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THE AFFECTS OF ACID MINE DRAINAGE ON THE WATER QUALITY, AND BENTHIC MACROINVERTEBRATE AND FISH POPULATIONS IN STREAMS IN MARYLAND

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INTRODUCTION

Despite the severity and long tenure of acid mine drainage in Maryland waters, there is presently little information available as to the species of benthic macroinvertebrates and fishes or to their occurrences and abundance in relation to acid mine pollution.

The purpose of this study was to measure and evaluate relationships between populations of benthic macroinvertebrates and fish, as well as variations in water quality in streams affected by acid mine drainage.

The area studied encompassed seven watersheds in Garrett and Allegany Counties, Maryland. These watersheds receive all the drainage from the coal mines of Maryland and are as follows: Youghiogheny River, Cherry Creek, Casselman River, Savage River, George's Creek, Wills Creek, and the Potomac River. This report covers only the Youghiogheny and Casselman Rivers and Cherry Creek watersheds. Watersheds not covered in this report, in addition to those of this report, will appear in a forthcoming special report of the Natural Resources Institute, University of Maryland.

Stations were chosen to sample the main stems of the three watersheds and to sample tributary streams which contribute mine wastes to the main stems of each watershed. For purposes of comparison, a number of streams unaffected by pollution are included. For specific locations of the individual sample sites see Figures 1 and 2, and Table 1. Field work for the project was initiated in April 1969 and concluded August 1971.

A list of the fishes collected during this study are presented in Table 2. The common and scientific names used in this report are from AFS (1970).

METHODS

WATER QUALITY DETERMINATIONS

Water quality sampling stations coincided in location with the stations selected for macroinvertebrate and fish collections and were performed each time fish and benthic collections were made. Additional water quality samples were taken during periods when stream conditions did not allow biological collections.

Determinations were made of dissolved oxygen, total alkalinity, total acidity, total hardness, total iron, sulfate, and turbidity, according to APHA (1965). Hydrogen ion concentration was measured with a Sargent pH meter and specific conductance with a Beckman conductivity meter. Water temperatures were measured by pocket thermometer.

BOTTOM FAUNA STUDIES

Benthic macroinvertebrates were collected from riffle areas using the standard Surber square foot bottom sampler and a modified Hess sampler when the water was too deep for the Surber sampler. Eight square foot samples were collected at each station. An attempt was made to take a random sample by collecting near the center of the stream and near each bank. Macroinvertebrates from each station were preserved in 10% formalin and returned to the laboratory where they were thoroughly washed and strained through 1/4 inch mesh hardware cloth on the top half and 60 mesh bronze screen on the bottom half. Organisms were sorted from debris by sugar flotation and were identified to order or class and the number in each group counted.

FISH FAUNA STUDIES

Fishes were collected by a d-c electric shocker. A section 400 feet long by approximately 15 feet wide was sampled at each station. For streams less than 15 feet wide, tne entire stream width was sampled. The collection at each station was preserved as a unit in 10% formalin and returned to the laboratory for analysis. At the laboratory each collection was divided into species and the number of each species was counted.

SPECIES DIVERSITY

The community structure of the benthic macroinvertebrate and fish populations at each station are described in terms of the relative abundance of certain organisms and species diversity. Species diversity was calculated by using the following equation (Patten, 1962).

$$\bar{H} = \sum_{i=1}^{m} \frac{n_i}{N} \log \frac{n_i}{N} \quad \text{(Diversity per individual)}$$

where (N) = Total number of organisms

(n_i) = Number of individuals per taxon

(m) = Number of taxa in a unit area

which expresses the distribution of individuals among species.

Base 10 logarithms are used.

Diversity indicies permit summarization of large amounts of information about numbers and kinds of organisms (Patten, 1962). Such parameters express the distribution of individuals among species. In this type of evaluation of a community, the main quantitative evaluation is based on the numbers of species of the major groups of organisms established in the area. Uses of associations or populations of aquatic macroinvertebrates or fish to describe aquatic communities usually involve cumbersome lists

and descriptions. Diversity indicies summarize community structure clearly and briefly by providing numerical indicies.

