Flow and Water Quality in UC Davis Arboretum and Putah Creek

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Abstract

Water quality in the Arboretum at UC Davis decreases throughout the year due to low flow and various sources of runoff. Every fall, after a large rain event, the Arboretum water is pumped to Putah Creek for flood management. This paper hypothesizes that after this pumping event, water quality in Putah Creek decreases. Flow, water hardness, total suspended solids, and dissolved oxygen concentrations were considered using data collected from the Water Resources Control Board alongside UC Davis Climate Station precipitation measurements. Data was collected from every season starting and ending with September 2012 and 2013, with a focus around the first rain event in Davis, California. In addition, estimated Arboretum flow was calculated using Putah Creek flow and water hardness. Results show that water quality changes minimally in response to the Arboretum pumping according to analysis of those mentioned above. Dilution could play a large part in the measurements taken, which could skew the result. Nevertheless, pumping the Arboretum after the first rain does not significantly affect Putah Creek water quality.

Introduction

As a group, we recognized that the water quality in Putah Creek and the Arboretum was low. We proposed that quality would probably differ between the Arboretum and Putah Creek depending on when pumping occurred. We understood that the Arboretum would be pumped into Putah Creek after the first big rain of the year, which could change the water by either decreasing or increasing quality. Both options have valid reasons why they would occur. The water quality would increase if the water in the Arboretum was diluted by rain water. Then once it is pumped, it would lead to overall better quality. On the other hand, if the water from the Arboretum contained solids or contaminants, then it would infiltrate into Putah Creek after the pumping, causing the overall water quality to be worse in Putah Creek after the pumping. This problem is important in determining how the time of pumping affects water quality.

Objective

The main objective was to analyze whether or not the water quality was lower or higher after pumping. In order to do this, we would need the water history in both the Arboretum and Putah Creek before and after rains in every season. Through comparing individual monthly data we could analyze whether or not our hypothesis was true. Our tasks included obtaining precipitation data along with monthly data from the Arboretum and Putah Creek. Then, we designate which data we would analyze in order to determine quality. This leads to comparisons and calculations between the two locations. From analyzing our own data, we could make our final conclusions.

Hypothesis

We propose that water quality is lower in Putah Creek after the first rain due to pumping from the Arboretum.

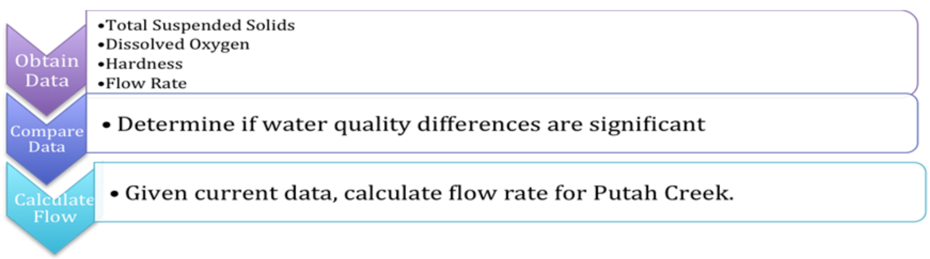
Data Sources

The data that we used for the project was obtained from Lisa Moretti of UCD Wastewater Treatment Management. Because UC Davis's Environmental Health and Safety Department does not collect water quality samples or analyze water quality data from Putah Creek, Lisa Moretti instead provided our group with data that was collected by the Waste Water Treatment Plant for the State Water Resources Control Board ("California Integrated Water Quality System"). This data is submitted by the plant each month, and data is collected for both the Arboretum waterway and the general Putah Creek waterway. In the report, the Arboretum is labeled as site "002" and the "North Fork of Putah Creek". The actual Putah Creek waterway is designated as site "001", the "South Fork of Putah Creek".

The concentration of dissolved oxygen in the waterways is measured using the 4500-O Oxygen Method ("4500 O-Oxygen (Dissolved)"). The concentration of dissolved oxygen in the water is measured by the rate of diffusion of the oxygen across a membrane electrode. The total dissolved solids are measured by drying the solids at temperatures between 103 and 105 degrees Celsius in accordance with Standard Method 2540D ("2540 Solids"). Hardness is measured by the concentration of calcium and magnesium ions using the titrimetric method outlined in Standard Method 2340 C ("2340 Hardness"). The method for collecting flow data was not specified. For both the Arboretum and the main Putah Creek water channel, samples were taken at locations upstream and downstream of the discharge sites.

