Exploring Citizen Science Use of Monitoring Urban vs. Agricultural Watersheds in the Kansas Flint Hills

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Abstract:

Public involvement in the evaluation of surface water quality educates local communities about possible water pollution problems, provides researchers with a larger pool of data to use, and encourages community involvement in environmental issues. These concepts can be applied to the question “Is there a significant difference in surface water quality between watersheds within the Flint hills ecoregion?”. Based on the research question at hand, the hypothesis to be tested is: If surface water quality is compared between agricultural and urban watersheds then there will be an insignificant difference in the variables tested. Data was collected at six locations from watersheds in the Flint Hills region to represent differences between urban and agricultural effects on water quality. The main focus of this research distinguishes between the Anderson (urban) Watershed and the Marlatt (agricultural) Watershed in Manhattan, Kansas. Streams were evaluated using pH, electrical conductivity, nitrates, and phosphates with instruments provided in Hach Water Analysis Kits. After data collection was completed, data analysis was conducted using R programming and ArcGIS to visualize watersheds and create graphical representations of the sampled data. The Kolmogorov-Smirnov (KS) Test was then used to run the statistical analysis. Data collected showed elevated levels of every tested variable in the Marlatt Watershed versus the Anderson watershed with the exception of electrical conductivity. The median value, and the upper quartile range is higher for phosphorus, nitrate, and pH. Electrical conductivity (EC), however, had a higher median value and overall quartile range in the Anderson Watershed. The overall range of the tested values in the Marlatt Watershed data values were higher, indicating more variability. Based on the KS Test, there was a statistically significant difference at a 95% confidence level that the pH and phosphorus values differed between the two studied watersheds. The Marlatt Watershed, with its agricultural characteristics, contains elevated levels of phosphorus and pH. This signifies that surface water quality is ultimately affected by the land cover characteristics that each individual watershed possesses, to a certain extent. This testing is designed to create a standardized system to which local concerned citizens who are equipped with the proper knowledge and equipment can monitor local streams for surface water quality and provide relevant and accurate results to an overseeing entity. Involving citizens in data collection can be very effective; however, proper training and consistency are crucial for effectiveness.

Introduction:

When looking at water quality, there are many factors at play. Runoff carrying sediments and chemicals drives surface water quality. Surface water quality is important for many reasons: it is a primary source of municipal potable water, biotic and abiotic functions, irrigation, etc. Increasingly, surface water is being exposed to various pollutants in increasing quantities. Runoff is picking up sediments and excess compounds and carrying them to larger bodies of water. The side effects from this are detrimental to individual ecosystems and the environment in general.

Water quality can have several implications on potable water security and recreational activities. Urban watersheds often face decreased stream quality due to the over-fertilization of lawns. Lack of knowledge and ill-appropriate timing of fertilizers can lead to increased nutrients in water whether through surface runoff or leaching. In agricultural watersheds it is much of the same. Over application and the potential for nutrients, especially phosphorus, to runoff into streams is causing large issues with eutrophication in surface waters. Eutrophication leads to algal blooms which can then lead to hypoxic zones, killing aquatic species. This type of water is also dangerous for humans to come into contact with or ingest. The quality of streams and bodies of water also impact appeal of a particular area and can help the citizens visualize water quality issues. One way to bring this awareness to citizens is to involve citizens in data collection. Phenology, landscape ecology, and species-specific studies are all primary veins of study for the layperson conducting data work (Dickinson et al, 2012). Citizen scientists offer the ability to observe, collect, and sometimes even interpret vast quantities of information that would be unavailable to professionals otherwise. The numerous physical points of data collection offered through a volunteer network allow for diversity of information to be collected. The vast amounts of data that could be collected can be a catalyst for scientific knowledge when analyzed and interpreted by professionals, and the greatest amount of data can be collected when working in tandem with citizen volunteers (Conrad et al, 2016). This potential strength is currently largely untapped. Access to vast amounts of data are crucial to most scientific research, but the use of volunteers to collect that data is far from being optimized (Theobald et al., 2015).

In addition to enhancing the amount of data available, involving citizens in water quality analysis can also help create awareness of what humans and human activities are contributing to the problem. In a study done by Lei Wu, et al (2012), Impacts of Climate and Land-Use Changes on the Migration of Non-Point Source Nitrogen and phosphorus During Rainfall-Runoff were studied. “Annual pollution load would obviously change due to variations of runoff and livestock and poultry breeding, the largest growth months in one year for total nitrogen and total phosphorus load are both in June, which is in accordance with changes of rainfall amount.” When analyzing pollution runoff, it is important to have a clear definition of human use. In this study, animal waste was considered human use.

Human use in the form of fertilization application can have further effects on pollution runoff and water quality. Differences between agricultural and urban fertilizer use may cause differences in runoff. Homeowners use different fertilizers than farmers which may have an impact on chemical runoff. Outside of urea, which is mainly nitrogen, fertilizers such as Diammonium Phosphate (DAP) or Monoammonium Phosphate (MAP) may be used for crops. These contain a much higher percentage of phosphorus per total amount of fertilizer applied versus what a typical lawn fertilizer might apply. Homeowners, on the other hand, typically use a fall application fertilizer containing the N-P-K ratio of 28-0-6, or even a 32-0-10. According to K-State’s Turfgrass Information webpage, phosphorus deficiency is very uncommon in an established turfgrass setting unless other factors hinder it such as an unfavorable pH level or extremely low phosphorus levels (Kansas State University, n.d.). Assuming an established turfgrass exists, homeowners would be less likely to apply any phosphorus fertilization and stick with the common nitrogen fertilizer.

