Non-point phosphorus pollution from groundwater in Georgia, Vermont

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BACKGROUND

Phosphorus is a highly reactive element that is essential for life and forms a variety of compounds in terrestrial and aquatic ecosystems. In agriculture, phosphorus is added to soil by using chemical fertilizers, manure, and composted materials. Leaching of applied fertilizer and surface runoff of phosphorus from the soil can contribute to excess growth of algae in downstream water bodies, a condition known as eutrophication- which depletes dissolved oxygen. Low concentrations of dissolved oxygen can stress or kill sensitive species living in the water and lessens the overall value of water bodies for humans.

PURPOSE AND HYPOTHESIS

Phosphorus is largely retained in soil by a process called adsorption. Soils have a limited capacity to store phosphorus, and once the capacity of soil to adsorb phosphorus is exceeded, the excess will dissolve and move more freely with water either directly to a stream or downward to an aquifer. Surface-water runoff from rainstorms or excess irrigation is the primary way that phosphorus or soil containing phosphorus is transported to streams in most watersheds. However, there is a growing awareness that long-term over-application of manure and chemical fertilizer contributes to phosphorus movement into the groundwater system, resulting in a significant groundwater source of phosphorus to streams and lakes, as well as potential contamination of the groundwater resources.

In this study we sought to quantify the contribution of dissolved phosphorus in groundwater to phosphorus pollution in streams and other water bodies. We hypothesized that in response to rainfall, rising groundwater levels can add significant dissolved phosphorus to streams from the edges of fields.

Figure 1. Site Map showing flow of water from fields and forests into stream (bottom picture) and sites where piezometers were placed (top picture).

MATERIALS AND METHODS

The Site: 21 holes were hand-augered to a depth of ~4 feet, and a miniature piezometer was placed in each. (Figure 1)

Monitoring: At least once per week and after precipitation events, the hydraulic head heights in each piezometer were measured using an electronic depth gauge.

Surveying: Used total station to find the vertical distance between reference points of piezometers to calculate relative hydraulic head heights.

Water Sampling: To collect water samples from each piezometer, a peristaltic pump was used to pump water from well until clear of sediment and pumped into 250 mL bottles. These water samples were refrigerated within an hour of collection or processed immediately using the Murphy and Riley (1962) colorimetric determination of orthophosphate concentration in solutions.

Soil Sampling: From each of the four sites, a bag of soil was collected from each foot in depth. The soil was then air dried in an oven overnight at 65° C and sieved. To determine phosphorus bound to the soil particles, a Parkinson and Allen digestion was performed and Phosphorus was measured using the Murphy and Riley (1962) method and a spectrometer.

RESULTS

The dissolved phosphorus readings obtained from the spectrometer for the water samples from all piezometers were below detection limits. The total phosphorus readings from the digested field soil samples showed a range of 5 to 12 mg/kg (Figure 2).