Our group also used climate data collected by UC Davis's Department of Land, Air, and Water Resources ("UC Davis Climate Station"). This data was collected at two specific sites: the Russell Ranch Facility near Winters, California, and the Campbell Tract Facility near Davis, California. Monthly data is available for two years from 1998 to 2013. In using this data, we were concerned with using it to determine the times for precipitation events, rather than the amounts of precipitation. This precipitation data was collected by using a tipping bucket that adjusts with each 0.01 inch increments of accumulated precipitation ("UC Davis Remote"). The data provided by these facilities is very useful given that it is collected at facilities that are so close to Putah Creek and the Arboretum.

Methods and Assumption



Relationship Between Precipitation and Putah Creek Flow

First, we examined whether Putah Creek flow is influenced by isolated rain events occurring within different seasons. We conducted this analysis by comparing the Putah Creek average flow 5 days prior to the first isolated rain of the season with the average flows for 5 days afterward. We considered an "isolated rain event" as precipitation that occurred on a date following at least 10 precipitation-free days. We obtained the dates of isolated rain events for each season from UC Davis's climate station data. From this data, we were able to identify the dates of isolated rain events as follows: October 22nd, 2012 (Fall); March 20th, 2013 (Spring); June 25th, 2013 (Summer); and September 22nd, 2013 (Fall). Precipitation also occurred on March 21, 2013 and June 26th, 2013, but this precipitation was much less than what had fallen on the previous days. We used two fall seasons so as to have a better understanding of the interannual variability between fall flows. We were not able to identify an isolated rain event occurring in December 2012 during the winter season—all precipitation in this month was followed quickly by equally or more intense precipitation.

Total Suspended Solids

1. We took the data for total suspended solids and organized it into a table and graph, from January to September, and in both Putah Creek and the Arboretum.
2. In the September data, we examined the amount of total suspended solids before and after September 21, the day of the big rain.
3. The amount of total suspended solids after the big rain was greater than the amount of total suspended solids before the rain in both locations.
4. Thus, we concluded that water quality was lower after the rain.

Dissolved Oxygen

Dissolved Oxygen is commonly measured in water sources as a test of water quality because it is essential to marine life. Once dissolved oxygen concentrations drop below some threshold, aquatic organisms die from hypoxia. Therefore, higher measurements of dissolved oxygen correspond to higher water quality. DO concentrations were measured in Putah Creek at an upstream site as well as a downstream site. Our hypothesis focused on pumping in the Arboretum after the first rain, specifically before and after September 20, 2012 and September 21, 2013. Averages were taken at these points to compare concentrations around known rainfall events. In addition, averages were taken in December, March, and June to compare concentrations throughout the year in Putah Creek.

Water Hardness

Water hardness was calculated at both the Arboretum and Putah Creek to eventually estimate the flow of the Arboretum. Averages for September and December 2012, along with March, June and September 2013 provided seasonal information.

Arboretum Flow

Because the flow of the arboretum was unmeasured by the Waste Water Treatment Plan, we were interested in seeing a quantitative value representing Arboretum Flow. We realized that, because the Arboretum's water is drained to Putah Creek after the first rain, the waterways form one system in which a mass balance equation can be used to determine the Arboretum's flow. We also realized that, although hardness values do not necessarily represent or portray water quality status, they can instead be used to quantify the mass of a solute in the waterway system. Likewise, the amount of water represents the volume of solute. Therefore, the product of the Arboretum's flow and hardness should be equivalent to the product of Putah Creek's flow and hardness below the discharge site.

Calculation/Results

Relationship Between Precipitation and Putah Creek Flow

After performing the analysis of the data, we found that the Putah Creek flow increased after the Summer 2013 and Fall 2013 isolated rain events. This is advantageous for the system because it helps to dilute pollutants that have accumulated in Putah Creek. This is especially important for the 2013 Fall flows because the draining of the Arboretum occurs at this time. Therefore, suspended solids and other pollutants released from the Arboretum will be diluted with these higher flows. However, flows remained equal before the rain event occurring in September 2012. Also, flows decreased after the Spring 2013 rain event.

2012 Fall	*MG/D*
10/17/2012	1.815
10/18/2012	1.902
10/19/2012	1.702
10/20/2012	1.454
10/21/2012	1.559
5-Day Average Before Rain:	*1.6864*
10/22/2012	1.709
10/23/2012	1.663
10/24/2012	1.757
10/25/2012	1.652
10/26/2012	1.644
5-Day Average Before Rain:	*1.685*

2013 Spring	*MG/D*
3/15/2013	1.603
3/16/2013	1.455
3/17/2013	1.344
3/18/2013	1.628
3/19/2013	1.762
5-Day Average Before Rain:	*1.5584*
3/20/2013	1.605
3/21/2013	1.584
3/22/2013	1.523
3/23/2013	1.327
3/24/2013	1.162
5-Day Average After Rain:	*1.4402*

