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Water Quality at Brush Creek

In an effort to discover the water quality of Brush Creek and its ability to support life, a series of tests coordinated by Dr. James Murowchick were used. Before beginning the project we first read, in Web Lab Module 10, a brief history of Brush Creek; then took a virtual tour of the drainage basin and the creek itself. A visual survey of the site to be tested was then conducted based on photographs in the same Web Lab. On 10/18/2004 at 8:30 A.M. a series of tests were conducted at the site. A visual stream survey was conducted, stream measurements to calculate stream discharge were made, a kick test was also performed in order to estimate the type and number of macroinvertebrates living in the water. This is the basis of the water quality rating. On 10/25/2004 at 8:30 A.M. another series of tests were conducted to determine temperature, nitrite and nitrate content, percent saturation, conductivity, turbidity, pH, hardness and alkalinity, total chlorine and free chlorine. On 11/1/2004 at 8:30 A.M. fecal coliform tests were performed on a sample of water from Brush Creek water collected that day; the colonies were then counted 24 hours later. This is a summary of the history of Brush Creek discussed in web lab module 10, partly upon which the hypothesis is based. The drainage basin of Brush Creek covers an area of about 80 square kilometers and is completely urbanized from its beginning in Overland Park, Kansas until it empties into the Blue River in east central Kansas City, Missouri. The creek bed was first paved with concrete in the mid 1930's. It flooded the plaza area of Kansas City, Missouri in 1977 when 12-16 inches of rain fell over a 24-hour period; it flooded the same area again in 1998 with 7.7 inches of rain. The creek bed has since been widened and deepened to prevent future incidents. The urban setting of Brush Creek's drainage basin is its nonpoint source of pollution; this is pollution comprised of emissions from vehicles, pesticides, refuse, oil, spilled gasoline, animal droppings and many other waste products of urban life. Another source of pollution comes from sewage water discharge into the creek during periods of heavy rainfall and snowmelt. It was discovered in 1995, through fecal coliform bacteria testing, that dry-weather discharges of sewage were flowing into the storm drains and into the creek. This problem was quickly rectified, and with regular maintenance of the sewage system should no longer be a problem. In taking the virtual tour of Brush Creek, it appears that upstream from site #1 usage is basically all residential. A visual survey was conducted on the condition of the creek based on the images shown below. The water looks brown in the photo, this could be because it is very shallow; other than that, the creek and the surrounding banks appear to be clean and free of litter. In the photo where the creek does not appear to be swollen there is no dry-weather discharge shown coming out of the storm drain.

The entire drainage basin of Brush Creek is urbanized. It is known that when excess water flows into the creek, the water brings with it many pollutants from the urban environment. However, based on the history of Brush Creek and the images shown above, the testing conducted during this project is under the hypothesis that, in the absence of excess water, the water quality of Brush Creek is good enough to be within EPA standards.

Photographs of location site #1, from Web Lab Module 10

Site Description

The tests were conducted in Brush Creek at location site #1. This site is located in Johnson County, near the intersection of 63rd Street and Indian Lane in Mission Hills, Kansas. The legal location is NE¼, NE¼, NW¼, Sec. 15, T12S, R25E.

The land use in the flood plain of this site is well manicured and completely residential. Riparian cover, for a distance of 100 feet from the bank, consists mostly of trees and grass. There is almost no bare ground, and, since it is a very affluent neighborhood, there is a minimum of houses and streets. The stream banks are covered mostly by a stone wall and grass; in very few places it is covered by trees, bare ground and a sidewalk built into the wall. Our visual survey was not preceded by rain, so we were able to get a good look at the streambed. It was mostly solid bedrock; it is limestone, but had the look of slate. The rest is a pretty even mixture of sand, gravel, cobble and boulders with a little silt thrown in for luck. The signs of human use are the wall, sidewalk and a small dam. The only bottom cover is trash; there is a rusty grate, a very old deflated football and a few pieces of plastic litter. Below are pie charts to illustrate these observations.

There is quite a bit of algae; it covers nearly the entire streambed. Most of this is close-growing and only five percent of it is filamentous. The water was quite clear with a small amount of sediment suspended in it. The water had a very mild musty odor; this, from my experience, is a normal smell in a healthy stream.