Study Area/Methods

Water samples were collected for 8 weeks in the fall of 2016 from 6 locations around the Manhattan, Kansas area. The Anderson Watershed was established as the base for "urban" water, and the Marlatt Watershed near the North Agronomy Farm as the "agricultural" data point as shown in Figure 2. The aim was to study watersheds specifically within the Flint Hills Region of Kansas.

Figure 1 shows the Flint Hills Region and its relative size compared to the Midwest region of the continental United States.

Figure 1: Flint Hills region in the Midwest highlighted in dark green

The data collected was combined with the sampling efforts from classes of previous years. The goal of this project was to develop water sampling processes that could be easily translated into use by everyday concerned citizens. In collecting data,the quality of local watersheds was monitored, and potential hurdles were identified that would need to be overcome in the implementation of a citizen science water quality sampling effort.

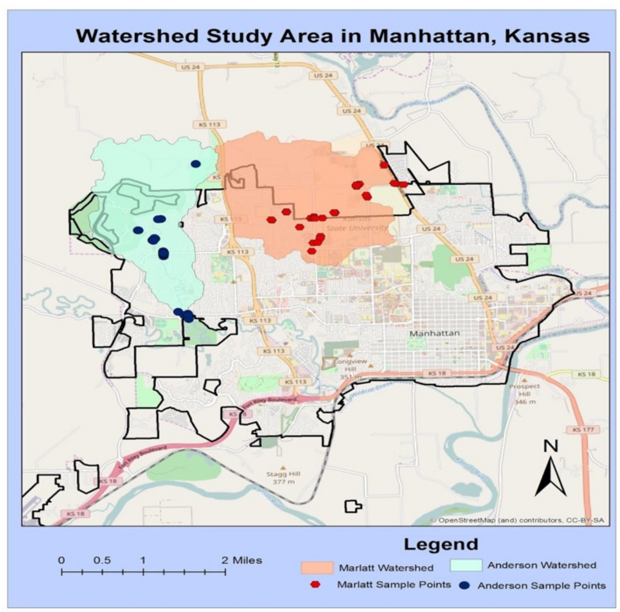

Figure 2: Anderson Watershed (blue) and Marlatt Watershed (red) in Manhattan, Kansas

In order to define the watersheds as urban and agricultural, it is necessary to see what land cover types are present to ensure the labels are accurate. This is made possible by creating tables which show what type of land use is prevalent in each watershed, how much of it there is, and its percentage relative to the total acreage in the particular watershed. The Marlatt Watershed is almost 400 acres larger than the Anderson Watershed. While the Marlatt Watershed has roughly the same urbanized percentage of land use as the Anderson Watershed, the area delineated as the Marlatt Watershed contains a significant portion of agricultural land. In comparing "urban" vs. "agricultural" it is important to note that the Marlatt Watershed contains about 22% agricultural land, whereas there is none in the contrasting watershed. This is crucial for properly defining the research question at hand. These two watersheds share many of the same qualities as each other in terms of land cover type except for the proportion of agricultural land. It is this piece of information that allows us to confidently label them as contrasting watersheds.

Water samples were tested in six different locations in the Manhattan, Kansas area. One location was the Konza Prairie to serve as a natural control. Two locations were at the Kansas State University Agronomy North Farm to represent the effects of agricultural practices on water quality. The three remaining locations were used to represent urban land use on water quality. These locations included Campus Creek on KSU campus, Little Kitten Creek on Anderson Avenue and Little Kitten Creek on Kimball Avenue. The main areas with sufficient data to provide relevant results were only the sample points along the Little Kitten Creek which is a part of the Anderson Watershed and then the sample points within the Marlatt Watershed in which the Agronomy North Farm is included.

Land Cover Type	**Acres**	**Percent of Total Acres**	**Total Acres**
Open Water	1.6	0.09	1831
Developed, Open Space	319.6	17.45	1831
Developed. Low Intensity	339.4	18.54	1831
Developed, Medium Intensity	62.8	3.43	1831
Developed, High Intensity	2.8	0.15	1831
Deciduous Forest	117.2	6.4	1831
Grassland/Herbaceous	971	53.03	1831
Woody Wetlands	16.9	0.92	1831

Table 1: Anderson Land Cover Types and Relative Percentage of Total Acreage

Land Cover Type	**Acres**	**Percent of Total Acres**	**Total Acres**
Open Water	12.9	0.59	2198
Developed, Open Space	275.7	12.54	2198
Developed. Low Intensity	506	23.02	2198
Developed, Medium Intensity	137.5	6.26	2198
Developed, High Intensity	49.9	2.27	2198
Deciduous Forest	141.9	6.46	2198
Evergreen Forest	52.9	2.41	2198
Grassland/Herbaceous	371.5	16.90	2198
Pasture/Hay	145.1	6.60	2198
Cultivated Crops	481.6	21.91	2198
Woody Wetlands	22.9	1.04	2198

Table 2: Marlatt Land Cover Types and Relative Percentage to Total Acreage

A variety of tests were completed using Hach Water Analysis Kits, provided by Kansas State University, including temperature, electrical conductivity, pH, phosphorus, nitrogen, ammonium-nitrogen, and turbidity. Tests were completed in a variety of weather conditions, with some being after major rainfall events and others in periods of no precipitation.

