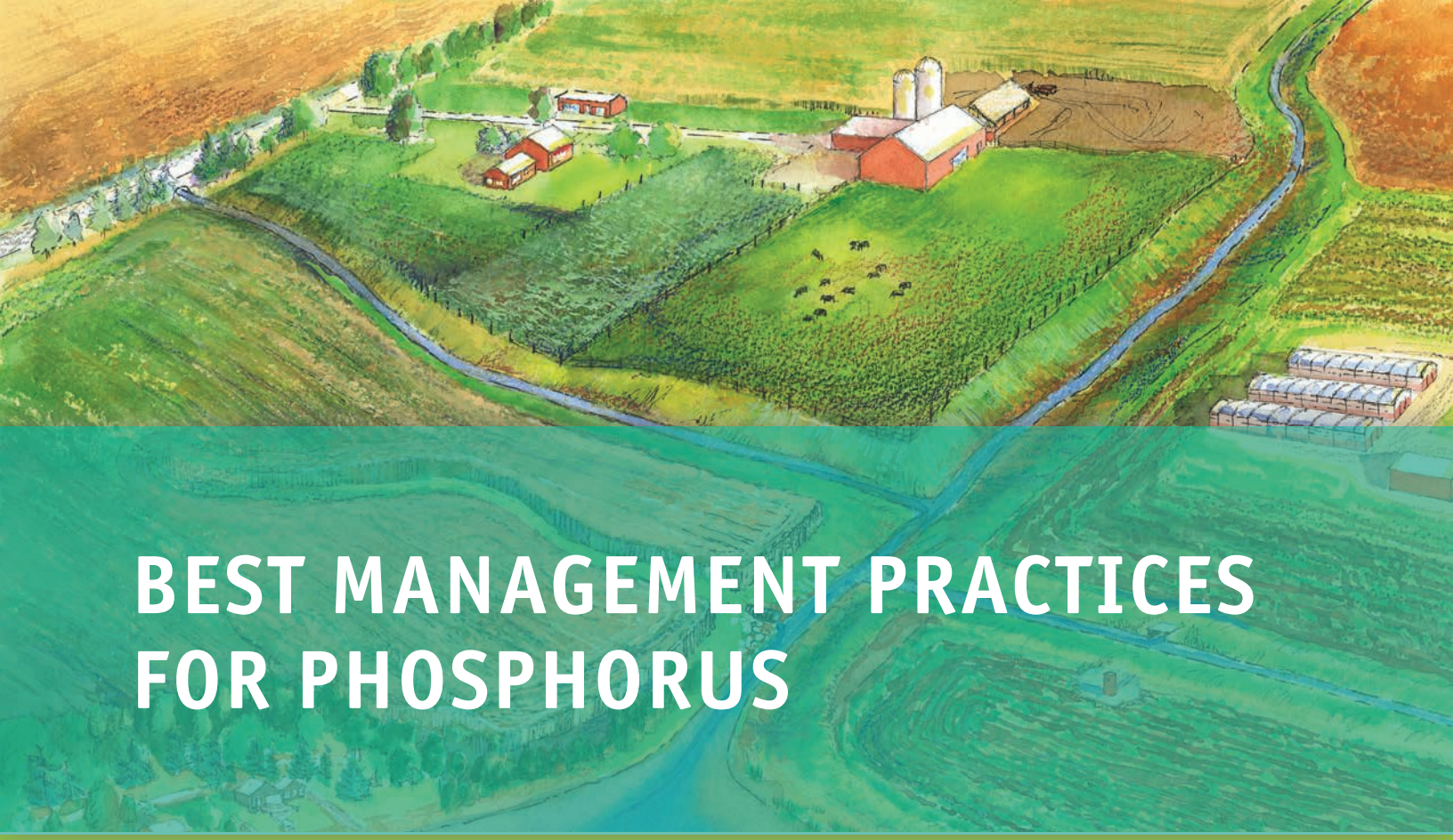


BEST MANAGEMENT PRACTICES FOR PHOSPHORUS

Phosphorus is an essential nutrient for crop growth.

When best management practices (BMPs) are used in its application and management, phosphorus stays in its intended place and crops enjoy maximum benefit.

Phosphorus can travel with eroded soil and cropland runoff to reach surface waters. Too much phosphorus in lakes, rivers and ponds can impair water quality.

