) how your inputs and removal of nutrients changes these levels. Talk to your local Crop Adviser to determine the best soil sampling plan for your farm.
2. **Try and balance your soil nutrient account**. There are some simple tools available to estimate the removal of nutrients by growing crops on your farm. Remember, high yield production goals require an adequate supply of available nutrients. Growing big crop yields leads to a drawdown of nutrient supplies which have to be addressed if future production goals are to be achieved. The Potash & Phosphate Institute has developed a P and K calculator which helps to balance nutrient inputs with crop nutrient removals. While not a replacement for soil testing, it can complement a soil test by providing insight into how your production is impacting on soil nutrient depletion. This calculator, called PKalc, can be found on the PPI website: www.ppi-ppic.org, look under "Toolbox Resources" on the home page.
3. **Know where you are relative to local watersheds**. Keeping nutrients, and soil, out of water has to be one of our primary goals in agriculture. This means avoiding soil movement into streams or sloughs. It also means paying careful attention to livestock wintering areas to ensure that they are not located such that runoff from them can enter any water bodies. Where manure is applied to fields be sure and avoid application close to sensitive water bodies, leaving an adequate buffer strip to intercept any potential nutrient movement.
4. **Get involved in, or start, a local watershed group in your area**. The development of a local watershed group is the first step in building awareness on agricultural nutrients in the environment. This is particularly true for those who farm near resort developments influenced by watersheds from surrounding agricultural lands. Obtain help from provincial and federal agencies on establishing the watershed boundaries your farm is in. Meet with your neighbors to share information on how potential problem areas can be addressed to minimize impact. In other provinces where EFP's have been developed, there have also been some funding support structures, land and livestock management changes where required.
5. **Be aware of provincial legislation and regulations that affect farm operations**. Be sure you are aware of any regulations or guidelines that exist in the province related to handling of crop inputs, oils, fuels, garbage, etc. on your farm. While this would be part of any EFP process that is sure to develop in Saskatchewan, starting now to modify your practices can start you on the road to achieving your on-farm environmental goals.