The tests used in this study differed from some other water quality tests in that the use of bioindicators of stream health were not used. There are several environmental agencies that utilize different water quality assessments. These agencies pondered the question "Are these tests effective for analyzing stream health?"

A study by Ward, T. A., et al, 2003, compared different United States agencies' methods for water quality assessment in stream health. The different agencies used were the NRCS, EPA, BLM; each agency uses a different test to assess stream health. 234 rangeland riparian streams were tested to find how consistent the tests were and how the variation of stream type affected the results.

The authors found the EPA and the NRCS tests which focus mostly on habitat evaluation were very similar and consistent with each other. The BLM uses a different test that is focused more on hydrologic function and differed in results from the other two agencies. The authors concluded that the two different types of tests should be combined to give an accurate assessment of stream health.

Varieties of tests and evaluation methods can be beneficial to understanding water quality, however it is important to practice consistency and to use appropriate procedures. The USDA set forth a universal procedure for collecting grab samples correctly. The purpose of this was to eliminate error in the procedure of collecting samples, assuming all would follow this same format. The sampling spot should have fast moving water at least 6-8 inches deep. If the water is shallower than 6 inches, then be careful not to disturb the stream bottom. The sample should always be taken upstream from any artificial structure and approach the targeted sampling point from downstream to help avoid sediment disturbance. Before the actual sampling, be sure to record all necessary information such as time of day, year and geographic location. Allow ample time for the thermometer to equilibrate as it may take a few minutes. Also, make sure gloves are worn and not touched by anything other than the sample container. Avoid touching the face after the gloves are put on as nitrates can reside there. (Musselman 2012). To prepare the container for the sample, always rinse it with deionized water, and after rinsing, pour the water downstream from sample spot. If the container has a cap, be sure to rinse this beforehand as well. Once cleaned, take the sample container and reach it as far away as possible upstream. Rinse the container three times with the sample water before capturing the final sample. Try and take the sample from the middle depth of the stream if possible. Place the container flat on its side under the water pointing the mouth of the immersed container upstream (Musselman 2012). If any sample needs to be transported off-site, be sure to refrigerate as soon as possible. Repeat these same steps for multiple samples to ensure all have been prepared equally.

Nitrates:

Nitrates were tested using the nitrate test and the ammonium-nitrogen test provided in the Hach Water Analysis kits. Nitrogen is found as nitrates and nitrites in water with excessive levels of nitrates and nitrites coming from fertilizer runoff and wastewater. Excessive levels can be very damaging to human health. In drinking water, the EPA limit on nitrates is 10 mg/L.

Phosphates:

Phosphorus was measured using low-level phosphate test provided in the Hach Water Analysis Kits. Phosphorus is a vital element to organisms and is generally the growth-limiting factor for plants and animals in a lake ecosystem. Phosphorus is found naturally in water as it is released from rocks due to weathering; however, excessive amounts of phosphorus can be the result of fertilizer runoff. Phosphorus is not toxic to animals or plants; however, excessive phosphorus can increase photosynthetic activity and cause cyanobacterial blooms , or more commonly known as blue-green algae.

Electrical Conductivity:

Electrical conductivity meters were provided in the Hach Water Analysis Kits and were used to measure how well water conducts electricity. Water with higher concentrations of dissolved salts has a higher electrical conductivity reading. Readings of electrical conductivity are taken with the assumption that water temperature is 25°C. Most meters have ATC or automatic temperature compensation to display a correct reading. However, it is also important to check meters for correct calibration.

Turbidity:

Turbidity was measured using turbidimeters. Turbidity is measured in NTU or Nephelometric Turbidity Units. Turbidity is the measure of clarity. Some factors that affect turbidity are suspended soil particles, organic and inorganic materials, and organic compounds. The higher the turbidity measurement, the larger amount of suspended particles in the water. Increased amounts of phosphorus in the surface waters can lead to eutrophication and algal blooms which then leads to higher turbidity. Fish health can be adversely affected by high turbidity levels. Also, it costs more for water treatment plants to clean a more turbid water system and remove all impurities.

pH:

pH was measured by pH meters in the Hach Water Analysis Kits. pH is a measure of hydrogen ion concentration in a solution which is measured on a scale of 0-14. pH measurements that are lower than 7 are considered acidic, measurements greater than 7 are alkaline, and 7 is considered neutral. Typical values of pH in freshwater lakes and streams is between 6.5 and 8.5. Due to the limestone bedrock that Manhattan sits on, pH levels are more likely to be more alkaline in nature.

GIS Techniques:

ArcGIS is a powerful geographical information system created by the Economic and Social Research Institute (ESRI) to use geographical data to compile data and create visual maps. It is a platform that can be useful from professionals to the general public. ESRI's ArcGIS mapping program was used to process data and model water systems, create digital elevation models within the Manhattan, Kansas area, delineate certain watersheds and create graphics that are visually appealing and spatially accurate.

'R' Programming:

'R' is a free programming language used to create statistical and graphical analysis between whatever information the user chooses. It requires a specific directory to pull information from and then a chain of commands is required to begin a comparison of certain datasets. (Two data sets can be compared to give a visual representation of any differences. The watersheds were compared with one another regarding pH, electrical conductivity, nitrate levels and phosphorus levels. The 'R' program was used to create box and whisker plots, histograms and Kolmogorov-Smirnov tests.

Box and Whisker Plot:

Box and whisker plots were used to compare the urban watershed vs. the agricultural watershed. These plots are set up to give the median of all the values, along with the upper and lower quartile range representing the "box" of the box and whisker plot. Any values outside of the interquartile range are shown by points outside of the box. These values represent the extreme outliers and give an idea of the extent of the data set from high to low. Box and whisker plots are an excellent way of showing the distribution of data based on the median

Histogram:

A histogram is a graph describing the frequency of certain values in a particular data set. It aids in showing what an expected reading might look like for someone wanting to conduct more research in a similar fashion. Relative frequencies were compared between urban and agricultural watersheds to show which area has a higher number of certain values as compared to the other. This can help show a trend in what a normal data point might bring at one watershed versus the other.

Kolmogorov-Smirnov Test:

The Kolmogorov-Smirnov (KS) test is a nonparametric test used to compare two samples. This essentially means it is not basing its results on any underlying parameters and does not make assumptions as to how the results have been distributed. The graphical results show the probability of what a certain value might be and how its probability compares to the other data set. Along with the graphical results comes an analysis of the two data sets. The D-Value represents the maximum distance between the Cumulative Distribution Functions (CDF) of both the samples. The p-value leads to the rejection or acceptance of the set significance value created by the researchers. So a p-value of <0.05 means there is a 95% chance that there is a significant difference between the two point sources and the hypothesis can be accepted for that rationale. A p-value >0.05 means there is no significant differences between the two data sets.

Results:

Figure 3 shows that in every instance except for electrical conductivity, there are elevated levels of the tested variables in the Marlatt Watershed (agricultural) versus the Anderson Watershed (urban). The median value, and the upper quartile range are higher for the phosphorus, nitrate, and pH and temperature. However, the results are different and electrical conductivity (EC) has a higher median and overall quartile range in the Anderson Watershed (urban). Usually, a higher temperature leads to a higher EC value, but these results are the opposite. It is crucial to see that the overall range of the Marlatt Watershed (agricultural) was higher meaning it was more variable in its readings.

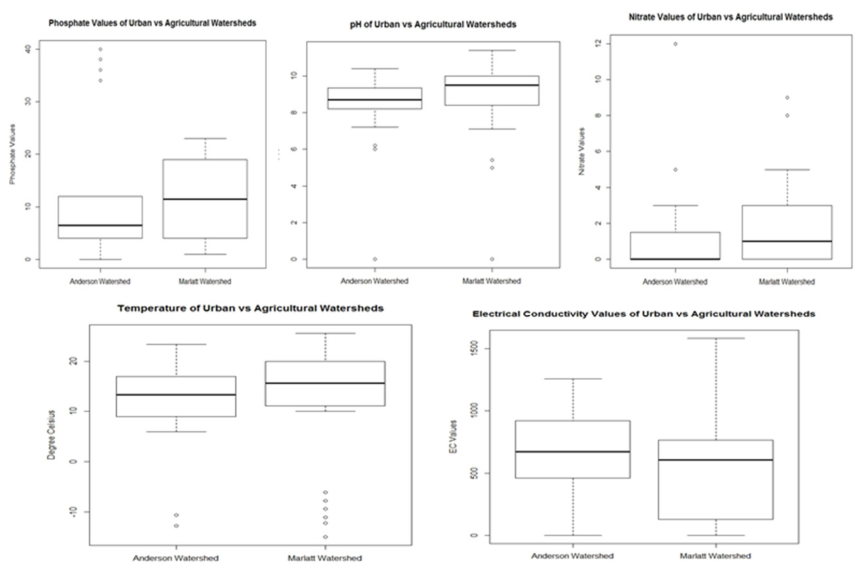

Figure 3: Boxplot comparisons of temperature, nitrate, phosphorus, electrical conductivity and pH between Marlatt and Anderson watersheds

	pH	Nitrate	Phosphorus	EC	Temperature °C
Mean	8.044681	0.93617	13.45652174	648	12.74234043
Minimum	0	0	0	0	-12.8
Maximum	10.4	12	40	1258	23.3
Median	8.7	0	6.5	674	13.3
Mode	9.2	0	6	1125	15
Std. Dev	2.610683	2.046317	14.38554003	346.7697	7.1057541

Table 3: Minimum, maximum, mean, median, mode, standard deviation for tested variables in Anderson watershed representative of

	pH	Nitrate	Phosphorus	EC	Temperature °C
Mean	8.880952	1.77561	17.08809524	556.9762	11.89047619
Min	0	0	0	0	-15
Max	11.4	9	40	11.4	25.6
Median	9.5	1	15.5	607	15.6
Mode	9.8	0	0	0	21.1
Std. Dev	2.29199	2.361147	14.33906091	420.5814	11.33743923

Table 4: Minimum, maximum, mean, median, mode, standard deviation for tested variables in Marlatt watershed representative of 47 separate

It is also important to also see the outliers in each boxplot. Temperature had many outliers in the box plots especially in the Marlatt Watershed. Looking at the phosphorus plots, the

Anderson Watershed results showed quite extreme outlier values on the higher end of the spectrum. Even though these were extreme values, it did not change the median values or the quartile range enough to push it higher than the Marlatt Watershed. The values for pH were fairly high in general for both watersheds averaging around a pH of nine. Nitrate values were fairly sparse in both watersheds with most of the of the readings being zero or very near zero. This can be seen in Table 3 below which represents the statistics for the Anderson Watershed. The data set total for this table is 42 separate data points. In the Anderson Watershed, the median and mode values for nitrate were both zero. This signifies that most the nitrate tests registered zero for its concentration in the water. Also, the standard deviation for nitrate is low at ~2. This shows that 68% of all values are within the mean nitrate value of ~0.9 and are not dispersed over a wide range. Compare that to the Marlatt Watershed and it shows that 68% of all the values in this watershed are within ~2 of the mean nitrate value of 1.77. Phosphorus standard deviations are quite a bit higher between the two watershed. There is a higher mean phosphorus value in the Marlatt Watershed as was shown in Figure 3 along with Table 3 & 4. The standard deviations, however, are much higher but in both watersheds the deviation is around the same value of ~14.

The histograms shown in Figure 4 & 5 help to illustrate the distribution of points and what trends show up in each watershed. First, Figure 4 describes the frequency of values for the Anderson Watershed. It is apparent that pH trends towards a value somewhere between 8 and 10 with the next highest value falling somewhere between 6 and 8. Since there were forty-seven data points total, it is accurate in saying that the frequency of a pH value of 8 to 10 likely happened over 60% of the times sampled. This is a heavy trend of this range of pH values. Next,

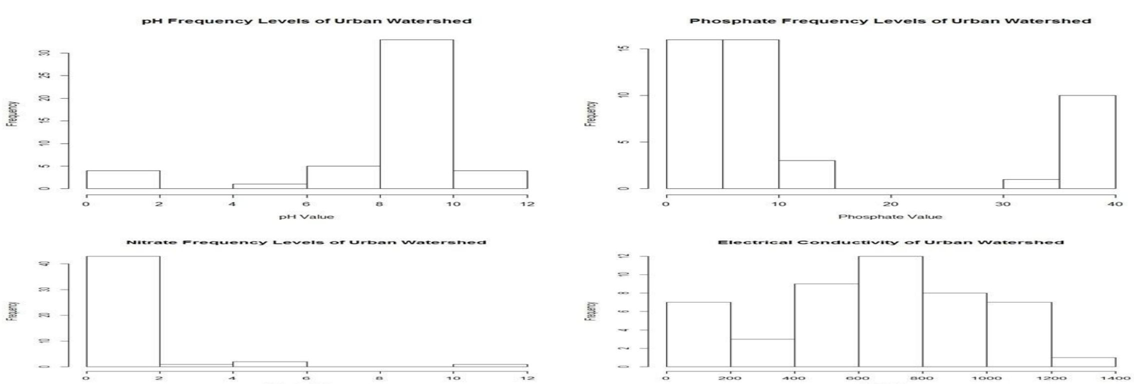

Figure 4: Histogram data describing pH, electrical conductivity, phosphorus and nitrate in the Anderson Watershed

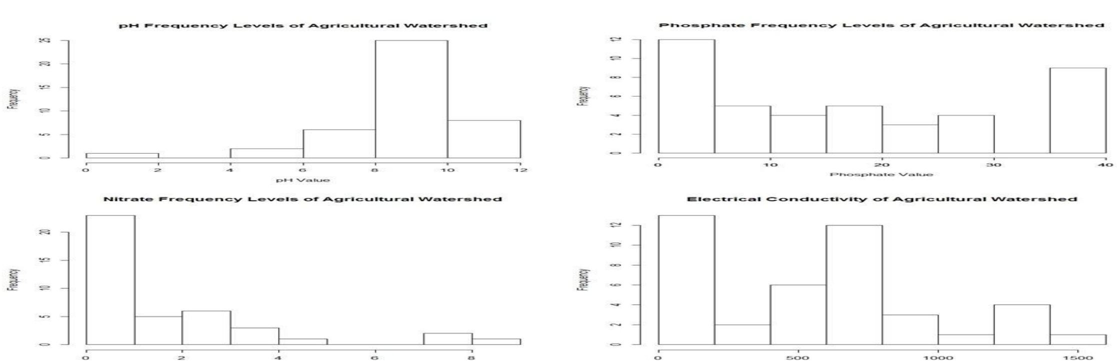

Figure 5: Histogram data describing pH, electrical conductivity, phosphorus and nitrate in the Marlatt Watershed

the phosphorus histogram represents very low values of phosphorus with over 30 data points registering under a value of 10. This graphic also shows the outliers that were described previously in the boxplots. Nearly 10 data points had a phosphorus value near 40. There were hardly any values registered between these two extremes. Moving on to nitrate, it is extremely apparent that nitrate was barely found in the Anderson Watershed with over 40 points recorded between 0 and 2. Electrical conductivity nearly followed a bell-curve distribution with the highest frequency of points falling in the middle of the spectrum between 600 and 800. It is important to note the amount of values that are between 0 and 200 for electrical conductivity. These were most likely holes in data due to faulty measuring equipment.