This info sheet explains phosphorus: its forms, the chemical changes it can undergo in soil and water, and the implications of these changes for your operation and the environment.

You will also find a wide range of BMPs that can keep phosphorus in its rightful place.

Canada
Ontario
OFA Ontario Federation of Agriculture

Forms of Phosphorus (P)

Phosphorus occurs in many chemical forms.

In woodlands or croplands, phosphorus is on soil particle surfaces as well as in soil minerals, soil solution, plants and animals.

In watercourses or lakes, phosphorus is in solution, attached to suspended or settled sediments, and in aquatic plants and animals.

Besides its natural presence in soils, phosphorus takes several forms as part of human-driven industrial, urban and agricultural activities. Excessive loss of phosphorus from these activities is harmful to aquatic ecosystems.

In agricultural settings, phosphorus can be found in:

- cropland soils
- manure and fertilizers
- greenhouse growth solutions
- milkhouse washwaters.

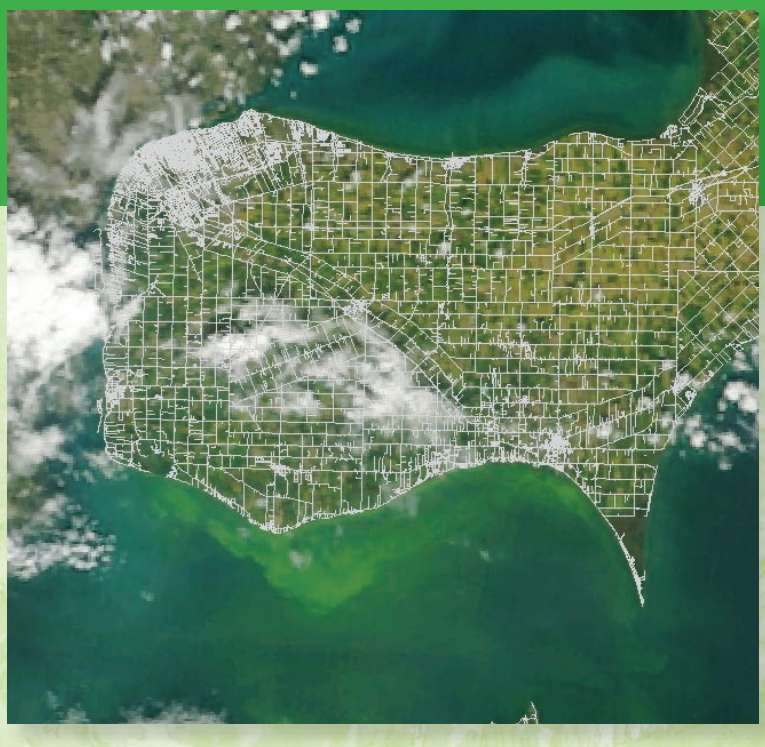
In Soil

The soil P system is commonly described as having three pools of P. Knowing the difference between the pools will help you understand when it is available or unavailable for crop growth, and when it is vulnerable to loss.

Soluble P is dissolved phosphate that plants take up. It comprises a small fraction of the total P.

Labile P is a major pool of phosphorus that is held loosely by soil particles and replenishes the soluble P supply.

Stable P is a strongly held pool of phosphorus in the form of mineral compounds, such as calcium phosphates.



In fresh waters, elevated phosphorus levels lead to reduced oxygen in lakes, ponds and rivers – harming cold-water fish.

Elevated P levels also speed up aquatic plant growth and create algal blooms. This can: impair municipal and private drinking water supplies and increase the cost of treatment; degrade the quality of irrigation water; contaminate livestock water; and foul beaches.

The risk of phosphorus polluting surface water can be reduced with BMPs for applying manure, composted material, biosolids, and mineral fertilizers.

Remember to do it RIGHT!

- Right source
- Right rate
- Right time
- Right place

Phosphate is the form of phosphorus used in the metabolism of plants and animals, and most commonly found in minerals.

Phosphate reacts with so many different compounds and elements in the soil that only a small amount remains in solution at any time.

When soluble P is added to the soil as fertilizer or manure, most of it is rapidly converted to labile forms. It then converts to progressively more stable forms.

Over time, soil P tends to accumulate in the most stable compounds. However, some of it will also be released into solution to replace that which is taken up by plant roots. In this way, some of the stable P becomes available. Soil tests are required to determine how much crop-available P is present in the soil at the time of planting, so that the proper rate of P is applied.

