Effects of a Chicken Processing Plant on Graves Creek in Blount County

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Abstract:

Nutrient pollution causes eutrophication of aquatic systems. Although eutrophication is associated with collapse of lotic ecosystems, rivers and streams are also impacted by excess nutrients. In 2014, Alabama reported 193 and 586 river miles impaired by nitrogen and phosphorus, respectively. Waste from animal feeding and processing operations may contribute to this nutrient loading. Alabama has numerous poultry operations, including an active chicken processing plant in Blount County. This plant discharges wastes into a wetland that empties into Graves Creek, a tributary of the Locust Fork of the Black Warrior River. We predicted that these discharges would result in higher conductivity and elevated levels of Nitrates and Phosphates in Graves Creek downstream of the plant compared to upstream. We collected duplicate water samples on three occasions at eight locations in Graves Creek, monitored the conductivity, and tested them for Nitrates and Phosphates using HACH colorimeter test. We also used a Spectrometer (Shimadzu ICPE-9000) to do elemental analysis of the water samples. Nitrates, and Phosphates downstream of the plant were significantly higher than upstream as were elemental calcium, potassium, sodium, phosphorus, and conductivity. Although Alabama does not regulate nitrates and phosphates in surface waters designated for "Fish and Wildlife," the levels in the discharge were higher than recommended for aquatic life by other states. The discharges of phosphorus from the wetland exceeded ADEM water quality criteria (AL 335-6-10) for aquatic life (≤ 1.0 mg/L). The discharges into Graves Creek have the potential to create eutrophication and contribute to Alabama's impaired waters.

Introduction:

- Alabama has abundant ground water that could infinitely sustain its inhabitants if minatained properly.
- Nitrates and unauthorized hazardous waste disposal sites are top sources of ground water pollution (ADEM, 2015).
- Nitrates are necessary for life. However, an overabundance of nitrate creates hypoxic conditions that threaten aquaticecosystems.
- Excess phosphate in water can cause eutrophication.
- The excess algae blooms that occur in response to eutrophication can make people sick if they come into contact with polluted water, consume tainted fish or shellfish, or drink contaminated water (EPA, 2015).
- Concentrated animal feeding operations (CAFOs) are sources of nitrate and phosphate pollution (Goodman, 1999).
- Discharge from concentrated animal feeding operations (CAFOs) enter creeks, rivers, and oceans through improper infiltration and surface runoff (EPA, 2015).
- Less is known of the effects of animal processing facilities on adjacent water systems.

Hypothesis:

We predicted that Graves Creek downstream from a wetland that filters runoff from a settling pond associated with a chicken processing plant would contain higher concentrations of nitrates and phosphates than upstream and that the increased levels of nitrate and phosphate would result in a higher conductivity downstream of the wetland discharge. We also predicted that the wetland would significantly decrease the concentration of nutrients compared to the concentrations in the settling ponds.

Methods:

- Graves Creek is located in the Locust Fork Watershed of the Black Warrior River in Northern Alabama (Fig 1).
- Samples were collected in Feb, April, and August.
- We collected 2 samples from each of 8 sites along Graves Creek (Fig 2).
- Samples were collected in acid washed, 250 mL plastic or glass bottles
- At each sample site, we measured the conductivity (HACH HQ14D).
- Samples were refrigerated (4 °C), then rewarmed (22 °C) to test for the presence of phosphates and nitrates using a Colorimeter (DR/890, HACH) and proprietary methods [phosphates (PhosVer 3 Phosphate Reagent, HACH), and nitrates (NitraVer X Test 'N Tube nitrate reagent, HACH)].
- After testing for nitrate and phosphate, samples were acidified (2% nitric acid) and analyzed for elements in water by spectrometry (Shimazdu, ICPE 9000).
- Differences in mean conductivity, nitrates, phosphates at different sites were compared using ANOVA (SPSS). Results were considered significant at $\alpha < 0.05$.

