Iron in Turfgrass Irrigation Water

Why some laboratory tests don't provide a complete picture of the results.

Figure 1. Two irrigation water samples from different golf courses in northern Pennsylvania. The sample on the left (LM-1) shows a reddish-brown or rust color, whereas the sample on right (CO-1) is clear and colorless. Photo: Peter Landschoot, Penn State

Turfgrass irrigation water samples taken from ponds or wells sometimes show a reddish-brown or rust color. The appearance of these samples indicates the presence of higher-than-normal iron concentrations, which may be of concern to turfgrass managers due to possible negative effects on irrigation systems and other cosmetic problems. Although rust-colored irrigation water typically suggests high iron levels, lab results often show below-normal concentrations of iron. The reasons for this could relate to the different forms of iron in water and how the laboratory analyses irrigation water.

Iron is a common metallic element found in soil and rocks in the earth's crust. As water percolates through soil and bedrock it dissolves iron-containing minerals which accumulate in groundwater. Under anaerobic conditions in deep wells, boreholes, or lakes/ponds that do not turn over (circulate) rapidly, iron exists in the dissolved or soluble form. Dissolved iron is referred to as ferrous iron and is designated as Fe +2. Water containing soluble ferrous iron tends to be clear but turns cloudy when exposed to air. As water becomes increasingly aerated, the iron is oxidized to the less soluble ferric state (Fe +3) and turns a red-brown or rust color. Some or most of the iron will eventually precipitate out of solution as iron oxide (Fe_2OH_3) and will sink or remain suspended, leaving the water with a reddish-brown cast.

The pH of water also influences iron reactions. Iron exists in the dissolved ferrous state in very acidic water and becomes insoluble and precipitates as iron oxide if the pH of water increases and becomes less acidic.

Because aeration and pH influence the solubility of iron in irrigation water, it's no wonder that lab results can be somewhat confusing. When an irrigation water sample is sent to a lab, the water is often filtered and analyzed without adjusting the pH. This makes sense because you want to know what's in your water and how it will influence soils and plants at their normal pH. If your pH is near neutral or basic, most of the iron will not be in the dissolved state and thus, will not be detected by certain types of analytical equipment. However, by analyzing water under very acidic conditions (pH <2.0), most of the iron will revert to the dissolved form and be detected by analytical equipment.

In the case of the reddish-brown water sample shown in Figure 1 of this article (designated LM-1), the pH was 7.1 and the iron content was reported as <0.1 ppm (Table 1). This is well below the upper limit value of 5 ppm iron suggested in textbooks and on turfgrass irrigation water test reports. When the water in this same sample was not filtered and acidified to a pH of about 2.0 (according to Penn State's Agricultural Analytical Services Lab drinking water test procedure for high iron turbidity), the iron concentration was 48.5 ppm, a significant increase over the original reported value.

Based on these results, we suspect almost all the iron in the non-acidified water sample (pH 7.1) was precipitated or suspended as iron oxide, and therefore not detected by the procedure and equipment used for irrigation water analysis. In summation, if you want to know the total amount of iron (dissolved and non-dissolved) in your irrigation water, be sure to check with Penn State's Agricultural Analytical Services Lab to see if they can analyze the sample according to the drinking water test procedure for high iron turbidity (non-filtered and acidified).

Table 1. Iron concentrations resulting from two methods of analyzing irrigation water for two different irrigation water samples. The first procedure involved passing each sample through a 1 µm filter and analyzing the water at the existing pH of 7.1. In the second procedure, the water was not filtered and was acidified to a pH of about 2.0 with 1% nitric acid

(HNO_3) just prior to analysis.

Sample	Laboratory Test Procedure	Reported Iron Concentration (ppm)
LM-1: Rust-colored water	Filtered @ 1 µm, not acidified (pH 7.1)	<0.1
LM-1: Rust-colored water	Not filtered, acidified with 1% HNO_3 *	48.5
CO-1: Clear, colorless water	Filtered @ 1 µm, not acidified (pH 7.1)	1.4
CO-1: Clear, colorless water	Not filtered, acidified with 1% HNO_3 *	4.2

*Standard procedure for drinking water samples when turbidity is <1 Nephelometric Turbidity Units

Problems associated with excess iron in irrigation water

Although many labs consider >5 ppm of iron undesirable in irrigation water, this does not mean it will harm your plants and soil. In fact, turfgrass and soil problems due to high iron concentrations in water are rare. Potential problems due to high iron in irrigation water mostly center around staining of concrete surfaces, plugging of irrigation equipment and drainage tile, as well as unsightly deposits of rust-colored material on ornamental plants. High iron concentrations in spray tank water can clog screens or nozzles and negatively affect the performance of some pesticides. If concentrations are exceptionally high, and iron-laden water is used frequently and continuously, some nutrient deficiencies may result.

Figure 2. Deposit of iron oxide-infused material extracted from a partially obstructed drainage tile from a golf course in western Pennsylvania. Photo: Peter Landschoot, Penn State

Another common problem associated with high iron concentrations is biofouling. Biofouling is the result of the proliferation of bacteria under low oxygen or anaerobic conditions. The stringy bacterial slime can coat intake screens, reduce pumping efficiency, and cause unpleasant odors. Biofouling can be associated with stagnant ponds and deep wells with low oxygen levels.

Treatment of irrigation water containing excess iron involves precipitating the dissolved iron before it reaches your irrigation system. This can be accomplished by oxidizing iron via aeration, raising the pH of your reservoir to at least 7.2 with hydrated lime, or by running water over a bed of crushed limestone. Filtration is sometimes required to prevent clogging of irrigation equipment if precipitated iron does not settle to the bottom of the reservoir and is taken into the irrigation lines.

References

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Authors

Peter Landschoot, Ph.D.
Professor of Turfgrass Science
pjl1@psu.edu
814-863-1017

extension.psu.edu

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