White Paper

Managing Farm Phosphorus Losses to Catchments

Phosphorus levels in waterways and catchments is a contributing factor to reduced levels of water quality and increased eutrophication. Reducing nutrient loss pathways needs to be a focus for all farmers.

Overview of Phosphorus (P) Loss Pathways

Nutrient losses from farming operations to waterways and catchments are a known source of contamination.

Phosphorus losses occur through several pathways. These pathways or modes are defined[i] as –

- Leaching modes: the dissolution of phosphorus in the soil to water flows above or through the soil.
- Physical modes: the loss of P through soil loss due to erosion and detachment (such as stock movement over pastures disturbing soil).
- Intermediate modes: relate to loss or transfer of farm amendments of P such as fertiliser, manure and applied composts.

Most of the phosphorus that enters watercourses occurs in autumn during the first flush of winter rains, before pasture plants have emerged and developed sufficient roots, or during extreme storm events.

Phosphorus persists in the soil or sediment and can become mobile in wet conditions or during waterlogging.

Chemical fertilisers contain very high levels of water-soluble P, and this can be washed deep into the soil or across it before soils are able to bind with the P.

In sandy soils phosphorus is either dissolved and leached down into the soil or runs across the surface when the soil profile fills up with water. On clay soils, the water flows across the surface to nearby drains and waterways with phosphorus dissolved or attached to clay particles.

Phosphorus can also be lost via short circuit pathways, such as through cracks or macropores in the soil, similar to small tunnels. The loss is neither normal leaching nor run-off. Water travelling via this route can reach streams very quickly, and because nutrients have minimal contact with the soil column, large amounts can be transported quickly.[ii]

Details on Modes of P Loss

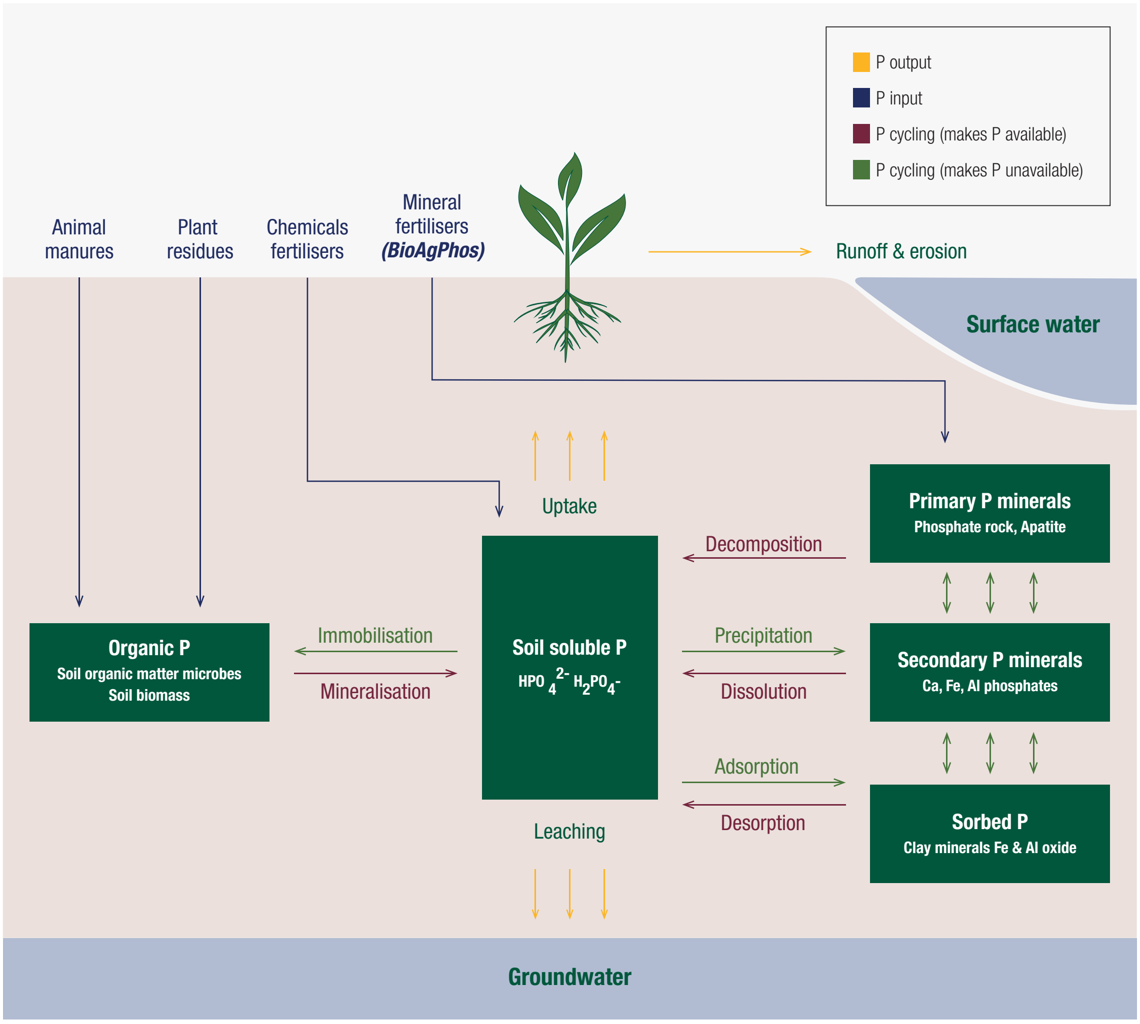
Leaching losses occur when P is extracted from the soil by water flow events. This can occur as water flows through or over soil with high levels of reactive P. Reactive P is readily assessed by performing an Olsen P soil test. Where Olsen P levels are above recommended levels for soil types, the potential for leaching is increased.

