Copper Sulfate: Liquid or crystals?

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Copper sulfate (CuSO4) has been widely used for disease treatment in aquaculture, particularly as a treatment for protozoan parasites and fungal infections. It is also useful against snails (the intermediate hosts of fish trematodes) and as a treatment for off-flavor produced by blooms of blue-green algae. Copper can be toxic to fish, and this must be kept in mind when using it!

The toxicity of copper to fish, parasites, snails and algae is strongly influenced by water chemistry. At low alkalinities, copper stays in solution longer and less than 0.5 ppm CuSO4 may be toxic to fish. At very high alkalinities, copper quickly forms insoluble compounds, so doses exceeding 2 ppm may be ineffective against target organisms (parasites, snails, algae, etc.). The toxicity of CuSO4 is also influenced by pH, hardness, temperature, and organic carbon.

To avoid problems with copper toxicity and solubility in different waters, copper has been sold in formulations including chelated liquid products (claiming to reduce toxicity and increase effective half-life) and non-chelated liquid products (advertised as delivering copper ions more effectively); both products are much more expensive than CuSO4 crystals. Chelated liquid copper has not been widely used in the aquaculture industry, but the non-chelated liquid CuSO4 products are heavily promoted and commonly used. In a recently published study by Goodwin and Straus (2006), we compared the toxicity of a popular non-chelated liquid CuSO4 product and CuSO4 crystals to fish and parasites.

Two separate experiments were conducted to evaluate copper toxicity to channel catfish and free-swimming Ichthyophthirius multifiliis or Ich (the stage of Ich that can be treated); the compounds we used were CuSO4 crystals and a non-chelated liquid CuSO4 product. In 96 hr tests conducted in aquaria at both low (48 ppm) and high (243 ppm) alkalinity, there was no difference in toxicity to catfish between the two products. Likewise, there was very little difference in toxicity to free-swimming Ich. Based on equivalent concentrations of copper, we found no evidence that the liquid CuSO4 product would be more effective than CuSO4 crystals.

Based on an equivalent concentration of copper, our results suggest that copper in the liquid product would be no more effective than CuSO4 crystals, but the liquid product is 10 times more expensive.

An interesting finding in this study was the difference in the effect that alkalinity had on the toxicity of copper treatments to fish and parasites. Farmers generally calculate the CuSO4 dose as 1/100 of the total alkalinity; for example, at 100 ppm total alkalinity, a treatment dose of 1.0 ppm CuSO4 crystals is used, and at 200 ppm alkalinity, a dose of 2.0 ppm is used. This calculation relies on the assumption that toxicity decreases consistently as alkalinity increases. Our data show this is true for catfish but not for free-swimming Ich. Copper was about 5 times more toxic to catfish at the lower alkalinity (48 ppm) than at the higher alkalinity (243 ppm). Copper was about 2 times more toxic to free-swimming Ich at the lower alkalinity. Because of this, copper treatments calculated by the 1/100 rule for protozoan parasites may be more reliable at higher alkalinities then at lower alkalinities.

Because we were unable to demonstrate a difference between CuSO4 crystals and the non-chelated liquid CuSO4 product, it is important to consider their relative costs. Based on mid-April 2007 prices, the copper in CuSO4 crystals costs about $1.50/lb, while the copper in the liquid CuSO4 product costs about $14.80/lb. For equivalent treatments, the liquid CuSO4 product is 10 times more expensive.

Anecdotal reports by farmers sometimes suggest better results with liquid CuSO4 products at dose rates much lower than those used for CuSO4 crystals. However, there is no scientific evidence that the liquid CuSO4 product would be effective at a dose lower than that used for CuSO4 crystals. It may be that these observations are the result of natural pond-to-pond variability in disease mortality, but another explanation could be that in some instances, the CuSO4 crystals are not completely dissolved before application and seem less effective than the pre-dissolved commercial form. This may be especially true when water temperatures are low, because CuSO4 crystals dissolve more slowly in cold water. If this is the case, pre-dissolving the CuSO4 crystals in water and applying this solution at the appropriate dose based on the total alkalinity should give similar results as the liquid product; this would prevent any loss of CuSO4 crystals into the sediments. As an example, the stock CuSO4 concentration for snail control along the pond perimeter is 10 lbs/70 gal water; completely dissolving this concentration in a quart of deionized water while stirring slowly took 20 minutes at 95°F and 49 minutes at 41°F.

In conclusion, we were unable to find any scientific evidence that the liquid CuSO4 product offers any advantage over CuSO4 crystals when treating Ich. Based on an equivalent concentration of copper, our results suggest that copper in the liquid product would be no more effective than CuSO4 crystals, but the liquid product is 10 times more expensive. Farmers who prefer the liquid product could achieve the same benefits by thoroughly dissolving CuSO4 crystals prior to pond application. Future studies should address effect of liquid copper products to control algae.

For more information see: Goodwin, A.E., and D.L. Straus. 2006. Solid and Liquid Formulations of Copper Sulfate: Efficacy at High and Low Alkalinities. *North American Journal of Aquaculture*, 68(4):359-363.