2013 Summer	*MG/D*
6/20/2013	1.373
6/21/2013	1.373
6/22/2013	1.203
6/23/2013	1.109
6/24/2013	1.415
5-Day Average Before Rain:	*1.2946*
6/25/2013	1.598
6/26/2013	1.629
6/27/2013	1.735
6/28/2013	1.848
6/29/2013	1.731
5-Day Average After Rain:	*1.7082*

2013 Fall	*MG/D*
9/17/2013	1.309
9/18/2013	1.517
9/19/2013	1.43
9/20/2013	1.431
9/21/2013	1.456
5-Day Average Before Rain:	*1.4286*
9/22/2013	1.31
9/23/2013	1.582
9/24/2013	1.83
9/25/2013	1.62
9/26/2013	1.671
5-Day Average After Rain:	*1.6026*

We suspect that the Spring 2013 decrease may have occurred because of higher water demand from living organisms (particularly plants) during this season. Precipitation falling at this time is intercepted and used by the plants, rather than passed as runoff to the water system.

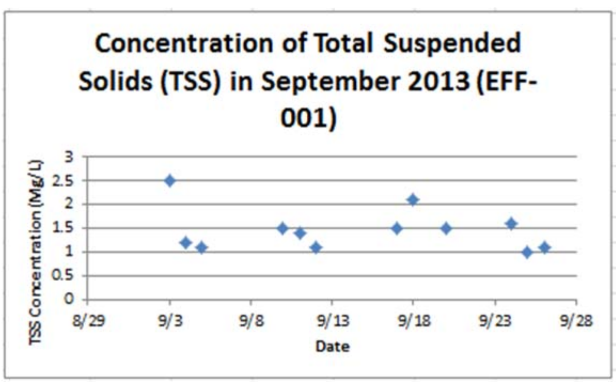
Dissolved Oxygen

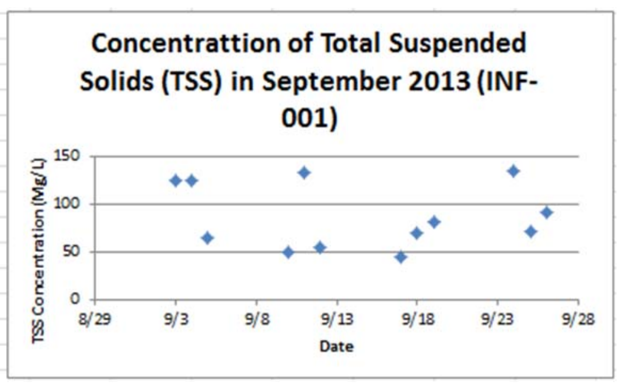
Dissolved Oxygen results showed that although concentrations changed slightly in September of both years, it was not a large enough change to concretely relate Arboretum pumping and Putah Creek DO concentrations. The table below shows the given concentrations and the calculated averages corresponding to each of the five months.

Dissolved Oxygen Concentrations (RSW-001D and RSW-001U)			
Date	Calculation Type	Average Concentration	Units (mg/L)
Sep-12	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	Before Sept 20 Downstream	6.825
	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	After Sept 20 Downstream	8.07
	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	Before Sept 20 Upstream	6.625
	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	After Sept 20 Upstream	7.565
Dec-12	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	Downsteram	9.314
	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	Upstream	9.605
Mar-13	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	Downstream	9.48
	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	Upstream	9.585
Jun-13	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	Downstream	6.825
	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	Upstream	7.8935
Sep-13	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	Before Sept 22 Downstream	8.8967
	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	After Sept 22 Downstream	7.6200
	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	Before Sept 21 Upstream	9.2333
	Standard Method (19th) 4500-O G:Diss. O by Membrane Electrode	After Sept 21 Upstream	8.5900

Total Suspended Solids

Total Suspended Solids is measured in EFF-001 which refers to effluent in Putah Creek, as well as INF-001 which refers to influent in Putah Creek. Data was recorded throughout the year, and the table below shows the data for the month of September (the first big rain occurred on September 21). The amount of total suspended solids, measured in milligrams per liter, fluctuated throughout the month, but increased after September 21 in both EFF-001 and INF-001. There was no data available for the Arboretum section of Putah Creek. Therefore, the hypothesis is impossible to confirm because it relies on total suspended solids. Testing the hypothesis testing would require information from the Arboretum as well as the southern branch of Putah Creek.





