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THE INFLUENCE OF URBANIZATION ON MUDDY RUN

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ABSTRACT

This three-week biotic and chemical study examined the water quality of Muddy Run, a stream located in Huntingdon County, PA. The results of our pH, conductivity, nitrate, and dissolved oxygen tests showed no significant differences between three sampling sites located near East Houses on the Juniata College campus. These tests led us to conclude that the pipes discharging into the stream near East Houses had no effect on its chemical composition. However, there was a difference in pH between the headwaters (a vernal pond) and the other sites, perhaps due to differences in their buffering capacity. Both qualitative and quantitative macro-invertebrate samples revealed that water quality is poor in Muddy Run. The macro-invertebrates found there were characteristic of water which is low in dissolved oxygen, which is an important indicator of poor water quality. This analysis provides background data for further studies, and may help planners with establishing appropriate methods for increasing the water quality of Muddy Run.

INTRODUCTION

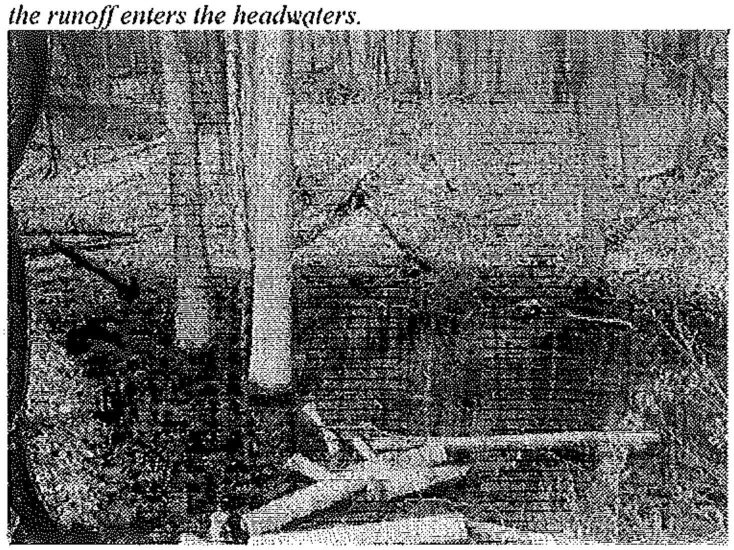
Our research focused on the influence of urbanization on Muddy Run. Muddy Run is a stream located in Huntingdon, Pennsylvania, whose headwaters begin at Westminster Woods (near Cold Springs Road) and runs aboveground to Quality Beverage (located on 15th street). Previous testing has indicated that Muddy Run is polluted. The goal of this study was to determine if Muddy Run was still polluted. We also sought to determine if its water quality was influenced mostly by pollution entering from discharging water pipes. Our null hypothesis was that a pipe's discharge would not affect the water quality of Muddy Run. Our working hypothesis stated that there would be a change in the water quality of the stream due to the water being discharged from the pipes. We also thought that the water quality would decrease as one traveled downstream due to the increasing number of pipes.

This research is significant because it allows us to observe the impact of humans on the environment. Degradation of our waters is a major issue in society today. Contaminated water affects all aspects of life. Because of this, we must be aware and make others aware of pollution and how to reduce it.

FIELD SITE

The four sampling sites were as follows. The first site was the headwaters of Muddy Run (Fig. 1a, b), which is a vernal (temporary) pond whose water level is dependent on runoff and precipitation. Variation of the pond's water level occurred during our testing, apparently due to an increase in air temperature and a decrease in precipitation. During sampling, the average air temperature for this area was 12.1° C. The Pond had the following dimensions: average width = 5.54 m; average length = 13.3 m; average depth = 0.48 m. These measurements were taken on a day when the water level had receded approximately 0.46 meters. Flow rate was undetectable.

Figure 1a. This is a picture of the headwaters of Muddy Run, located in Westminster Woods. The arrow designates where the runoff enters the headwaters.



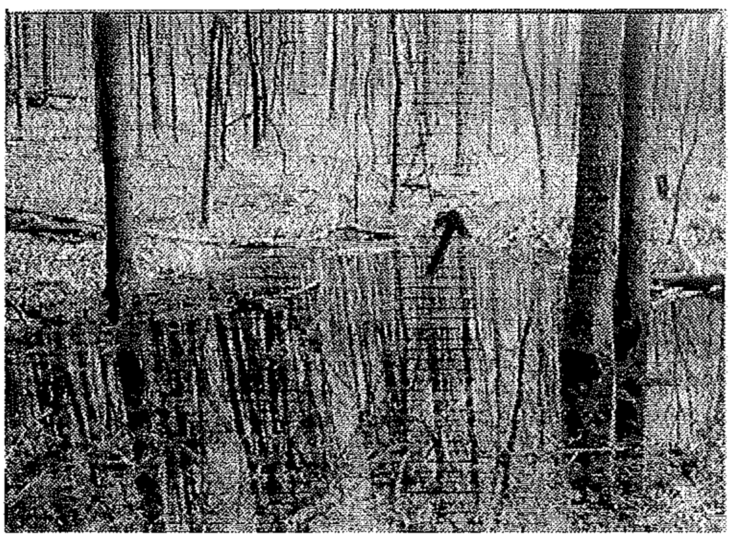


Figure 1b. Another view of the headwaters of Muddy Run. The arrow designates where the water flows out of the pond.

