Chemical and Physical Effects of Springs on a Stream System

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Introduction

Raccoon Creek is located about four miles west of Beloit College in Beloit, Wisconsin. The section of the stream being studied was about one-quarter of a mile long and flowed east to west. The stream originates about two miles northwest of the area under study and runs through an area dominated by farm fields. It is a low-energy stream that is only an average of six to eight inches deep, and supports only minimal biotic life such as minnows and an occasional crayfish. However, the stream is highlighted by the fact that it contains many visible springs that are located along the northern bank.

The study area of Raccoon Creek has been historically known as Chamberlin Springs. In the late 1800's, geologist T.C. Chamberlin owned and resided on the land that contained the springs. The springs were said to have medicinal properties and attracted many visitors, both sick and healthy. The Chamberlin's even had the springs analyzed and were told that "health-giving minerals were present". The Chamberlin Springs property is now owned and preserved by Beloit College.

The purpose of this study was to analyze the water from the springs to determine its chemical content and to determine how this water affected the chemistry of the normal stream discharge. Time was also spent analyzing the physical effects, such as volume and temperature, of the springs on the stream system .

Field Methods

Chamberlin Springs is located in a heavily wooded area along Raccoon Creek. It is bounded in all four directions by farm fields, accessible only by a main road to the north of the woods. The path to the stream was heavily overgrown, taking two days to clear a trail to the site.

After the site was reached, it was necessary to determine the number and locations of the springs. Springs were identified mostly by sight and verified by temperature readings. The springs were located only within the north side of the stream bed and sometimes on the northern bank of the stream. A characteristic light colored ring of fine grained sediment often accompanied a spring located within the stream. If a spring originated in the bank of the stream, it was also accompanied by a trail of light colored sediment.

The temperature of the springs was about 10 - 11° C while the temperature of the stream was about 22° C on average. Ten springs were identified in the two-tenths of a mile stretch of the stream that was studied. Once the springs were identified, water samples were taken and pH and conductivity were measured.

In order to assure that accurate water samples were obtained, it was necessary to determine the rate at which spring water mixed with regular stream discharge. A powdered dye was added to the stream, at approximately six inches upstream from a spring. The dye turned a bright green color upon contact with the stream. It was observed, however, that when the spring water was introduced, it remained clear and colorless as it flowed from the mouth of the spring. The spring water eventually combined with the stream flow a few inches away and turned a similar green color as the stream had. Therefore, the spring water does not immediately mix with the regular stream discharge and can be sampled near the mouth of the spring without any contamination from the surrounding stream water. A turkey baster was used to sample the water next to the mouth of the spring before it was mixed in with the regular stream flow.

Water samples were taken at various points in the stream such as upstream from the springs, in between springs, and downstream from the springs. It was neccessary to assure that representative samples were being collected. Three samples were taken along the cross section of the stream at an equal distance apart to check that the spring and stream water were well-mixed. There was no observed variability in water samples across the stream (fig. 1). Therefore, all further stream samples could be taken from the center of the stream cross section and be representative of the entire cross section. Samples were also taken from the springs themselves as well as from an abandoned well that was located to the north of stream. Chemical tests including conductivity and pH were also performed at the same locations as water samples were taken from.

Bacteria results for HAL show levels of 3,400/100ml total coliform, 770/100ml fecal coliform, and 71,000/100ml fecal streptococcus. WPL results indicated a total coliform count of 2,700/100ml, a fecal coliform count of 440/100ml. and a fecal streptococcus count of 14,800. The discharge revealed a count of 210/100ml for total coliform, 43/100ml for fecal coliform, and 161,000/ 100 ml for fecal streptococcus. The total coliform counts at all sites were above the 200/100ml recommendation of the State of Wisconsin. The only site to be below the 200/100ml Wisconsin limit for fecal coliform was the discharge. All sampling are extremely high in comparison to the EEC limit for fecal streptococcus at 100/100ml.

The 5-day biochemical oxygen demand was .887 mg/L at HAL, 5.440 mg/L upstream from the storm sewer, 5.067 mg/L for the discharge, 4.680 mg/L downstream from the storm sewer, and 3.120 mg/L at WPL. The State of Wisconsin recommendations lists a BOD limit of not less than 3 mg/L. The only site that is below this limit is the HAL station. This could be due to the course of the stream through an agricultural region prior to HAL.

Onsite measurements for all day at Hormel indicate a steadily increasing temperature throughout time and a fluctuation in discharge, due to the internal working of the corporation. (See Figure 3)

SUMMARY

The high color and high turbidity measurements are based on drinking water standards; therefore, the stream can be considered in its natural state. The high nitrate levels can be contributed to the agricultural runoff from crops that have been fertilized. The agricultural nature of the region also impacts the stream through high bacteria counts and the low BOD at HAL. The conductivity of the discharge is higher than EEC regulations, but is within the stream's natural level. This is also true for the nitrate concentration. The calcium, magnesium, and silicon concentrations of the discharge is within the stream's natural limits. The temperature of the discharge from the Hormel Corporation is of some concern due to the fact that the temperature seems to increase throughout the day. If the discharge is constant in temperature throughout the year, problems could occur in the winter months when the natural stream temperature would be much lower than the discharge. The impacts on aquatic life during the winter months could be investigated further. Overall , the discharge does not seem to be causing any detrimental damage to the stream, with exception to the temperature which may cause problem during the winter months if it continues to be released at its present temperature.

