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James J. Hoorman
Hoorman Soil Health Services
Cell 419-421-7255

Reducing Sediment and Nutrient Runoff: Problems (Part 1)

In 2019, Lake Erie had the 5th largest Harmful Algae Bloom (HAB) due to record water runoff and 2-3 feet higher water levels than normal. Lake Erie also had the highest total sediment, total nitrogen, and total phosphorus loads ever recorded, but the extra water diluted the sediment and nutrient concentrations, possibly reducing the impact. Examining the facts and problems may offer some possible solutions.

About 60% of phosphorus (P) nutrient loads come from the Maumee River watershed (Johnson, 2018). Roughly 30% of P comes from surface runoff and 70% from subsurface (tile) runoff through preferential flow (soil cracks, crevices) with about 90% of the losses occurring during the most intense rainfall events (Watters & Hoorman, 2018, Fussell et al. 2017). Depending on the soil and landscape, 60 -90% of P come from 10-40% of land, generally on soils located close to or with access for transportation to ditches and streams. Average Ohio P loss is 1-1.2# P/acre with a goal of losing less than .4# P/acre. Farmers are roughly 97% efficient at keeping P fertilizer on the land (assumes 1.2# of P lost for 35# of P fertilizer applied). As much as 50-70% of soluble soil nutrients (N & P) may be lost in late winter (snow melt) & early spring (heavy rains) according to Owen et al. 1995. These facts vary by soil type and local conditions. The following factors are important:

Weather: Rainfall events are more numerous, larger intensity and longer duration since 1970's. The soluble reactive phosphorus (SRP) flows with the water but Particulate P (soil attached P) also erodes from the soil and is 30% bioavailable in surface runoff. Soils lose most SRP during the most intense high rainfall events.

Tillage: Average Ohio soil erosion rates are 2.61 tons per acre or 1.7 pounds of topsoil lost for every pound of soybean produced based on 50-bushel average yield (USDA-NRI, 2015). Tillage increases soil erosion by sealing off the soil surface. Vertically tillage on conventional fields have about five times more sediment losses and three times more SRP losses than long-term no-till fields (Smith et al. 2015). Tillage also causes poor soil structure (compaction) and the soil to shrink and swell, leading to higher preferential flow. Vertical tillage (2 to 4 inches deep) popularity has increased since 1995, causing new shallow plow pans to form and increased surface runoff.

Stratification/Placement of P at Soil Surface: Due to larger farms, most P fertilizer is broadcast on the soil surface, causing P to runoff during high rainfall events from soil sealing from tillage. It is not uncommon to see standing water in fields now after light rains. The form of P fertilizer has changed too with DAP and MAP being more soluble than the old triple super phosphate fertilizer. Some researchers advocate incorporation (heavy tillage) to mix and dilute SRP in soil surface.

Tillage tries to fix the SRP problem but may cause excessive soil erosion and then seals the soil surface, breaking down soil structure, and decreasing water infiltration.

How is P stored in the soil? About 50-70% of soil P and 85-90% of N is stored organically in soil organic matter and this form is plant available. Aluminum **(AL),** Iron **(Fe),** Calcium and Magnesium **(Ca/Mg)** store P inorganically, but NONE is directly plant available. Al ties P up tightly, Ca/Mg less tightly. Fe has two forms: Ferric P (Fe^{3+}) and Ferrous P (Fe^{2+}) which are unstable. Ohio soils have about 1.43% iron content. Ferric-P (soil looks red/pink) and becomes Ferrous-P (blue gray) under saturated (wet) soil conditions, releasing SRP which may be lost to surface water or through preferential flow to tile water. However, when the soil dries, iron can steal P from Ca/Mg, which means it can be lost again with another rainfall event. This explains why Ohio SRP concentrations remain steady and high even after many rainfall events.

Rainfall pH: Another confounding factor, the 1995 Clean air act changed rainfall water pH from 4.2 (acid rain) to 6.2 (more alkaline) today. The main effect is that iron (Fe) in the soil now holds on even less tightly to SRP when it rains due to changes in rainfall pH (Smith et al. 2017)! This may explain why even forested land is losing SRP to surface water. While we may have cleaner air, the unintended consequence may be more SRP in surface water. We'll look at possible solutions next time.