A Study of Macroinvertebrate Communities in Reach Six of Huff Run to Determine Water Quality

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Abstract

Huff Run is a watershed in Central-Eastern Ohio that has been affected by acid mine drainage produced by deep and surface mining in the area. Huff Run, the stream named after its watershed, is under restoration processes performed by the Huff Run Watershed Restoration Partnership, Incorporated. Assessment of the stream has been performed using macroinvertebrate populations living in the upper and lower part of the stream, but not for Reach Six., which is a middle section of the stream. In this study, Hester-Dendy traps and Kicknets were used to collect macroinvertebrate samples in Reach Six in addition to upper and lower parts of the stream for comparisons. Conductivity and pH were also measured in the field. Macroinvertebrates were identified to the family level. With this data, Cumulative Index Values (stream quality index), Jaccard's Index (similarity) and the Shannon Index (Diversity) were all calculated. Index results suggest that Reach Six is a poor habitat with low diversity and is in need of further restoration.

Introduction

Huff Run is a watershed polluted by acid mine drainage that stretches between Carroll and Tuscarawas counties in Central-Eastern Ohio. The watershed covers 12,775 acres – that is 14.7 square miles - while the stream itself is 9.9 linear miles long (Kleski ix). Mineral City is the only incorporated town. There has been surface mining and deep mining in this area since the early 1800s. The last deep mine closed in 1946. The Huff Run Watershed Restoration Partnership, Incorporated has worked hard to revitalize the health of the stream. To one area, Southside Tipple, they have revegetated, and regraded existing coal refuse, and drained impoundment. At the Linden Mine Site, they removed exposed spoil and pit impoundments and constructed a bioremedation passive treatment system. The Harsha North Site is being remined so that the mining company will relcaim the area.

The stream has been divided into eight Reaches for research and restoration purposes by the Huff Run Acid Mine Drainage Abatement and Treatment Plan. Reach Six is the main focus of this study and is in the middle section of Huff Run, which crosses State Route 542. (See Figure 1.)

Metal concentrations and pH levels influence water quality. Acid mine drainage (AMD) from the abandoned mines in the area affect these factors. AMD is produced "during the weathering process from the oxidation of sulfite minerals disseminated in coal and coal waste-rock. As the acidic effluent moves through the near surface environment, constituents that are soluble under acid, oxidizing conditions, such as Fe, Al, SO_4, Cu, Pb, Zn, Cd and Se, become concentrated in the effluent" (Brake 458). The pH of Huff Run decreases as it flows south but it is not toxic to aquatic life. The metal concentrations of aluminum and iron however do affect quality of life in the water. If these metals are dissolved, they can be poisonous; if they are precipitated, they coat gills and the bodies of fish or macroinvertebrates. Again, metal concentrations get worse (higher) as the stream flows south. (Gannett 8) Macroinvertebrates are a valuable asset in water quality assessment. Different species of macroinvertebrates are tolerant in varying degrees of pH levels and metal concentrations. Their diversity and density are great indicators of water quality. Above Reach Six, measurements from previous Cumulative Index Value (CIV) studies show good to fair quality, while below Reach Six, the quality decreases to poor in Reach One. (Kleski 45) There has been no previous research concerning Reach Six. Thus, the objective of this study is to determine the water quality of this Reach.

Materials and Methods

On June 18, 2001, 27 Hester-Dendy traps were set in Huff Run with the aide of Dr. Charles McClaugherty and Kimberly Arbaugh. Traps were set in flowing water and tied to a brick so not to float away. The brick was tied to a tree on the shore to make sure the brick itself did not get carried away by the current. Three traps were set per brick with three bricks at locations in Reaches Three, Six and Seven. (See Figure 2.) Conductivity and pH were taken at each site. Kick-nets samples were collected at each site also. (See Figure 3)

On August 15, 2001, the Hester-Dendy traps were removed from Huff Run and placed into containers with stream water and formaldehyde. (See Figure 4.)

