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The Phosphorus Cycle – From Mine to Farm, to River

Phosphorus (P) is one of the most vital elements and nutrients on the planet. There is no substitution for it biologically in plants, animals, or people. Very likely, this nutrient will become more and more controversial in the future. Understanding the near monopolized market of this fertilizer, why it is so expensive, and how it can even be monopolized requires an understanding of the nature of the element itself and where it can be found.

Phosphorus makes up 0.09% of the Earth's crust by weight. That's actually a fairly common element. On average there is around 3000 lbs P per acre locked within the rock and soil matrix. Phosphorus is very rare in some places on the planet and some locations have lots of it in the form of rock phosphate. This rock phosphate was formed from the mineralization of ancient sea creatures that were deposited within sediments on the ocean floor. Much like oil and natural gas, economically viable concentrations occur in specific places on the planet. In the U.S., most of our P comes from Florida, and nearly all of it is owned by the Mosaic Company (which has 80% of the U.S. market share). Other states with (much smaller) phosphate mines include North Carolina, Idaho, and Utah.

For the past hundred years, the United States has mined and used the most phosphorus. Only in the past decade has China become the dominant miner and user. This is in contrast to where most of the concentrated P is located. The little county of Morocco is said to contain 70% of the world's phosphate rock. The U.S. and China have less than 10%. The need for phosphorus in the U.S. and China is so great that despite being large P producers, Moroccan P imports have increased since the 90s.

The real question is, what are we going to do about high phosphorus prices, and how can phosphorus be better managed? Not only now, but also in the future when P becomes even more difficult to find. The American Chemistry Society states that 80% of P that is mined never makes it to the dinner plate. There are some logical places for some of those losses as most of our grain crops go into animal production, and not all animal waste is redistributed back into crop fields. When it does, it's not always even. One study estimated that in the U.S., 27% of farm ground has an excess amount of P. This percentage is certainly much higher in locations with a concentration of cattle feed lots, poultry or swine operations. These areas of high P levels result in an increased loss from the P cycle. As phosphorus is tightly bound to soil particles, much of ag P loss happens with soil erosion. It is estimated that over 50% of applied P is lost to agricultural runoff. Personally, I'm fairly certain that the real percentage of P lost in runoff is way lower, but still leakage from the P cycle is an issue. As many of you know, much of this P loss results in our lakes and rivers having huge quantities of P laden sediment trapped at their bottoms and a much smaller portion dissolved in the water. There is currently no economical way to get this P back onto crop fields. There are likely 100s of thousands of tons of P trapped within the sediments of rivers and lakes just within Kansas, though no study has really estimated this number recently.

What can we do to tighten the P cycle? One big change to P loss in the U.S. would be to spread out confined feeding operations and, therefore, manure applications. Hauling manure is expensive due to its weight, but so is altering industrial supply chains. As a society, another place to limit P loss is in areas of confined human operations, aka cities. Millions of tons of P pass through municipal water supplies each year while millions more tons end up in landfills from food waste. Of course, reducing food waste would mean less need for P fertilizer in the first place, affecting both sides of the P loss cycle. However, altering people's habits on such a massive scale is in no way an easy task.

On the local level, there is still plenty that homeowners and farmers can do. It begins with taking and fully following the results of a soil test. There are lots of yards out there that get fertilized and never need it, lots of gardens out there with more phosphorus than will be used in an entire generation, and lots of fields out there with far more P applied than will increase yield. Of course, since most P is adsorbed onto soil, limiting soil loss will play a big part in it. Pastures are part of the process, too. While pastures have less total P loss because they lose less topsoil, they often have a high dissolved P loss. Having the hay bunks next to waterways and feeding in the same location year after year only concentrates the nutrients while increasing P losses. Nearly every pasture is going to have P "hotspots" that need to be accounted for during soil sampling. Hay fields and pastures can often represent both extremes, with P hotspots in some areas and also areas that are completely devoid of plant available P. Phosphorus is complex, non-renewable, and one day might be as hard to come by as oil, except P will never have a substitution. For now, all we can do is preserve what we've got by only applying if needed, limiting areas of high P concentration in the field and pasture, and preventing soil erosion. And, as you know, extension has lots of publications on the topic. If you have any questions about soil fertility, please give James a call at 620-724-8233.

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