RESULTS

WATER QUALITY

A summary of the water quality for each sample station is presented in Table 3. Dissolved oxygen was routinely measured in 1969 and 1970 at all stations, but was discontinued in 1971 since only one measurement was found to be less than 6 mg/l. It did not appear to be a limiting factor affecting the survival, growth, reproduction, and general well being of aquatic organisms in the streams being studied.

YOUGHIOGHENY RIVER WATERSHED

Measurements of water quality for the Youghiogheny River watershed were taken at 16 sampling stations, six of which were located on the main stem of the Youghiogheny River and 10 on tributaries. Tributaries sampled and known to be significantly affected by acid mine drainage included Salt Block Run, White Rock Run, Trap Run, Laurel Run (Friendsville), and Laurel Run (Crellin). (Personal communication, Maryland Department of Water Resources.)

Youghiogheny River Stations

The average water quality values varied slightly from station to station, with greater variation occurring from one sampling date to another at a given station.

Hardness ranged between 26 and 72 mg/l at the six sampling stations on the Youghiogheny River and averaged between 41 and 52 mg/l. Sulfate values fluctuated from 4 to 40 mg/l, averaging between 10 and 30 mg/l

for the six stations. The pH averaged from a few tenths below neutral to a few tenths above at each station except one (Station 9), where pH averaged 6.3 and ranged from 5.6 to 7.1. Total iron was present in small quantities at each station averaging between 0.18 and 1.25 mg/l. On several sampling dates no values for iron were measured at Stations 1 and 3, and a high of 2.40 mg/l was measured at Station 9.

Turbidity was always very low, averaging less than 25 JTU for each sampling station. Acidity ranged between 0 and 61 mg/l, averaging from 2 to 17 mg/l. Acidity was highest at Stations 7 and 9, reflecting the influence of acid mine drainage from Laurel Run (Crellin) and sewage from the Little Youghiogheny River. Total alkalinities were low to moderate ranging from 9 to 45 mg/l and averaging between 7 to 29 mg/l. Alkalinities were due entirely to bicarbonates except at Station 1 where 2 mg/l of alkalinity was due to carbonates on one sampling date. Conductance values ranged from 53 to 122 mhos/cm, averaging from 61 to 105 mhos/cm. The highest average values were measured at Stations 7 and 9, where water quality was influenced by Laurel Run and the Little Youghiogheny River.

No unusual patterns of concentration were noted except at Station 9 which had slightly higher average acidity and conductance values.

Tributary Stations

The water quality on tributary stations varied somewhat from station to station, but except for pH, water quality values were similar to those found at Youghiogheny River stations. The pH values at tributary stations ranged from a low of 3.9 at Station 14 (White Rock Run), to a high of 7.8 at Station 16 (Sang Run). Lowest pH values were measured in streams known to have been receiving acid mine drainage.

CHERRY CREEK WATERSHED

Water quality in Cherry Creek was measured at one station with a total of four samples being taken. Values changed only slightly from one sampling date to another. In general, Cherry Creek was characterized by having no total alkalinity and a low pH (average of 4.3). Other water quality values were close to the usual values for unpolluted waters in Appalachia (Table 4).

CASSELMAN RIVER DRAINAGE

The water quality in the Casselman River watershed was measured at 13 stations. Two of the stations were located on the main stem of the Casselman, while four were located on the North Branch Casselman, and two on the South Branch Casselman. Five additional sampling sites were located on tributaries. The North and South Branches of the Casselman and Meadow Run were considered to be significantly affected by acid mine drainage. (Personal communication, Maryland Department of Water Resources.)

Casselman River Stations

Average water quality measurements varied slightly from station to station, with wider variations occurring from one sampling date to another at the same station.

Hardness ranged between 10 and 108 mg/l, averaging from 16 to 50 mg/l. Sulfate values ranged from 9 to 65 mg/l, and averaged between 13 and 31 mg/l. The pH ranged from a low of 4.7 at Station 35 to a high of 7.7 at Station 37, averaging from 6.3 to 7.1. Stations located on the North Branch averaged slightly lower pH values than those for main stem Casselman and South Branch stations. Total iron was present in trace amounts, seldom exceeding 1 mg/l on any sampling date, while averaging

only 0.19 to 0.46 mg/l.

