Phosphorus Problems and Solutions: Part 1

Ohio legislators are considering a number of rules and regulation regarding phosphorus (P) fertilizer and manure. The following article outlines some facts about P runoff. Weather is one of the biggest culprits in P runoff. Over the last several decades, precipitation has changed with more numerous precipitation events occurring with higher amounts, longer duration, and increased intensity. Due to weather, the key facts are that 90% of P runoff comes from 1-2 major runoff events each year and 80% of P runoff comes from 20% of the soil (Dr. Andrew Sharpley). Location and transport are key factors. Fields close to a creek, stream, or river contribute a considerable amount of P in surface runoff. Most soil P is stratified and P is located in the top 2-3 inches of the topsoil and subject to soil erosion and surface runoff.

On measuring P runoff, the P concentration (usually measured in parts per million) times the transport factor (volume of water runoff) equals P lost in surface water. Many researchers concentrate too much on P concentration and sometimes ignore the P transport. For example, no-till and cover crops typically have 10% to 50% higher P concentrations in the surface water, however; they also have a 10-100x times less runoff (Dr. Kevin King Research). A Coshocton study on long-term (>50 years) conventional fields had >1500 inches of runoff compared to long-term no-till with <7 inches. A major focus should be on reducing water runoff volume and reducing the energy in moving water by slowing it down because less runoff reduces the amount of P lost from farm fields.

Reducing the speed that water runoffs off the soil surface reduces nutrient loss. A doubling of the speed of water in a ditch or creek increases expediently (2^6 = 64X more) the amount of water and nutrients that can be carried away. So water moving at 16 mph in a stream carries 512X more nutrients and at 32 mph 1,024X more nutrients than water flowing at 1 mph. Slowing water runoff reduces the flashiness of our streams and reduces the amount of nutrients lost from a field. Cover crops and no-till protect soil from erosion, increase water infiltration, and reduce the speed and flow of water so that less nutrients are lost in the surface runoff.

How is soil P stored? Organic P (humus, active organic matter) tie up 50-80% of soil P in a stable form that can be made plant available. Aluminum (Al^{3+}), Iron (Fe^{3+}, Fe^{2+}), calcium (Ca^{2+}), and dissolved reactive P (DRP) are inorganic forms of P associated with the soil mineralogy. There are two forms of P that are plant and algae available, exchangeable P (ExP) from active organic matter and DRP which is an inorganic form. The ExP has a longer carbon chain and is less likely to be lost from the soil profile. Active organic matter in the ExP comes from live root exudates and mucilage, microbial wastes, and other carbon sources (ExP > DRP in soil storage).

Soil organic matter (humus) ties up a majority of soil P in a stable form compared to the inorganic sources (SOM>Al^{3+} > Fe^{3+} > Fe^{2+} > Ca^{2+}) however SOM levels have decreased 50-60% in the last 50-100 years due to excessive tillage. The aluminum, iron, and calcium P is not considered plant available however they can become plant available slowly over time unless the soil becomes saturated.

Iron is a major element in our soils and is a major problem in Northwest Ohio soils because it releases the P to surface water. Under saturated soil conditions, Fe^{3+} release DRP quickly and converts to Fe^{2+} and when the soil dries out, the Fe^{2+} converts back to Fe^{3+} tying up DRP. How often do you see saturated soils after a rain in Northwest Ohio? When water is standing on your field, iron is the bad boy releasing DRP to our creeks, ditches, and streams. Saturated soils are a common problem due to poor soil structure and soil compaction caused by excess tillage.

In my next article, looking at possible solutions, I discuss how no-till and cover crops improve soil structure, reduce soil compaction, increase water infiltration, improve water storage, and result in less water and P runoff. Increased active carbon from live roots improves soil structure and results in long-term SOM. All these soil health benefits can save the farmer money through reduced fertilizer inputs and increase crop yields over time resulting in improved long-term profits.