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 waste 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 Spectrophotometer (Shimadzu ICP-R5000) to do instrumental analysis of the water samples. Nitrates, and Phosphates downstream of the plant were significantly higher than upstream as well as elemental calcium, potassium, sodium, phosphorus, and conductivity. Although Alabama does not regulate nitrates and phosphates in surface waters, 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 (As 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 indefinitely sustain its inhabitants if mismanaged 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 nitrates creates hypoxic conditions that threaten aquatic ecosystems.
• Excess phosphate in water can cause eutrophication.
• The algae blooms that occur in response to eutrophication can make people sick if they come in 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).
• Loss 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 HQ40D).
• Samples were refrigerated (4°C), then rewarmed (22°C) to test for the presence of phosphates and nitrates using a Colorimetric (DR890, HACH) and proprietary methods (pho[V]3 Phosphate Reagent, HACH), and nitrates (NitravIR T Test ’N Tube nitrates reagent, HACH).
• After testing for nitrate and phosphate, samples were acidified (2% nitric acid) and analyzed for elements in water by spectrometry (Shimadzu, ICPQ 5000).
• Differences in mean conductivity, nitrates, phosphates at different sites were compared using ANOVA (SPSS). Results were considered significant at α < 0.05.

Results:
• Mean conductivity downstream of the wetland discharge was significantly greater than upstream (F = 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 that upstream (Fig 3).
• 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). Sodium, 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.
• Nutrient concentration was significantly higher in sites downstream of the wetland discharge compared to upstream (F = 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 = 31.695, P < 0.001) (Fig 4).
• Mean phosphate concentration was significantly higher in sites downstream of the wetland discharge compared to upstream (F = 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 in Graves Creek (F = 33.695, P < 0.001) (Fig 5).
• There was seasonal variation in mean nitrate (F = 53.994, P < 0.000) (Fig 6) and phosphate (F = 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 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 processing plant is contributing to the nutrient loading and affecting the chemical stability of Graves Creek.
• The concentration of phosphorus from the wetland exceeded ADEM water quality criteria (As 335-6-10) for aquatic life (≤ 1.0 mg/L).
• The wetland did to absorb some of the nutrients, particularly nitrate, 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: