Hydrogeochemical Processes and Water Quality Assessment of Five Penns Creek Headwater Streams
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Introduction
The quality of a body of water is very important in determining how well an ecosystem will thrive. In this study, five headwater streams were analyzed based off of several factors to determine the quality of the stream. After the data were collected, they were compared and contrasted to determine any difference between the streams. Each of the five headwater streams are located in the Valley and Ridge Province and are all found in the same general area, all running into Penns Creek. The headwater streams include Henstep, Coral Run, Lick Run, Little Weikert, and Green Gap. The factors that were taken into consideration were Water Quality Index (WQI), topography, distance, the type of bedrock, and discharge. The WQI was based off of eleven parameters including pH, Conductivity (mS/cm), Total Suspended Solids (mg/L), concentration of Nitrate (NO₃), concentration of Ammonium (NH₄), concentration of Phosphate (P), Chemical Oxygen Demand (mg/L), Biological Oxygen Demand (mg/L), Dissolved Oxygen (mg/L), and Temperature. By accumulating this data, a single value was calculated, based on a 1-100 scale to determine an overall index. Each parameter was weighted for importance to produce an accurate quality of water.

The expected WQI for each stream is between good and excellent water quality. Temperature was also used to determine differences between the streams. By knowing various values of temperature, variations in topography and distance between sampling sites and the highest elevation to which the stream reaches can be supported.

Methods
Henstep and Little Weikert are located at a slightly higher elevations while Coral Run, Lick Run, and Green Gap are located at lower elevations. Additionally, the sampling points of Henstep and Little Weikert were located farther away from the initial access point of the stream than Coral Run, Lick Run, and Green Gap. A YSI multiparameter was used to collect the physical characteristics of the stream including pH, conductivity, temperature, and dissolved oxygen. Water samples were collected to run through an Ion Chromatography System, testing for anions and cations in the water. A flow meter was used to measure the velocity of the stream flow. This data was multiplied by the total surface area to calculate discharge. The equation below was used to draw a conclusion on the Water Quality Index.

$$WQI = \frac{\sum P_i C_i}{P_i}$$

Equation 1: Water Quality Index where $P_i$ is the sum of the relative weight of each parameter and $C_i$ represents the calculated value for each parameter.

Results and Discussion
While the headwater streams are all relatively clean and have very similar characteristics, there are some differences that are worth noting. The WQI of each stream ranged from roughly from 91 to 94, making them all classified as streams with excellent water quality.

Table 3: Water Quality Index results for each stream and their ranking on the Water Quality Index Scale

<table>
<thead>
<tr>
<th>Stream</th>
<th>WQI</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coral Run</td>
<td>93.85</td>
<td>Excellent</td>
</tr>
<tr>
<td>Lick Run</td>
<td>93.85</td>
<td>Excellent</td>
</tr>
<tr>
<td>Green Gap</td>
<td>92.31</td>
<td>Excellent</td>
</tr>
<tr>
<td>Little Weikert</td>
<td>91.2</td>
<td>Excellent</td>
</tr>
<tr>
<td>Henstep</td>
<td>93.46</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

Analyzing temperature specifically can tell a great deal of information about some of the characteristics of the stream. Overall, the temperature of the water in the Little Weikert stream was lower than the other streams. After doing some more research on the elevation of the streams, it was apparent that Little Weikert is generally at a higher altitude than the rest of the streams which would cause the water to initially be cooler. Little Weikert also runs very close to the water table for the entirety of its length, allowing it to be continuously fed by the groundwater, also contributing to the cooler temperatures found in this stream. Little Weikert is, however, one of the longer headwater streams and along with Henstep, the distance that the water has to travel will result in a higher water temperature due to friction.

There are many parameters being studied to indicate just how similar the headwaters are. While the WQI data can give a tangible number to prove the overall difference in water quality, it is difficult to claim that one is necessarily better than the other. Each one is so similar that the specific examples of difference must be analyzed in order to make a stable conclusion. While many water quality indices are used throughout studies such as this, these eleven specific parameters seem to be one that most closely represent the water quality for such polluted streams. It is very reassuring that each headwater stream was found to be characterized as excellent. Understanding the differences in temperature range helped draw conclusions on how the topography, elevation, and length of the stream have on the overall temperatures of the stream.

Future Work
Further research may include the difference in WQI throughout different seasons. Other studies show that water quality increases during the autumn months... Some equipment was deployed at each headwater site to help back up the physical components of this study over a long period of time. More in depth studies will be done in the future to see the correlation between the temperature, season, and weather, and the quality of the water over time. Discharge data was recorded for Henstep and will be a significant component of this study as research continues. By understanding the discharge of the streams over time, the total load will be able to be calculated to observe how much of an impact these headwater streams have on the water quality of Penns Creek and the Susquehanna River.

Figure 3: Rating curve showing the discharge of Henstep over time.

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