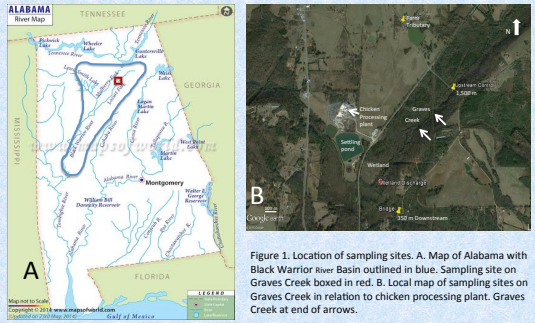

Figure 1. Location of sampling sites. A. Map of Alabama with Black Warrior River Basin outlined in blue. Sampling site on Graves Creek boxed in red. B. Local map of sampling sites on Graves Creek in relation to chicken processing plant. Graves Creek at end of arrows.

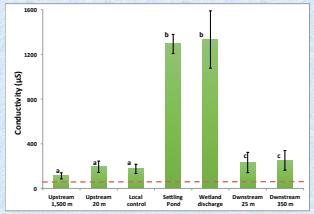

Figure 2. Comparison of mean conductivity of Graves Creek to wetland discharge and Settling Pond. Dotted line indicates mean conductivity in a farm stream that is a tributary to Graves Creek immediately upstream of the wetland. Letters indicate homogeneous populations (p <0.05) and bars indicate standard deviation.

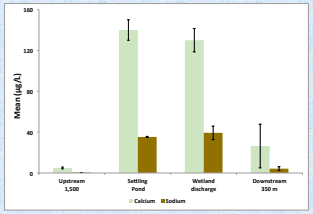

Figure 3. Comparison of mean concentration of calcium and sodium in Graves Creek. Both calcium and sodium were < 1 mg/L in a farm stream tributary of Graves Creek immediately upstream of the wetland. Error bars as in Figure 2.

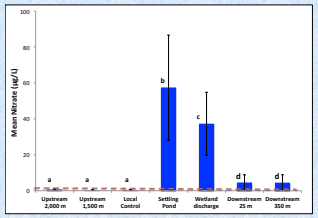

Figure 4. Comparison of mean nitrate concentration in Graves Creek to local nutrient sources including wetland and settling pond. Dotted line, letters and bars as in Figure 2.

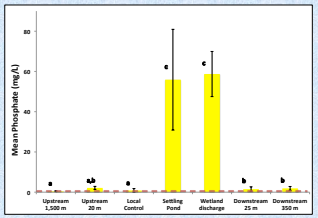

Figure 5. Comparison of mean phosphate concentration in Graves Creek to local nutrient sources including wetland and settling pond. Dotted line, letters and bars as in Figure 2.

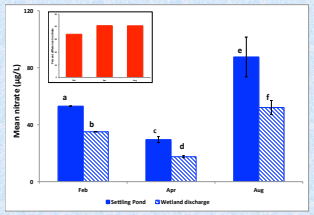

Figure 6. Comparison of mean nitrate concentration in nutrient sources. A. Insert of percent decrease in mean nitrogen between the settling pond and wetland discharge. Letters and bars as in Figure 2.

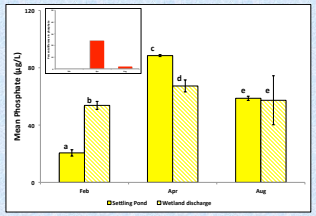

Figure 7. Comparison of mean phosphate concentration in nutrient sources. A. Insert of percent decrease in mean phosphate. Letters and bars as in Figure 2.

