IRON, MANGANESE, AND SULFATE CONCENTRATIONS IN TREATED AND UNTREATED WATER SAMPLES OF WELLS AT THE RAYSTOWN FIELD STATION

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ABSTRACT

High iron, manganese, and sulfate concentrations are characteristic of the Scherr Formation, which underlies the Raystown Field Station in Huntingdon, Pennsylvania. We hypothesized that the concentrations of iron, manganese, and sulfate would be lower in an ozone treated well than in untreated wells. We collected samples over a period of six weeks in fall 2001 from two wells at the Raystown Field Station using a Kemmerer sampler and from a faucet yielding treated water from a third well. Concentrations of iron (2.96 ± 0.68 mg/L) and manganese (0.44 ± 0.33 mg/L) were significantly greater in the untreated wells than in the treated wells (0.3 ± 0.37 mg/L; 0.100 ± 0.0707 mg/L, respectively), ($t=12.89$, $P=<0.001$, $df=9$; $t=5.04$, $P=<0.001$, $df=30$ respectively). However, concentrations of sulfate were significantly greater in the treated well (20.00 ± 2.45 mg/L) than in the untreated well (14.87 ± 5.01 mg/L) ($t=-3.57$, $P=0.004$, $df=11$). The water treatment system at the Raystown Field Station reduces iron and manganese concentrations in the water. Higher sulfate concentration found in the treated sample could be due to the oxidation of sulfide to sulfate by the ozonater in the treatment system or the absence of sulfate reducing bacteria after treatment.

Keywords: Iron, Sulfate, Manganese, aquifer, wells, water chemistry, groundwater, Raystown Field Station

INTRODUCTION

Groundwater makes up approximately 0.6% of the earth's freshwater, which is relied upon by 250 million people in the U.S. alone (EPA 1999). A groundwater cycle includes recharge areas, aquifers, confining units, and discharge areas and groundwater quality is an important issue given the demand for the resource. Contamination of groundwater can come from natural sources including metals that dissolve from surrounding rocks or soils such as iron and manganese (Moody 1990). Although these two metals are not harmful, high concentrations can cause distasteful water and stains in laundry (Moody 1990).

The Scherr formation underlying the Raystown Field Station, which consists of shale and siltstone, is known to yield high concentrations of manganese and iron (Taylor et. al, 1989). Because of drought

conditions in the fall of 2001 at the station, the water table was below normal levels (personal obs 2001). Higher concentrations of iron, manganese, and sulfate may occur during the recharge of the aquifer (Muhlherr et al, 1998).

      The goal of our study was to test the effectiveness of the water treatment system at the station during drought conditions when metal concentrations are high. There were four wells at the station, one that provides drinking water. Without treatment, the levels of sulfur and iron cause the water to have a disagreeable odor and taste, as well as staining shower walls (personal comm.). There is little known about the levels of metals and dissolved solids in the groundwater here. We tested the hypothesis that the concentrations of iron, manganese, and sulfate will be the same before and after ozone treatment.

SITE DESCRIPTION

      We conducted this study at the Raystown Field Station, Entriken, PA. The bedrock is made up of the Scherr Formation, which is made primarily of siltstone, shale, mudstone, and sandstone (Fig. 1). The depths of the wells in this formation range from 33 feet to 580 feet while shallow wells are abundant in this formation (Taylor et. al, 1982).
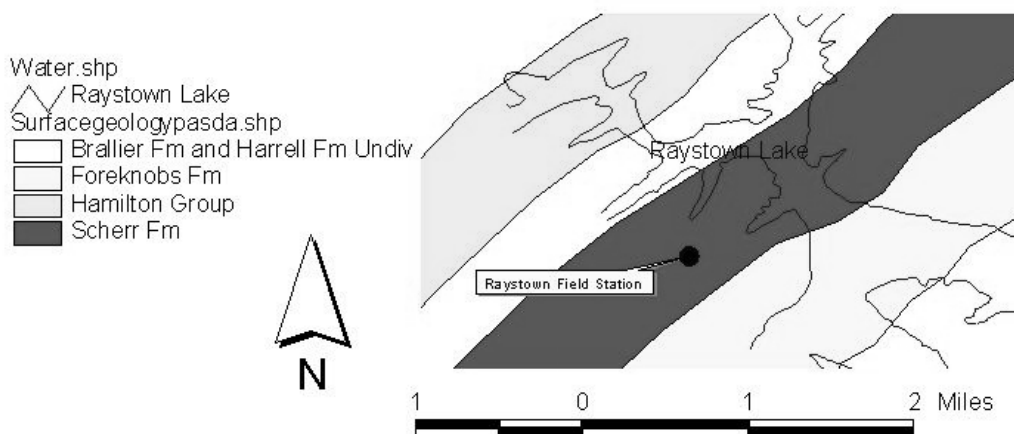

Figure 1. Surface geology underlying Raystown Field Station.

