THE VALIDITY OF THE MINNESOTA WILD RICE SULFATE STANDARD

By Len Anderson

The Minnesota Chamber of Commerce and the mining industry in Minnesota have challenged the validity of the state wild rice standard for sulfate. It presently and appropriately stands at 10 mg/L of sulfate. I do not fault them for trying to get the standard relaxed because all of the proposed metallic sulfide mines are in Northeastern Minnesota and would impact existing wild rice stands. To mine in these watersheds they would need to have active sulfate water treatment in perpetuity, which would be expensive.

I do however, fault their application of available science. They seem to be attracted to easy science but natural plant communities that have become adapted to their unique ecosystems do not easily give up their secrets. The scientific community, for reasons of economy and clarity, usually opts for the more simple or easy analysis. We have had great success in science using that approach. However, it is so simplistic that in the real world it can lead to deceptive conclusions if we are not humble enough to admit that we don't have a complete model of all the complexities impinging on a natural ecosystem. This is what has happened in the literature cited by the Chamber in their attack on the wild rice standard.

The real complexity of natural wild rice stands involves an interplay of all the biotic and abiotic factors that have come to play on the stand for hundreds and thousands of years. Our natural stands are genetically diverse and perfectly adapted to the water and soil condition of that specific water body. Of course we must protect this genetic diversity. A quick study of one or two stands, or a laboratory study with unnatural or absent soils is not adequate.

The perfect way to study the interplay of sulfate and wild rice would be to look at hundreds of stands in diverse conditions over decades or centuries and then document where wild rice is established. That sounds impossible, but fortunately it has been done. At a meeting with the MPCA on ll-30-10 the wild rice standard was discussed. Several members of the Bois Forte Band of Minnesota Chippewa were present and spoke to the issue. They suggested that the standard should be even lower than 10 mg/L because decades ago, before any industrial impact on wild rice in their part of the state, the natural condition of the water was low sulfate(less than 10 mg/L) and many of the important rice stands were better then, compared to the present. That testimony represented the wisdom of the ages and we ignore it at our own peril. It is a compilation of years and years of people of keen intellect, standing in a canoe and observing the productivity of a stand they are about to harvest. You don't need a sophisticated statistical analysis when your data base is that massive. However, the rules of the game are rigged against that kind of data. State agencies want and value “hard science”. Unfortunately, that usually means a quick study of one stand or bench work.

Fortunately we have an example of hard science based on massive observation and it is in complete agreement with the testimony of the Bois Forte elders. That science is the seminal work of John B. Moyle and his published peer reviewed research. I had the privilege of working in wild rice stands and reporting to him in the late 1950s. In about 1961 I asked him why he was so interested in wild rice and he said it was intriguing to him. That is pure science. He was not working for any vested interest. He was a DNR scientist trying to understand an important part of the natural world. His methodology was to observe and document hundreds of wild rice stands and then to analyze the abiotic conditions that supported them. In other words, he was collecting massive amounts of data in the real world. Many physical parameters impact wild rice stands, such as water movement by wave action, or

current or rising water levels, and of course the chemistry of the water and now we realize the importance of bottom sediments. Because of its extreme sensitivity, wild rice is not found in most of the aquatic habitats of the world. In Moyle's analysis, published in the Journal of Wildlife Management, Vol. 8, No. 3, July 1944, he said "No large stands of rice occur in waters having a SO4 content greater than 10 p.p.m., and rice generally is absent from water with more than 5 p.p.m." In this published journal article (the very definition of legitimacy in science) he does not say there are no stands in sulfate water with levels of 100 mg/L. Instead, he defines what is necessary for the most productive stands. Finding a natural or paddy rice stand with higher levels in no way negates his conclusion that levels above 10 mg/L are harmful to natural stands of wild rice in this part of the state. In his article Some Chemical Factors Influencing the Distribution of Aquatic Plants in Minnesota, in Table 1. he lists *Zizania aquatica* L., var. *angustifolia* Hitche. as having a sulfate ion range of 3.0-36.0 with a median of 4.2. *Angustifolia* is the variety of wild rice found generally east of the Mississippi, which is the region where metallic sulfide mining would threaten natural rice stands. *Angustifolia* is the variety that is most susceptible to high levels of sulfate, whereas, west of the Mississippi we find *Zizania aquatic* L. in water that has a median sulfate level of 21.2.

