**Phosphorus Problems and Solutions: Part 2**

An ecological solution to keeping phosphorus (P) in the soil profile is to mimic natural ecosystems by keeping live plants and live roots recycling soil nutrients. P stratification in the topsoil is natural in forests and prairie systems and occurs from decomposing vegetation. Live plants absorb soluble nutrients and keep both nitrogen (N), P, and other micronutrients recycling. The soluble nutrients accumulate at the soil surface, but with good soil structure, the nutrients are washed slowly into the soil, where either the plant roots or the soil mineralogy tie up dissolved reactive phosphorus (DRP).

Our natural ecosystem has been broken from excessive tillage, a loss of SOM, and plow pans 7-9 inches deep, causing soils to become hard and saturated with water. Vertical tillage (3-4 inches deep) has become popular and is creating new soil layers that restrict the downward movement of water into the soil profile. Under saturated conditions, iron is releasing DRP and is subject to P runoff, either over the surface (0.5#P/Acre) or directly to tile lines through preferential flow (1.2#P/Acre) without being treated (Dr. Kevin King). In natural systems, the micropores generated by live roots and earthworms slow the water down, allowing the DRP to be absorbed. ECO Farming using no-till and cover crops mimics the natural cycles and restores the soil so that the P stays in the soil profile.

All farmers should obtain a soil test to know how much P fertilizer or manure to apply and the soil tests should follow university recommendations for P fertilization. No fertilizer should be applied over the critical level needed for crop production. The goal is to get farmers to use less P and to use it more efficiently. Current P use efficiency is only 10-30%. P fertilizer is expected to become more expensive as USA phosphorus reserves are used up by the year 2040.

Farmers should be encouraged to inject P fertilizer, not incorporate fertilizer. Incorporation implies tillage (plowing or disking) which is causing poor soil structure and soil compaction, and increased soil erosion. The bioavailable P in sediment is 30% available to algae and plants and is a significant source of P runoff. Farmers are banding less P with their starter fertilizer because it slows down planting but fall surface applied P fertilizer may be lost with snow melt or spring rains. Technology needs to be developed that encourages P injection without excessively tilling the soil for our conventional tillage farmers.

For No-till farmers, encourage cover crops and allow applying surface P fertilizer since improved soil structure, increased water infiltration, and higher water storage allows P to be tied up by plant roots or the soil mineralogy. High levels of active organic matter (ExP) and humus bind soil P. The P in the residue remains plant available and improves P use efficiency so that less P fertilizer is needed.

A total ban on Ohio winter application of manure will be difficult because of numerous small dairies that do not have adequate manure storage. The banning of manure to snow covered soils on conventional tilled fields (especially soybeans) may be justified but not on pasture, hay fields, or grass cover crops (2-4 inches of dense growth). Grass cover crops like cereal rye, annual rye, barley, triticale, wheat have live roots that soak up soluble manure nutrients. The soil is not frozen solid because the live roots cause the soil to honey comb. Bare soils are not insulated and tend to freeze deeper and denser. When conventional soils melt, they melt quickly and water runs off, taking soluble nutrients with the flowing water. With pastures, hay fields, and cover crops; the soil melts earlier and slower, allowing manure nutrients to be slowly absorbed, reducing nutrient runoff.

In some areas, legacy P is a major issue where soil tests P levels are so high that the soil is super saturated with P. These soils are constantly releasing DRP whether it is in the sediment, waterways, filter strips, stream beds or in the soil profile. Some soils are so saturated, they just may not be able to hold any more P. Legacy P is a major reason why most of our best management practices appear to be slow to respond. The legacy P is so high in the system, that it takes a long period of time before P is tied up (250 to 300 years in some cases). The best way to manage legacy P is to tie it up into a stable form including SOM and aluminum (alum/aluminum sulfate).