Animas River water quality

-Akos Varga and Lance Aguilar-

Task statement:

Our task during this project was to determine the water quality of the Animas River without measuring its actual water quality but by using the water quality of the rivers and creeks which makes the Animas River, so they are the tributaries of Animas River. These creeks were the Upper Animas, the Cement Creek and the Mineral Creek.

Introduction:

Our goal with this project was to investigate how the tributaries of the Animas River affect its water quality. The water quality parameters that we were measuring at the 3 tributaries were temperature, pH, turbidity, conductivity and streamflow. We also measured the amount of dissolved oxygen in the water, but as we don't have official data to compare it, we won't use it. The table below shows some information about the parameters of the river that we were measuring.

Table 1: *Measured water quality parameters*

Name of water quality parameter	**Unit**	**Description**
Temperature	°C	Tells you the temperature of the water.
pH	-	Tells you if the water is acidic, neutral or basic (can be used to determine the amount of H^+ ions in the water).
Turbidity	NTU	Gives you information about the cloudiness of the water.
Conductivity	$\frac{uS}{cm}$	Tells you how much the water is conducting electricity. This data can be used to determine the amount of dissolved ions in the water.
Streamflow	$\frac{feet^3}{s}$	Tells you the speed of the river, how much water is going through the river every second.

Our main task was to figure out a way how we can most accurately calculate the water quality of the Animas River. This experiment is a quantitative one as we had to make calculations and we had to be familiar with mathematical formulas. In my group we used the following formulas to predict the water quality of Animas River:

Table 2: *Mathematical formulas that we used in our calculations*

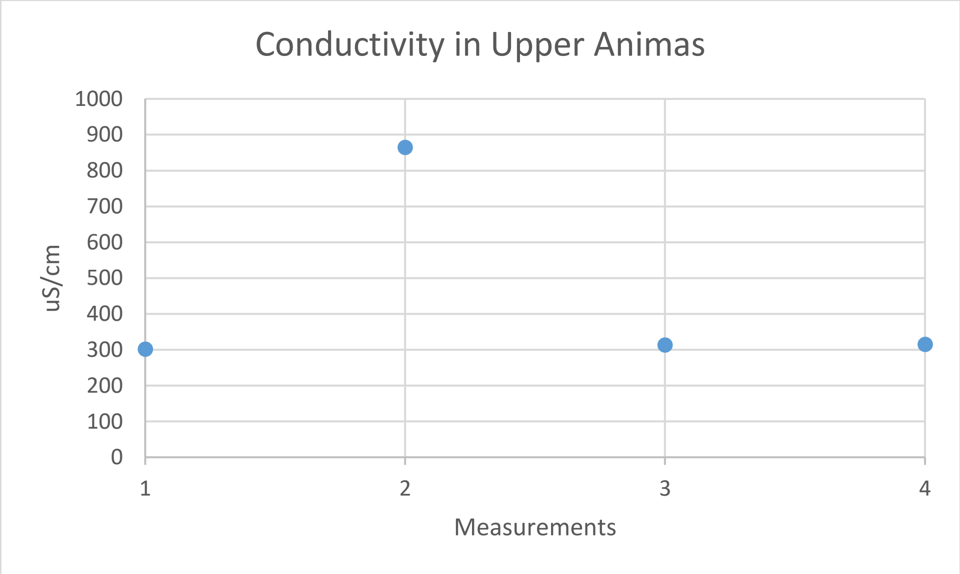
Name of mathematical formula	Description
Minimum	The data with the smallest value
Maximum	The data with the biggest value
Average	The arithmetic mean of numbers
Standard deviation	Mathematical formula used to measure the dispersion of all the data points

Visual representations:

When we are trying to make predictions about the Animas River using the collected data, we can easily get answers that are very far from the real value because we used measurements that were faulty. These wrong measurements can change our calculated values in a wrong way and make our work harder. For this reason it's very important that we delete the wrong data before making our calculations. For this, one effective way is to create charts which are showing all the data points and the average of all this data. Data points that are far from the average can be considered faulty measurements. To solve this problem we can also have a look at the minimum and the maximum of the data. If they are far from the average they are probably wrong measurements.

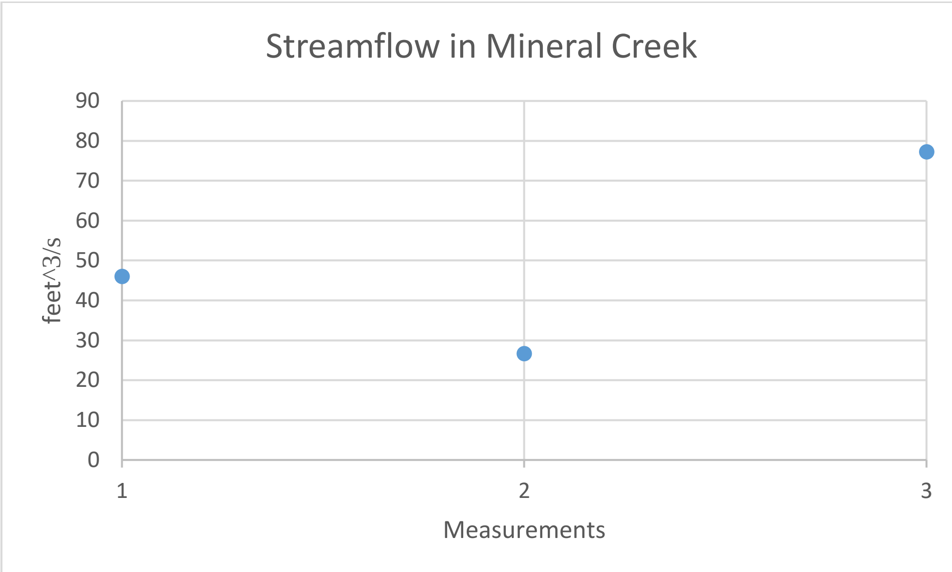
Here I included the most spectacular cases for this problem.

Chart 1: *Conductivity in Upper Animas*



We can see from this chart that most of the measurements were around 300 but we had a measurement that was more than 800! This measurement was probably not right. So we should exclude it from our data because it can have a bad influence on our calculations.

Chart 2: *Streamflow in Mineral Creek*



2 of our 3 measurements were close to each other 46 and 26.65 but someone measured 77.25 for the streamflow of the same creek. This measurement cannot be right as it's too far from the value of the other measurements. This is why we should delete this data point.

Methods and Process:

The Animas River below Silverton is only "made of" the creeks: Mineral Creek, Cement Creek and the Upper Animas. It means that by using the water quality of theses 3 rivers we should be able to predict the water quality of the Animas River.

At this point all of our data is thought to be reliable as we tried to select the ones that are unreliable as it was described in the *Visual representations* part. Now we should examine all of our water quality parameters and figure out how we can use them to predict the water quality of the Animas River and then compare them to the real values measured by USGS (*United States Geological Survey*).

Streamflow:

As the 3 creeks make the Animas River the water that is going through each of the creeks should get into the Animas River. This is why the streamflow of the Animas River should be the sum of the streamflow of the three rivers. ($streamflow = sf, Animas\ River = A, Cement\ Creek = C, Mineral\ Creek = C, Upper\ Animas = U$)

$sf_A = sf_C + sf_M + sf_U$

For us the average of the measured data was the following:

Table 3: *Streamflow of the 3 tributaries*

Name of tributary	**Streamflow ($\frac{feet^3}{s}$) average of all measurements**
Cement Creek	28.94
Mineral Creek	36.325
Upper Animas	20.6

If we add the streamflow of the tributaries: $28.94 + 36.325 + 20.6 = 85.865$ ($\frac{feet^3}{s}$), which is the streamflow of the Animas River.

Temperature, Turbidity, and Conductivity:

In case of these 3 parameters of the Animas River it's not just the sum of the average of measurements for the Mineral Creek, Cement Creek and Upper Animas, but it's a bit more complicated. The value for these parameters of the Animas River also depends on how much water we get from each tributary.

For example there is a river with bigger streamflow and higher temperature and there is a river with smaller streamflow and lower temperature. If these 2 rivers meet then the temperature won't be the average of the 2 temperatures but it will be closer to the higher temperature as there is more of that water in the river that these 2 rivers have created, because the river with the higher temperature has a bigger streamflow.

We should calculate the temperature, turbidity and conductivity using a weighted average. We can calculate it with the following equations ($temperature = T, sf = streamflow, trubidity = t, conductivity = c, Animas\ River = A, Upper\ Animas = U, Cement\ Creek = C, Mineral\ Creek = M$):

$$T_A = \frac{T_U \times sf_U + T_C \times sf_C + T_M \times sf_M}{sf_U + sf_C + sf_M}$$

$$t_A = \frac{t_U \times sf_U + t_C \times sf_C + t_M \times sf_M}{sf_U + sf_C + sf_M}$$

$$c_A = \frac{c_U \times sf_U + c_C \times sf_C + c_M \times sf_M}{sf_U + sf_C + sf_M}$$

Now we can rewrite these equation using our measurements. We use the average of our measurements for each creek.

$$T_A = \frac{T_U \times sf_U + T_C \times sf_C + T_M \times sf_M}{sf_U + sf_C + sf_M} = \frac{4.72 \times 20.6 + 9.48 \times 28.94 + 6.88 \times 36.33}{20.6 + 28.94 + 36.33} = 7.24$$

The estimated temperature for the Animas River is 7.24 °C.

$$t_A = \frac{t_U \times sf_U + t_C \times sf_C + t_M \times sf_M}{sf_U + sf_C + sf_M} = \frac{14.05 \times 20.6 + 5.38 \times 28.94 + 13.7 \times 36.33}{20.6 + 28.94 + 36.33} = 10.98$$

The estimated turbidity for the Animas River is 10.98 NTU.

$$c_A = \frac{c_U \times sf_U + c_C \times sf_C + c_M \times sf_M}{sf_U + sf_C + sf_M} = \frac{310 \times 20.6 + 989 \times 28.94 + 427 \times 36.33}{20.6 + 28.94 + 36.33} = 588.38$$

The estimated conductivity for the Animas River is 588.38 $\frac{uS}{cm}$.

pH:

To calculate the pH we need to use more advanced mathematics. In case of pH we also need to consider the streamflow of the rivers. To calculate the pH of the Animas River we used the following equation ($streamflow = sf, Animas\ River = A, Cement\ Creek = C, Mineral\ Creek = M, Upper\ Animas = U$):

$$pH_A = -\log_{10} \frac{10^{-pH_C} \times sf_C + 10^{-pH_M} \times sf_M + 10^{-pH_U} \times sf_U}{sf_C + sf_M + sf_U}$$

Now we should use this equation with the measured data.

$$pH_A = -\log_{10} \frac{10^{-pH_C} \times sf_C + 10^{-pH_M} \times sf_M + 10^{-pH_U} \times sf_U}{sf_C + sf_M + sf_U}$$
$$= -\log_{10} \frac{10^{-3.82} \times 28.94 + 10^{-7.05} \times 36.33 + 10^{-6.35} \times 20.6}{28.94 + 36.33 + 20.6} = 4.29$$

The estimated value for the pH of the Animas River is 4.29.

Solutions and predictions:

In the *Methods and Process* part of our report we calculated the estimated streamflow, temperature, conductivity, turbidity and pH of the Animas River. We made our calculations as accurately as we possibly could, using precise mathematical equations. The next step for us was to compare our calculations with the actual measurements of USGS.