Turbidity was usually very low and measured less than 25 JTU on most occasions. Alkalinities were due entirely to bicarbonates and were low averaging less than 20 mg/l per station. Alkalinity values were slightly lower at stations located on the North Branch than for main stem and South Branch stations. Acidity values ranged from 0 to 25 mg/l and averaged from 2 to 8 mg/l. Conductance ranged from 30 to 200 mhos/cm, averaging 36 to 131 mhos/cm.

The average pH and total alkalinity values were slightly lower at stations located on the North Branch than for Casselman and South Branch stations. The average acidities at stations on the North Branch were slightly higher than for Casselman and South Branch stations.

Tributary Stations

Water quality characteristics of tributary stations were very similar to those found in main stem Casselman and North and South Branches, and were within the normal range expected for unpolluted streams in Appalachia.

BENTHIC MACROINVERTEBRATES

YOUGHIOGHENY RIVER WATERSHED

Benthic macroinvertebrates collected from sample stations in the study area are listed in Table 5. The average values and ranges for numbers of individuals per ft^2, number of species, and diversity found at each station are presented in Table 6. Except for Station 13, benthos collections were attempted from all sample stations.

Benthic macroinvertebrates were collected from six stations on the main stem of the Youghiogheny River and one station each was located on nine tributary streams.

A total of 15 major taxonomic categories of macroinvertebrates were identified during the study from the Youghiogheny River watershed. The majority of macroinvertebrates collected belonged to insect orders, which comprised from 86 to 99% of the faunal composition at each station. Based upon all collections from each station, Diptera accounted for 43%, Tricoptera 26%, and Ephemeroptera 14% of the faunal composition.

Youghiogheny River Stations

The average number of species found at stations on the Youghiogheny River ranged from 12 (range 10-14) at Station 9 to 21 (range 16-26) at Station 4. The number of individuals/ft^2 ranged from an average of 12 (range 7-22) at Station 9 to 91 (range 68-117) at Station 7. Diversity averaged from 1.51 (range 0.86-1.95) at Station 7 to 2.13 (range 1.87-2.40) at Station 4.

Their was considerable variation in individual values from date to date and a lesser variation in the average values for number of individuals/ft^2, number of species, and diversity from station to station.

No discernable trends are apparent with location of stations except that the smallest number of individuals/ft^2 and number of species occurred at Station 9. Station 9 was located several hundred feet below Laurel Run (Crellin) which is the largest contributor of acid mine drainage to the Youghiogheny River watershed. The smallest diversity was measured at Station 7 located a short distance downstream from the Little Youghiogheny River which is polluted by untreated domestic sewage. This may have had some influence on the lower diversities found at Station 7.

Tributary Stations

Benthic data from tributary streams are based on one sample per station. The smallest number of species taken was 2 at Station 14 (White Rock Run) and the largest was 25 at Station 16 (Sang Run). Individuals/ft^2 varied from a low of 1 at Station 14 to 2.77 at Station 20 (Bear Creek). Stations with the lowest number of species, individuals/ft^2, and diversity were all located on streams receiving significant amounts of acid mine drainage.

CHERRY CREEK WATERSHED

The benthic macroinvertebrates collected at the Cherry Creek Station are shown in Table 7. The average values and ranges for number of individuals/ft^2, number of species, and species diversity found at each station are presented in Table 8.

Benthic macroinvertebrates were collected from one station on Cherry Creek. Two samples were made at this station and seven major taxonomic categories of macroinvertebrates were collected. Tricoptera accounted for 66% and Plecoptera for 22% of the benthic fauna collected. Other insect and non insect groups appeared in about equal numbers.

Seven species of macroinvertebrates were taken on both sampling dates. The number of individuals/ft^2 for the two samples were 3 and 6, and diversity was 0.94 and 1.53.

CASSELMAN RIVER WATERSHED

The benthic macroinvertebrates collected at each station are shown in Table 9. Average values and ranges for number of individuals 1 ft^2, number of species, and species diversity at each station are presented in Table 10. Except for Station 40, benthos collections were attempted

from all sample stations.