Physical losses relate directly to the movement of soil particles in any run-off or water flow from a source such as eroded soil, disturbed soil from stock movement, roads, and tracks.

Intermediate losses are greatest when involving run-off containing fertiliser, particularly water-soluble fertilisers, before it has had time to bind with soil particles (soil sorption).

Hydroscopic and non-wetting soils have a natural water repellence, and sorption of water-soluble P fertilisers can take longer. As such, applying water-soluble P fertiliser to these soils, even in dry conditions, is likely to result in elevated incidental losses if the first rains or irrigation create a run-off event.

Other incidental losses include the run-off of manure and other applied products containing P and grass or feed that has become mobile after grazing, mowing, or any other activity.



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Practices to Reduce Losses

Recommended steps to reduce P losses are typically based on the following key points [iii] –

- Time your fertiliser applications to avoid periods of intense run-off, and do not apply fertiliser when the soil is saturated, or rain is forecast.
- Place fertiliser within the soil or under surface vegetation and avoid the use of broadcast applications.
- Apply fertilisers as the plants need them by giving several light applications rather than one heavy dose.
- Apply soluble fertiliser through an irrigation system with drippers or low-pressure micro-jets.
- Use stubble mulching, trash blanketing and other methods to protect soils from water and wind erosion to help keep nutrients where they should be (on the paddock, waiting for the next crop or supporting increased pasture growth).
- Consider land forming and the use of contour banks to help reduce the amount of soil and nutrients lost from paddocks.
- Test your soil regularly to assist in determining your soil's nutrient and trace element requirements and avoid over fertilising.

New Zealand research has shown that grazing prior to a run-off event increased P loss. While there was no significant difference in P losses due to stock type, P losses were increased due to increased soil disturbance, losses of grazed pasture (a filter to particulate runoff) and increased nutrient run-off from fresh manure. The research also found that, higher soil pore space, a greater water infiltration rate or increased time since the paddock was last grazed decreased losses.[iv]

Research has demonstrated that water-soluble P fertilisers be applied at least 21 days before any run-off event. In a 21-day period the P applied will typically undergo soil sorption (binding with soil particles and antagonists). After which time, the incidental losses of P would be in line with untreated soils with an equivalent Olsen P, where Olsen P is a measure of the readily available or highly reactive P in soils.

Research also shows that P desorption into solution (out of the soil and into running water over or through soils) is proportional to Olsen P concentration in the soil.[v] It is, therefore, fair to conclude that even after P sorption into soils, if soils have elevated Olsen P levels; in soils with low to moderate phosphate buffering index (PBI)[vi] and where P has been applied prior to uptake by plants; losses due to leaching will occur.

But what if plant-available P can be stored in soils in a form other than the highly available form measured by Olsen P?