The second site, designated site #1 is located in front of the East Houses on Juniata College campus (Fig. 2). During sampling, the average air temperature was 14° C. The average width' length and depth of the sampling area were 2.24 m, 27.4 m, and 0.18 meters, respectively. Three flow rate measurements were taken in different areas due to visible differences in water velocity. The average flow rate at the beginning of the site was 6.32 m/s. The average flow rate at the middle of the site was 5.29 m/s. And the average flow rate before the first pipe was 2.28 m/s.

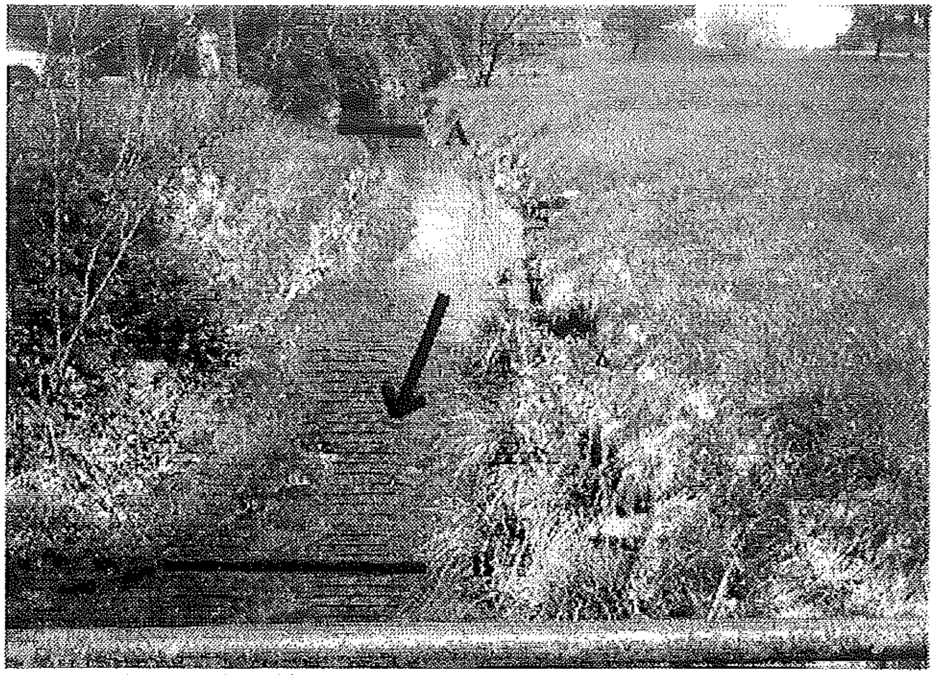


Figure 2. Site #1 of Muddy Run on Juniata College campus (East Houses are located on the right). "A" designates the beginning of the site and "B" designates the end of the site. The arrow shows the direction of water flow.

