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Reducing Sediment and Nutrient Runoff: Potential Biological Solutions (Part 2)

Dealing with sediment and nutrient runoff issues is complicated. The 4R's (Right Source, Rate, Place and Time) are15-30% effective at keeping soluble nutrients out of surface water and fails to address how soil nutrients are stored. Our carbon (C), nitrogen(N), and phosphorus (P) cycles may be damaged, so water quality improvements may be difficult until these biological cycles are restored.

Soil organic matter (SOM or carbon) is a warehouse for holding water and soluble nutrients and buffers soil pH. The cation exchange capacity (ability to hold soluble positive soil nutrients) is 9-10X higher in SOM than in clay soil particles. As our soils lose their SOM (50-80% loss due to tillage), soil function declines and our soils become leaky. If this is really a biological problem, then maybe the 4R's and technology might not be the best overall solution. What evidence exists to show that biological solutions may solve this problem?

First, Brady and Weil, (Nature and Properties of Soils) show that conventional tilled soils with low SOM had 8X higher soil erosion and soluble nutrient loss than undisturbed natural soils. Both had high P soil test, but the natural undisturbed soil had more organic P (P tied up by carbon) while the tilled soil was mostly inorganic P. Disturbed tilled soils are leaky and promote poor soil structure and higher sediment and soluble nutrient runoff.

Second, is there anywhere in the USA where biological solutions have been successful? The Chesapeake Bay region has promoted cover crops and long-term no-till for 15 years, resulting in a 42-45% improvement in water quality. The Chesapeake Bay is a huge body of water and large watershed; so it took 10-15 years for the soluble nutrients and sediment to move to the bay. The good news for Lake Erie (and possibly other smaller watersheds), is that the water retention time is shorter (two years for Lake Erie), so significant change may occur quickly.

Third, Smith et al. 2015 showed that long-term no-till fields had 3x less SRP, 3x less total P, and 5x less sediment loss than conventional tilled soil. Most research shows that using biological solutions and plants (buffers, filter strips, wetlands, cover crops, prairie strips) are effective, but large areas need to be covered to see positive results.

USDA-NRCS S has promoted Four Major Soil Health Principles that addresses soil erosion and nutrient runoff and restores soil function while producing economical high yields. **First Principle: Maximize soil cover** to reduce soil erosion and to reduce rain drop impact. A raindrop on bare soil may move soil 2 feet high and 4 feet out, displacing both soil and soluble soil nutrients.

Second Principle: Minimize soil disturbance to maintain soil structure and water infiltration AND soil connectivity to subsoil**.** Long-term no-till soils allow water to flow slowly and evenly into soil so that nutrients are absorbed by either plant roots, soil microbes, or soil minerology. Tillage ruins soil structure (causing compaction) and decreases water infiltration, causing water to runoff the soil surface OR flow by preferential flow (PF) to surface water via tile discharge.

Third Principle: Maximize live roots to 1) increase soil pore space, water infiltration, and water storage; 2) to fill soil cracks, earthworm holes, and large voids to prevent PF, 3) to allow live roots to absorb soluble N & P and 4) to increase SOM. Most soluble nutrients are absorbed and recycled by the soil microbes and live roots which together build SOM. There are 1000-2000X more soil microbes near live roots and each microbe is just a soluble bag of fertilizer feeding the plant.

Fourth Principle: Maximize Biodiversity with multispecies cover crops and diverse crop rotations. Grasses have fibrous roots and broadleaves have taproots which move water into the soil profile. Soluble nutrients are stored in living plant tissue during the fall, winter, and early spring months and released in the summer to fertilize our grain crops.

In stable undisturbed soils, arbuscular mycorrhizae fungi (AMF) flourish, forming a soil network that transports nutrients and water to the plant in exchange for sugars. AMF supply the plant with 6X more P than the plant can obtain by itself, greatly reducing the need for P fertilizer. Tillage, bare fallow soils, fungicides, and over P fertilization cause AMF levels to decline in the soil. The Four Major Soil Health Principles allow AMF and biological diversity to flourish, decreasing the overall need for fertilizer and restores our broken C-N-P cycles.