2016

# Studying macroinvertebrate diversity in an urbanized watershed of Rock Island, Illinois.

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**Contents**



## 1. Introduction

Urban land-use covers 26 million hectares of the United States (Morse et al. 2003). Rock Island is an urbanized city in Illinois, U.S.A. that currently has issues with their Stormwater system. For the past few years, the water quality of the streams in their watershed has been examined, but the biodiversity which can also contribute to water quality knowledge, has not been studied in depth.

The study to be proposed is based on the amount of biodiversity in the streams at ten sites in the Rock Island watershed and the water quality at those same sites. It will look at the biodiversity of each site and compare them with the water quality at each site using ANOVA in SPSS to see if there are any significant results between specific parameters of water quality testing and the biodiversity.

## 2. Upper Mississippi Center for Sustainable Communities

The Upper Mississippi Center for Sustainable Communities (UMC) is a research center at Augustana that focuses on projects that help communities be more sustainable. The Center has been studying the Urban Watershed since 2013. This project initially started with 11 watersheds in Moline and Rock Island, Illinois with only a few sampling sites within each watershed. After the first year, one watershed was selected to focus on in order to see detailed changes occurring within a single watershed. This watershed contains 21 sampling sites and is comprised of two sub-watersheds. The project focuses on water quality sampling for the City of Rock Island for better managing their stormwater runoff.

## 3. Stormwater

Stormwater is any water, usually rainwater, which drains /runs across the land collecting pollutants when it hits the ground and travels to the nearest stream (The Science of Stormwater 2015). Those outside the scientific community think stormwater is clean since they do not realize the amount of pollutants collected as the water travels. Stormwater runoff eventually makes it to rivers and lakes which is the same as dumping pollutants directly into these bodies of water. There are some management principles suggested for stormwater systems to protect both aquatic and terrestrial ecosystems (Walsh et al. 2016). Terrestrial areas also increase the water quality of freshwater habitats (Zipper et al. 2011). To get programs like the one proposed in Zipper et al. 2011 implemented, we need more research to show stakeholders how important aquatic ecosystems are.

**4. Biodiversity**

Biodiversity is the rich and wonderful variety of plants and animals in an ecosystem (Helfrich et al. 2009). Biodiversity is used for an abundance of reasons and is important to different stakeholders. There are multiple ways to value biodiversity which will be discussed further in this paper as well.

Declines in biodiversity are happening at a much greater pace in freshwater ecosystems than in terrestrial ones (Dudgeon et al. 2006). It is critical to understand all the stakeholders that biodiversity has and to understand the ways to value such an entity. The more biodiversity there is in an area, the less toxic stormwater runoff is to the environment.

**4.1 What is biodiversity?**

Biodiversity is the richness of species, but it is so much more. Biodiversity is also their genetic variety and multiple habitats and ecosystems in which these plants and animals can survive and reproduce (Helfrich et al. 2009). The habitats provide all the necessities to the plants and animals to help them survive. There are alarming threats to biodiversity that are occurring due to human-interactions.

**4.2 Threats to biodiversity**

There are five major threats to biodiversity in regards to freshwater ecosystems stemming from human actions: overexploitation; water pollution; flow modification; destruction or degradation of habitats; and invasion by exotic species (Dudgeon et al. 2006). These five categories are all interconnected (Figure 1) and can all influence each other. Overexploitation mostly affects the animals living in or near freshwater ecosystems where the other four categories affect even the smallest things down to microbes and affect more plants as well. All these categories are affected by humans, some directly while others are affected indirectly. Without the rich natural diversity of native plants and animals, our lives would be poorer, the supply of medicines more limited, career opportunities scarcer, and the economy less healthy (Helfrich et al. 2009). We need to value our biodiversity and try to limit the threats we place on it every day.

### 4.3 Why biodiversity should be valued

There are a multitude stakeholders involved in biodiversity of freshwater ecosystems. Not only are the animals and plants effected, but people are as well. When there are threats to the biodiversity in a freshwater ecosystem, that means there are fewer benefits that can be extracted from the ecosystem by people. Biodiversity is valued for provisioning, regulating, cultural, and support services (Laurila-Pant et al. 2015). Some stakeholders are those that value biodiversity for their jobs such as fishermen, others value it for recreation, and some even value it as a part of their culture. Sustaining biodiversity is essential to the health of the environment and to the overall quality of human life (Helfrich et al. 2009). Conserving biodiversity can help people to discover new drugs and medicines; provide food; add oxygen and reduce carbon dioxide in the ozone layer; and add more jobs and tourism based around the environment (Helfrich et al. 2009).