REFERENCES

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Figure 1. Comparison of 3 Samples in a Cross Section of the Stream

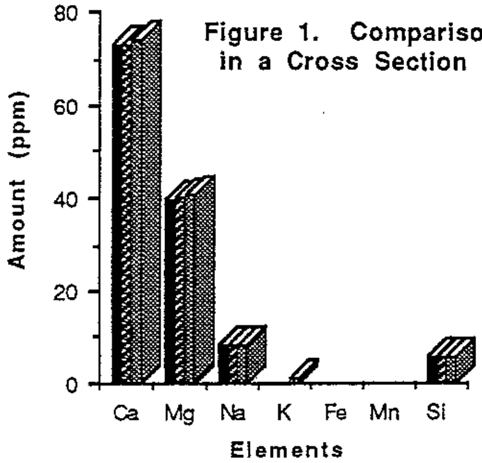


Figure 2. Depression Spring

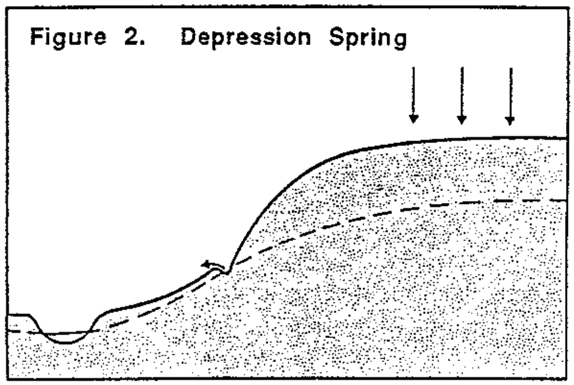
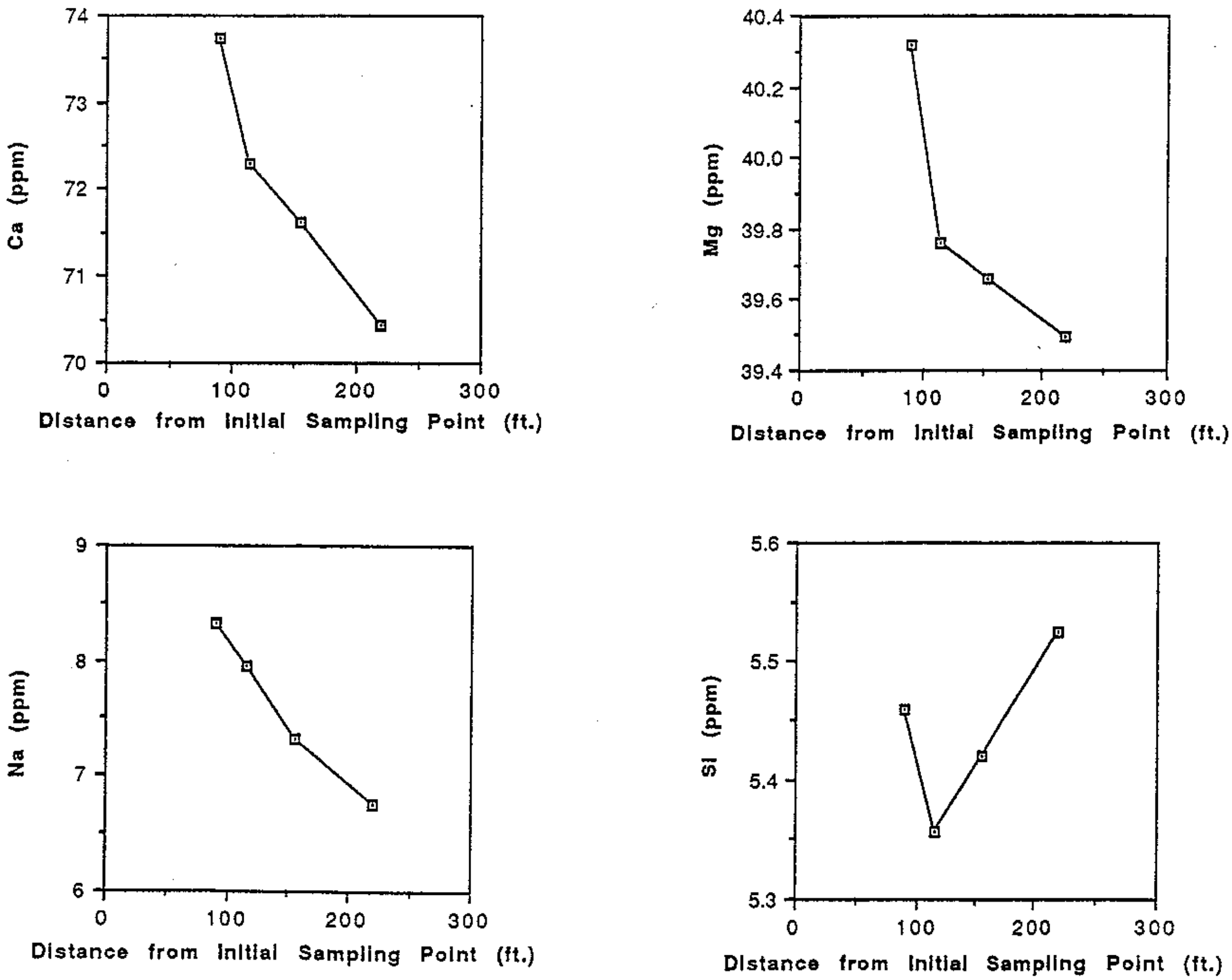


