Gypsum Increases Soluble Reactive Phosphorus and Blue-green Algae in Catfish Production Ponds

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Gypsum (calcium sulfate; typically, as a by-product of flue gas desulfurization) is commonly applied to ponds to increase hardness (i.e., concentration of calcium and magnesium in water) that supports the development of and physiological maintenance in fish. However, relatively little is known regarding the influence of gypsum additions on water quality. To understand how an application of gypsum (500 mg/L) affected water quality in active hybrid catfish production ponds, we conducted a replicated, six-month, whole pond experiment at a catfish farm in west Alabama from May to November 2022. The results showed significant effects of gypsum on several important water quality parameters, such as hardness (↑), alkalinity (↓), phosphorus (↑; including total and dissolved forms), and blue-green algae (↑). Such impacts of gypsum on available nutrients (e.g., phosphorus) that promote toxic and/or off-flavor producing blue-green algae (also known as cyanobacteria) could harm aquaculture production and reduce profitability, as the presence of off-flavors in fish flesh results in product waste and decreased market value.

To further explore the influence of gypsum on water quality in ponds, we used data from a recent experiment to show pond-specific dynamics in hardness (Figure 1A,B), alkalinity (Figure 1C,D), soluble reactive phosphorus (SRP) (Figure 1E,F), and blue-green algae (Figure 1G,H) after applying gypsum. In general, the untreated control ponds showed consistent patterns during the experiment. The exception to this pattern included two ponds that had spikes in blue-green algae (measured as the photosynthetic pigment, phycocyanin) at the start of the experiment (Figure 1G). By late June 2022, the control ponds stabilized for the remainder of the study.

Interestingly, ponds treated with gypsum showed both expected and some unexpected, undesirable impacts. First, hardness in ponds treated with 500 mg/L gypsum increased by 106% (average increase of ~130 mg/L $CaCO_3$) to ~250 mg/L $CaCO_3$ in the week following treatment, which is close to the expected hardness increase of 147 mg/L $CaCO_3$ given our gypsum dose (Figure 1B). Hardness quickly dropped to ~200 mg/L $CaCO_3$ and tended to stay at this concentration for the rest of the experiment.

Second, alkalinity in ponds treated with 500 mg/L gypsum rapidly decreased by 30% (with an average decline of ~36 mg/L $CaCO_3$) to ~83 mg/L $CaCO_3$ in the week following treatment (Figure 1D). Such a decline in alkalinity after increasing hardness with gypsum is expected due to calcium carbonate precipitation. Alkalinity continued to increase for the remainder of the experiment to an average of nearly ~200 mg/L $CaCO_3$.

Third and most surprisingly, the dissolved form of phosphorus that is used by phytoplankton to grow (soluble reactive phosphorus; SRP) increased in treated ponds by an average of ~455% to ~0.85 mg/L SRP from mid-June to October 2022 (Figure 1F). The control ponds only increased by 24% to ~0.16 mg/L SRP during the same time period (Figure 1E). Such an increase in available phosphorus can lead to more algae, including undesirable blue-green algae (Figure 1H). Curiously, one treated pond (H) showed no obvious effect of gypsum on soluble reactive phosphorus concentration. Such a high increase of available phosphorus after adding 500 mg/L gypsum in ponds was not expected (Wu and Boyd 1990); therefore, laboratory and field studies will be conducted to understand the factors that lead to SRP release from the sediments.

Lastly, although blue-green algae were increasing in most of the ponds before gypsum was applied in June 2022, blue-green algae doubled to ~771 µg/L phycocyanin the week following gypsum treatment and continued to increase to ~1100 µg/L phycocyanin by mid-August 2022 (Figure 1H). Although two of the treated ponds showed little change in blue-green algae over time (ponds 2 and 11; Figure 1H), the other three treated ponds had maximum blue-green algal concentrations that ranged from ~1,600 to ~2,400 µg/L phycocyanin during the experiment. There was relatively little change in blue-green algal concentrations in the untreated control ponds from July to November 2022 (Figure 1G).