The vast majority of phosphorus is taken up by plants through plant roots, root hairs, and other contact as they grow through the soil.

Low temperatures slow root growth and nutrient absorption, so plants are often unable to obtain sufficient P during cold weather, especially when they are small. It's beneficial to place phosphorus fertilizer where roots can access it, and to time fertilizer application so that P is available when required for optimum plant growth.

The purplish lower leaves on this corn seedling show signs of phosphorus deficiency.

Unless properly managed, phosphorus can reach surface waters from overland flow and subsurface drainpipe (tile) outflow. In these circumstances, the risk of non-point source pollution is greatest following snowmelt and storm events.

Soil test results that show high phosphorus levels indicate conditions at risk of phosphorus loss. Runoff and erosion from these areas can contribute high amounts of phosphorus to lakes and rivers.

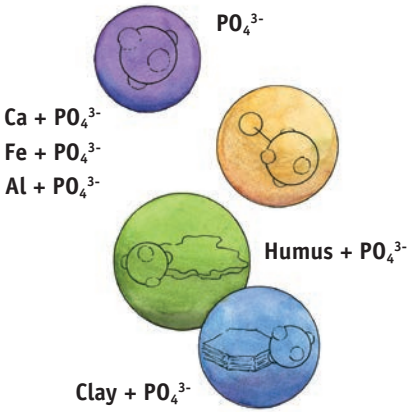
In Manure

Phosphorus in manure is present in the form of organic compounds and as soluble phosphate. Much of the phosphorus in manure becomes available to crops eventually. This phosphorus must be accounted for when determining crop nutrient application rates.

In Water

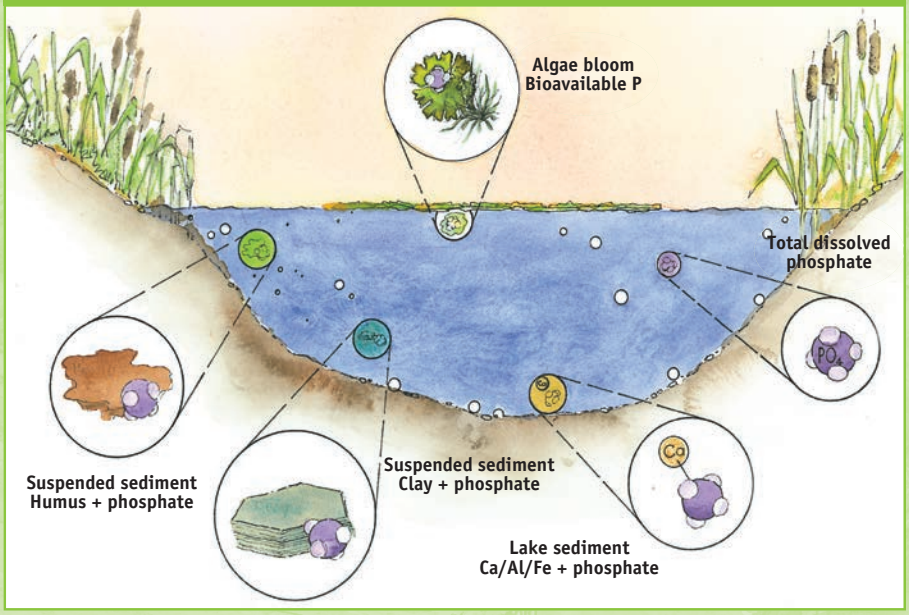
In unpolluted freshwaters, aquatic plant growth, including algae, is usually limited by the low level of phosphorus. When phosphorus is added to water, more algae and other plants are able to grow.

In recent decades, abundant algal growth has made the water in some lakes and rivers in Ontario unpleasing or unsuitable for drinking or swimming.