Figure 3.
Stream Samples Proceeding Downstream (7/30/91)



Three full sets of water samples were obtained and analyzed over the course of four weeks. A full set had 15 total water samples; nine of which were from springs, five were from the regular stream discharge, and one was from the nearby abandoned well.

To analyze the physical effects of the springs on the stream system, discharge measurements were calculated. A Price Pygmy Meter was used to record the velocity of the water at various points along the profile of the stream. These velocity readings were then multiplied by the individual sections in which they were taken. The total product was the discharge for that cross section. The low velocity of the stream did not allow for velocity measurements in shallow or obstructed areas. Therefore velocity readings could not be taken at consecutive intervals along the cross section but instead had to be taken where stream flow would allow.

Finally, well logs were obtained and well samples were taken from homes located to the north and to the west of Raccoon Creek. By knowing the stratigraphy of the area, similarities in the water chemistry of the springs and the wells might indicate what type of rocks the spring water came from. Also, rock samples were taken from a local quarry and from the stream area. Sediment samples were also collected near the springs.

Laboratory Methods

The water samples were then taken to the lab at Beloit College to run ICP tests (Inductively Coupled Plasma Analysis). Samples were refrigerated until analysis, which was within 48 hours of collection. The ICP tested for 16 cations; Ca, Al, Mg, Na, K, Fe, Mn, Ba, Co, Cr, Cu, Pb, Zn, Cd, Ni, and Si. These cations were compared with three known standards and a blank to determine their concentrations. The ICP was interfaced with an IBM computer to compile and record the data.

Results

Due to the topography of the area near the springs, these springs may all be classified as depression springs (fig. 2). They are discharging at the base of a slight hill or ridge where a low spot intersects the water table (Zaporozec 1982).

The discharge data proved to be inconclusive. Three separate sets of discharge measurements were taken on three separate occasions. A set consisted of taking velocity measurements along a cross section in as many as six different locations (upstream of the springs, downstream of the springs, in between the springs, etc.). The three sets of velocity measurements were extremely imprecise as they varied from each other by as much as 100%. It was determined that the stream's velocity was too low to make any accurate measurements of velocity and thus discharge was unable to be calculated.

The springs serve mainly as a dilution system within the stream. The springs have a lower concentration in parts per million (ppm) of Ca, Mg, Na, and K than the stream has. Thus those same elements are present at progressively lower concentrations in the downstream water samples (fig. 3). The concentration of Si, however remains fairly constant in the both the stream and the springs. The other elements that the ICP measured were not used either because they occurred at extremely low levels (< 0.0000 ppm) or they did not give consistent readings on the ICP. The ICP took three measurements from each sample and calculated a percent relative standard deviation (%RSD) for those three measurements. If the %RSD was greater than 5.0000, the reading was considered inaccurate and disregarded.

One anomaly is in the ICP data from 8/9/91 where the Ca concentration is greater in the springs than in the stream . These water samples were taken 24 hours after a 2.5 inch rainfall which may have affected the concentrations.

The pH of the stream is apparently influenced by the pH of the springs. The springs have a pH range of 7.06 to 7.55 indicating their possible origin in carbonate rocks (Zaporozec 1982). The pH of the stream registered 8.20 before the springs and decreased to 7.79 after the springs.

Conductivity is also affected by spring activity. Upstream from the springs, the stream has a conductivity of 620 millivolts. Conductivity of the stream is steadily decreased to 570 mV by the addition of spring water which has conductivities in the range of 450 to 545 mV.

The Rock River Basin area, where these springs are located, is dominated by three major rock groups (in descending stratigraphic order); various Pleistocene glacial deposits, the Prairie du Chien Group (dolomite), the St. Peter Formation (sandstone), and the Platteville-Galena Formation (limestone and dolomite). The Prairie du Chien Group may be thin to nonexistent in some places due to erosion before the deposition of the St. Peter sandstone (Zaporozec 1982). This particular type of sandstone is characterized by an almost 100% quartz content. As evidenced by samples collected from the area, the St. Pete is very friable, as well as very porous. The characteristic light colored ring of sand that surrounded a spring was made up of well-rounded quartz grains from the St. Peter formation. Therefore, the groundwater in the area apparently derives its high concentration of Si from the St. Peter Formation. This same formation may be the aquifer in which the spring water was contained, as evidenced by the sediments accompanying the springs.

References

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