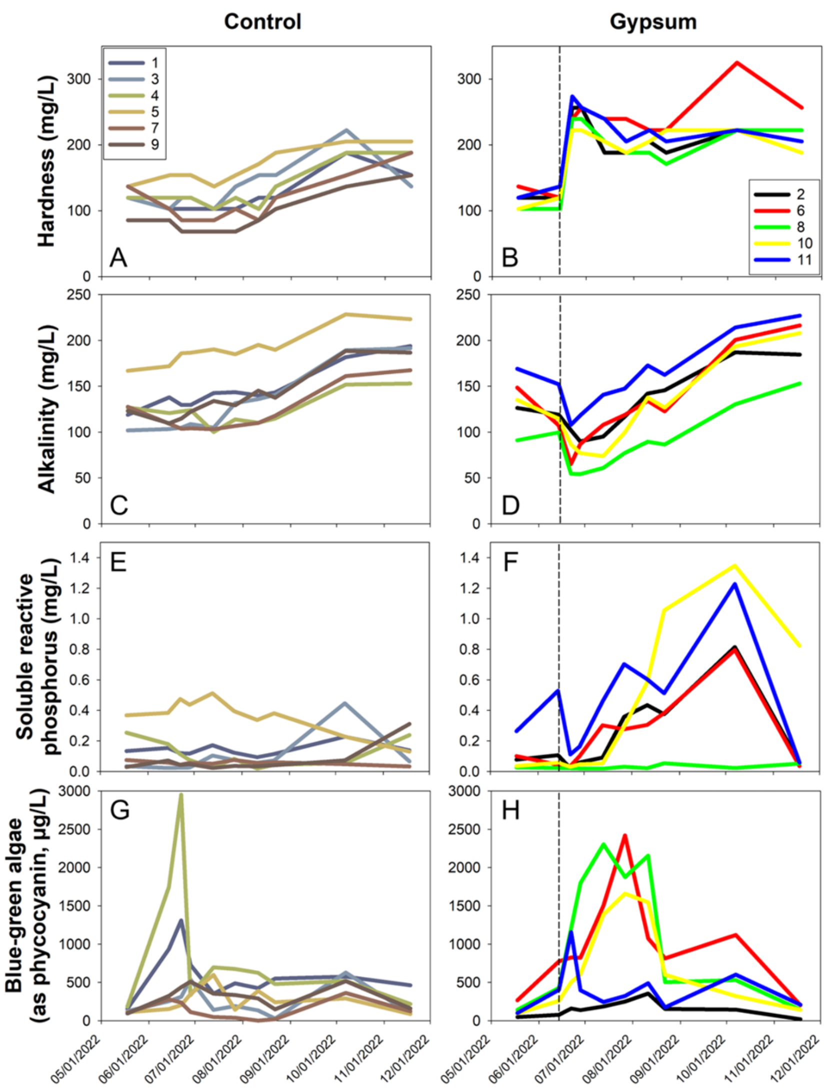

Figure 1. Water quality dynamics in catfish production ponds at one farm in west AL that were either left untreated (control) or treated with 500 mg/L gypsum on 14 June 2022 (dashed vertical line). Impacts of gypsum includes increased hardness (panels A,B), decreased alkalinity (panels C,D), increased soluble reactive phosphorus (panels E,F), and increased blue-green algae (panels G,H). Ponds are numbered 1-11.

Although gypsum applications to production ponds can benefit fish by making more calcium available for fish development and maintenance, the unexpected and dramatic increase in soluble reactive phosphorus following gypsum additions is likely due to the release of phosphorus from nutrient-rich pond sediments that subsequently promoted blue-green algae in most of the treated ponds. Since soluble reactive phosphorus is a dissolved form of phosphorus used by algae to grow, high soluble reactive phosphorus concentrations most often occur in ponds with little algae. However, we showed that gypsum additions led to both increased soluble reactive phosphorus and blue-green algae, suggesting that some other resources, such as nitrogen or light, were limiting algal growth in catfish production ponds.

In summary, we are actively conducting research to understand the interactions between gypsum and water quality and encourage aquaculture farmers to consider the pros (e.g., increased hardness) and cons (e.g., increased blue-green algae) of gypsum in advance of treatment to make sure that the desired results are achieved, and that plans are in place if water quality worsens.