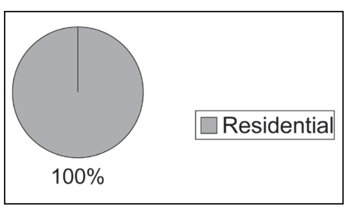

Figure 1: Floodplain land use

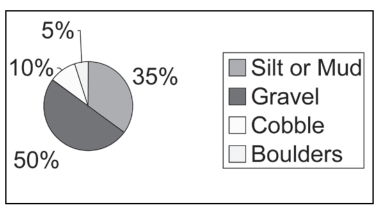

Figure 2: Riparian Cover

Methods

Testing at site #1 began on 10/18/2004 at 8:30 in the morning. To begin a visual survey was conducted; the survey took note of rainfall for the previous week, floodplain land use, riparian cover, condition of the stream banks, bed composition, bottom deposits, signs of human use, algae, water color and water odor. After this, tests were performed to determine stream discharge and to count macroinvertebrate life.

It rained on the first day of testing, but only 0.5 mm and had rained only 3 mm for the previous week (according to The Weather Channel). This small amount of precipitation allowed for a more accurate visual survey. Floodplain land use is determined by observing a 300-foot section of a stream and identifying what is the dominant land use. This is important to water quality in the stream because land use is a pretty good indicator of what types of nonpoint pollution likely will be flowing into the stream during periods of heavy precipitation. Riparian cover is determined by observing what covers the land area 100 feet from the top of the bank. This is important because riparian cover indicates how permeable the ground is and how readily polluted water will drain into the stream. The condition of the stream banks tells of what the banks consist. This is important because, if the bank is composed of materials that will not hold up during heavy flow, it becomes a source of sediment pollution. Bed composition is what the streambed is mostly composed of such as concrete, sediments, and bedrock. This is an indicator how quickly water is able to flow, also is an indicator of how much sediment pollution has occurred in the past. Bottom deposits are out of place deposits on the streambed such as trash, sludge, and precipitates. All are indicators of pollution. Signs of human use, such as paths, equipment and litter, show that people will or have used this stream. This could indicate what types of pollution could be introduced into the system through human use. The presence of algae on the stream bottom indicates a healthy stream capable of supporting life. Too much algae could indicate nitrate or phosphate pollution. Water color and odor can both be indicators of the presence of pollution.

Determining stream discharge proved difficult due to lack of riffle because it had not rained in the previous week. To begin, the cross sectional area had to be determined, the first step to this is to measure the average depth of the stream. Three measurements were made at one-foot intervals using a ruler since the water was very shallow. The average of the three measurements were multiplied by the width of the stream and this gave the cross sectional area. Next the average velocity of the stream needed to be measured to determine stream discharge. This was done by measuring out a distance of ten feet, releasing a hollow plastic ball at point zero, and then timing how long it took for the ball to float ten feet. This procedure was repeated five times. Due to the presence of a steady breeze, only once did the ball make it the full ten feet. For this reason the velocity was calculated, then these values were averaged to find the average surface velocity of the stream. Since the stream bottom is mostly smooth bedrock, the average surface velocity had to be multiplied by a correction factor of 0.9 to compensate for drag on the streambed to determine the average stream velocity. This value is multiplied by the cross sectional area and this gives the stream discharge in cubic feet per second.

Macroinvertebrate count is perhaps the most important test. The type of creatures found in a stream system will tell the long-term pollution story. Some types of organisms are completely intolerant of pollution and will die out while other organisms will thrive. If there is too little of one type of organism and too much of another, it is an indicator of a problem. To gather this information a kick test was performed. The test was performed in what little riffle we could find, this is because riffle is the part of the stream that supports the most diversity of life. To perform the test a net was held down stream while the stream bottom was disturbed upstream, whatever critters where hanging out would dislodge and float into the net. Then all of the organisms found in the net were sorted into an ice tray, than identified. This procedure was repeated three times, moving downstream to upstream. The stream was then given a water quality rating based on number of sensitive, somewhat sensitive and tolerant organisms.

The second day of testing was on 10/25/2004 at 8:30 in the morning. It was sunny and cool on this day and had rained only 1.1 mm in the previous week. The tests performed on this day were to test the chemistry of the stream. The tests investigated water temperature, percent saturation of dissolved oxygen, nitrite, nitrate, conductivity, turbidity, pH, hardness, alkalinity, total chlorine, and free chlorine.