Rogosin (1954) in An Ecological Life History of Wild Rice mentions on page 3, "-beds are usually either geographically isolated from other beds or occur in large dense stands that are relatively pure, so that there is little chance of pollen from other strains being introduced or having much success in markedly altering the genetic composition of the population." Then on page 4 he mentions that the variety *angustifolia*, with larger grains, is most valued by harvesters and is most characteristic of the northeastern counties of the state. Clearly, we have genetic strains of wild rice which have adapted to our naturally sulfate poor waters and we must preserve this valuable genetic diversity. It took thousands of years of genetic modifications to create these varieties and we could destroy them in a couple of decades.

Recently the Minnesota Chamber of Commerce has distributed four different documents. Some have gone to the legislature, the courts and the MPCA. Each of them attempts to prove that the 10 mg/L wild rice standard is too restrictive. I will try to defend the application of that standard by the state agencies.

They reference Moyle as supportive of 20 mg/L sulfate in the contested case hearing on a NPDES permit for Minnesota Power and Light. On page 5 of The Findings of Fact the hearing officer notes that Moyle testified that "it would be safe to allow a concentration of 20 p.p.m. of sulfate at the Cohasset plant." He made no indication that it would be appropriate for other stands. In fact in the cross examination he clearly defended his methodology in arriving at his 10 mg/L recommendation. There are reasons why the waters below the Cohasset plant can tolerate higher levels. This stand is located in the main flowage of the Mississippi River and as such there is constant current which brings oxygen to the sediments. As a result, the there is less of a reducing environment in the sediments and therefore, the sulfate is not reduced to hydrogen sulfide, which is the sulfur compound that damages the wild rice roots. This was discussed in greater detail by Dr Moyle on page 59 in "MP&L Clay Boswell Permitting Testimony Excerpts-March 19,1975." In waters with less current and less oxygen, which is typical of most wild rice stands, 20 mg/L would not be appropriate.

In these documents the Chamber references Tippler et al., Impacts of Commercial Wild Rice Production on Water Quality in Minnesota (1979) as supporting 22 mg/l to 390 mg/L as appropriate for wild rice waters. Tipppler et al., is not a peer reviewed journal article, and as such has nowhere near the credibility of conclusions of John B. Moyle, when he suggested 10mg/L in the Journal of Wildlife

Management, which is a peer reviewed journal. The most significant reason for rejecting the relevancy of Tippler et al., to the state wild rice sulfate standard for wild rice waters is that Tippler was only talking about domestic paddy rice water. There is complete agreement that the wild rice standard applies to natural stands of wild rice and not paddy rice. Paddy rice can tolerate much higher levels of sulfate. Paddy rice shows extremely high productivity because of the application of commercial fertilizers and pesticides. Also, because the paddy is drained each fall for harvest and the soil is then exposed to oxygen, the reducing environment for soil bacteria is eliminated and lesser amounts of toxic hydrogen sulfide are produced. Paddy rice studies do not predict natural rice productivity.

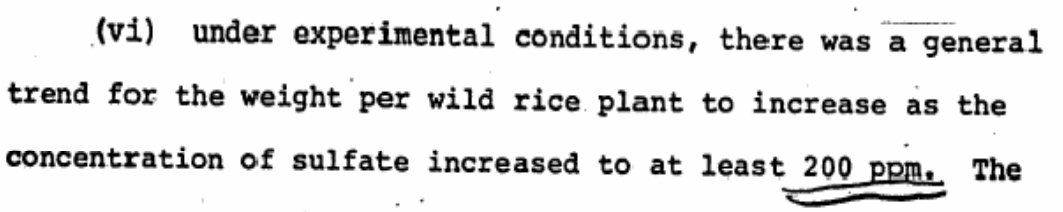
Next the Chamber references Abbas, Dutton, Nieber, Clanton and Canelon, *Minnesota Sulfate Water Quality Investigation* (University of Minnesota, June 2010) as supporting 50 mg/L for a standard. This research was conducted by the University for the Triennial Review that is being conducted by the MPCA. The 50 mg/L was in relation to paddy rice and again, paddy rice studies are not predictive of natural rice productivity. Also, the Triennial Review is in the final year of the orderly process mandated by law and should be allowed to run to completion, and in the end we should have a wild rice sulfate standard based on the best available science.