#### 4.3.1 Ecological Valuation

Ecological valuation is when the value of a resource is based on how the ecosystem functions (Laurila-Pant et al. 2015). This type of valuation is often the most difficult to determine because people do not always see individual species and understand how they need to be protected for the benefit of ecosystem function. There are different ways to measure biodiversity to access ecological valuation: alpha, beta, or gamma- biodiversity. Beta diversity is the variation in species along an environmental gradient, alpha is the average species diversity per habitat and gamma is the average total species diversity of the landscape (Laurila-Pant et al. 2015). The types of biodiversity are ecological valuation is generally more recognized by scientific stakeholders or those in the field of conservation and all types of biodiversity should be understood since they look at different areas.

#### 4.3.2 Socio-Cultural Valuation

The stakeholders that generally use the socio-cultural valuation are people from the community that reside in the area in question. These types of values are not monetary, but based on the people's spirituality or culture. These are usually found through interviews and surveys and are more qualitative than quantitative values (Laurila-Pant et al. 2015).

#### 4.3.3 Economic Valuation

Economic valuation includes putting a monetary value on biodiversity through both use and non-use terms (Laurila-Pat et al. 2015). There are three techniques to valuing the environment monetarily: revealed preference which is based on observed consumer behavior; stated preference which come from responses that people give regarding how much they are willing to pay for something; and direct market valuation preference is essentially market price and production function (Laurila-Pant et al. 2015). The main stockholders to use this are businesses and the government in determining how much the environment is worth when using or destroying part of it for their own purposes. One such purpose is to show that what a company is produces is worth more than what it gives off as waste through stormwater. This can be problematic if it is the only type of valuation looked at. It is crucial to investigate all three types of valuation when making environmental as well as business decisions.

### 4.4 Ways to detect biodiversity

There are multiple ways to detect biodiversity, but using macroinvertebrates is common. Literature reviews of running water assessments based on biological indicators identify at least one hundred indices developed over the past ten years. Of these, about 60% are based on macroinvertebrates (Uherek and Gouveia 2014 and Czerniawska-Kusza 2005).

#### 4.4.1 Why use macroinvertebrates

Macroinvertebrates are used as bioindicators due to the qualities they possess. First, macroinvertebrates are large enough to be seen with the unaided human eye, which is helpful when identifying organisms in the field or at low cost. Macroinvertebrates have fairly long life-spans so if they are in a stream that means there's a healthy stream quality not only in that moment, but over a long period of time (Uherek and Gouveia 2014). Macroinvertebrates are good bioindicators because they have little mobility further showing information on a stream in a given area. They are a common food source for fish and are generally abundant (Chadde 2016). This means that if there are few or no macroinvertebrates in an area, there are most likely no fish either since there would be no food source. The lack of macroinvertebrates that are generally abundant would also show there is something not right with the area you are studying. The diversity of macroinvertebrates are therefore a good indicator of stream health. This abundant information is why aquatic insects and other benthic invertebrates are the most widely used organisms in freshwater biomonitoring of human impacts (Bonada et al. 2006). Macroinvertebrate biomonitoring is generally a low-cost method of research.

### 4.4.2 How macroinvertebrates work as bioindicators

The presence or absence of macroinvertebrate diversity and abundance is used as a bioindicator. The presence, absence or even behaviors can reflect a stressor's effect on the biota in the area (Bonada et al. 2006). Initially there were few approaches to using insect biomonitoring—monitoring the environmental health through biological indicators—but in recent years it has expanded into a large number of methods. The method selected depends on the information that is wanted from the study, various priorities, complexity of the freshwater system, and precision for types of impact assessment (Bonada et al. 2006). There are a variety of biomonitoring approaches to be considered. Three main types of approaches are using biomarkers, bioassays, and fluctuating asymmetry. Biomarkers are used to measure the normality of a biological process such as the chemical levels in a stream (Adams et al. 2001 and Werner et al. 1999). Bioassays look at the effect of the environment on the organisms' survival (Crane et al. 1995 and Maltby et al. 2002). Fluctuating asymmetry is based on the theory of developmental instability where fluctuating asymmetry increases and human impact increases (Clarke 1994 and Polak 2003).

## 5. Stormwater monitoring: Water quality components

Some things to address when accessing water quality are the type of microhabitats present, the surroundings of a stream, as well as the pollutants that change the chemistry of the stream. All of these are useful in deciphering the stream ecosystem and the human impacts. The macroinvertebrates matter when looking at the stream since they live there for long periods of time and represent responses to the habitats (Uherek and Gouveia 2014). It is also helpful to note the surroundings of the stream, i.e., what percentage of the surroundings are forested versus impervious due to intense urbanization (Pompeu and Alves 2005). Impervious surface (e.g., concrete such as buildings and sidewalks) is important because stormwater quantity and quality is directly related to impervious area in the catchment (Mackintosh et al. 2015). Studies have shown that urban land-use is associated with physical, chemical and biological changes to stream ecosystems (Leopold 1968, Hammer 1972, Porcella and Sorenson 1980, and Morse et al. 2003). In the northern USA, chloride concentrations in surface waters can be >10x higher in urban than in forested areas (Wallace and Biastoch 2016). Chemical changes occur naturally and due to human impacts so concentrations are studied. Naturally occurring chemicals can be called freshwater pollutants when levels are too high or too low such as total dissolved solids, specific conductivity, and pH that can increase relative to pre-urban conditions (Utz et al. 2015). Stormwater in urban areas can have a big impact on stream ecosystems through changes that enhance urban land-use in a freshwater area.