Benthic samples were collected from 13 stations in the Casselman River watershed. Two stations were located in the main stem Casselman, four on the North Branch Casselman, and two on the South Branch. Five additional stations were located on tributary streams.

Fifteen major taxonomic categories of macroinvertebrates were identified. Based upon all collections from each station, insect orders dominated the collections by comprising 80 to 99% of all the organisms in the combined samples. Individually the other taxonomic groups seldom comprised as much as 1% of the macroinvertebrate collections. Tricoptera predominated over all other groups with 65% of all macroinvertebrates collected belonging to this order. Diptera were the second most abundant group, accounting for 16%, and Ephemeroptera were third with 10%.

Casselman and North and South Branch Stations

There was considerable variation in the average number of individuals/ft^2 and diversity from station-to-station and a smaller station-to-station variation for average number of species. There was also a wide variation from date to date for the above measurements.

The average number of species at stations on the main stem Casselman and North and South Branches varied from 11 (range 2-16) at Station 33 to 28 (range 24-32) at Station 38. The number of individuals/ft^2 varied from an average 10 (range 1-26) at Station 33 to 105 (range 43-250) at Station 31. Diversity averaged from 0.72 (range 0.61-0.90) at Station 36 to 2.22 (range 1.59-2.71) at Station 35.

Tributary Stations

These stations had station-to-station variation similar to stations

on the main stem Casselman and North and South Branch Stations. The average number of species varied from 16 (range 8-23) at Station 42 to 26 (range 17-42) at Station 41. Individuals/ft^2 averaged between 22 (range 8-36) at Station 43 to 57 (range 5-109) at Station 39. Diversity varied from an average of 1.13 (range 0.84-1.37) at Station 41 to 2.39 (range 2.18-2.60) at Station 43.

FISH FAUNA

YOUGHIOGHENY RIVER

The fish collections from each station are listed in Table 11. Average values and ranges for number of fish caught, number of species, and species diversity by stations are presented in Table 12. Except for Station 6, fish collections were attempted at all stations.

Collections of fish were attempted at six stations on the main stem of the Youghiogheny River and from nine tributary stations. A total of 18 species and six families of fish were collected from the Youghiogheny River watershed. The largest group of fish represented at nearly all stations were Cyprinidae, accounting for from 33 to 50% of the fish species caught and from 32 to 87% of the numbers caught.

Youghiogheny River Stations

The average number of species caught varied from 0 at Station 9 to 9 (range 8-10) at Station 3. The number of fish taken averaged from 0 at Station 9 to 289 (range 111-466) at Station 3. Diversity ranged from an average of 0 at Station 9 to 1.69 (range 1.56-1.81) at Station 10.

Their was little variation in number of species and diversity between stations with the exception of Station 9 (Crellin). No fish were caught nor observed at this station, which was located a few hundred feet below Laurel Run.

Tributary Stations

Tributary streams were small, and except for Station 11 where brook and rainbow trout were captured, the species composition was largely minnow and sucker species. At four tributary stations (12, 13, 14, 18) no fish were captured nor observed. The number of species at other tributary stations varied from 2 at Station 15 to 8 at Station 11. Diversity ranged from 0.38 at Station 15 to 1.56 at Station 20.

CHERRY CREEK WATERSHED

Fish collected from the Cherry Creek Watershed are shown in Table 13. Average values and ranges for number of fish caught, number of species, and species diversity are presented in Table 14.

Fish collections were made from one station on Cherry Creek which was located just above Deep Creek Lake. This station (21) was sampled three times over a three year period with three species of fish from three families being taken.

The number of species collected on each sampling date ranged from 1 to 3, number of fish caught ranged from 2 to 19, and diversity ranged from 0 to 0.95. The fish collected from Cherry Creek were not distributed throughout the 400-ft sample length, but were concentrated in a shallow pool within 200 ft of Deep Creek Lake and at the lower end of the station. This would indicate that Cherry Creek in the area is not suitable for a resident fish population and that the fish caught were lake residents that had temporarily moved into Cherry Creek.