For the Marlatt Watershed, pH follows a similar trend to the other watershed. Its highest values fall in the 8-10 range, but the biggest difference is that second highest frequency of values is in the 10-12 range. With 42 total samples taken for this watershed, a pH between and 8 and 10 has a 60% chance of occurring as well. This shows a more alkaline trend in the agricultural shed which will be discussed in more detail below. The frequency of phosphorus levels are more uniform across the range of values, yet it still holds the trend of many more values near zero and many around 40 as did the urban watershed. Next, the nitrate values still had an extremely high frequency of zero readings with nearly 25 recording this value, but there were more samples that indicated at least some level of nitrate in surface water as opposed to the urban watershed. Electrical conductivity followed a slight bell-curve shape but some outliers were

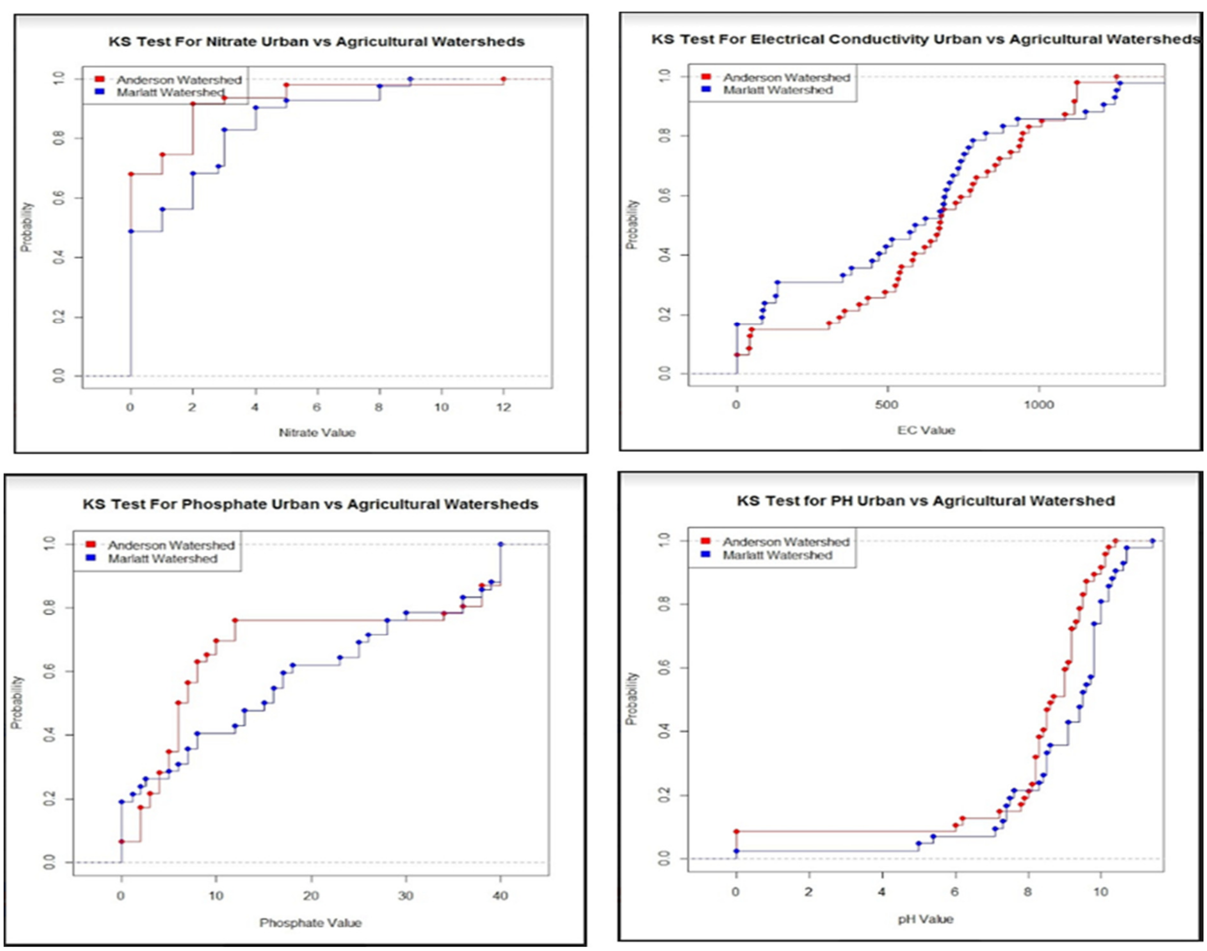

Figure 6: KS Test comparing pH, electrical conductivity, phosphorus and nitrate between the Anderson and Marlatt watersheds

present. Once again, many values registered around the zero mark with the culprit once again holes in the data due to faulty equipment. The highest frequency for EC was around the 700 mark, but there was a slight uptick in frequency of values at the 1300 mark as well.

Figure 6 represents the KS Test graphics for the comparison of electrical conductivity, pH, phosphorus and nitrate. Starting with electrical conductivity. As is apparent via Table 5, the d-value for this KS test is 0.175. It illustrates the maximum distance between the two Cumulative Distribution Functions (CDF) of the two watersheds. This shows how far apart the two EC values ranged from each other between the watersheds. The p-value is 0.4995. This means that these two watersheds are not entirely different based on the tested EC values. So there is no significant differences between the two watersheds that lead to drastically different values for electrical conductivity. The null hypothesis must be accepted, stating that these two sample points were drawn from the same distribution, as the p-value is outside of the significance level.

