Global Phosphorus Flows and Forms

by Tom Bruulsema, *CCA-ON*

The flows of phosphorus on a global scale are critically important to sustaining the health of humanity and ecosystems. But perceptions of these flows, and of stocks, vary widely, leading to different opinions on how to manage the issues related to phosphorus use. This article will attempt to sort out what's known and what's unknown about phosphorus flows. In so doing, we may learn something about phosphorus forms and improving their management.

At a recent workshop in Washington DC, a group of scientists discussed the theme of phosphorus sustainability.

Interesting differences emerged among their perceptions of global phosphorus flows. They agreed that the amounts mined and put into the agri-food system as fertilizer, feed and foods total to more than four times the amount in foods consumed. They disagreed, however, on the fate of the phosphate that doesn't get into the food. Some had the impression that global losses to water amounted to as much as 46 percent of the phosphorus mined. Others pointed out that measurements from monitoring runoff and drainage on-farm at field edge typically show much smaller losses to water, generally less than 5 percent, with a few occasional exceptions no more than 17 percent. Why so great a difference in scientists' perceptions of the ultimate fate of phosphorus?

It turns out that a lot depends on the estimate of the global rate of soil erosion.

Much work has been done to develop tools to measure and manage soil erosion. The Universal Soil Loss Equation, refined and revised over time, uses highly detailed input information to estimate the amount of soil eroded from a slope of defined gradient and length. It does not, however, indicate the fate of that soil. How much is deposited at the foot of the slope? Onto the alluvial plain beside a stream or river? How much is carried to far away bodies of water? These are important questions related to the fate of the particulate form of phosphorus. They remain unanswered in many regions of the world. It's possible that the high estimate of global losses arises from extrapolation of erosion rates to sediment delivery rates, when in fact much of the eroded soil may not have left the watershed, and maybe not even the field.

In a few large and diverse river basins, however, phosphorus balances provide a few answers. Total river exports of phosphorus, including the particulate form, amount to about 6-13% of the fertilizer P applied in major agricultural watersheds like the Maumee in the USA, the Thames in the UK and the Yangtze in China. That suggests that most of the fertilizer either goes into the harvested crop or remains in the soil. The amount delivered to water, though small relative to fertilizer, still needs to be managed, since in all three rivers, water quality would be improved if phosphorus losses were less.

The fraction remaining in the soil also needs to be managed.

On sloping land susceptible to erosion, sediment loss can indeed remove more phosphorus than crops. Soil health depends on controlling soil erosion. Conservation practices are essential to controlling the loss of particulate forms of phosphorus, while 4R practices—applying the right source of phosphorus at the right rate, right time and right place—control the loss of dissolved forms, and ensure that any legacy phosphorus is used for the benefit of crop production. With conservation practices and well managed applications, total losses can be reduced to as little as one percent of applied phosphorus, as documented in a recent *Better Crops* article by Andrew Sharpley and others on edge-of-field losses measured on privately-owned farms in Arkansas.

Perceptions of phosphorus flows influence how its forms are managed. At the farm level, paying attention to inputs, outputs and the stock in the soil pays dividends in terms of profitable crops, healthy soil, and improved water quality.

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