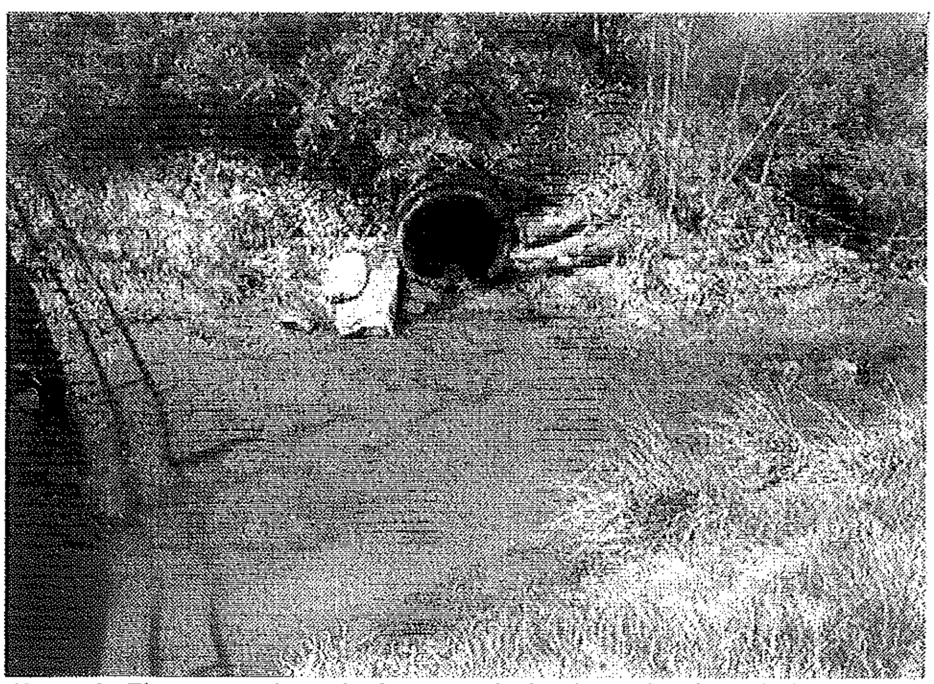


Figure 3. This picture shows the first pipe which is located at the end of site #1.

The third site, designated as site #2, is also located in front of the East Houses on Juniata College campus (Fig. 4). During sampling, the average air temperature was 14° C. The average width, length, and depth of the sampling area were 2.09 m, 129.7 m, and 0.17 m, respectively. Nine flow rate measurements were taken in different areas at approximately 10-14 meter intervals due to visible differences in water velocity. The average flow rates were 5.53 m/s, 1.33 m/s, 7.11 m/s, 2.09 m/s, 3.48 m/s, 2.73 m/s, 1.80 m/s, 5.50 m/s, and 3.57m/s respectively from A to B.

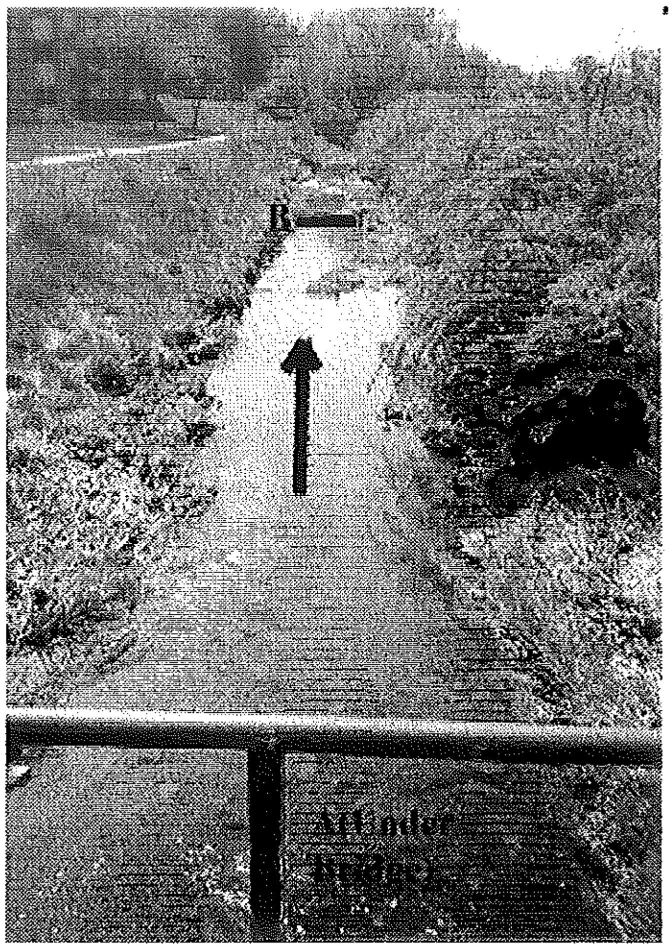


Figure 4. Site #2 of Muddy Run on Juniata College campus (East Houses are located on the right). "A" designates the beginning of the site and "B" designates the end of the site. The arrow shows the direction of water flow.