METHODS AND MATERIALS

      We sampled two test wells and a drinking water source from the same shale aquifer. The wells were spaced approximately 30 yards in distance (Fig. 2).

Figure 2. Location of the wells at the Raystown Field Station. The wells are represented by the dots. The center well supplies the treatment system.

We measured water depth in the well by lowering a weighted string down the well shaft until it hit the surface of the water. We then lowered a Kemmerer bottle 1 meter below the water level to collect five water samples from each well. We also took five samples from the tap inside the station house, as this was the easiest way to obtain the treated water. We collected 5 samples from each well on three separate dates. We recorded pH and temperature of the samples using a HACH pH meter and concentrations of iron with a 1,10 Phenanthroline method, manganese with a Periodate Oxidation method, and sulfate using the Sulfa Ver 4 method and a HACH DREL 2000 spectrophotometer (HACH, 1995).

We tested for normality using a Levene's test (MIITAB 1993) and for homogeneity of variances using an Anderson-Darling test (D'Augostino et. al. 1986). Before completing the two-sample t-test we ran one-way ANOVA's to compare sulfate, manganese and iron levels among sampling dates. We were able to pool our data for each untreated well because there was no difference among sampling dates. We used a two-sample t-test to compare the concentrations of iron, manganese, and sulfate between treated and untreated wells (MINITAB 1993). We used an alpha level of 0.05 and considered differences to be significant if $P \leq 0.05$.

RESULTS

We found no significance difference among sampling days for pH, iron, manganese and sulfate concentrations in the untreated well ($f \geq 0.43$, $P \geq 0.091$, df = 2,12). Also, there was no significance difference in pH between the untreated well (6.75 ± 0.15) and the treated well (6.67 ± 0.04). We found manganese levels in the untreated well (0.5 ± 0.3 mg/L) to be significantly higher than the treated well (0.1 ± 0.1 mg/L) ($t = 5.04$, $P \leq 0.001$, df = 30). We also found the untreated well water (15 ± 5 mg/L) to have significantly lower levels of sulfate than the treated well water (20 ± 2 mg/L) ($t = -3.57$, $P = 0.004$, df = 11). Iron in the untreated well water (2.96 ± 0.68 mg/L) was significantly higher than in the treated well water (0.30 ± 0.37 mg/L) ($t = 2.89$, $P \leq 0.001$, df = 9).

DISCUSSION

During our study period, Huntingdon County was under a drought warning based upon below normal water levels (DEP 2001). As the drought progressed, manganese, sulfate and iron concentrations in untreated water samples were not significantly affected. The water levels within the aquifer remained constant during our study period. Rock strata did not hydrate or dehydrate, thus having no affect on the contaminant concentrations. Raystown Field Station is currently equipped with a water treatment system to lower the concentrations of iron, and manganese in the water. There are two possible theories to account for the higher sulfate concentrations. First, there could be more oxygen present in the well causing the oxidation of sulfate to sulfide. It is possible for that presence of sulfate reducing bacteria (SRB), an anaerobe, in the wells kept the sulfate concentrations low by reducing the sulfate to sulfide. Although SRB are anaerobes they can survive under aerobic conditions and have been shown to consume 0_2 through respiration, a mechanism to avoid exposure to molecular oxygen (Holmer 2001). The water was then oxidized by the treatment system causing the sulfide to become sulfate, giving a higher sulfate reading after treatment (Domenico and Shwartz 1998). Sulfide and oxygen levels should be tested in future studies to determine evidence of SRB and therefore sulfate in its reduced state. Second, the sulfate present in the treated water sample could be the result of residual amounts of sulfate present in the Raystown Field Station plumbing before the treatment system was installed. Future research to test this hypothesis would include testing the plumbing as well as the filter medium in the treatment system for traces of sulfate.

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