The first test of the day was to take the temperature of the water, which was taken with a Fahrenheit thermometer and then converted to Celsius. The temperature of the water is very important because if the water is unseasonably warm it will artificially increase the ability of organisms to metabolize and plants to perform photosynthesis. Oxygen dissolves more readily in colder water. Plants and organisms don't need as much oxygen in the winter, but the bacteria does because it uses oxygen to break down all of the things that die in the winter. It is a very delicate cycle and this is why if an aquatic system is being thermally polluted, it can upset the balance of life in the system. To find the amount of dissolved oxygen in the water, first a sample of the stream water was scooped into a beaker then carefully, to avoid trapping air bubbles, poured into a glass bottle with a stopper. Then Dissolved Oxygen 1 and 2 reagent powder pillows were added to the water and carefully stopped and shaken. As the water and the two reagents mix it should for a precipitate that in the presence of oxygen should turn and orange-brown color. The precipitate was allowed to settle then shaken once again and allowed to settle. The dissolved oxygen 3 reagent pillow was then added, and the process above was repeated, only this time if oxygen is present the precipitate will dissolve and the solution will turn yellow. Some of this mixture was then poured into the small test tube provided and then poured into another bottle. To this Thiosulfate standard solution was added one drop at a time, while swirling, until the solution turned clear, with each drop representing 1 mg/L of oxygen in the water. With these values the quick and easy method was used to calculate the percent saturation of oxygen in the water.

The next test is for the presence of nitrogen in the water. Nitrogen is essential for the survival of all forms of aquatic life in this system. Nitrates and Nitrites are the usable forms of nitrogen. It is used by bacteria to oxidize organic materials turning this usable form of nitrogen into unusable dissolved nitrogen gases. This is a very important balancing force in the system, because an excess of usable nitrogen will allow algae to grow out of control, this would result in choking out life in the system. This is what we would likely see if unsafe fertilizers and pesticides were being washed into the stream. To test for nitrate and nitrite levels, test strips were used. The strip was dipped into a sample of the stream water for one second. After 30 seconds the color of the pad on the strip gave the Nitrite level, and after sixty seconds gave the Nitrate level.

Next was the test for the conductivity of the water. This means the ability of the water to conduct electricity. It is the presence of dissolved minerals in water that allow it to be a conductor, where pure water is an insulator. Brush Creek has a limestone streambed, so there should be plenty of dissolved minerals. Conductivity was tested using an electric conductivity meter. The meter was dipped into a sample of the water and the value given was multiplied by 10, this is the conductivity.

Turbidity is a test for the amount of suspended particles in water. These particles are a form of pollution and an indicator of water quality problems. This test is performed by pouring a sample of the water into a tube until the black and white markings on the bottom can no longer be seen.

The tests for Total Chlorine, Free Chlorine, Total Hardness, Total Alkalinity and pH were conducted using one test strip. The strip was first dipped into a sample of the water for one second, after thirty seconds the color of the pads indicated the values for hardness, alkalinity and pH. The strip was again dipped into the water and swirled for thirty seconds after which the colors on the pads indicated the values for Free and Total Chlorine. Chlorine occurs naturally in some aquatic systems, mostly salt water. However, in this particular system, any chlorine would likely come as runoff from our water treatment systems. The average pH of rivers and streams is between six and nine. The pH of clean rainwater is 5.6. It is the presence of the H+ hydrogen ion that determines pH; the more H+ ions there are the more acidic the water is. In areas such as this one where there is a lot of limestone, the H+ ions react with the calcium carbonate in the limestone to release calcium ions into the water, an abundance of which is necessary for life, making the water hard. This reaction leaves behind an excess of OH- ions in the water and thus raising the pH and making the water alkaline. This is a very delicate system; if anything were getting into the stream to make the water more acidic then usual, it should be obvious if any of the factors above are outside of the norm. Such as if the pH were too low or if the water were harder then expected.

The third and last day of testing took place on 11/1/2004 at 8:30 in the morning in the lab. Used for the testing was a sample of water from the site collected that morning. The air temperature was 23 degrees Celsius and the water temperature was 16.8 degrees Celsius. The difference this time is that it had rained 18.3 mm in the previous week, so the condition of the water was quite different. Instead of being clear and free nearly free of suspended particles, the water was murky green and dirty. On this day a fecal coliform test was performed, and will be a very good indicator of the type of pollution that gets dumped into the stream through runoff. Fecal Coliform is a type of bacteria found in the intestines and feces of animals that aids in digestion. As it says in web lab module 12, fecal coliform bacteria are not dangerous; what are dangerous are the pathogenic organisms that are found with it. Bacteria of this type will definitely be found in the water after rain, having been washed out of yards and sewers in the drainage basin. To begin the test, the work area had to be wiped down with a ten percent bleach solution to sterilize. Then six sterilized filter funnels were labeled for the amount of stream water that would be filtered through them. The first was the control, that would have only distilled water filtered through; the other five were labeled for 0.01 mL, 0.1 mL, 1 mL, 10 mL, and 100mL.