Any substance that can render water harmful to people or wildlife or impairs recreation or other beneficial uses of water is considered a pollutant (The Science of Stormwater 2016). A lot of pollutants in stormwater assessments are oils and greases that are known to be toxic to aquatic organisms at relatively low concentrations by coating fish gills, preventing oxygen from entering the water, and clogging drainage facilities.

Metals are also known as pollutants in stormwater due to contaminating both surface and ground waters, causing health problems for benthic organisms. Some other pollutants are chlorine which is toxic even at levels below 1mg/L. Chlorine does not occur naturally but is in stormwater through human drinking water, food and paper industries, and swimming pools. Fecal coliform is a bacterium found in digestive systems of warm blooded organisms and is something that can cause illness in humans and aquatic life when levels are too high. Fecal coliform is naturally found in animal waste, but additional pet waste and failing septic systems add more to stormwater. These pollutants occur in natural settings, but humans have increased the concentrations of these pollutants causing terrible effects.

Nitrates, ammonia, and phosphate are needed in an aquatic ecosystem to help with plant growth, but too much can cause algae blooms (Stormwater monitoring 2016). These pollutants come naturally from soils, rocks, leaves, and animal manure, but more is added to the ecosystem through human fertilizers and septic tank failures. High ammonia levels can be toxic as well. pH is also an indicator of water quality because it can affect solubility of some chemicals including ammonia, which impacts the availability of substances to organisms or can cause a toxic environment. The toxicity of ammonia depends on temperature and pH (Ammonia 2016).

Too much sediment also affects water quality by leading to low densities and taxon richness of macroinvertebrates, with some communities completely devoid of macroinvertebrates (Grapentine et al. 2008). Dissolved oxygen is the oxygen in water needed for fish respiration so when the oxygen level is too low, it is dangerous to aquatic life. Specific conductivity is the ability for water to conduct an electrical current, which is increased by human infrastructure. This increase can cause damage to freshwater ecosystems when occurring outside its natural range of electrical currency. Total suspended solids are particles suspended in the water that interfere with recreational use because water becomes cloudy. It also effects fish and other aquatic life negatively, preventing development of eggs and larvae (The Science of Stormwater 2015). Total suspended solids occur naturally from erosion and seasonal changes, but human land development can often increase their levels (The Science of Stormwater 2015). These pollutants occur naturally, but impacts are greater in freshwater systems due to human development, which are harmful to both humans and to aquatic life.

## 6. Studying a Mississippi watershed in Rock Island, Illinois

Multiple studies have looked at bioindicators or chemical parameters separately (Brinkmann 1985 and Han 2006), but few have looked at both within the same site in order to compare how they compare. This project will look at how bioindicators and water quality chemical parameters compare when tested in the same sampling sites. Bioindicators may show other water quality problems that are not tested for in our chemical sampling. This will show the Upper Mississippi Center the biodiversity that is able to survive in the given water quality that has been found through the chemical parameter testing.

### 6.1 Methods

Macroinvertebrate sampling will be used to compare the results of pollutant tests and bioindicators tests using the family-level biotic index. There are many biomonitoring approaches being put into practice as well, but bioassays, biomarkers, and fluctuating asymmetry are the three being focused on due to their simplicity. Ten of the twenty-one sites already created in the Mississippi watershed will be sampled for macroinvertebrates three times during the summer of 2016. There will only be ten macroinvertebrate sample sites due to time restrictions. The goal is to see how water quality effects biodiversity of macroinvertebrates to better understand how it effects total biodiversity. Macroinvertebrates are usually abundant and are a main food source for other aquatic organisms (Chadde 2016) so they are indicators of overall biodiversity. A study similar to the biodiversity testing of occupancy and abundance of stream salamanders in areas of mountaintop removal mining (Price et al. 2016) will be done. This study will be manipulated for the study in the Mississippi watershed and instead of using salamanders, will use macroinvertebrates. A map would be made for the Mississippi watershed of Rock Island with what point is the reference versus the other sites that are being sampled to look at the urbanization gradient (see figure 2). Site ten of the Mississippi watershed in Rock Island would be a reference site since it is in Blackhawk state park and mostly untouched by urbanization and impervious surfaces (see table 1). This gradient is something that was not included in the original study (Urban Watershed Project 2016) that will be implemented here since we know the percent of impervious surface and different average concentrations of pollutants at each site. I would take these samples by a travelling kick- and- sweep method (Wallace and Biastoch 2016). The family-level biotic index (FBI) will be used to identify the macroinvertebrates because it is an easy system to work with (Hilsenhoff 1988). The FBI will be used to evaluate water quality in this study for this reason (see table 2).