CASSELMAN RIVER WATERSHED

The fish collections from each station are listed in Table 15. Average values and ranges for number of fish caught, number of species, and species diversity by station are presented in Table 16. Except for

Station 43, fish collections were attempted at all stations.

Collections of fish were made from two stations on the main stem of the Casselman River, four from the North Branch Casselman, and two from the South Branch Casselman. Four stations were located on tributary streams.

A total of 16 species and 6 families of fish were collected from the Casselman River watershed. The dominant group of fish were Cyprinidae, accounting for from 33 to 66% of the fish species caught. Smallmouth bass were the only game fish caught and they were found only at Station 41. Three panfish species, rock bass, pumpkinseeds, and yellow perch were taken with rock bass being the most abundant and most widely distributed.

Casselman River Stations

The average number of species varied from 4 (range 2-6) at Station 34 to 9 (range 7-11) at Station 9. The number of fish caught ranged from 22 (one sample) to an average of 198 (range 122-297) at Station 32. Diversity averaged from 0.82 (range 0.56-1.14) at Station 34 to 1.75 (range 1.60-2.16) at Station 32.

Diversity and number of species were lowest at stations in the North Branch which receives the greatest amount of acid mine drainage and were highest at stations from the main stem Casselman. The diversity values from North Branch Stations were low while the values from main stem stations were intermediate in range.

Tributary Stations

The species composition was similar at tributary stations to Casselman River stations. The number of species at tributary stations ranged from 4 at Station 40 to 9 at Stations 39 and 41. The number of fish caught at

each station ranged from 50 at Station 40 to 292 at Station 41. Diversity ranged from 0.96 at Station 40 to 1.90 at Station 39.

DISCUSSION

YOUGHIOGHENY RIVER WATERSHED

Except for Station 9 (Crellin), stations located on the main stem of the Youghiogheny River had water quality characteristics similar to the usual values for unpolluted waters in Appalachia (Table 16). Total alkalinities were low at all stations, with only infrequent values measured above 20 mg/l. No fish were collected at Station 9, and the abundance of macroinvertebrates was lowest at this station. The average species diversity for benthos at Station 9 was 1.70 and was lower than at other stations except Station 7 with an average value of 1.51.

In order to compare the faunal composition at stations affected by acid mine drainage with what could be expected from unaffected areas, the following figures were compiled from selected stations from streams not affected by acid mine drainage in Garrett and Allegany Counties.

Benthic Macroinvertebrate	Average and Range
Individuals/ft^2	53 (6-269)
Number of species	22 (4-33)
Species diversity	2.17 (1.26-2.77)
Fish	
Number of individuals	175 (40-597)
Number of species	9 (6-18)
Species diversity	1.74 (1.21-2.53)

The average values for number of individuals, individuals/ft^2, number of species, and species diversity were slightly less than the average values found in stations unaffected by acid mine drainage, but were within the range of expected values. Exceptions were Station 7 with 99 benthic

organisms/ft, and Station 3 which had an average of 9 fish species and 289 individuals/sample.

It is apparent that acid mine drainage has little affect on water quality, and benthic and fish populations of Youghiogheny main stem stations, except at Station 9 and possibly Station 7. The Youghiogheny River has improved considerably since 1950 when it was polluted as far down river as Friendsville (Reppert, 1964), and considered practically lifeless, but with no pre-acid mine studies available it is difficult to determine whether water quality and aquatic population have attained the conditions found before coal mine pollution. It is significant that smallmouth and largemouth bass and trout species are doing well in the lower reaches of the Youghiogheny River.

The effects of acid mine drainage on tributary streams was most noticeable at Station 14 (White Rock Run) which had a pH of 3.9, a low benthic standing crop of 11 ft^2, a diversity of 0.59, and no fish population. Stations 12, 13, and 18 which were also affected by acid mine drainage had much higher diversity values than Station 14 for benthos, but was also devoid of fish life.

CHERRY CREEK WATERSHED

Based on water quality measurements, and benthic macroinvertebrate and fish collections from Station 21, the overall quality of the habitat of Cherry Creek must be considered as being poor.