Next the Chamber references Dr. Janis Grava's testimony on behalf of the MPCA in the 1975 contested case hearing as supporting 50-100 mg/L. Dr Grava had just completed the 1974 University of Minnesota Progress Report of Wild Rice Research in which he found evidence of hydrogen sulfide toxicity to wild rice and linked it to soil solution sulfur concentration. His research was in Pennington county and associated with paddy rice again. Also the native wild rice grown in that red river region of the state is *Zizinia aquatica*, which is the strain that is most tolerant of sulfate. In his actual testimony in the contested case, he suggests on Page 22 “50 p.p.m., on a temporary basis.” This is for one specific stand in the Mississippi River where he admits on page 24 that “flowing water has a kind of cleansing action that would carry away any hydrogen sulfide.” His very proper conservative scientific evaluation of a temporary situation under an ideal cleansing scenario should not be deliberately misconstrued to apply to all the different natural stands in the state that are covered by the wild rice sulfate standard.

Next the Chamber quotes Professor Paul R. Bloom (University of Minnesota, June 2010) as supporting 100 mg/L. He said, “The fact that paddy wild rice thrives even when irrigation water sulfates exceed 100 ppm shows that a regulatory limit of 100 ppm will not harm the wild rice growers. In fact, much higher concentrations might be acceptable.” I find nothing to disagree with in Professor Bloom's statement. I strongly challenge the Chamber's use of this as an excuse to relax the 10 mg/L standard for natural wild rice stands. In the testimony of Dr. Janis Grava that the Chamber mentioned in the paragraph above, they fail to mention his other comments that the high tolerance of paddy rice to sulfate could be due to “cultivar tolerance”. Again I will remind the reader that because paddy rice is raised on oxygenated soil and fertilized and treated with pesticides, results from paddy rice have limited transfer to natural stands. The Chamber failed to quote Professor Bloom where, in the same document, he very properly points out why paddy rice results may differ from results in natural lakes or streams. He said, “Given the alternate wetting and drying, the effect of sulfate might be different than in a lake or stream where the bottom sediment is continually saturated with water. In a lake bottom very high sulfate might eventually lead to sulfide buildup and the tie up of chalcophile nutrient elements (elements that have a high affinity for reduced sulfur) like copper and zinc.” I couldn't have said it better myself!

Next the Chamber quotes Lee and Stewart, Effects of the Clay-Boswell Power Generation Station on Stands of Wild Rice on the Mississippi (University of Manitoba 1976). They said, “Under natural conditions...sulfate levels can reach extremely high levels (120 ppm) with no obvious detrimental effects on wild rice.” This extremely high level was found in one sample at one site out of hundreds of samples analyzed. On the following page he acknowledges that of dozens of samples collected from surrounding river and lake wild rice stands, the mean sulfate level was 10.95 mg/L. You don't usually jump to conclusions based on one outlier, but as long as they did, I would propose the following explanation for that one outlier. It is located in the Mississippi River and according to his Table 5 from 1976, that site was well oxygenated the entire period of study. With adequate oxygen there would be no reduction of sulfate to hydrogen sulfide and therefore I would expect little damage at that level. I have no idea why Mr. Lee would make such a sweeping generalization based on one data point, but let me point out that this was not a peer reviewed journal article. Instead it was a document prepared for a polluter that was in violation of the wild rice sulfate standard. Lee and Stewart were “hired guns” working for Minnesota Power and Light.