There are multiple ways to test for water pollutants, however pollutant testing will generally be the same as in previous years. Water quality data will be taken for the same parameters that are available through the UMC. The only additional parameter that will be tested for this year is water flow which will be measured through a Hach flow meter that will be placed where the two sub-watersheds come together. In previous years and this coming summer, measurements of temperature, pH, chloride, nitrate, specific conductance, and dissolved oxygen were collected using YSI Professional-Plus Multi-parameter instrument. This instrument is a probe that is dipped in the water in the field and reads the measurement for each of these parameters. This method was chosen because Augustana College already owned the technology to do this type of testing and it is a quick way to test these pollutant concentrations. Fecal coliform samples are collected and sent to the City of Rock Island lab to be analyzed since they have the equipment to do so. $NH_3$ and phosphorus can be measured on a Hach DR850 colorimeter. For the $NH_3$ we use the salicylate method (Scheiner 1974) and for phosphorus we use the ascorbic acid method (John 1970) in the colorimeter. Samples that are collected and brought back to lab at Augustana College in polypropylene bottles (Demers and Sage 1989). These tests are then performed in the lab as well is the Biological Oxygen Demand (BOD) test. This test is a probe that is put into the bottles to test oxygen demand.

Impervious surface can be found using geospatial datasets that are publicly available and the same data will be used next summer. The table in Pompeu and Alves 2005 which shows the chemical parameters at each site with their concentrations is one that will work nicely with this data (see table 3). They did a similar study to this one in Brazil. They also did their study in an urbanized area and sampled tributary sites in a watershed which is what is will be done in the Mississippi watershed of Rock Island.

**6.2 Comparing the results**

After all the data collection is complete for the summer, averages for each pollutant at each of the ten sites will be found as well as  averages for the number of total invertebrates and average number of different taxa found at each sampling site. I will then use these data to run an ANOVA in SPSS to find the significance levels of each pollutant compared to the macroinvertebrate numbers at each site. I will also do the same with the percent impervious surface to see if there is a relationship between the percent of impervious surface at each site and the number of macroinvertebrates. I feel this will give more insight into the work we are doing in the Rock Island watershed. It may show us that there are things being missed if macroinvertebrates are not present in areas that our parameters seem to say water quality is good. This could show either something wrong with the hypothesis or something is missing that could be a physical difference between the reference site and study sites as well. This will be an interesting study to work on this summer.