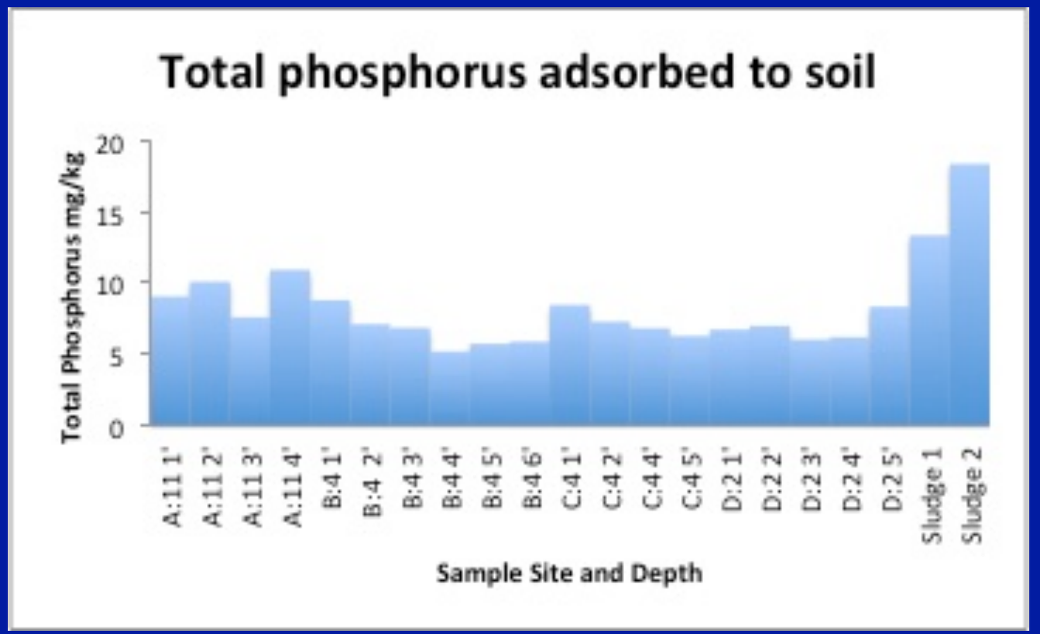

Figure 2. Soil was collected from one hole from each site at various depths. Soils from Site A had slightly higher total phosphorus levels than other sites.