Of course our calculations cannot match exactly the measurements of USGS, so we came up with the following process to evaluate our calculations. If the value that we calculated is more than the 80% of the value measured by USGS and less than the 120% of the USGS data, then the measurements of the students can be considered correct.

$$(USGS\ data) \times 0.8 \leq calculted\ value \leq (USGS\ data) \times 1.2$$

This table contains all the information to decide if our measurements were accurate or not:

Table 4: *Comparison with USGS data*

Water Quality Parameter	**Calculated value**	**USGS measurement**	**80% percent of USGS data**	**120% percent of USGS data**	**Did our calculated value matches the USGS data?**
Streamflow ($\frac{feet^3}{s}$)	85.87	102	81.6	122.4	YES
Temperature (°C)	7.24	8	6.4	9.68	YES
pH	4.29	6.6	5.28	7.92	NO
Conductivity ($\frac{uS}{cm}$)	588.35	512	409.6	614.4	YES
Turbidity (NTU)	10.98	7.7	6.16	9.24	NO

We can see from **Table 4** that in case of streamflow, temperature and conductivity our estimated is in the acceptable range compared to the USGS data.

In case of pH, the value, that we estimated is not in the acceptable range. The reason for this is not the wrong measurements but some chemical process that makes the pH of the Animas River different from our calculated value.

In case of turbidity the reason why we get different value than the original is because many of the students' measurements were very inaccurate (for example negative values). However we tried to delete all faulty measurements but as a result we get only a very few data which made it nearly impossible to make accurate predictions about the actual value of turbidity.

Evaluation:

Both of us agreed that this project itself was the most important, as it showed all of us how to correctly make pivot tables, graphs, and strengthening our ability to create write-ups. This project to both of us was both challenging and simple, in some aspects such as this write-up, we found it to be fairly simple and straightforward.

However, if we were to change aspects of this project it would be to help the students understand how to better use the equipment and how to properly measure pH and streamflow and turbidity. For example, five groups had not tested pH at their location, and only half of the class tested for turbidity, eight groups did not record streamflow, and many numbers recorded were outliers or just completely inaccurate. We think that we also did not have nearly enough time to thoroughly measure everything and analyze the collected data. If we would have more time we would be able to make more measurements, which would result in more accurate pivot tables and calculations.

We also hope that next time we will accurately test the dissolved oxygen content in each stream, and that we would have certain groups assigned to certain things to measure, as people could be held responsible for any inaccuracies. Overall, we both enjoyed the project! We also thought that the way we made our calculations was difficult, as we had to develop sophisticated functions in

Excel, using logarithm or weighted average; and we found the write-up to be demanding.

Importance:

The importance of our work was tremendous, as testing the river for acidic pH level, turbidity, temperature, streamflow and conductivity are some of the many aspects that either determine it to be a thriving river or a contaminated waste stream where no fish or wildlife would be able to survive. These calculations tell us about what we should or shouldn't do to the water in the river, in addition, it tells us if it is safe for humans to do water activities such as rafting and kayaking.

The best thing we can do to help the water quality in Silverton is to recognize that we need to fund Silverton if we want to have clean water, so that both humans and animals can be capable living around. Although we did not test for it, things like heavy metals and lead are dangerous for fish, humans, and for all animals, and testing for materials that could be considered dangerous, are important to bring to the public's eye, and it is a major importance to water quality and could have been important to our results as well.

Self-assessment:

We believe our group deserves to have a 100 percent score + a considerable amount of extra credit on our project because we had gone above and beyond with both our write-up, data tables, charts and we showed equations that show our understanding of the subject and the data given to us. We clearly showed our evaluation of the data, and we decided to compare all of our data to USGS' data, and decided its reliability, and made rigorous equations and functions in Excel. We have made everything to make our work easily analyzable not counting the time and hard work we had to spend on this project to accomplish it! *(Evidence: Photo 1)* Although some of our data was considered inaccurate, our process was correct, but the data provided by the students was not. We overall went above and beyond what was really necessary for this project, and that is why we believe we should get our desired credit!

Photo 1: Water quality scientists Akos Varga and Lance Aguilar (PhD) are working tirelessly
Photo by Alma Wolf