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**Appendix 1**

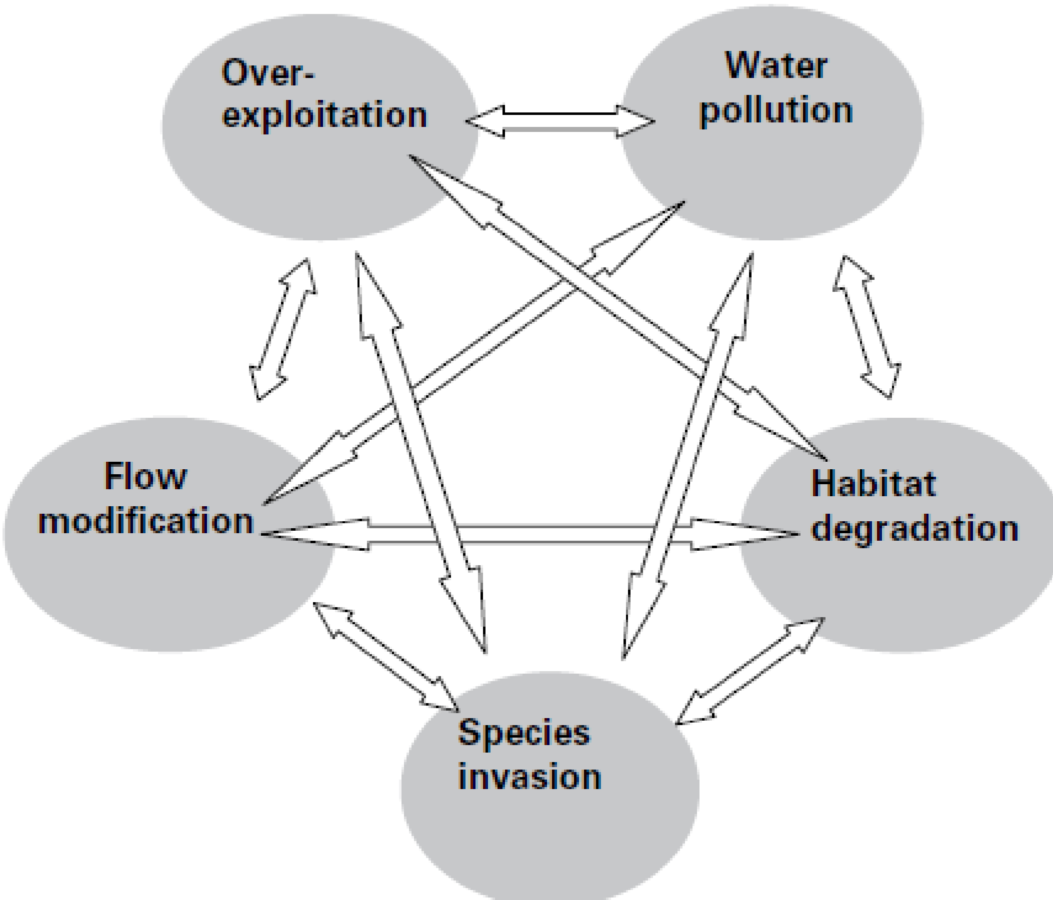


**Fig. 1.** The five major threat categories and their established or potential interactive impacts on freshwater biodiversity. Environmental changes occurring at the global scale, such as nitrogen deposition, warming, and shifts in precipitation and runoff patterns, are superimposed upon all of these threat categories.

Figure 1. This is a figure taken from Dudgeon et al. 2006 that shows the impacts of aquatic biodiversity.

**Table 1.** Site-specific average (±SE) for select water chemistry attributes, specific conductance, total organic carbon (TOC), pH, manganese (Mn), sulphate ($SO_4$), calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na), at mountaintop removal and valley-filled (MTR/VF) and reference streams (R) located in eastern Kentucky, USA. Overall treatment means are represented by mountaintop removal mining and valley filling (MTR/VF) or reference (R) treatment. Parameters denoted with an asterisk indicate limited sample size. One asterisk denotes one sample, while two asterisks represent two samples. Manganese means noted as 0·00 mg $L^{-1}$ were below detection limits