Typically practices to reduce P losses do not include evaluation of the type of fertilisers used and its potential to increase or decrease P losses. Australian research has shown that use of chemical P fertilisers increased losses of P during both rain-induced and irrigation induced water run-off.[vii] However, East Coast Australian research on P losses for various fertiliser types is limited. In New Zealand, a significant amount of research on P losses for chemical and Reactive Rock Phosphate (RPR) fertiliser has been performed, primarily because of the availability of RPR as a fertiliser.

Chemical Fertilisers Compared to Reactive Rock Fertilisers

Chemical fertilisers contain high levels of water-soluble P, e.g., 80% or more of the P in single superphosphate (SSP) and 100% of the P in ammonium phosphate (MAP or DAP). Chemical fertilisers have driven significant improvements in farming yields and produce quality. As a result, they have become common practice in nearly all farming sectors to the point where alternatives are often not known or considered.

An alternative to chemical fertilisers is Reactive Phosphate Rock (RPR) based fertilisers. RPR's and Direct Application Phosphate Rock (DAPR's) are available under different brand names; *BioAgPhos*®, Soft Rock and Colloidal Rock are just three examples, and each performs differently as a fertiliser. To read more on the differences between rock phosphate fertiliser, please view our white paper "Reactive phosphate rock fertiliser."

Several studies have been performed in New Zealand to evaluate P losses when using a water-soluble P fertiliser, SSP, against RPR, containing no water-soluble P.

Intermediate Losses

These trials found that in the 21 days post-application of a P fertiliser, losses were reduced when applying RPR instead of SSP.[viii, ix, x, xi] This is directly related to the amount of water-soluble P being applied and rain events causing run-off before the P in SSP has had time to be sorbed within the soil.

Leaching Losses

Losses, after SSP had been sorbed into the soil, is related to leaching or desorption of P and correlated to the soils Olsen P levels.[v] High Olsen P levels correlate to an increased capacity for P losses from soils in run-off. Therefore, managing Olsen P levels is key to managing the risk of P losses to.

Spikes in Olsen P occur when water-soluble P fertilisers are applied and can be reduced by applying water soluble fertilisers at lower rates more frequently and is commonly recommended in environmentally sensitive areas. However, this is typically impractical. An increase in the frequency of water-soluble P fertiliser applications increases the probability of a rain event within 21 days of one or more of the applications and consequently 'Intermediate Mode'.

RPR fertilisers provide an alternative to chemical fertilisers that can supply P while maintaining lower Olsen P levels[x]; thus, reducing the risk of leaching losses.

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RPR Based Fertilisers

RPR based fertilisers provide P in a non-water-soluble form. The P is liberated through the decomposition of the RPR. The decomposition is primarily caused by organic acids produced in the rhizosphere. As a result, P is liberated by the action of plants and more in line with the requirement of plants with less stored as readily available P within soils.

The ability of organic acids to decompose RPR can be buffered or aided by soil parameters and plant activity. For example, a long growing season increases the time organic acids interact with RPR particles increasing decomposition. Conversely, the action of organic acids can be buffered by a high soil pH.

While dependent on soil types and parameters, typically, RPR fertilisers will provide a pool of plant-available P in a less reactive non-leaching form.

RPR particles that have not been decomposed remain plant-available but will not be measured using an Olsen P soil test. When using an RPR based fertiliser, the Resin P test is considered to provide a better estimate of plant-available P than other tests[xii] However, it is not commonly utilised or correlated to soil types and crops. To read more about testing for P when using RPR based products, you should consider reading the BioAg white paper on "Measuring P in soils when using natural phosphate fertilisers."

Spreading around Dams and Waterways

While efforts should always be made to not spread over dams and watercourses (including dry creek and stream beds), the fact is that at times this is difficult to achieve, especially when using aerial spreaders.

RPR fertilisers have a significantly reduced impact on watercourses or storages than chemical, water-soluble fertilisers.

RPR fertilisers are not soluble in water and remain inert unless decomposed by acids. So, while not ideal, as a portion of the monetary value of the fertiliser is wasted, an RPR based fertiliser only adds inert particulate P, not water-soluble P (a cause of algal blooms), to a dam or watercourse.