As far as water quality is concerned, pH was the most limiting factor averaging only 4.3. Other water quality parameters were similar to values usually found in unpolluted waters in Appalachia.

The average standing crop ($4/ft^2$) and average diversity (1.23) of

benthic macroinvertebrates was low, when compared to average standing crops and species diversity values found in unpolluted western Maryland streams.

Fish populations were apparently more severely affected by acid mine drainage than benthic populations with an average of 9 fish per collection and an average diversity of only 0.54. In unpolluted western Maryland streams a diversity ranging from 1.21 to 2.53 (average 1.74) was found.

Further indication of poor fish habitat in Cherry Creek is the fact that fish collected were concentrated in a pool at the lower end of the 400-ft long sample section located just above Deep Creek Lake, and that they were atypical for the boulder riffle habitat of Cherry Creek. Minnows and sculpins which would be expected from a stream like Cherry Creek were not found, but instead, the collection consisted of yellow perch and one specimen each of chain pickerel and smallmouth bass.

CASSELMAN RIVER WATERSHED

Water quality values, and benthic macroinvertebrates and fish populations appear to have recovered to pre-acid mine drainage levels, except possibly at the stations located on the North Branch Casselman where pH values below 6.0 were measured.

The fish populations in the North Branch are apparently affected to some extent, as indicated by lower species diversity values than other Casselman River stations averaging less than 1.00, compared to an average of 1.74 from unpolluted water. Further evidence that acid mine drainage may still affect fish population in the North Branch is the fact that on 30 April 1970 no fish were caught at Station 33 and pH values were low through the preceding winter.

The benthic macroinvertebrate fauna of North Branch stations were not evidently affected by acid mine drainage as indicated by standing crops, number of species, and diversity indicies equal to or better than found at other Casselman River stations and similar to values found in streams unpolluted by acid mine drainage.

Before acid mine pollution started in the 1940's, smallmouth bass and trout species (brook and rainbow trout) were commonly caught in the Casselman River. Following acid mine pollution, bass and trout populations were eliminated and never have become reestablished.

Based on abundance and diversity indicies from stations on the Casselman River, benthic and fish population appear to have recovered to pre-acid mine conditions. However, since no studies were conducted prior to acid mine drainage in the Casselman River, it is difficult to assess the levels of recovery and figures can only be compared to what is found in unpolluted water in Garrett and Allegany Counties.