| Study Site | Specific conductance (μS $cm^{-1}$) | TOC (mg $L^{-1}$ C) | pH [H+] | Mn (mg $L^{-1}$) | $SO_4$ (mg $L^{-1}$) | Ca (mg $L^{-1}$) | Mg (mg $L^{-1}$) | K (mg $L^{-1}$) | Na (mg $L^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| MTR/VF-1 | 1692·00 (113·61) | 10·52 (8·40) | 6·39 (0·31) | 2·69 (1·02) | 379·04 (181·02) | 28·16 (2·48) | 10·39 (0·15) | 8·48 (0·42) | 9·14 (0·43) |
| MTR/VF-2 | 1644·67 (112·06) | 25·72 (14·62) | 7·07 (0·23) | 1·83 (1·02) | 489·48 (120·42) | 29·25 (3·37) | 10·36 (0·36) | 10·91 (2·27) | 9·65 (0·32) |
| MTR/VF-3 | 1916·00 (174·43) | 2·48 (0·31) | 4·60 (0·09) | 11·11 (2·16) | 570·32 (122·28) | 29·16 (2·93) | 10·66 (0·30) | 7·10 (0·15) | 7·17 (0·64) |
| MTR/VF-4 | 2345·50 (223·44) | 3·93 (1·12) | 6·01 (0·10) | 6·70 (2·12) | 391·31 (128·06) | 30·61 (3·06) | 10·87 (0·31) | 8·54 (0·17) | 13·15 (0·90) |
| MTR/VF- 5 | 2132·50 (95·43) | 24·21 (2·74) | 6·97 (0·04) | 10·30 (2·72) | 440·15 (103·38) | 30·03 (2·75) | 10·77 (0·24) | 8·98 (0·23) | 9·17 (0·24) |
| MTR/VF- 6 | 1940·25 (294·89) | 2·99 (0·52) | 4·96 (0·12) | 13·41 (4·01) | 645·70 (189·52) | 28·34 (3·14) | 10·80 (0·38) | 6·80 (0·15) | 10·01 (1·27) |
| MTR/VF- 7 | 972·50 (86·70) | 5·39 (0·91) | 6·81 (0·08) | 0·13 (0·06) | 206·37 (40·33) | 25·58 (2·64) | 9·79 (0·18) | 5·32 (0·13) | 5·76 (0·34) |
| MTR/VF- 8 | 1431·00 (457·60) | 7·37 (3·21) | 6·13 (0·71) | 2·42 (0·99) | 352·54 (139·42) | 28·00 (5·17) | 10·24 (0·65) | 6·24 (1·11) | 7·99 (1·89) |
| MTR/VF- 9 | 1006·67 (294·17) | 8·90 (6·23) | 6·08 (0·56) | 0·71 (0·31) | 738·85 (227·16) | 25·87 (1·69) | 9·74 (0·22) | 5·15 (1·37) | 6·89 (0·70) |
| MTR/VF- 10 | 2365·00 (72·40) | 7·24 (1·37) | 6·46 (0·02) | 10·01 (1·72) | 853·61 (256·42) | 30·31 (2·71) | 10·89 (0·26) | 9·04 (0·34) | 14·66 (0·24) |
| MTR/VF-11 | 1821·75 (151·21) | 3·63 (0·86) | 6·00 (0·10) | 11·08 (3·14) | 629·30 (59·30) | 28·81 (2·73) | 10·58 (0·26) | 7·33 (0·25) | 9·95 (0·72) |
| MTR/VF Treatment | 1780·22 (88·11) | 8·96 (1·74) | 6·11 (0·14) | 6·74 (0·95) | 517·21 (49·72) | 28·62 (0·82) | 10·49 (0·10) | 7·64 (0·31) | 9·50 (0·45) |
| R – 1 | 58·77 (7·36) | 2·27 (0·18) | 5·71 (0·05) | 0·07 (0·07) | 4·63* | 1·62 (0·11) | 1·12 (0·19) | 1·62 (0·10) | 2·57 (0·83) |
| R – 2 | 81·25 (25·54) | 2·88 (1·17) | 4·89 (0·50) | 0·04 (0·04) | 19·63 (0·38)** | 1·50 (0·26) | 1·63 (0·46) | 4·34 (2·54) | 1·7 (0·14) |
| R – 3 | 71·40 (1·98) | 2·91 (0·55) | 5·64 (0·15) | 0·06 (0·06) | 8·41 (1·48) | 2·94 (0·89) | 1·66 (0·33) | 3·51 (1·71) | 2·67 (0·35) |
| R – 4 | 44·75 (3·16) | 1·76 (0·12) | 5·72 (0·18) | 0·00 (0·00) | 6·01 (1·03) | 1·18 (0·17) | 1·38 (0·18) | 1·71 (0·05) | 1·77 (0·12) |
| R – 5 | 58·23 (13·99) | 2·07 (0·14) | 5·78 (0·24) | 0·00 (0·00) | 5·96 (1·84) | 1·34 (0·14) | 1·50 (0·24) | 1·64 (0·10) | 3·44 (1·76) |
| R – 6 | 42·75 (1·76) | 2·02 (0·29) | 5·65 (0·17) | 0·00 (0·00) | 6·04 (1·16) | 1·19 (0·20) | 1·06 (0·13) | 1·49 (0·05) | 1·09 (0·08) |
| R – 7 | 50·83 (8·58) | 2·89 (0·11) | 6·51 (1·11) | 0·00 (0·00) | 4·33 (0·87) | 1·11 (0·17) | 1·50 (0·21) | 1·78 (0·10) | 2·64 (1·31) |
| R – 8 | 57·63 (5·86) | 2·72 (0·62) | 5·85 (0·31) | 0·01 (0·01) | 5·68 (1·57)** | 1·55 (0·35) | 1·42 (0·19) | 1·74 (0·06) | 3·02 (1·27) |
| R – 9 | 73·18 (15·75) | 2·46 (0·22) | 5·42 (0·39) | 0·00 (0·00) | 7·54 (0·05)** | 1·40 (0·29) | 1·57 (0·11) | 3·11 (1·36) | 3·10 (2·00) |
| R – 10 | 38·80 (5·91) | 1·92 (0·12) | 5·30 (0·09) | 0·00 (0·00) | 6·65 (2·33) | 0·89 (0·23) | 1·02 (0·10) | 1·61 (0·08) | 1·99 (0·60) |
| R – 11 | 48·40 (3·87) | 2·55 (0·33) | 5·54 (0·06) | 0·00 (0·00) | 6·57 (2·29) | 1·94 (0·45) | 1·39 (0·18) | 1·65 (0·08) | 1·70 (0·13) |
| R – 12 | 78·33 (9·47) | 1·85 (0·30) | 5·74 (0·61) | 0·01 (0·01) | 19·25 (0·92)** | 1·84 (0·42) | 1·93 (0·33) | 3·23 (1·88) | 1·54 (0·13) |
| R Treatment | 58·41 (3·52) | 2·35 (0·13) | 5·64 (0·13) | 0·01 (0·01) | 7·67 (0·84) | 1·51 (0·11) | 1·43 (0·07) | 2·27 (0·31) | 2·25 (0·28) |

Table 1. This table is from Price et al. 2016 that compares the reference sites and the treatment sites from their study clearly. It will be manipulated to show something similar in the Rock Island watershed study of macroinvertebrates.