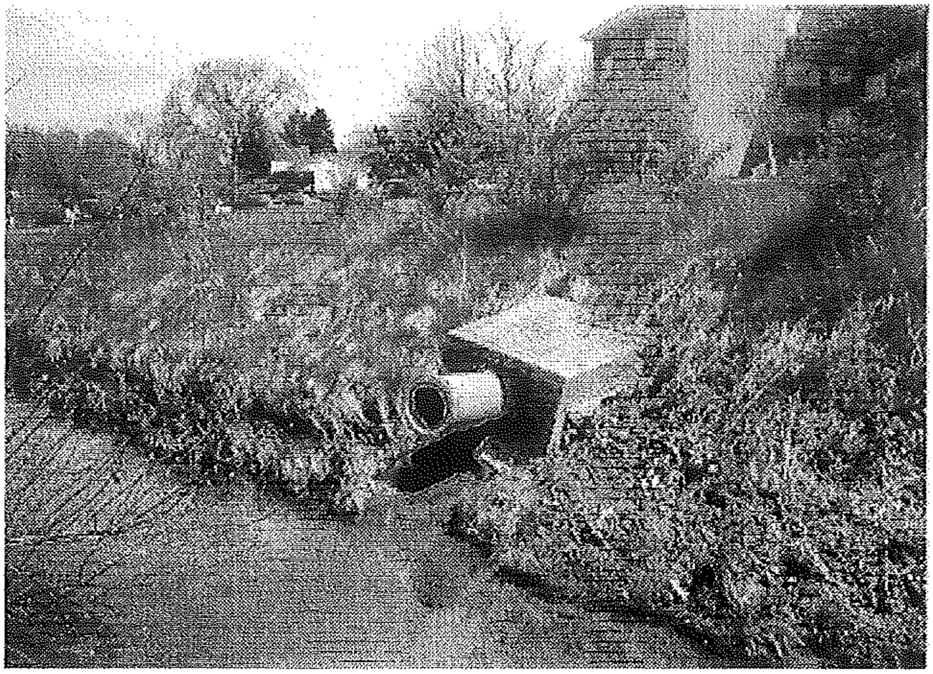


Figure 5. This picture shows the second pipe which is located at the end of site #2.

The fourth site, designated as site #3, is also located in front of the East Houses on Juniata College campus (Fig. 6). During sampling average air temperature was 14° C. The average width, length and depth of the sampling area were 2.4 m, 27 m, and 0.15 m, respectively. Flow rate measurements were taken at the beginning and end of the site due to visible differences in water velocity. The flow rates were 5.2 m/s and 2.0 m/s respectively from A to B.

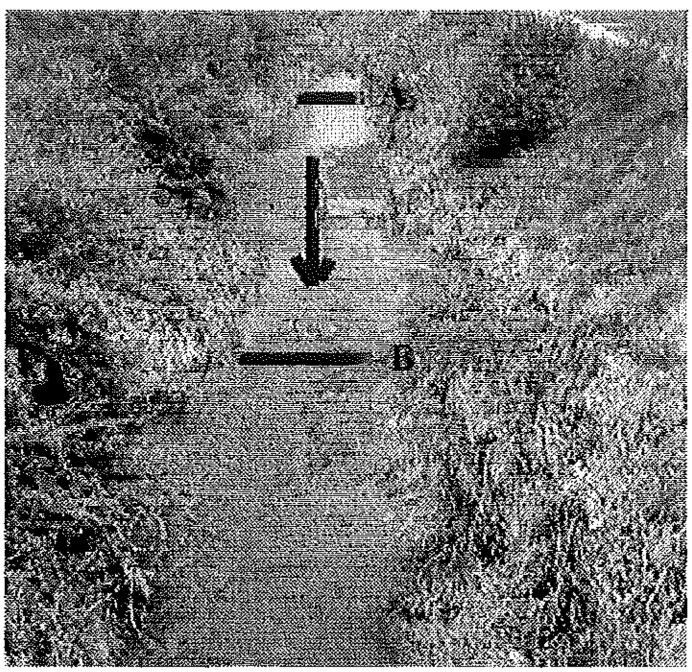


Figure 6. Site #3 of Muddy Run on Juniata College campus (East Houses are located on the right). A designates the beginning of the site and B designates the end of the site. The arrow shows the direction of water flow.

METHODS AND MATERIALS

During three consecutive weeks, from March 20, 1998 to April 3, 1998, we tested the biotic and chemical components of each of the four study sites, including the two areas near discharging pipes. We picked two consecutive pipes, 129.7 meters apart, which are near two small bridges on the Juniata College campus. Site #1 is 27.4 meters upstream from the first pipe, site #2 is 129.7 meters long and located directly between the two pipes, and site #3 is 27 meters downstream from the second pipe. The distance before and after the pipes is roughly one-fourth of the length between the pipes, because we were not able to sample in areas located near private property.

Chemical and Physical Measurements

During the first and third week we conducted chemical tests and completed physical measurements. We used a pH meter, dissolved oxygen meter, and a conductivity meter. We also tested the nitrate content using a process called the Cadmium Reduction Method (Hach Method 8171) in the Juniata College water-chemistry laboratory. We completed three trials of each chemical test at each of the four sites. We randomly chose the vicinity where we conducted our tests. We also measured temperature with a thermometer because it can effect pH, conductivity and dissolved oxygen concentration.

We also completed physical measurements. Using a tape measure, we found the length of each site by measuring along the middle of the stream. Also, we measured flow rate by dropping a buoyancy device (a bob) a couple of feet upstream from a meter stick. By measuring the time it took for the device to travel along the meter stick, we determined the rate of water flow. We calculated the rate each time the river changed speeds, which we determined by the observation of small rapids. We took three trials at each individual spot and then averaged the results.