Macroinvertebrates were removed from their traps, cleaned and placed into 70% ethyl alcohol in bottles sorted by site. Alcohol was put into the bottles containing the macroinvertebrates from the kicknet collections instead of

formaldehyde and water.

Conductivity and pH readings were again taken in October.

Merritt's An Introduction to the Aquatic Insects of North America and Needham's A Guide to the Study of Fresh-Water Biology were used for aides in identification. The macroinvertebrates were identified by order and family, noting obvious species differences.

Macroinvertebrates were rated using the Cumulative Index Value which has been used in previous stream assessments in Huff Run and will therefore be given more weight in this study than the other indices. (See Figure 5.) The CIV gives values and weights to different species of macroinvertebrates depending on their pollution tolerance. Values of above 22 are considered excellent; values between 17 and 22 are deemed good; 11 to 16 is fair and values below 11 are poor. The Jaccard Index was also used which is a measure of similarity. This equation is

$J = \frac{2w}{(A + B - w)}$ where A = number of taxa in community A, B = number of taxa in community B, w = number of taxa in common

The Shannon Index was also used to calculate diversity. This is its equation:

$H' = - \sum p_i \log p_i$ where p_i = decimal fraction of individuals belonging to the i^{th} species

Table 1: Amount of macroinvertebrates collected in all Reaches, identified by common name, order and family. Shannon Index results (H') also displayed. Taxa are separated by CIV assessment groups.

Taxa\Reach	Reach Seven		Reach Six		Reach Three	
Group I Taxa	traps	kicknets	traps	kicknets	traps	kicknets
Mayfly nymph Ephemeroptera Heptageniidae (species 1 – large)	1	0	0	0	0	0
Ephemeroptera Heptageniidae (species 2 - darker)	2	0	0	0	0	0
Ephemeroptera Heptageniidae (species 3 – gray)	3	0	0	0	0	0
Mayfly nymph Unidentified Ephemeroptera	1	0	0	0	0	0
Stonefly nymph Capniae Plecoptera	3	0	0	0	0	0
Caddisfly larvae Trichoptera	2	70	10	64	0	10

Hydropsychidae						
Snails Gastropoda Physidae	2	0	0	0	0	0
Beetle Unidentified Coleoptera adults (species 1 - small)	1	1	0	0	0	0
Unidentified Coleoptera adults (species 2 – fat)	4	1	0	0	0	0
Unidentified Coleoptera adults (species 3 –triangular)	0	1	0	0	0	0

Group 2 Taxa

Crayfish Decapoda Camaraidae	1	1	0	1	0	0
Coleoptera Lampyridae (species 1)	2	0	1	0	0	0
Coleoptera Lampyridae (species 2)	0	0	1	0	0	0
Beetle larvae Coleoptera **Elmidae** (species 1 – dark)	2	1	4	1	0	0
Coleoptera **Elmidae** (species 2 – spotted)	1	0	0	0	0	0
Dragonfly Unidentified Odonata larvae	1	0	0	0	0	0

Group 3

Midge larvae Diptera Chironomidae (Speices 1 –red)	39	1	30	0	1	0
Diptera Chironomidae (Species 2 - clear)	27	4	18	6	0	0

Other

Alderfly larvae Megaloptera Sialidae	0	0	1	0	0	2
Fly larvae Unidentified Diptera	2	0	1	0	0	0
Fly Pupae Unidentified Diptera	1	0	0	0	0	0
Fly Larvae **Diptera** **Empididae**	1	0	0	10	0	0
Adult Caddisfly **Trichoptera** **Philopotamidae**	0	1	0	1	0	0
Mayfly Larvae **Ephemeroptera** **Siphlonuridae**	0	1	0	0	0	0

Mayfly adult Ephemeroptera Ephemera	1	0	0	0	0	0

Totals: 341	97	82	66	83	1	12
Total taxa: 25	20	10	8	6	1	1
H' results	1.88	0.59	1.29	0.75	0	0.42