RESULTS

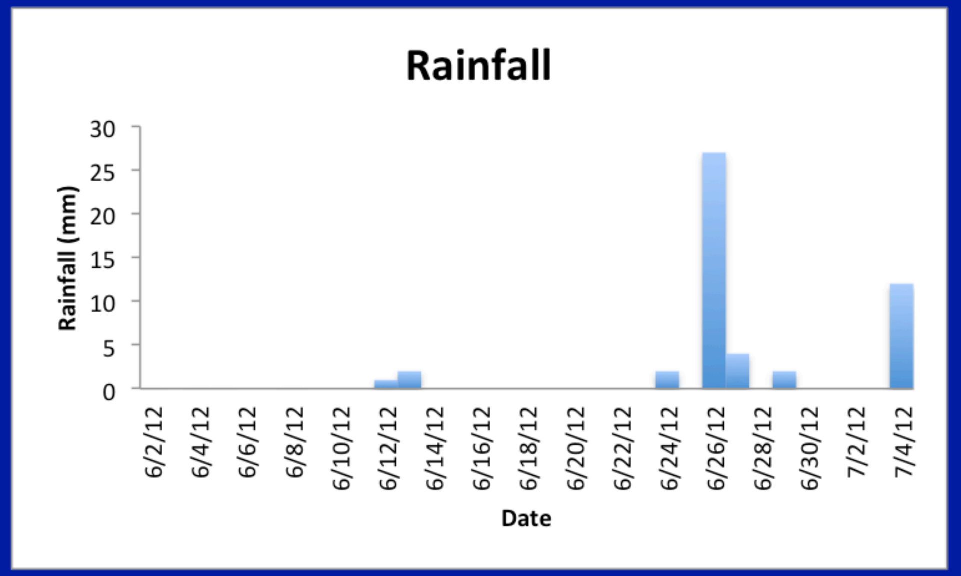

Figure 3. Rainfall

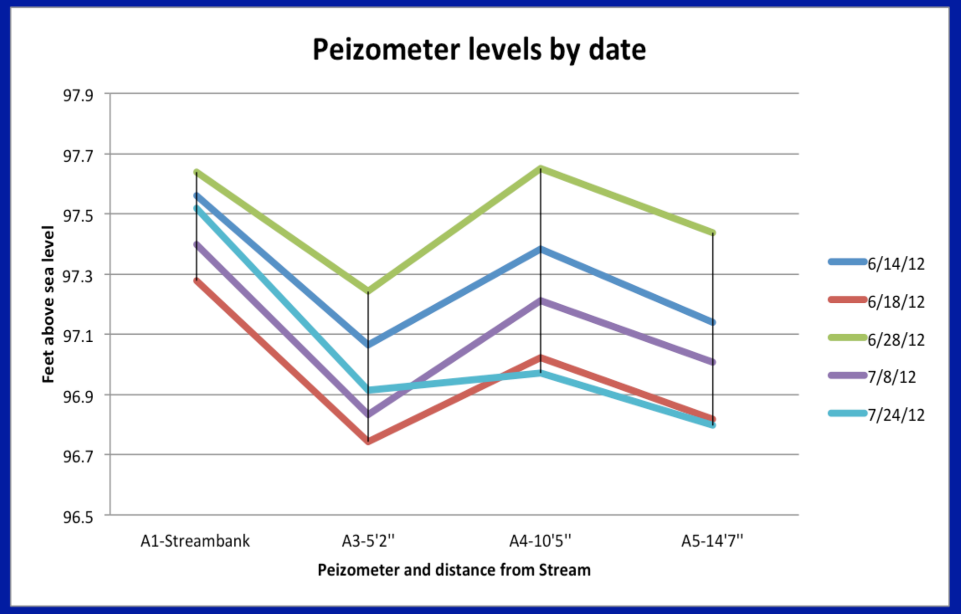

Figure 4. Water Levels-North Transect

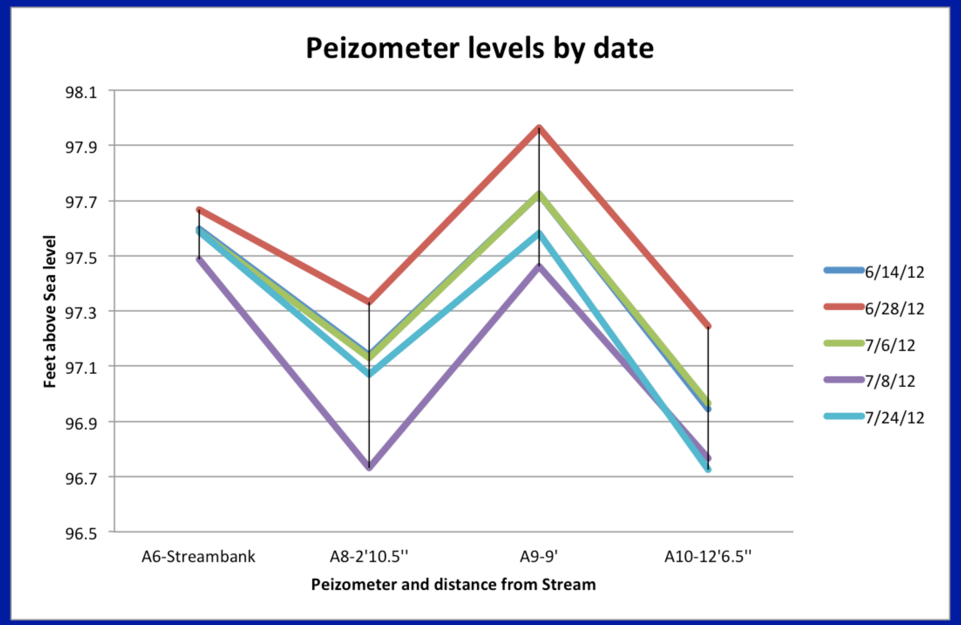

Figure 5. Water Levels-South Transect

Figure 6. Site A Piezometers

DISCUSSION

The strikingly low amounts of phosphorus contained in the groundwater at all sites was a surprise. We believe that low rainfall over the course of the summer field season failed to detach phosphorus from soil particles and make its way into groundwater (Figure 3). The trend line of the piezometers reflects what we might expect from a season with very little rainfall (Figures 4 and 5). Overall, the water levels decrease as you move away from the stream, indicating an overall flow of water out of the stream into the soil and ground water flanking the stream. In a season with more rainfall, we might expect the flow of water to be in the opposite direction with the streams being fed by groundwater. In both of the transects we see the highest water levels in all piezometers the day of and after the largest rain event of the summer. This rain event shows the affect of overland flow and how water travels from above the field of study, through the forest and down through the ditches and the field to collect in the stream at Site A (Figure 1). Even during this large rain event, the overall flow of water was flowing out of the stream in the groundwater, supporting the notion that there was not groundwater flow to detach and carry dissolved phosphorus to the stream. The total phosphorus found in the soil samples supports the possibility of leaching of dissolved phosphorus from the soil and groundwater movement of phosphorus (Figure 2).

CONCLUSIONS

From this study we can conclude that in a summer characterized by low rainfall, ground water levels are not sufficiently elevated to support adequate groundwater flow to add dissolved phosphorus to streams. However, to create a complete picture of the addition of dissolved phosphorus to streams, this study should be carried out during summers with average or above average rainfall.

References

Domagalski, J.L., and Johnson, Henry, 2012, Phosphorus and Groundwater: Establishing Links Between Agricultural Use and Transport to Streams: U.S. Geological Survey Fact Sheet 2012-3004, 4 p.

"Phosphorus Doesn't Migrate in Groundwater? Better think again!." USGS:Toxic Substances Hydrology Program. N.p., 13 2010. Web. 12 Dec 2012. <http://toxics.usgs.gov/highlights

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