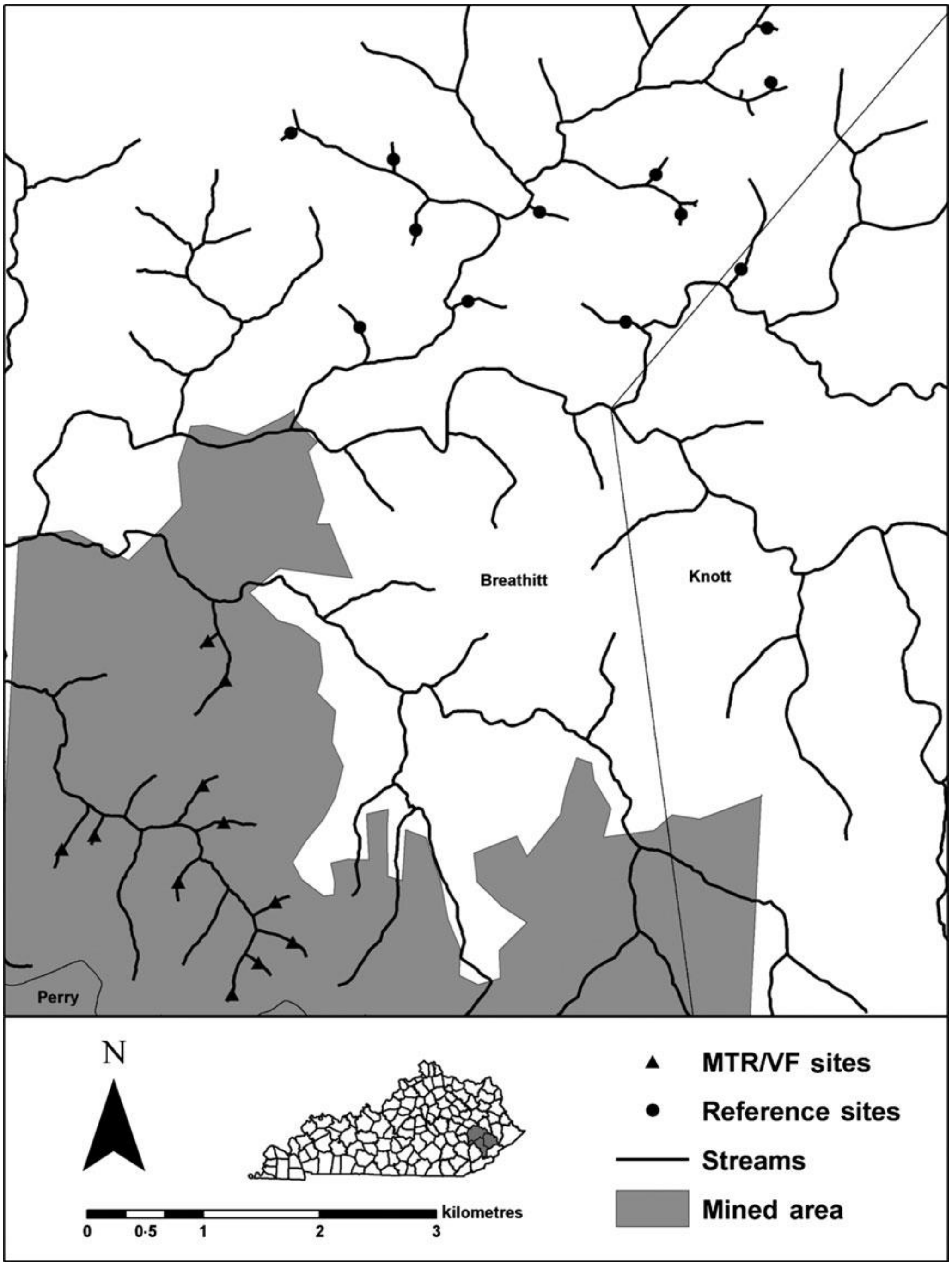


Figure 2. This figure taken from Price et al. 2016 shows the reference sites used in the study as well as the treatment sites on one map to see their relationship between each other and in regards to the mined area. There will be used for a similar map in Rock Island with reference sites and urbanized sites instead of mined sites.

TABLE 2. Evaluation of water quality using the family-level biotic index.

| Family Biotic Index | Water Quality | Degree of Organic Pollution |
|---|---|---|
| 0.00–3.75 | Excellent | Organic pollution unlikely |
| 3.76–4.25 | Very good | Possible slight organic pollution |
| 4.26–5.00 | Good | Some organic pollution probable |
| 5.01–5.75 | Fair | Fairly substantial pollution likely |
| 5.76–6.50 | Fairly poor | Substantial pollution likely |
| 6.51–7.25 | Poor | Very substantial pollution likely |
| 7.26–10.00 | Very poor | Severe organic pollution likely |

Table 2. This table is from Hilsenhoff 1988 shows how to use the family biotic index to determine water quality of an area and the likelihood of pollution at that site. This will be used in the Mississippi watershed of Rock Island study.