A hand pump was used to create a vacuum to pull the water samples through the filter as it was pipetted into the monitor; each sample was followed with a packet of m-FC broth that was pulled through the filter in the same fashion. For the two smallest samples, 1 mL of stream water was added to 99.0 mL of dilution water, then 1 mL and 10 mL of the solution were filtered the same as above. The six Petri dishes were then sealed, placed in a waterproof bag, and placed in an incubator for 24 hours. The next day the colonies were counted.

Results

Water Chemistry

Water Temperature: 13.3°C
Dissolved Oxygen: 6 mg/L
Percent Saturation: 57%
Nitrite-N: 2 ppm
Nitrate-N: .15 ppm
Conductivity: 0
Turbidity: >60
pH: 6.8
Hardness: 25 ppm
Alkalinity: 120 ppm
Total Cl: 0 ppm
Free Cl: 0 ppm
Stream Discharge: .476 ft^3/s

The results from the water chemistry tests all suggest a healthy stream system. The percent saturation of dissolved oxygen in the water is which is within a normal range with consideration to how much organic matter was within the stream and lack of riffle. The level of Nitrates and Nitrates is acceptable and there was no overgrowth of algae to suggest otherwise. The turbidity test showed clean clear water that appeared to be free of suspended particles; the tube could be filled completely to the top without losing sight of the black and white markers. The thing that is concerning is the lack of conductivity, for which a value of zero was given. Perhaps it is not the presence of just any dissolved minerals in the water but rather the presence of sodium ions that dictates conductivity. The results of the test for chlorine gave results of zero, which is an indicator of clean water. The water had a pH of 6.8, which is within the normal range for healthy streams. Due to the limestone stream bottom, the hardness and alkalinity seem to be within a normal range.

Fecal Coliform

>200 colonies/100 mL
>60 countable blue colonies per plate

The number of fecal coliform colonies that grew in the Petri dishes was quite high; however, not surprising due to the amount of precipitation experienced in the previous week. The stream itself shows to be quite healthy. The amount of pollution that obviously enters the stream during period of high precipitation, however, is a cause for concern. The number of colonies that grew is way over the allowable limit. It is difficult to believe that animal droppings could contribute this high of a concentration of this type of bacteria.

Macroinvertabrate Counts

Only two types of somewhat-sensitive organisms (crayfish and damselfly nymphs) were found and 6 types of pollution tolerant organisms (aquatic worms, midge larvae, pouch snails, leeches, and tadpoles) were found. No organisms from the sensitive category were found, and of the 60 organisms found only 5 were somewhat-sensitive. The stream shows all of the signs of being healthy, but received a water quality rating of poor (<12). Perhaps the stream is in good condition only in dry weather, but during periods where there is heavy runoff the water quality is entirely too poor to support the pollution intolerant creatures. Another possible solution is the time of year, the water could be too cold, or perhaps there is not enough oxygen in the water due to the large amount of organic matter and lack of riffle.

Visual Survey

The use of the floodplain leading to this site looks to be mostly residential and at the site it is completely residential. Riparian cover is mostly trees and grass. The stream bank is mostly grass and bedrock. The streambed looks to be mostly bedrock and was about 90% covered with algae, mostly the close growing kind. The look and smell of the water seemed to be very clean. It was a bit shocking to see what trash there was in the seemingly clean water; the trash being a rusty grate, an old football, and a bit of plastic litter. The signs of human use are the trash, the dam, a storm drain, and a narrow walkway across and along side the stream. From the visual survey Brush Creek looks to be a very well kept neighborhood spot.

Conclusion

Based on the test results, the hypothesis is supported. Brush Creek appears to be healthier then originally expected. The macroinvertebrate count gave a poor water quality rating, but this could be due to any number of factors including pollution. It is more likely the fact that the riffle was almost nonexistent. The thing that is the most concerning is the results of the fecal coliform test. The look of the water and the number of colonies that grew from it do not suggest a healthy stream. The water used for this test was collected after a few days of rain and looked nothing like the water tested during the previous two weeks. The source of the pollution must be coming from runoff and mostly from sewers. It is difficult to say what can be done, except that the sewer system should be completely cut off from the storm drains. If this experiment were to be performed again, there should be two sets of tests; one where all of the tests are performed during dry-weather conditions and another set of the same tests were performed during periods of high precipitation. The results would likely tell two very different stories.

References

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