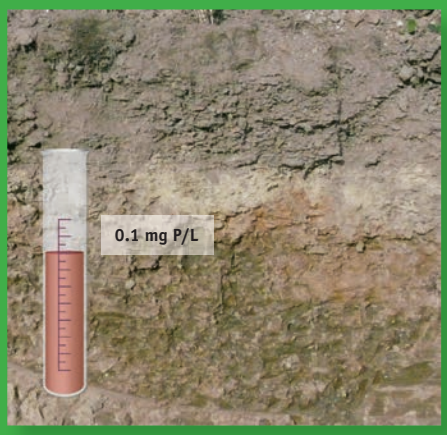
- Phosphate (PO_4^{3-})
- Calcium phosphates ($Ca + PO_4^{3-}$)
  Iron phosphates ($Fe + PO_4^{3-}$)
  Aluminum phosphates ($Al + PO_4^{3-}$)
- Humus + phosphate (PO_4^{3-})
- Clay + phosphate (PO_4^{3-})

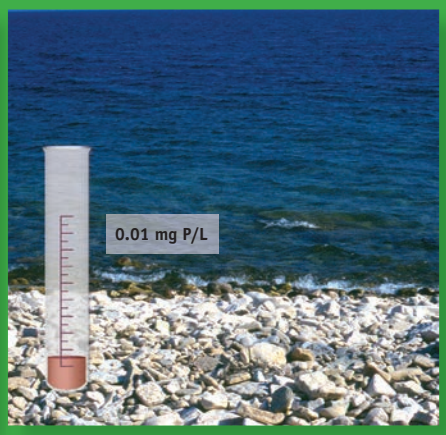
FORMS OF PHOSPHORUS IN A LAKE ENVIRONMENT



In streams and lakes, phosphorus is described in one of four ways.

1. **Total dissolved P** is mostly very small particles of dissolved phosphates and organic P.
2. **Particulate P** is also known as **sediment P**. This form of P can be in suspension or in lake sediments. It is defined as:
   - insoluble P compounds, formed by reactions between phosphate and minerals in solution – see gold spheres
   - P attached to sediments – see blue spheres labelled clay + phosphate, and
   - organic P, attached to the surface of or incorporated into organic compounds, including living organisms – see green spheres labelled humus + phosphate.
3. **Bioavailable P** (BAP) is also known as **algal-available P,** and referred to as algae bloom / bioavailable P in the illustration. It is defined as the portion of total P that is available to algae. It includes all of the total dissolved P and the portion of particulate P that algae are able to extract.
4. **Biological P** refers to the significant amounts of P that are stored by plants, insects, mollusks and fish in a healthy aquatic system. The P cycles through the system.





Small losses of phosphorus from cropland can have large impacts on the water quality of lakes and rivers.

Concentration of phosphorus in soil solution of a fertile soil for plant growth is about 0.1 mg P/L. Maximum acceptable concentrations in lake water are usually less than 0.01 or 0.02 mg P/L, depending on the natural phosphorus concentration of the system. Higher concentrations can cause algal blooms and excessive aquatic plant growth.

Phosphorus and BMPs on Farm Landscapes

The right source, right rate, right time, and right place approach will help you meet your goals for sustainable production: optimum yields and environmental protection.

ISSUE Manure runoff contains phosphorus, ammonium, organic matter, and pathogens.

BMP Design and size liquid manure storages to contain all manure solids and contaminant liquids from livestock operations.

ISSUE Operators of greenhouses and outdoor container nurseries need to manage irrigation water, nutrient solutions, and nutrient-enriched water containing phosphorus.

BMP Capture, collect and store nutrient solutions and nutrient-enriched water. Ensure collection ponds for captured liquids are properly designed to hold the maximum anticipated volume, and have no contact with ground or surface water. Store irrigation and nutrient solutions, which can subsequently be treated and applied to other specialty crops or adjacent alternative crops (e.g., orchards, lawns).

ISSUE Winter application of nutrients poses a risk for cropland runoff to surface water.

BMP Apply nutrients as close as possible to the time when the crop needs it. Spring application of nutrients will reduce the risk of runoff.

ISSUE Steeply sloping cropland is at a greater risk for erosion and runoff. Most forms of phosphorus – soluble, labile and stable – can be found in cropland runoff.

BMP In a no-till cropping and tillage system, the soil is undisturbed prior to planting, and well-protected from erosion and runoff. Soil conservation structures and management practices such as planting crop rows across slopes (not up and down) will further reduce the risk of erosion, runoff, and loss of phosphorus.

ISSUE Some of the nutrients applied to improve crop growth can reach nearby surface water during runoff events such as rainstorms. This is a particular concern when cropland soil test results indicate excessive levels.

BMP The "right rate" approach balances crop needs with environmental protection.

Calibrate all nutrient application equipment to ensure desired rate is being applied.

