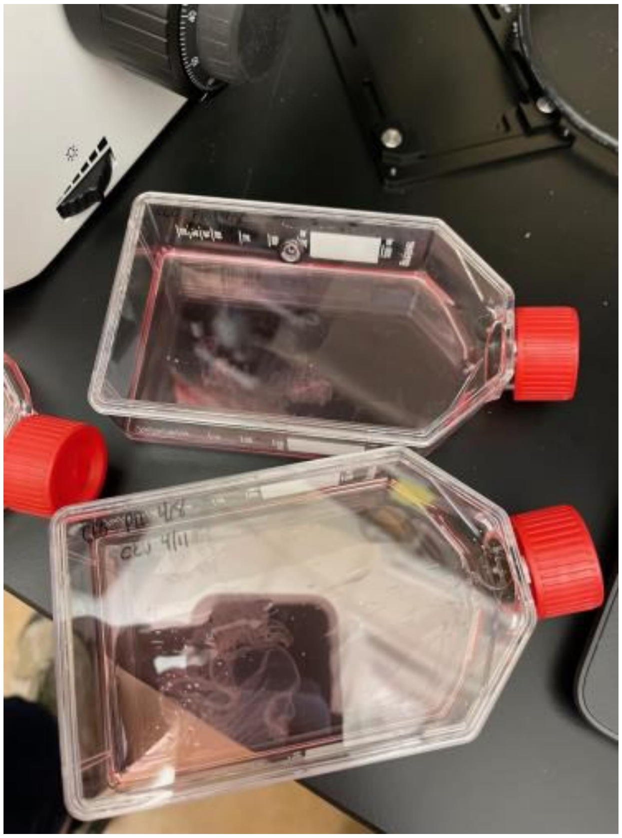

Figure 1. Channel catfish ovary (CCO) cells infected with 2013-CCV-DRB. These CCOs are used to propagate the virus for use in challenge studies.

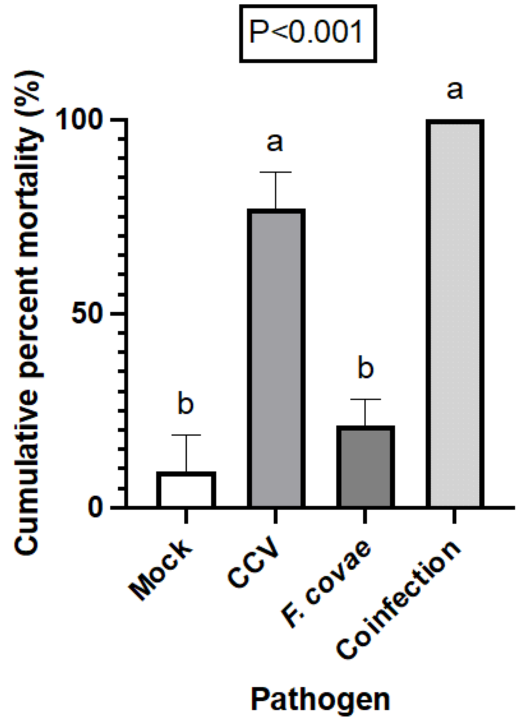

Figure 2. Endpoint cumulative percent mortality from the juvenile channel catfish challenge trial (13 days). Each bar represents the mean ± SEM (Standard Error of Mean) of three exposed tanks. Note, the coinfection group was simultaneously exposed to half-doses of the CCV and *F. covae*, whereas the single-infection groups received whole doses.

Are Heavy Metals a Concern in Catfish Aquaculture?

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Heavy metals like arsenic, cadmium, copper, lead, mercury, and selenium are naturally occurring elements that can have harmful effects on fish and people who consume them when present in high concentrations. Pond aquaculture could be a concern for heavy metal accumulation due to the large amounts of feed and chemicals (e.g., copper sulfate) that can be added to ponds year after year to control disease and algal blooms. This concern could be compounded by the fact that aquaculture ponds are rarely drained in some areas, leading farmers and consumers to ask, "Are heavy metals something I need to worry about?"

The fate of heavy metals is either to remain in the water column and enter fish tissue through the gills or be trapped and buried in the sediments (Figure 1). In other words, just because a metal is present in the water does not necessarily mean it can make its way into the fish and cause harm. Whether or not a metal can enter a fish through the gills or other avenues (in other words, toxic to the fish) depends on several factors, referred to as the "bioavailability" of a metal.

When discussing heavy metal bioavailability (toxicity), it is important to understand the environmental factors that can increase or decrease the toxicity of these elements. The two main factors of interest are the pH and the amount of dissolved organic matter (DOM) in the water. Water pH in most