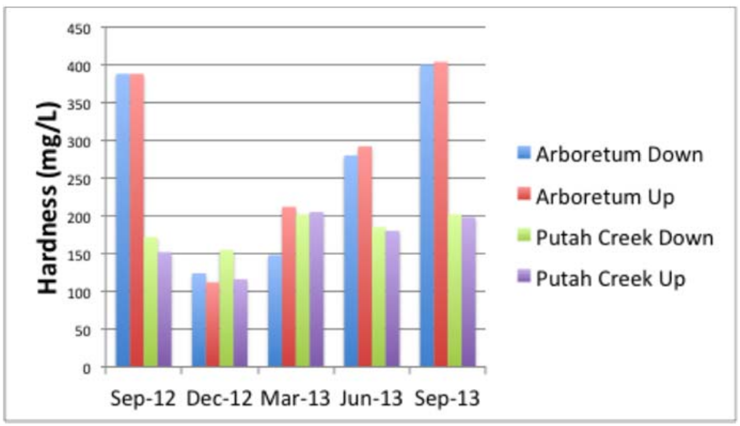
Monitoring Point	Result (Mg/L)	Sample Date
EFF-001	1.5	9/20/2013
EFF-001	1.6	9/24/2013

INF-001	82	9/19/2013
INF-001	136	9/24/2013

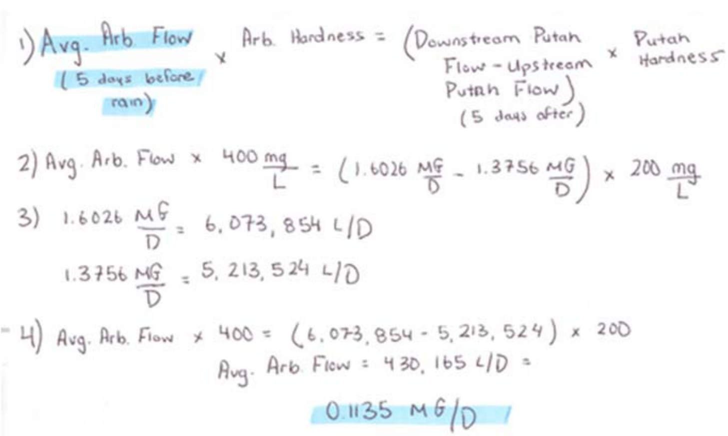
Water Hardness

Water hardness data combined with precipitation data revealed that the greatest difference in water hardness was during September of both years--due to the seasonal relationship. The table and correlating graph below show the results.

	002Down	002Up	001Down	001Up
Sep-12	388	388	172	152
Dec-12	124	112	155	116
Mar-13	148	212	202	205
Jun-13	280	292	185	180
Sep-13	400	404	202	198



Arboretum Flow



Our group estimated a flow of 0.1135 million-gallons per day in the Arboretum prior to the draining. We believed that this estimate is likely higher than the Arboretum's actual flow. The high estimation can perhaps be explained by the work that must be done and the energy that must be added to the Arboretum water in order to release the water into Putah Creek. This release likely leads to much faster flow of water in the Arboretum by creating turbulence in the waterway.

Conclusions

Although intuitively it would make sense that water quality in Putah Creek would decrease after the first rain due to the pumping of the Arboretum, we found that the quality is not significantly affected. Our hypothesis, thereby, was false. By approaching our research through analyzing flow, hardness, total suspended solids, and dissolved oxygen over the four seasons, we were able to get a generalized sense of how consistent water quality is in Putah Creek despite input from the nutrient rich waters in the fall. Our data can be used, however, to calculate an estimated flow of the water in the Arboretum using flow and water hardness. This could be useful to further research into water quality and/or water management relating to Putah Creek or the Arboretum. As a result of our calculation, we found that Putah Creek flows at least twice as fast as the Arboretum. It is possible that the pumping of the Arboretum may be diluted faster than it has time to accumulate in the water of Putah Creek. The method could be approached on a larger scale to solve a lot of water quality problems worldwide. Some errors may have occurred in the data collection process, skewing the actual measurements either upstream or downstream; however, we were able to collect enough data over an entire year to discourage large errors. This project in general showed us that information is available regarding water quality. These measurements are easily accessible to the public due to sources such as the Water Resources Control Board. This data can and should be used for many types of analyses by anyone that has water quality, water management, or even ecological questions.

Recommendation/Limitations

There were limitations in the data that we received and used. For example, the data for total suspended solids samples only included that of Putah Creek and not the Arboretum. Also, dates of measurement were chosen in blocks of three; not all days in a month were included. Measurements should be taken for all days in the month, instead of just a few. Also, data should be measured for both Putah Creek and the Arboretum. The terms “total suspended solids” and “hardness” lack important specificity. “Hardness” could imply many different types of chemicals that may or may not be harmful to the health of the people that consume that water, or the environment and wildlife, all grouped under a basic umbrella term of hardness. The same is true of total suspended solids. The water should therefore undergo testing to find the nature of the total suspended solids and the chemicals that make the water hard.

References

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