The next graphic from Figure 6 showcases the varying pH levels between the two watersheds. What is made apparent is that there is an obvious increase in pH levels in the Marlatt Watershed (agricultural) versus the Anderson (urban) Watershed. The probability for a pH of 10 to occur in the Marlatt Watershed is nearly the same probability for a pH of 9 in the Anderson Watershed. Also, the d-value for this KS test is 0.325 which is substantially higher than for the electrical conductivity meaning there is a larger distance between the two sample points. For the p-value it is 0.018 which is well below the threshold of 0.05. This means the hypothesis of the pH values being drawn from the same distribution can be rejected and with 95% certainty these samples were taken from two different distributions. The KS Test for nitrate values is shown next. Nitrate was not found rarely in either watershed, but the research noted a specific absence in the Anderson Watershed. There is almost a 70% probability of not registering any nitrate in that watershed at a given time versus 50% probability in the Marlatt Watershed. The d-value for this KS test was 0.23 showing a relatively large difference between the two CDF's. Also, the p-value of 0.18 means that according to these statistics, these values were drawn from the same distribution. Next, phosphorus values differed widely between the two watersheds with the Marlatt Watershed having a notably higher phosphorus presence. The d-value for this data set was 0.33 which shows large distribution between the two CDF's. The p-value was 0.015, which

Pollutant	Test Statistic (D)	Probability
Electrical Conductivity	0.175	0.4995
pH	0.325	0.018*
Nitrate	0.23	0.18
Phosphate	0.33	0.015*

Table 5: Results from the Kolmogorov-Smirnov tests for the pollutants electrical conductivity, pH, nitrate, and phosphate. Probabilities highlighted by an * indicate a statistically significant difference at a 95% confidence

means that these values did not come from the same distribution and were distinctly different by some degree.

Conclusion:

The question of whether there is a significant difference in surface water quality between agricultural and urban watersheds was found to have mixed results. Along with confident results from the KS Test which will be discussed shortly, the boxplots helped to confirm a trend in higher values in the Marlatt Watershed for all tested variables besides electrical conductivity. However, when looking at the EC value comparison, the Marlatt Watershed still has a wider range of values. This can possibly be explained due to the agricultural inputs that take place in this watershed. As has been mentioned before, factors that affect EC include the amount of dissolved salts in the water, and since these salts can be in the form of fertilizers, it is possible that with a flux of fertilizer, EC values can spike depending on the time when the sample was taken. Then, when the fertilizer has run-off and moved out of the watershed, the values return to a low level. Agricultural practices typically attempt caution in preventing over-fertilization of fields to save money and become more efficient. Also, the fertilization is usually completed in a specific time slot and is completed fairly quickly across the spectrum. However, this is not the case for homeowners who may accidentally fertilize too much and too often leading to excess runoff of salts and fertilizers into the surface water over a longer period of time. Homeowners' schedules are all different leading to alternate fertilization times such as during the fall season. Some of this is speculation in terms of homeowner trends but there is still common sense truth behind the claim. With these explanations, it is possible to see why the urban watershed may contain a higher EC value versus the agricultural watershed, yet the agricultural watershed having a lower floor and higher ceiling in terms of extreme values.

Moving forward to the KS Test statistics, phosphorus and pH were found to be significantly higher in the agricultural watershed versus the urban watershed. This claim comes with a 95% confidence based off the KS Test statistics. Explanations are possible to justify the KS statistical results. An important speculation as to why phosphorus levels may be higher in the agricultural water is the type of fertilizer applied versus the urban watersheds. Outside of urea, which is mainly nitrogen, fertilizers such as Diammonium Phosphate (DAP) or Monoammonium Phosphate (MAP) may be used for crops. These contain a much higher percentage of phosphorus per total amount of fertilizer applied versus what a typical lawn fertilizer might contain. According to the International Plant Nutrition Institute(IPNI), DAP contains about 46% P2O5 or about 20% phosphorus (Bahrle-Rapp, 2007). This could be a reasoning for the elevated levels of phosphorus in the surface water in the agricultural watershed even if conservative fertilization practices are performed. Also, according to the IPNI, DAP leads to an increased alkalinity in the surrounding soils as it dissolves(Bahrle-Rapp, 2007). With this information, and the assumption of DAP used for phosphorus fertilization within the Marlatt Watershed for agricultural fertilization, it is possible link why this watershed has significantly higher phosphorus value and pH value. Also, in general, the pH values were fairly alkaline for both watersheds when compared to normal pH level of 7. This could be because of the limestone bedrock that the Flint Hills region sits upon. Looking at the urban fertilization methods, a common fertilizer for fall application contains the N-P-K ratio of 28-0-6, or even a 32-0-10. It is apparent that minimal amounts of phosphorus are popular for use as a fertilizer during fall fertilization. According to K-State's Turfgrass Information webpage, phosphorus deficiency is very uncommon in an established turfgrass setting unless other factors hinder it such as an unfavorable pH level or extremely low phosphorus levels (Kansas State University, n.d.). Assuming an established turfgrass exists, homeowners would be less likely to apply any phosphorus fertilization and stick with the common nitrogen fertilizer. These types of claims certainly need more research to provide any concrete declaration, as this is mostly speculative to explain the found results.

Adding on to the analysis of phosphorus, while out in the field with the Hach Kit, phosphorus values were read straight from the color wheel instead of reading the value and then dividing by a certain value to obtain the phosphate value. This ensured a consistent data set with groups from previous years who utilized this methodology. In other words, these are all relative measures of water quality and are not the absolute values of phosphate in milligrams per liter. The values collected during Fall of 2016 group had a much lower average phosphorus value than previous years' data. A hypothesis for this is meteorological: 2016 was a consistently rainier year than previously experienced in the area. Since it rained constantly like it did for during the Fall 2016 sample period, a constant flux of phosphorus values with no extremely high or low values was found. If it has been dry for many weeks, and a heavy rainfall produces a large amount of runoff, then a spike in phosphorus levels for a short period of time as those phosphorus compounds wash out could be evident. Also, that means during the dry periods, phosphorus values would be near zero which is evident in the historical sampling data. It is important to note that temperature was not included for the histograms or the KS Test. This is because the temperature was similar in value and did not seem relevant in order to compare surface water quality.