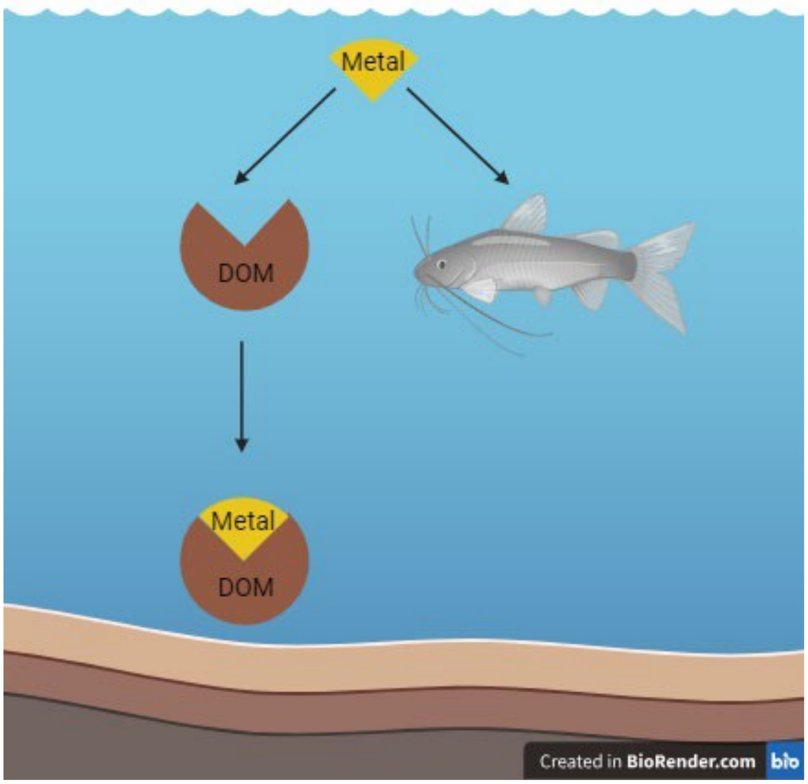

Figure 1. Metal ions in the water column can either be taken into fish through the gills or incidental ingestion or be bound to dissolved organ-

catfish ponds will fluctuate throughout the day, lowest just before sunrise and increasing until sunset. This is due to photosynthetic algae removing carbon dioxide from the water, raising the pH throughout the day. Dissolved organic matter refers to water material ranging from fish waste products to undigested feed to decaying algae and other organisms. Generally speaking, higher pH values make heavy metals less available and, therefore, less toxic to fish and other organisms. Similarly, high amounts of dissolved organic matter can reduce the toxicity of metals to fish. Dissolved organic molecules act as metal scavengers that can quickly take up metals, binding them and making them unavailable for uptake through fish gills.

The highly productive nature of catfish aquaculture ponds creates a unique environment that has the potential to minimize any toxic effects of heavy metals that enter them. The high amounts of nutrients allow for intense algal blooms that raise the water pH to levels above those typically seen in more natural systems and increase the amount of organic matter in the water as the cells naturally decay (Table 1). This creates an interesting scenario in which catfish farms may be uniquely situated to alleviate any harmful effects of heavy metals without any intervention from the farmer.

The USDA Food Safety and Inspection Service tested 737 catfish tissue samples from domestic and foreign sources from 2008-2009 and released the findings in a 2010 report. Of the 737 samples, the USDA found that only 17 tissue samples contained detectable levels of heavy metals (arsenic, cadmium, lead, and mercury), and none of the 737 samples exceeded regulatory

Aquatic System (Source)	Chlorophyll (µg/L)	pH	Dissolved Organic Carbon (mg/L)
Aquaculture Ponds (Wilson, unpublished)	257	7.73	31.8
Canadian Shield Lakes (Welsh et al., 1996)	n/a	6.20	5.68
Laurentian Great Lakes Region (Mahdiyan et al., 2021)	4.68	n/a	5.04
Fawn Lake (West et al., 2003)	n/a	5.9	9.1
Lake of Bays (West et al., 2003)	n/a	6.8	1.8

Table 1. Average chlorophyll (estimate for algal abundance), pH, and dissolved organic carbon (a form of dissolved organic matter) from aquaculture ponds and natural systems, according to published literature, or personal observations.

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

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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-

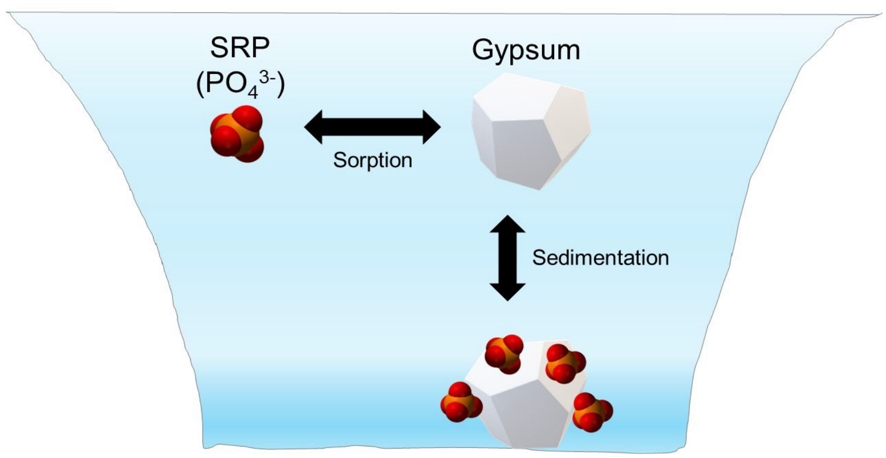

Figure 1. A schematic showing how soluble reactive phosphorus (SRP; solute) can be removed by gypsum via sorption, followed by sedimentation in the water column that eventually settles down at the pond bottom. Sorption refers to removing a compound (SRP) from water by a solid constitute (gypsum).