BMP Septic systems don't last forever: eventually all systems need to be replaced.

Proper care can extend the life of your septic system. Have your tank inspected for sludge and scum buildup on a regular basis (3–5 years).

Clean it out when a third of the depth of your tank is full of sludge and scum. Look for signs of septic failure: slow drainage, septic smells, spongy beds, and sewage backups and breakouts.

ISSUE Grey water from domestic laundry, kitchens, and bathrooms contains soap and detergent-based phosphorus. Black water from toilets is a source of organic P.

Improperly functioning septic systems or illegal systems hooked up to pipes that discharge to rivers, ponds or lakes are a point source of phosphorus for surface water.

For More Information

BEST MANAGEMENT PRACTICES

For more detailed information on closely related BMPs, we urge you to see several in-depth BMP books, including:

A Phosphorus Primer
Buffer Strips
Controlling Soil Erosion on the Farm
Cropland Drainage
Managing Crop Nutrients
Manure Management
Nutrient Management Planning
No-Till: Making It Work
Soil Management

ONTARIO MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS

OMAFRA offers many publications on related topics. Of particular relevance:

Soil Fertility Handbook, OMAFRA Publication 611

HOW TO OBTAIN COPIES OF BMP AND OMAFRA PUBLICATIONS

A complete listing of all OMAFRA products and services is available at www.omafra.gov.on.ca/english/products/index.html

To obtain copies of Best Management Practices and OMAFRA publications, please order:

- **Online** at www.publications.serviceontario.ca
- **By phone** through the ServiceOntario Contact Centre
  Monday to Friday, 8:30 am – 5:00 pm
  - 416-326-5300
  - 416-325-3408 (TTY)
  - 1-800-668-9938 Toll-free across Canada
  - 1-800-268-7095 TTY Toll-free across Ontario
- **In person** at ServiceOntario Centres located throughout the province or at any Ministry of Agriculture, Food and Rural Affairs Resource Centre.

If you have a question regarding farming, agri-business, or rural business, contact the Agricultural Information Contact Centre at 1-877-424-1300 or e-mail ag.info.omafra@ontario.ca

Canada

Ontario

OFA Ontario Federation of Agriculture

Acknowledgements

The Best Management Practices Program is a partnership of Agriculture and Agri-Food Canada, the Ontario Ministry of Agriculture, Food and Rural Affairs, and the Ontario Federation of Agriculture. Funding for this publication has been provided by Agriculture and Agri-Food Canada and the Ontario Ministry of Agriculture, Food and Rural Affairs.

CONTRIBUTORS
(in alphabetical order by association and surname)

Task Team Chairperson – Agriculture and Agri-Food Canada: Keith Reid

Task Team and Authors – Agriculture and Agri-Food Canada: Andrew Jamieson, Keith Reid, Donna Speranzini; International Plant Nutrition Institute: Tom Bruulsema; Nottawasaga Valley Conservation Authority: Fred Dobbs, Shannon Stephens; Lake Simcoe Region Conservation Authority: Phil Davies; Ontario Ministry of Agriculture, Food and Rural Affairs: Christine Brown, Christoph Kessel, Kevin McKague, H.J. Smith, Ted Taylor; Ontario Ministry of the Environment: Jennifer Winter; University of Guelph: Ivan O'Halloran

Technical and Visuals Coordinators – Ontario Ministry of Agriculture, Food and Rural Affairs: H.J. Smith, Ted Taylor

Photographers – Agriculture and Agri-Food Canada: Keith Reid, Donna Speranzini; Agri-Food Laboratories: Jack Legg; Carl Hiebert; Corporate Photography: Kerry Little; Essex Region Conservation Authority: Michael Dick; International Plant Nutrition Institute: Tom Bruulsema; Ontario Ministry of Agriculture, Food and Rural Affairs: Christine Brown, Kevin McKague, H.J. Smith, Betty Summerhayes; Ontario Ministry of the Environment: Environmental Monitoring and Reporting Branch; Ontario Soil and Crop Improvement Association: Andrew Graham; Raisin River Conservation Authority; University of Guelph: Dr. R. Larry Peterson; Upper Thames Region Conservation Authority

Editor: Alison Lane

Watercolour Illustrations and Sketch Artist: Irene Shelton

Graphic Designer: Neglia Design Inc.

Printed 2012

AF149