The depth of the stream was measured with a meter stick at 10 random locations in the headwaters, at 10 locations in site #1 and #3, and at 25 locations in the relatively long site #2. We took readings from both sides and middle of the stream in order to get representative values.

Macro-invertebrate Sampling

The second week was dedicated to quantitative and qualitative macro-invertebrate sampling. For the qualitative tests, we designated one 20-min. period per site to search for macro-invertebrates using small nets and placing the samples into labeled buckets. We also collected 10 randomly placed quantitative samples at each site. For this we used a sediment sampler which we pushed into the ground, and a spade which was used to keep the sample from falling out before it was placed in a labeled bucket. The collected species were identified and counted throughout the next two weeks. We carefully searched through each sample and identified the organisms by using appropriate taxonomic keys.

Statistical analysis and Special Calculations

We calculated within-site averages, standard deviations, and confidence intervals for all of the chemical and biotic parameters that we tested. Inter-site comparisons were then made between average values for pH, conductivity and dissolved oxygen. Inter-site differences in the qualitative and quantitative macro-invertebrate samples were assessed with the Kruskal-Wallis Test and Mood Median Test. We also described the four macro-invertebrate samples taken from Muddy Run using the following community descriptors:

$$S = \text{taxon richness (or number of taxa)}$$

$$\text{Simpson's Diversity Index, } D = 1/\sum(P_i)^2,$$

where P_i = the proportion of the total number of individuals in the community that belong to the i^{th} taxon (expressed as a percentage).

E= taxon equitability = D/S

Rank-abundance diagrams were also constructed by plotting log P_i against a taxon rank abundance.

RESULTS

The water chemistry of the headwaters was different from that at the other sites in front of East Houses. The headwaters had the lowest pH with an average of 4.13 $\pm$ 0.17. Sites #1-3 were relatively alkaline (7.61 $\pm$ 0.14, 7.42, and 7.46 $\pm$ 0.17, respectively; see Fig. 7). The headwaters also had the lowest level of dissolved oxygen with an average of 3.23 $\pm$ 0.85 mg/L [Note the headwaters also exhbited considerable intra-site variation in D.O. levels, from 1.9 to 4.3 mg/L]. In contrast, sites #1-3 were relatively oxygen-rich (9.80 $\pm$ 0.30, 9.50 $\pm$ 0.57, and 10.07 $\pm$ 0.17 mg/L, respectively; see Fig. 8). In addition the headwaters had the lowest conductivity levels with an average of 0.032 + 0.004 mS/cm. Sites #1-3 were more ion-rich (0.21 $\pm$ 0.17, 0.24 $\pm$ 0.11, and 0.201 $\pm$ 0.086 mS/cm, respectively; see Fig. 9). However, nitrate levels were low at all sites.

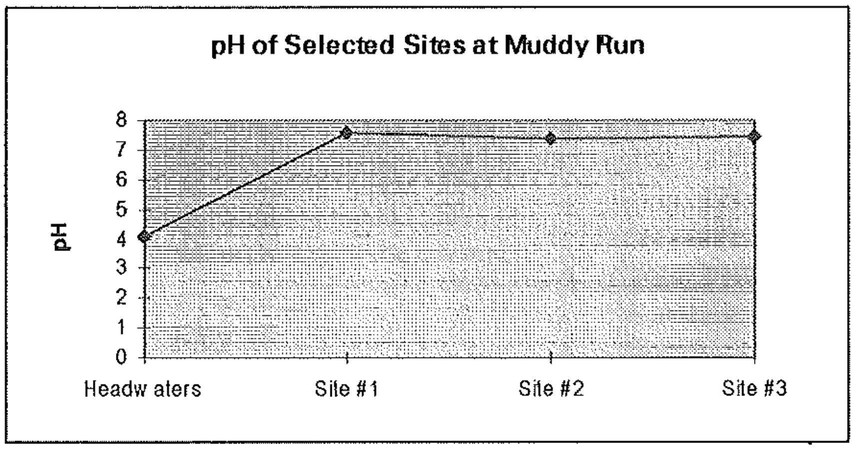


Figure 7. Average pH values at the headwaters and sites 1-3 along MuddyRun.