To summarize, these results neither completely disproved nor assured the hypothesis. Some significant differences in pollutants occurred between the agricultural watershed and urban watershed while others were found to have no statistical differences at all. Based on this, the hypothesis cannot be fully rejected nor accepted. However, there are assumptions to be made as to why elevated pH and phosphorus levels occurred in the agricultural watershed, which were touched on briefly above but require more research and review of past literature. Some surprises in the data only consisted of malfunctioning equipment in the Hach Kit leading to illogical values for pH and electrical conductivity. These issues will be discussed below.

Discussions:

Expectations:

The expectations from this study were that phosphorus and nitrate would be found in similar levels in the agricultural watershed and the urban watershed. This was expected because while there might be fertilizer runoff from agricultural practices, it was also thought that homeowners might also have significant runoff due to over application of fertilizer on lawns. Electrical conductivity and pH were expected to be in the vicinity of each other. This differs from the tested hypothesis. Nitrates were found at different levels, but not at a significant difference which also supported the hypothesis. The agricultural watershed being higher in phosphorus differed from the hypothesis. Past projects have shown that higher amounts of phosphorus and nitrate within the urban watersheds was to be expected.

Validity:

Throughout the eight weeks of water sampling, there were occurrences that hindered total confidence in the overall validity of the results. The Electrical Conductivity meters, along with the pH meters, had issues with consistency and accuracy on a few occasions. As a result, those specific data points were either not included or were noted as outliers. In addition, the tests for nitrates and phosphates use a color wheel that is used to compare the color of the tested water with a reference for determining an approximate quantity of said nutrients. The problem with this is the potential for user error. Since the water is not being tested in a laboratory, the perceived reading from an untrained individual can have an indeterminate potential for error.

Importance of Training:

Implementation of citizen science to monitor water quality, whether in an urban or in a rural setting, can be successful. Recommendations for future success would be the development and communication of clear data collection processes. It would be beneficial to have a class for any interested citizen scientists to learn how to properly take readings using a Hach Kit. Step by step processes listed out on the inside cover of the kit would also be beneficial to ensure replicability.

The importance of proper training must not be ignored as it affects the consistency of data collection. A study by researchers Hannaford, Barbour, and Resh, 1997, showed the importance of training in water quality testing.

The researchers (Hannaford, et al 1997) aimed to determine if people collecting data with no previous training and only written instructions would be as accurate as people trained in habitat assessment. The study involved two different groups of assessors, one with training, the other with written instructions. After the initial study, the group with no training was given training and both groups assessed a new site.

The authors found that in the initial study, training had a significant impact on accuracy. It was also found that at the final site there was small difference between the two groups. However, the authors found that it is important for there to be training at multiple sites to be able to assess stream health effectively.

Steps to Successfully Implementing Citizen Science Efforts:

Continuous communication and a coordinated marketing and publicity campaign are keys to success. Being up-to-date on current social trends, especially via the internet, will prove to be integral to the success and sustained momentum of a citizen science movement (Dickinson et al., 2012). Projects involving citizen science must clearly define the goals and objectives. One area that must be concisely defined is the balance between the 'learning goals' one would have for the citizen scientists who are involved, and the 'scientific goals' that one desires to achieve via the data collection (Jordan et al., 2012). Data must also be communicated in an efficient and attention-grabbing manner, via maps, tables, and graphs (Barnard et al.). The use of standardized testing and clear practices are necessary. Even though the lay people involved in the act of citizen science are often still not seen as 'scientists' and are often dismissed by those working in a particular area of expertise, the establishment of clear standards for data collection can still give a voice to the reality that these 'citizen scientists' are exposing, therefore giving them a voice by communicating facts (Ottinger, 2010). It was noted by Boakes et al. that the greater ease with which one could identify a species of plant or animal, the greater number of reported sightings would follow. There is a broad spectrum of involvement from citizen scientists, and to increase engagement it is necessary to have a clearly communicated goals and to have testing/data collection that is of relative ease (Boakes et al., 2016) The three main takeaways for a successful venture are; 1). Over-communicate and be relevant. 2). Have clear, standardized forms of data collection. 3). Involve the community.

Recommendations:

The future for citizen science is very bright. The untapped resource of concerned citizens who can collect data for the interpretation of the trained professional can bring about change in the current format of scientific research. The research group looked to format the collection of data in a way that would be replicable for future citizen science endeavors. Much was learned regarding both the strengths and weaknesses to the format of the study.

Figure 7: Typical Hach Water Analysis Kit

The Hach Kits themselves are an invaluable asset to the data collection process. The ease of access with which one can go into the field, or one's own backyard, make this tool a necessity for future collection efforts. The Hach Kit was well assembled with written instructions for any needed clarifications. However, the validity of the readings with pH and electrical conductivity meters from the Hach Kits were in question. It would be necessary to have a system for regularly calibrating equipment and maintaining battery charge.

With clear communication, proper training, and easy to follow procedures, there can be great gains within the scientific community. The potential for further scientific understanding is immense, especially regarding the monitoring of water. Water is constantly on the move, and the more data made available to the scientific community, the better.

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