Next the Chamber again quotes Lee and Stewart (1976). The Chamber said, “General trend of wild rice plant weight to increase as sulfate concentration increased up to 200 mg/L.” Let's look at exactly what Lee and Stewart said. On page 144 we read:



(vi) under experimental conditions, there was a general trend for the weight per wild rice plant to increase as the concentration of sulfate increased to at least 200 ppm. The

What the Chamber quotation fails to include is the critical qualifier “Under experimental conditions,”. If most of the damage from sulfate pollution to wild rice occurs under reducing conditions in the sediments in contact with the root mass, then we need to examine those experimental conditions and see how well they fit a typical wild rice waterbody. In this experiment Lee and Stewart used sterile sand for laboratory soil. There would be no sulfide reducing bacteria to reduce the sulfate to hydrogen sulfide. In fact there was no sulfate at all until different solutions were added. Sulfur is an essential building block for any protein molecule. Therefore, the first dilution showed a completely expected increase in biomass as the plants could now synthesize the all important protein molecules. It is disingenuous at best to pretend this experiment is relevant to the application of the sulfate wild rice rule as it is applied in the real world where anaerobic sulfide producing sediments are the norm in every natural wild rice stand.

The next Chamber quotation refers to Stewart, A Review of the Effects of Sulfate Ion Concentration on Wild Rice Distribution (University of Manitoba. 1978), where he said, “Sulfate is an essential nutrient and never acts alone. 250 ppm is optimal for nutrient uptake.” This number comes from Vicario and Helstead (1968) in which they added magnesium salts to wild rice growing in pots. This study is a poor fit for rice grown naturally in Minnesota. It again occurs in the laboratory and the addition of sulfate at first charged the pots with the sulfur missing from the system and actually made protein synthesis possible. The lack of detrimental effect would be explained by the lack of organic sediments with a reducing condition necessary for the formation of hydrogen sulfide derived from the sulfate. Also the project used Saskatchewan seed which is known to be more resistant to sulfate pollution than rice from Northeastern Minnesota. Again this was not published in a peer reviewed scientific journal.

The next Chamber reference was to a University Extension Service Bulletin published in 1982 called Wild Rice Production in Minnesota. In which they said, “Wild rice has grown satisfactorily with sulfate concentrations of 250 ppm.” The actual quote appears on page 21 and goes like this, “Wild rice has been grown satisfactorily in experiments at sulfate concentrations of up to 250 part per million.” Notice the deliberate misquote that drops the all important two words that this was “in experiments”. I have dealt with this deception above. Completely unnatural settings with completely unnatural soils does not prove that the state of Minnesota should change the established wild rice sulfate rule. Once more this is not a peer reviewed journal article.

The next Chamber reference is again from Lee (2000). They summarize this work as “No adverse effects on wild rice plants at sulfate concentrations of up to 2,000 mg/L.” Again it is the same old story. This is not peer reviewed and it is lab work.

Finally, the Chamber quotes the above study again. “Summary: 3,000 mg/L represents a safe water quality limit for the protection of wild rice seedlings from adverse effects of sulfate” These two tests were done for a mining company with severe sulfate problems this time and of course it is not peer reviewed and it was lab work using hydroponic conditions with no mention of the lack of soil issues.

In the Minnesota Chamber of Commerce Petition for Rulemaking they claim “Because the state water quality rules are not grounded in research or science, the rules do not protect waters where natural beds of wild rice exist. They are wrong. The present rule is based on peer reviewed science. All the science they quote is not peer reviewed. The data that Moyle gathered over a lifetime of research has stood the test of time and peer review. The data the Chamber quotes is from single stands over the limited time of a single growing season or a bench test. Similarly data from Canada and rice paddies in no way should replace the work Moyle did in Minnesota. I would suggest a quote from the document Sulfate and Sulfide Residuals in Water and Sediment, Sandy River and Pike River, Fall-Winter 2000 prepared by Bois Forte Department of Natural Resources Water Quality Program as a very appropriate conclusion. On page 6 under Sulfur Relation to Wild Rice they say:

(*Lee,* 1999) suggest that wild rice plants can withstand substantially high levels of dissolved sulfate (thousands of ppm) without detrimental impact to plant growth. While these laboratory results assuredly are reported with a substantial degree of confidence, great care must nonetheless be used in interpreting these results since such studies are again inherently removed from the natural interactions that occur under field conditions. These thus cannot be construed to be reflective of optimum wild rice plant nutrient requirements in the water system.

Respectfully submitted, Len Anderson 218-879-6521

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