guidelines (Table 2). A more recent study carried out at Auburn University (2024) measured the heavy metal concentrations in water samples and fish tissue from West Alabama farms, and found no cause for concern in these systems.

Heavy Metal	Number of Samples Tested	Samples with Detectable Amounts of Heavy Metals
Arsenic	735	2
Cadmium	736	2
Lead	736	14
Mercury	737	0

Table 2. Results of catfish fillets from foreign (151) and domestic (586) sources tested for heavy metal residue. The 18 tissue samples with detectable amounts of heavy metals were below regulatory guidelines. Further detail can be found in the USDA Food Safety and Inspection Service's 2008-2009 report.

Conclusions

Heavy metals, in most cases, they appear to be less of a problem in catfish aquaculture. High water pH due to algal productivity coupled with high amounts of organic matter from fish waste, undigested feed, and decaying algae come together to create an environment that counteracts the toxicity of any present heavy metals.

Understanding How Phosphorus Could be Removed in Aquaculture Ponds by Gypsum

Dengjun Wang[1] Ansley K. Hamid[1] Islam M. Radwan[1] Alan E. Wilson[1]
H. Allen Torbert[2] and Benjamin H. Beck[3]
[1] SFAAS, [2]USDA-ARS National Soil Dynamics Laboratory,
[3]USDA-ARS Aquatic Animal Health Research Unit

Phosphorus (P) is a required element for all living organisms. However, P overloading in catfish aquaculture ponds can negatively impact fish production and water quality. For example, high concentrations of P, especially soluble reactive phosphorus (SRP), in aquaculture ponds are strongly linked to harmful blue-green algal blooms since SRP can be directly used by algae. Blue-green algal blooms and their release of toxins are seen as some of the most critical stressors facing catfish producers, especially in the warmer summer months and early Fall. Therefore, controlling P, especially SRP, in catfish aquaculture ponds is needed to mitigate algal blooms and enhance catfish production in aquaculture ponds.

A particular type of gypsum called flue gas desulfurization (FGD) gypsum, an energy plant waste by-product resulting from sulfur removal, has recently raised attention as a cost-effective sorbent for removing SRP from water (Figure 1). Therefore, we performed experiments in laboratory-simulated systems to investigate the removal efficiency and mech-

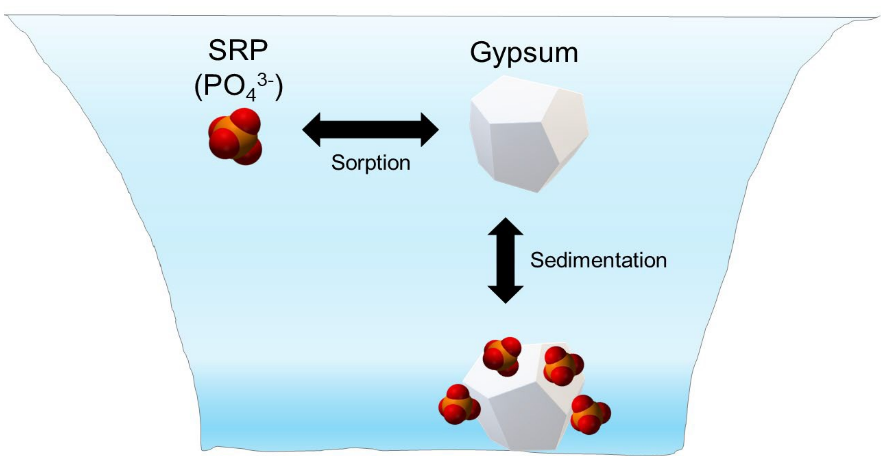

Figure 1. A schematic showing how soluble reactive phosphorus (SRP; solute) can be removed by gypsum via sorption, followed by sedimentation in the water column that eventually settles down at the pond bottom. Sorption refers to removing a compound (SRP) from water by a solid constitute (gypsum).

anisms of SRP by FGD gypsum in water. The P concentrations used in the laboratory experiment encompass concentrations commonly found in ponds (13 oz per acre-foot) up to quantities in industry processing systems, such as in wastewater treatment plants (WWTPs).

We found two types of removal mechanisms, depending on the contact time between SRP and gypsum (Figure 1). Specifically, SRP removal increased quickly during the first 1 hour of contact and then increased slowly until an equilibrium was reached at approximately 24 hours. The initial rapid phase during 0–1 hour refers to the quick sorption of SRP onto gypsum surfaces until all active sites on gypsum surfaces are completely occupied. The second phase, during 1–24 hours, is the slower sorption step within the "interior" of the gypsum structure. The maximum sorption removal capacity of SRP by the FGD gypsum was calculated at ~1.0 lb SRP per 1,000 lb of gypsum (0.1%) in a simple water matrix.

The results from our laboratory-controlled systems suggest that the FGD gypsum can potentially remove SRP in water, but the removal efficiency is relatively low (0.1%). The removal of SRP by gypsum is most efficient during the first 1 hour, followed by a much slower removal efficiency after 1 hour (until 24 hours). However, caution is needed for farmers to translate our laboratory findings to their pond studies since water chemistry is significantly different from actual ponds. Ponds contain many biotic factors (algae, microorganisms, etc.), which are expected to significantly impact SRP removal by gypsum. In addition to the sorption potential (Figure 1), the FGD gypsum can release calcium cations (Ca2+) in aquaculture ponds, which will increase the water hardness of ponds and bring additional benefits to fish and water quality. The released Ca2+ from gypsum can form calcium phosphate (Ca3(PO4)2) or hydroxyapatite (Ca5(PO4)3OH) minerals at alkaline pH conditions, which will further decrease SRP concentration in aquaculture ponds. However, future whole pond tests are needed to carefully test the benefits or adverse effects of the FGD gypsum on SRP removal, water quality, and algal blooms.

Evaluation of Orally Delivered *Aeromonas hydrophila* Vaccines in Channel Catfish

Allison Wise[1], Craig Shoemaker[1], Benjamin H. Beck[1], Troy Bader[1], Dunhua Zhang[1], Mark R. Liles[2], Tim Bruce[3] and Priscilla Barger[4]

[1]USDA–ARS Aquatic Animal Health Research Unit, [2]AU Dept. Biological Sciences, [3]SFAAS, [4]AU College of Veterinary Medicine

In 2023, Alabama raised 96 million pounds of catfish and generated $112 million in revenue, making it the second-largest catfish producer in the United States. Eighty-three percent of losses were attributed to bacterial diseases. The most prevalent bacterial disease last year in Alabama (2023) was caused by virulent *Aeromonas hydrophila* (vAh). Farmers can lose over 50% of a harvest yield in less than a week due to vAh infection, thus increasing the urgency for an effective preventative measure. Vaccination is a promising avenue to control/prevent fish disease. One vaccine approach that has proven successful in aquaculture is bacterin vaccines. Bacterins are formulated using killed bacterial cells. Bacterins promote a strong immune response and produce specific antibodies, especially following a second (booster) dose. Frequently, bacterin vaccines are formulated by mixing with certain adjuvants. An adju-