Picture of stockpiled RPR stored outside inert in water/rain.

Choosing an RPR Based Fertiliser, there are Differences

While it is evident RPR products benefit the reduction of P losses, care needs to be taken to ensure the RPR product you choose is providing benefit as a fertiliser.

Take the time to understand the reactivity and availability of P in any rock phosphate-based product. Next, understand your soil and environment to evaluate if an RPR is suitable. Finally, trials and testimonials on similar soil types provide the best guide regarding the efficacy of a product on your farm.

When using RPR, you need to change the way you measure available P in your soils. Olsen P and Colwell P will underestimate the plant-available P in soils treated with any rock phosphate fertiliser. Managing your P levels with Olsen or Colwell P alone will mean you over fertiliser and miss an opportunity to reduce the leaching of P out of soils.

BioAgPhos is a phosphate rock-based fertiliser manufactured by BioAg using RPR of the highest reactivity in the Australian market. It is composted with a proprietary microbial phosphate digester to aid breakdown of the product when applied on farm. We have a range of trials and case studies highlighting the efficacy of *BioAgPhos* and its blends.

Theory into Practice

South Australian farmer and BioAg customer Jeff Higgins has implemented farming practices that consider the long-term sustainability of his beef enterprise. His approach to farming for the future is diligent and thoughtful, whether planting native vegetation to enrich the natural landscape or farming by observation of his cattle and crops.

A key to Jeff's success has been implementing soil testing to guide replenishment of nutrients on-farm, including phosphorus, Sulphur and minor elements removed by grazing and haymaking. Correcting deficiencies includes using reactive rock phosphate in the form of *BioAgPhos*, resulting in a rich mixture of sub clover and grasses.

Rich mix of sub clover and grasses following corrective action utilising BioAgPhos®.

Phil Toy of BioAg explains the difference between traditional superphosphate and reactive rock phosphate is that while the old 'super' habits give some immediate benefits, they do not have the benefits of P being steadily released. One-third of the P in *BioAgPhos* is immediately available due to being citrate soluble, and the remainder is slowly made available by micro-organisms and soil chemistry.

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Then there is the difference between *BioAgPhos* and other forms of reactive rock phosphate. BioAg uses a high-grade base product, reactive phosphate rock (RPR), inoculated with a microbial culture to make nutrients more readily available.

A key benefit in using *BioAgPhos* is the reduction in P runoff and phosphorus leaching, which has, in Jeff's opinion, been the reason for high populations of yabbies and fish in his dams.

As Jeff says, this can be the most cost-effective renovation you can get. There is no weedicide program; bracken is kept at bay with a good P regime in the paddocks and dumping hay on plants that are seen when supplementary feeding.

i Terminology for Phosphorus Transfer; P. M. Haygarth* and A. N. Sharpley; 2000

ii Environmental impact of nitrogen and phosphorus fertilisers in high rainfall areas of Western Australia; 2020

iii Protect our waters Protect our health A guide for landholders on managing land in drinking water catchments; Victorian Government 2010

iv Effects of stock type on soil physical properties and losses of phosphorus and suspended sediment in surface run-off; Fiona Curran-Cournane etal; 2010

v Estimating phosphorus loss from New Zealand grassland soils; R. W. MCDOWELL, L. M. CONDRON: 2004

vi Corangamite Region 'Brown Book' - How to optimise your soils to enhance productivity

vii A field study of phosphorus mobilisation from commercial fertilisers; D. NashA,C, etal; 2004.

viii Alternative fertilisers and management to decrease incidental phosphorus loss, W. McDowell & W. Catto, 2005

ix Potential phosphorus losses in overland flow from pastoral soils receiving long-term applications of either superphosphate or reactive phosphate rock, R. W. MCDOWELL, etal; 2003

x Phosphorus fertilizer form affects phosphorus loss to waterways: a paired catchment study; R. W. McDowell; 2010

xi The mitigation of phosphorus losses from a water-repellent soil used for grazed dairy farming; R.W. McDowella, W. Catto, N.L.S. McDowell; 2019

xii Development and evaluation of an improved soil test for phosphorus. 2. Comparison of the Olsen and mixed cation-anion exchange resin tests for predicting the yield of ryegrass grown in pots; S. Saggar etal; 1992

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