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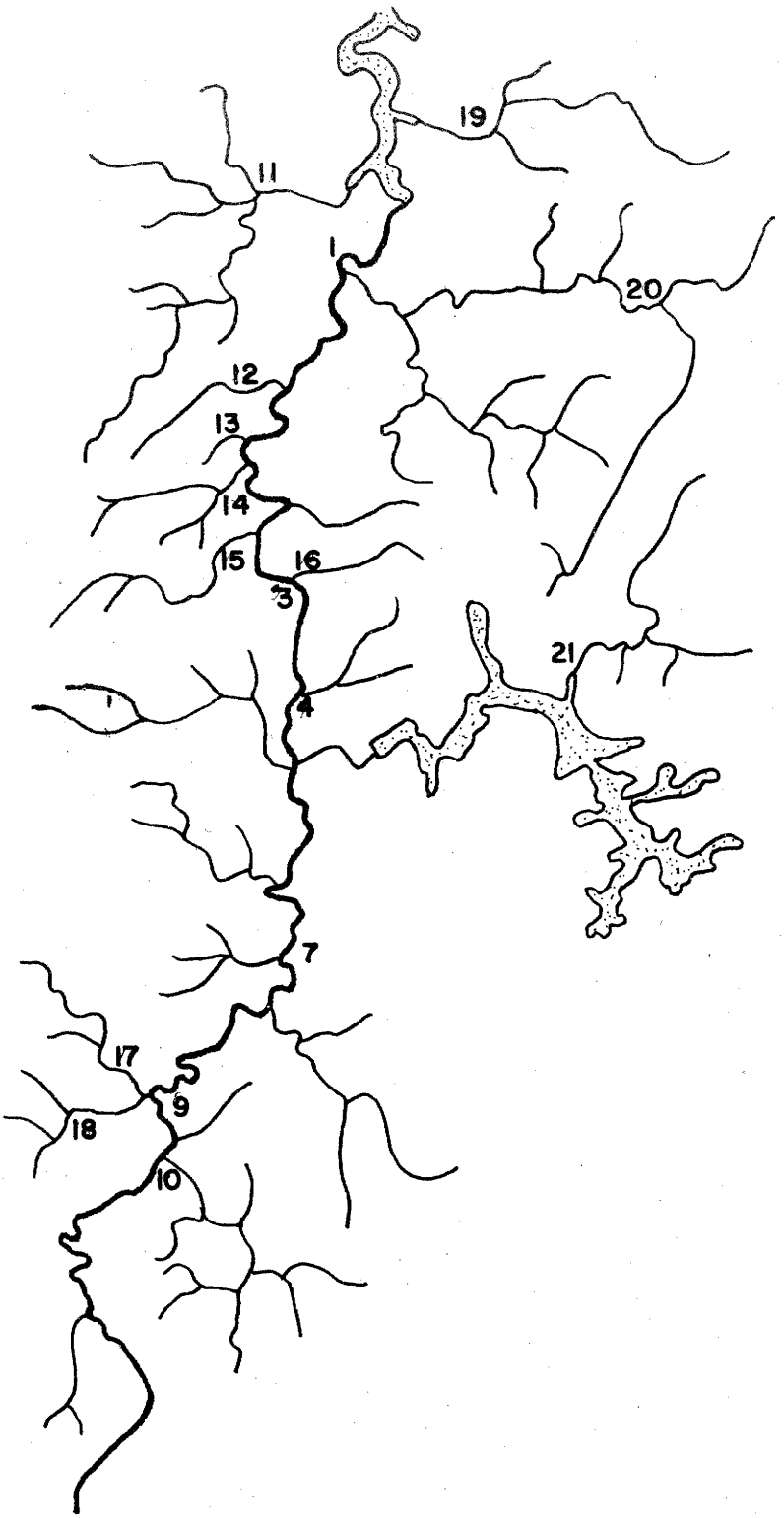

FIG. 1. Youghiogheny and Cherry Creek Watersheds

Table 1. Sampling stations and locations.

Station Number	Maryland Coordinates	Location
		Youghiogheny River Watershed
1	677-125	Youghiogheny River Friendsville Island
3	640-117	Youghiogheny River Sang Run
4	625-120	Youghiogheny River Hoyes Run
7	589-116	Youghiogheny River Herrington Manor Road
9	572-104	Youghiogheny River Crellin
10	567-104	Youghiogheny River Underwood
11	686-114	Buffalo Run Buffalo Run Road
12	664-110	Laurel Run Trap Run Road
13	658-110	Trap Run Trap Run Road
14	651-110	White Rock Run River Road
15	644-110	Salt Block Run River Road
16	640-117	Sang Run
17	576-102	Snowy Creek, Bridge at Snowy Creek Road
18	574- 98	Laurel Run, Bridge at Crellin Mine Road
19	692-134	Mill Run, Mill Run Road below Co. Rt. 53
20	671-152	Bear Creek, Bear Creek Road near U.S. 219

Table 1. (cont'd). Sampling stations and locations.

Station Number	Maryland Coordinates	Location
		Cherry Creek Watershed
21	629-134	Cherry Creek, Bridge on Meadow Mountain Road
22		Casselman River Watershed
31	693-205	Casselman River, 1.0 miles south of Pennsylvania-Maryland state line
32	685-196	Casselman River U. S. Route 40
33	676-186	North Branch Casselman River Maryland Route 495
34	672-179	North Branch Casselman River Durst Road
35	664-168	North Branch Casselman River Dung Hill Road
36	639-168	North Branch Casselman River Pleasant Valley
37	675-187	South Branch Casselman River, just above confluence with North Branch
38	667-184	South Branch Casselman River Mogart Mine Road
39	676-186	Shade Run at Route 495
40	681-208	Meadow Run below Little Meadow Lake
41	691-238	Piney Creek at Wilhelm Road
42	668-186	Big Laurel Run Jennings Road
43	667-186	Little Laurel Run Jennings Road