Results:

- Mean conductivity downstream of the wetland discharge was significantly greater than upstream ($F_{(7,73)} = 235.45$, $P < 0.001$). The conductivity in the discharge from the wetland mirrored that of the settling pond and was an order of magnitude larger than upstream controls (Fig. 2).
- The settling ponds and wetland discharge had concentrations of calcium and sodium at least two orders of magnitude greater than upstream Graves Creek (Fig 3). Iodine, potassium, magnesium, phosphorus, and sulfur were all at least an order of magnitude greater in the wetland discharge than upstream.
- Mean Phosphorus in the wetland discharge was 3.18 ± 1.42 mg/L.
- Nitrate concentration was significantly higher in sites downstream of the wetland discharge compared to upstream ($F_{(3,28)} = 4.705$, $P < 0.000$) (Fig. 4). Peak acute mean nitrate downstream of the wetland was 9.7 ± 0.7 mg/L.
- Mean nitrate was significantly higher in the settling pond than in the wetland discharge and both were significantly greater than upstream and downstream in Graves Creek ($F_{(6,42)} = 187.261$, $P < 0.001$) (Fig. 4).
- Mean phosphate concentration was significantly higher in sites downstream of the wetland discharge compared to upstream ($F_{(3,28)} = 4.705$, $P < 0.000$) (Fig. 5)
- Mean phosphate concentration was equivalent in the settling pond and wetland discharge, but significantly higher than upstream and downstream downstream in Graves Creek ($F_{(6,42)} = 31.695$, $P < 0.001$) (Fig. 5).
- There was seasonal variation in mean nitrate ($F_{(2,47)} = 53.994$, $P < 0.000$) (Fig. 6) and phosphate ($F_{(2,67)} = 5.423$, $P < 0.007$) (Fig. 7) concentrations. Nitrate had a three-fold concentration range in the settling pond, wetland discharge, and downstream of the discharge with lows in April and highs in August. Phosphate varied less with highs in April and the lows in February.
- The wetland removed up to 41% of the nitrate in the settling pond with a greater percent removal in April and August than in February (Fig. 6), but removed far less of the phosphate (Fig. 7).

Discussion:

- As hypothesized, nitrate and phosphate were higher downstream of the discharge from a wetland associated with a Chicken processing plant.
- Single samples of nitrate in Graves Creek exceeded the allowable maximum contaminant level (MCL) and the mean for the collection in February approached it, despite the fact upstream and local through farm properties did not exceed 1/10 of the MCL. This suggests that the chicken processing plant is altering the chemical stability of Graves Creek.
- The concentration of phosphorus from the wetland exceeded ADEM water quality criteria (AL 335-6-10) for aquatic life (≤ 1.0 mg/L).
- The Wetland does act to absorb some of the nutrients, particularly nitrates, but there is still a demonstrable effect on water chemistry.
- The most effective removal of nutrients by the wetland was during April in a season of rapid plant growth. The least effective was in February.
- The hypoxic effects of excess nutrients are persistent across decades in aquatic ecosystems (Jenny et al., 2015).
- These results suggest that more attention be given to the impacts of animal processing operations on Alabama's valuable resources and ecosystems.

Literature Cited:

EPA. (n.d.). Retrieved May 4, 2015.

Estimated Animal Agriculture Nitrogen and Phosphorus from Manure. Retrieved May 7, 2015, from http://www2.epa.gov/nutrient-policy-data/estimated-animal-agriculture-nitrogen-and-phosphorus-manure

Goodman, P. (1999, August 2). Permitting a Pattern of Pollution. Retrieved May 7, 2015, from http://www.washingtonpost.com/wp-srv/local/daily/aug99/chicken2.htm

Jenny, J.-P., F. Arnaud, B. Alric, J.-M., Dorioz, P. Sabatier, M. Meybeck, and M.-E. Perga (2014), Inherited hypoxia:A new challenge for reoligotrophicated lakes under global warming, Global Biogeochem. Cycles, 28, 1413–1423,

Hubbard, R.K.; Newton, G.L.; and Hill, G.M., "Water Quality and the Grazing Animal" (2004). *Publications from* USDA-ARS/UNL *Faculty.* Paper 274.

Nitrogen and Water. (2015, August 5). Retrieved September 7, 2015.