Table 2: Jaccard's Index Results

Reaches Compared	Jaccard's Index Results
7, 6	0.58
7, 3	0.18
6, 3	0.36

Results

A total of 341 macroinvertebrates were collected between all three Reaches. Reach Seven, by far had the most taxa. There were a total of 97 macroinvertebrates found in the Hester-Dendy traps and 82 in the kicknets. Seven's total taxa from the traps was 19 while ten taxa collected from the kicknets. Reach Six had a total of 66 macroinvertebrates found in the traps and 83 from the kicknets. However, Reach Six only had eight taxa collected from Hester-Dendies and six taxa from kicknets. Reach Three had only 13 macroinvertebrates found total with 12 of these 13 from kicknet collections. Only three taxa were found in Reach Three. According to the CIV index, Reach Seven had "good" water quality. (See Figure 6.) This Reach scored a 22 which is the highest score in this category. It had many macroinvertebrates in Group One Taxa category including mayfly nymphs (See Figure 7.), caddisfly nymphs, riffle beetle adults, snails and stonefly nymphs. These species are pollution intolerant. It also had species from the other Groups which are recorded in Table 1. Reach Six scored 8, putting it in the "poor" assessment bracket. Caddisfly larvae were the only macroinvertebrate found that belonged in the pollution intolerant Group. There were also beetle larvae (See Figure 8.), crayfish - which are in Group Two - and midge larvae - which are in Group Three and are pollution tolerant (See Figure 9.). Although caddisflies were present, Reach Three only scored a four on the CIV index, deeming it "poor" along with Six. Jaccard's Index is a measure of how similar communities are through their common species. Scores range from 0 (no common species) to 2.0 (all species in common). When Reach Seven and Reach Six were compared, they scored a 0.58. The score between Reach Seven and Three was 0.19. Reach Six and Reach Three together scored 0.40. (See Table 2.)

The Shannon Index is a measure of how diverse populations are. The higher the result, the more diverse the population is. Shannon Indices are represented by H' results. Results are exhibited at the bottom of Table 1.

Conductivity data showed that Reach Three had the highest metal ion load with an average of 1.70ms, Six was 0.70ms away with 1.00ms and Seven was at 0.33ms. pH readings did not show much difference between the Reaches. Reach Seven was slightly over neutral at 7.27, Reach Six read at 7.14 and Three was 6.54. pH was slightly lower further along the stream. (See Table 3.)

Discussion There are many factors that contribute to poor water quality which in turn contributes to small macroinvertebrate populations and few pollution intolerant species. As stated in the Introduction, pH and metal

concentrations are the largest contributors of problems caused by acid mine drainage.

The number of macroinvertebrate taxa found in Reach Seven, along with the high number of pollution-tolerant species, shows that Reach Seven is indeed of relatively "good" quality. A high number of macroinvertebrates were collected from Reach Six, but diversity among the taxa was much lower. In addition, species in the middle bracket of the CIV index were the most prevalent but the species with the highest number were midge larvae and are in the pollution tolerant Group. These factors indicate Six's "poor" status. Reach Three's lack of variety of species and its low numbers point to a "poor" water quality also. The CIV index is in agreement with the results from the quantity data. Jaccard's Index shows that there are more similarities between Reaches Six and Seven and Six and Three than Reaches Seven and Three. The Shannon Index suggests Six and Three both have low diversity among communities. This also concurs with water quality conclusions. Conductivity readings show high ion loads in the low water quality sections of Huff Run. Again, this data confirms that Reaches Six and Three are of much lower quality than Seven and that macroinvertebrates are having a hard time dealing with the iron concentration. pH readings are almost the same in the different Reaches even though their macroinvertebrate populations and metal concentrations are very different. This supports that macroinvertebrates are a better indicator of stream quality. pH and metal concentrations can change with the seasons or weather changes. Macroinvertebrates show whole quality of the water because they have lived through these changes. Readings only show one small fact about that specific area of the stream at that exact time.

Conclusions Reach Six is of poor water quality according to its macroinvertebrate population. Work has been done downstream of Reach Six to restore water quality and wildlife. However, if this area is still in need of treatment, efforts downstream will not be as effective with Reach Six's high ion load flowing into it. Restoration to Reach Six is therefore necessary.