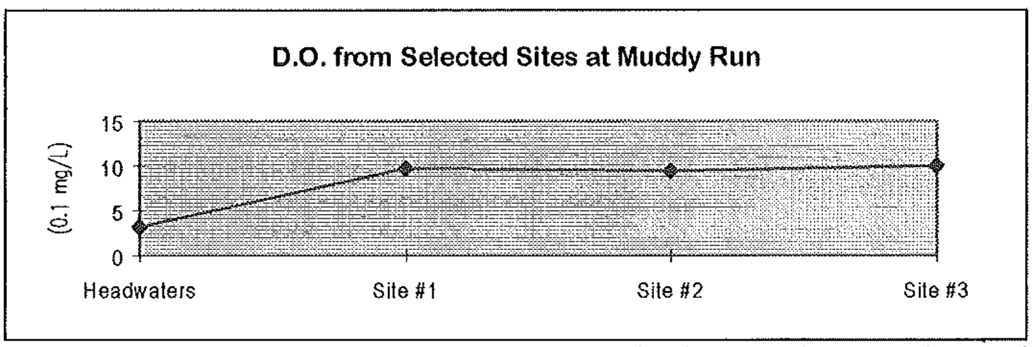


Figure 8. Average dissolved oxygen concentrations at the headwaters and sites 1-3 along Muddy Run.

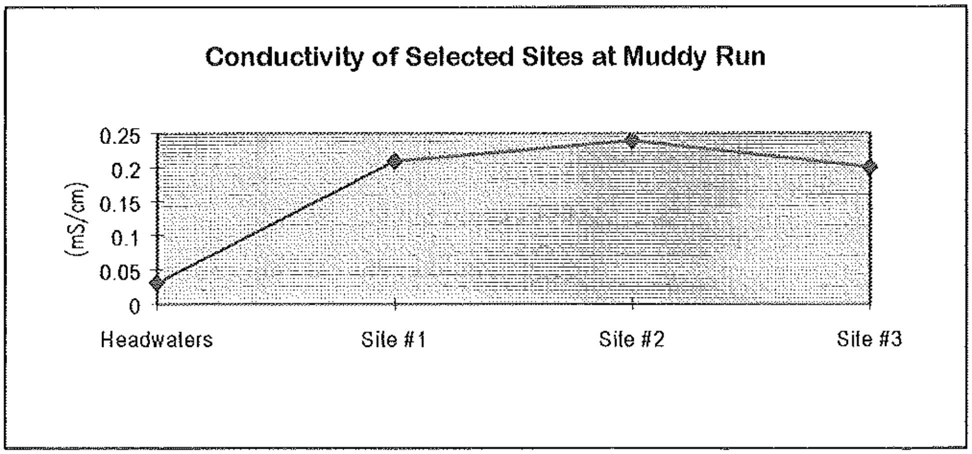


Figure 9. Average conductivity values at the headwaters and sites 1-3 along MuddyRun.

Tables 1a-d show the total number of macro-invertebrates found in each quantitative sample taken from each of the four sites. The macro-invertebrates are classified at the order, family, or species level. Table 2 also lists the taxa found in the qualitative samples at each site.

Table 1a.

Muddy Run Macro-invertebrate Sample Survey: Headwaters										
Taxon	1	2	3	4	5	6	7	8	9	10	**Totals**
Culicidae (mosquito larvae)	0	2	0	0	0	0	2	0	0	0	**4**
Coleoptera (beetle larvae)	0	0	0	0	0	1	0	0	0	0	**1**
Totals	**0**	**2**	**0**	**0**	**0**	**1**	**2**	**0**	**0**	**0**	**5**

Table 1b.

Muddy Run Macro-invertebrate Sample Survey: Site 1											
Taxon	1	2	3	4	5	6	7	8	9	10	**Totals**
Chironomidae (fly larvae)	22(2 adult)	12	8	9	0	0	0	0	0	2(dead)	**53**
Nematoda (roundworm)	0	0	0	0	0	0	0	1	0	0	**1**
Totals	**22**	**12**	**8**	**9**	**0**	**0**	**0**	**1**	**0**	**2**	**54**

Table 1c.

Muddy Run Macro-invertebrate Sample Survey: Site 2											
Taxon	1	2	3	4	5	6	7	8	9	10	**Totals**
Ephydridae (*Prachydeutera puparium*)	0	2	0	0	0	0	0	0	0	0	**2**
Tipulidae (crane fly larvae)	0	0	0	0	0	0	0	1	0	0	**1**
Sialidae (alderfly)	0	0	0	0	0	0	0	0	1	0	**1**
Chironomidae (fly larvae)	0	0	0	0	0	0	0	0	1	0	**1**
Totals	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**0**	**5**

Table 1d.