TABLE 1. Water quality in upper, middle, Belo Horizonte metropolitan region (MRBH) and lower das Velhas River (*, not measured).

| Sampling subbasins | Depth (m) | Width (m) | Velocity (m/s) | Flow (m³/s) | pH | Conductivity (µS/cm) | Dissolved oxygen (mg/L) | TDS (mg/l) | Turbidity (NTU) | Temp (°C) | Total-N (mg/L) | Total-P (mg/l) | E. coli (N/mL) | Fecal Streptococcus (N/ml) | Sediment organic matter (% dry weight) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper part | | | | | | | | | | | | | | | |
| Minimum | 0.5 | 4.5 | 0.58 | 3.11 | 5.9 | 26.5 | 6 | 44 | 2 | 18.2 | 0.019 | 0.019 | 2,400 | 1,500 | 0.99 |
| Maximum | 2.0 | 25.0 | 2.5 | 29.00 | 7.78 | 85 | 8.4 | 112 | 11 | 25.6 | 1.3 | 0.74 | 24,000 | 20,000 | 7.19 |
| Mean | 1.3 | 17.5 | 1.92 | 18.50 | 7.05 | 40.22 | 6.95 | 71.00 | 5.50 | 22.60 | 0.250 | 0.20 | 9,700 | 12,000 | 3.06 |
| Standard deviation | 0.8 | 8.5 | 0.70 | 13.5 | 0.65 | 25.68 | 1.19 | 29.10 | 3.94 | 3.18 | 0.75 | 0.36 | 12,000 | 9,500 | 2.20 |
| MRBH | | | | | | | | | | | | | | | |
| Minimum | 0.5 | 4.5 | 0.58 | 3.11 | 5.77 | 275.00 | 0.50 | 264.00 | 18.00 | 22.70 | 12.00 | 0.60 | 24,000 | 6,000 | 48.01 |
| Maximum | 2.5 | 25 | 2.00 | 29.00 | 8.61 | 605.00 | 4.48 | 428.00 | 120.00 | 27.90 | 24.00 | 5.40 | 98,000 | 200,000 | 0.66 |
| Mean | 2.0 | 12 | 1.57 | 15.50 | 7.46 | 459.50 | 1.73 | 308.60 | 44.50 | 24.49 | 16.66 | 2.16 | 45,000 | 20,000 | 5.74 |
| Standard deviation | 1.5 | 3.5 | 0.55 | 5.79 | 0.66 | 96.02 | 1.45 | 59.60 | 29.8 | 1.36 | 4.83 | 1.28 | 22,500 | 15,500 | 10.33 |
| Middle part | | | | | | | | | | | | | | | |
| Minimum | 0.6 | 25 | 0.44 | 15.00 | 7.33 | 13.5 | 3.2 | 10 | 3.4 | 23 | 0.019 | 0.019 | 160 | 56,000 | 0.5 |
| Maximum | 1.7 | 50 | 1.28 | 22.44 | 7.4 | 260 | 7.5 | 172 | 127 | 27.2 | 7.12 | 1.5 | 8200 | 6 | 7.81 |
| Mean | 0.71 | 25 | 0.50 | 20.20 | 7.25 | 146.06 | 5.65 | 116.25 | 49.90 | 25.16 | 2.55 | 0.39 | 2,400 | 11,435 | 4.01 |
| Standard deviation | 0.3 | 15 | 0.65 | 2.30 | 0.35 | 71.85 | 1.40 | 52.22 | 55.65 | 1.22 | 4.60 | 0.74 | 6,500 | 24,314 | 2.57 |
| Lower part | | | | | | | | | | | | | | | |
| Minimum | 1.0 | 50 | 0.16 | 4.75 | 6.7 | 15.00 | 6.2 | 24.00 | 3.4 | 22.00 | * | 0.019 | 0 | 0 | 0.17 |
| Maximum | 3.18 | 100 | 1.18 | 212.50 | 7.93 | 275.00 | 8.00 | 84.00 | 145.00 | 29.3 | * | 0.21 | 15,000 | 1,020 | 15.47 |
| Mean | 2.2 | 75 | 0.43 | 136.03 | 7.25 | 75.25 | 6.80 | 57.00 | 48.29 | 25.80 | * | 0.05 | 5,200 | 790 | 3.78 |
| Standard deviation | 2.5 | 60 | 0.67 | 67.85 | 0.33 | 81.16 | 0.56 | 23.58 | 52.79 | 2.04 | * | 0.07 | 2,420 | 320 | 4.40 |

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Table 3. This from Pompeu and Alves 2005 shows all the sites they sampled with the concentrations for each of their chemical parameters measured. This Mississippi watershed study will use a similar formatting once the data is collected.