Muddy Run Macro-invertebrate Sample Survey: Site 3										
Taxon	1	2	3	4	5	6	7	8	9	10	**Totals**
Chironomidae (fly larvae)	0	2	0	0	0	2	0	0	0	0	**4**
Culicidae (mosquito larvae)	0	1	0	0	0	0	0	0	0	0	**1**
Gomphidae (dragon fly larvae)	0	1	0	0	0	0	0	0	0	0	**1**
(round worm)	0	0	0	0	0	1	0	0	0	0	**1**
Physella (snails)	0	0	0	0	0	0	0	0	2	0	**2**
Totals	**0**	**4**	**0**	**0**	**0**	**3**	**0**	**0**	**2**	**0**	**9**

Table 2.

Macro-invertebrates found in 20-minute timed sample	
Site #1	**Number Found**
Cyprinidae (minnow--*Notropis bifrenatus*)	1
Cambaridae(crayfish)	1
Site #2	
Cyprinidae	2
Agrionidae (stream damselfly)	2
Site #3	
Agrionidae	1
Aeshnisae (dragonfly)	3
Cyprinidae	2
Head Waters*	
Frogs (saw but did not catch)	2
*NOTE: also found many *Copepoda* (micro-invertebrates)	

The macro-invertebrate community of the headwaters had a taxon richness (S) of 2, a Simpson's Diversity Index of 1.417, and a taxon equitability of 0.736. Fig. 10 shows the rank-abundance curve for this community.

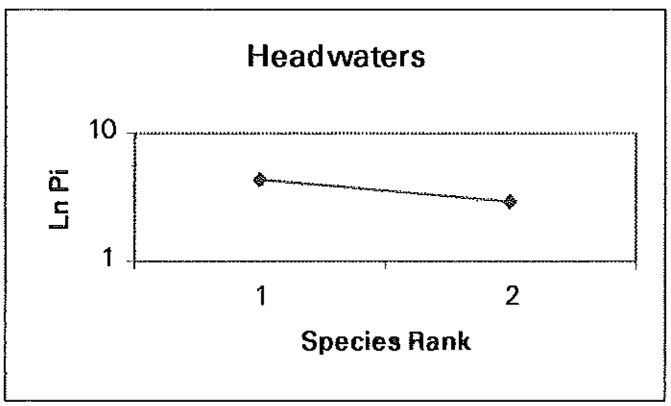


Figure 10. Rank-abundance graph for headwaters.

At site #1, the taxon richness (S) was 2, the Simpson's Diversity Index was 1.040 and taxon equitability equaled 0.520. Fig. 11 shows the rank-abundance curve for this community.

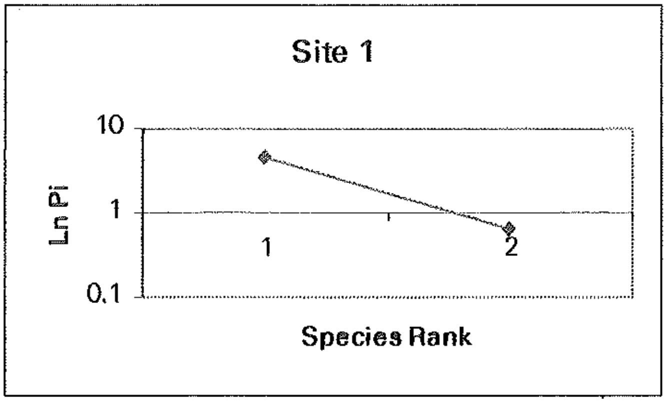


Figure 11. Rank-abundance graph for site #1.

At site #2, the taxon richness (S) was 4, the Simpson's Diversity Index was 3.751 and taxon equitability equaled 0.893. Fig. 12 shows the rank-abundance curve for this community.

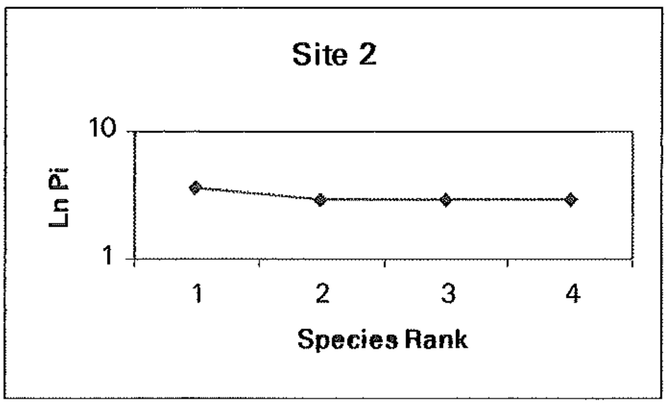


Figure 12. Rank-abundance graph for site #2.

At site #3, the taxon richness (S) was 5, the Simpson's Diversity Index was 3.546 and taxon equitability equaled 0.709. Fig. 13 shows the rank-abundance curve for this community.

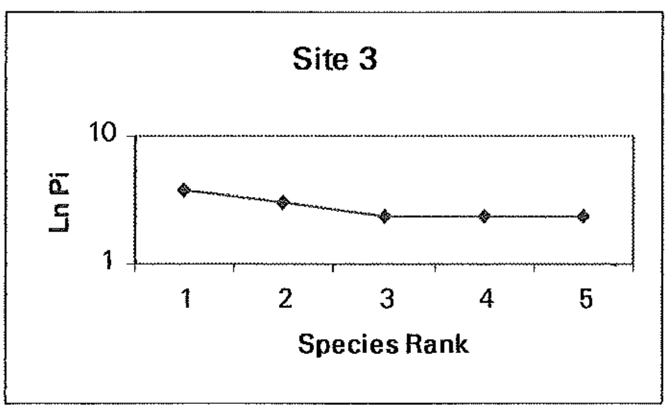


Figure 13. Rank-abundance graph for site #3.

A rank-abundance curve for all of the macro-invertebrates at the four sites is shown in fig. 14.

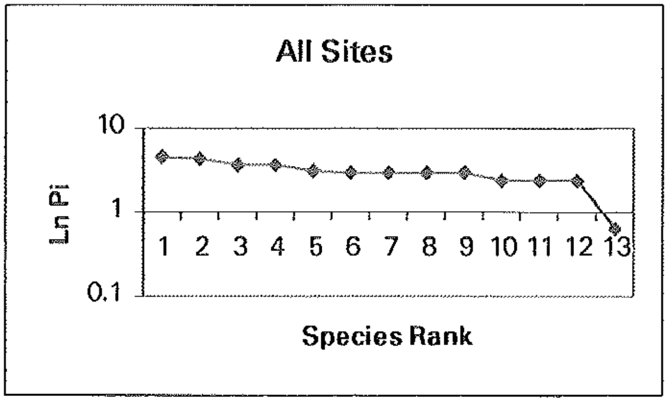


Figure 14. Rank-abundance graph for all sites. Percentages are in descending order . Due to this factor the sites are not in order.

The taxon-abundance curve at the headwaters site and site #1 decline more steeply than those at sites #2 and #3. Perhaps this indicates that species dominance is more pronounced at the headwaters and site #1. A Kruskal-Wallis Test (Table 3) and Mood Median Test showed no significant differences in macro-invertebrate abundance among the four sites.

Table 3. Comparison of macro-invertebrate abundance at four sites along Muddy Run. Results of a Kruskal-Wallis Test are given.

Sample Site	Headwaters	Site #1	Site #2	Site #3
Average # Macro-invertebrate Individuals Collected (± SD)	0.50 ± 0.53	5.40 ± 4.56	0.50 ± 0.53	0.90 ± 0.94
	$H = 0.73$	$df = 3$	$P = 0.867$	

DISCUSSION

Our data have many limitations because of difficulties with the chemical testing equipment, weather changes during our three weeks of testing, and the short amount of time given to the project. We would have liked to have performed more trials to obtain more reliable and extensive data for more rigorous statistical analysis.

Past studies have indicated that Muddy Run is polluted. Unfortunately, due to time restraints, this report lacked any prior results from earlier studies. We set out to substantiate whether the water of Muddy Run is indeed polluted. We originally intended the headwaters site to serve as a "pristine control" for assessing the human impact on downstream sites near East Houses. However, unexpectedly, the headwaters was found to be oxygen-poor (Fig. 8) and very acidic (Fig. 7). This may because it is heavily influenced by runoff and precipitation which is highly acidic in central Pennsylvania. However, the water at downstream sites is relatively alkaline perhaps because it has become buffered by flowing over limestone-rich rocks and soil. Limestone contains calcium carbonate which is a very effective buffer against pH changes. This hypothesis is consistent with the higher ionic content (conductivity) of downstream sites (Fig. 9). In any case, the water chemistry tests helped us little in determining whether Muddy Run is polluted.

As a another possible indicator of water pollution, we examined the kinds of macro-invertebrates found in Muddy Run. Pollution-intolerant taxa, such as caddisfly larva, stonefly nymphs, and mayfly nymphs were conspicuously absent in Muddy Run. The most abundant macro-invertebrates were chironomid fly larvae, which as a group are pollution-tolerant (Tables 1a-d). Additionally, the bright red color of these larvae suggests that the sediments they were found in are oxygen-poor. The red color results from high concentrations of hemoglobin, an oxygen-carrying respiratory pigment that allows these larvae to exist in environments with little or no available oxygen.

It is important that human societies understand fully the consequences of their effects on the earth's environment. We initially set out to determine the effects of Huntingdon on Muddy Run. Unfortunately, we were not able to pinpoint a source of pollution. However, we did determine that the water of Muddy Run appears to be incapable of supporting diverse animal communities.

ACKNOWLEDGEMENTS

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