Proceedings of the Pennsylvania Academy of Science 50:59—65. 1976

A STUDY OF MACROINVERTEBRATES AND FISHES ABOVE AND BELOW TWO SEWAGE TREATMENT PLANTS IN THE CODORUS CREEK DRAINAGE, YORK COUNTY, PENNSYLVANIA

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ABSTRACT

Macroinvertebrate and fish communities above and below two sewage treatment plants in York County, Pennsylvania, were studied over a six-month period in 1975. A total of 36 macroinvertebrate and 16 fish collections were made. Samples of macroinvertebrates from an A-frame net and D-frame net (dip net) were compared. The A-frame net is described. Data for macroinvertebrates were analyzed on the basis of total taxa, relative abundance of predominant taxa, species diversity indices, indicator organisms, and indicator communities to compare the stream ecosystems above and below the treated effluents. Fish data were analyzed on the basis on total taxa and relative abundance. Differences in data for both faunal groups were obvious. However, the magnitude of differences appeared closely correlated with the amount of sewage treatment effluent (organic load) relative to stream flow.

INTRODUCTION

Studies of aquatic communities in the vicinity of sewage treatment plants have been conducted by many investigators (Gaufin and Tarzwell 1952 and 1956, Hynes 1962, Avery 1969, Tsai 1973). The literature relative to macroinvertebrates is voluminous and studies that include reviews were usually centered around certain aspects such as water pollution in general (Mackenthun 1969), indicator species and the importance of species identification (Resh and Unzicker 1975), aquatic organisms and sedimentation (Rosenburg and Snow 1975). A recent extensive review and discussion of the relationship of sewage treatment effluents to fishes was presented in Tsai (1975).

This study constitutes the first attempt to describe the aquatic faunal communities above and below sewage treatment plants in the Codorus Creek drainage. Research should continue in an effort to define annual changes and to identify zones of recovery. Preliminary base-line data for the drainage and review of the literature were published in Denoncourt and Stambaugh (1974) and Denoncourt and Polk (1975).

The purposes of this paper are: (1) to record data relative to macroinvertebrate and fish communities immediately above and below sewage treatment plants on the South Branch Codorus Creek and on Oil Creek; (2) to compare two qualitative techniques for macroinvertebrates, A-frame and field sorting with D-frame and laboratory sorting; (3) to increase base-line data in the Codorus Creek drainage for future research.

Codorus Creek has its origin in Southcentral Pennsylvania near the Maryland border and flows in a northeasterly direction to enter the Susquehanna River approximately ten miles northeast of York, Pennsylvania (Fig. 1).

Two areas of study were chosen in the headwater streams of the Codorus Creek drainage. One area of study was located in the South Branch Codorus Creek where width varied from 4 to 10 meters and the approximate discharge was 20 cfs (13.3 MGD). A sewage treatment plant, which served a resident population of 1600 and a few small industries, was located about one-half mile downstream from the borough of Glen Rock. The plant was designed for tertiary treatment with a capacity of 0.3 MGD (= .45 cfs). Excess load often prevented

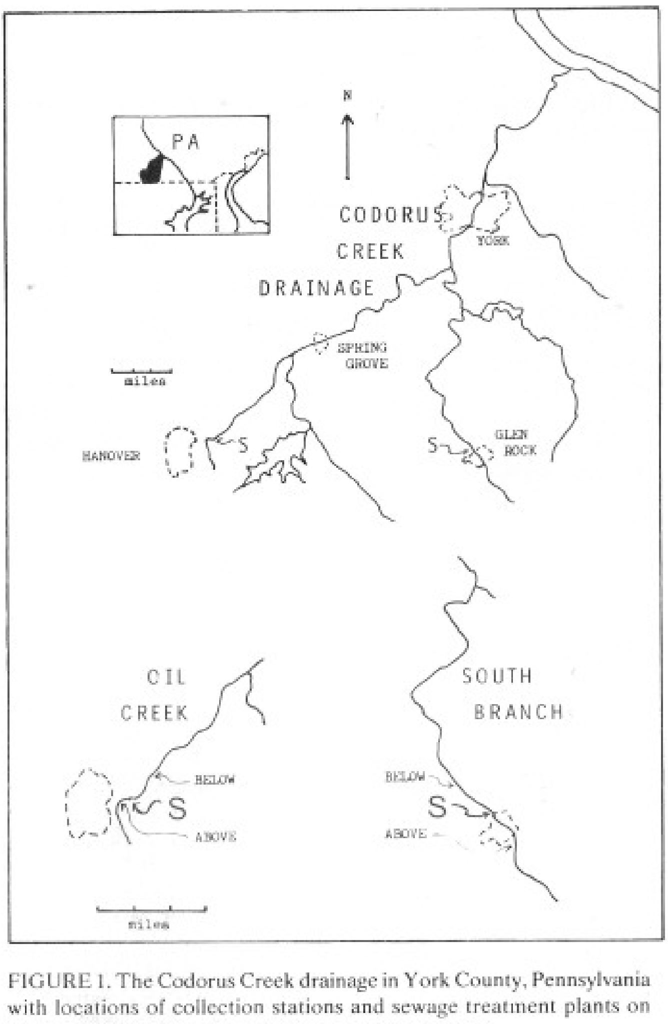

FIGURE 1. The Codorus Creek drainage in York County, Pennsylvania with locations of collection stations and sewage treatment plants on the South Branch Codorus Creek and on Oil Creek.

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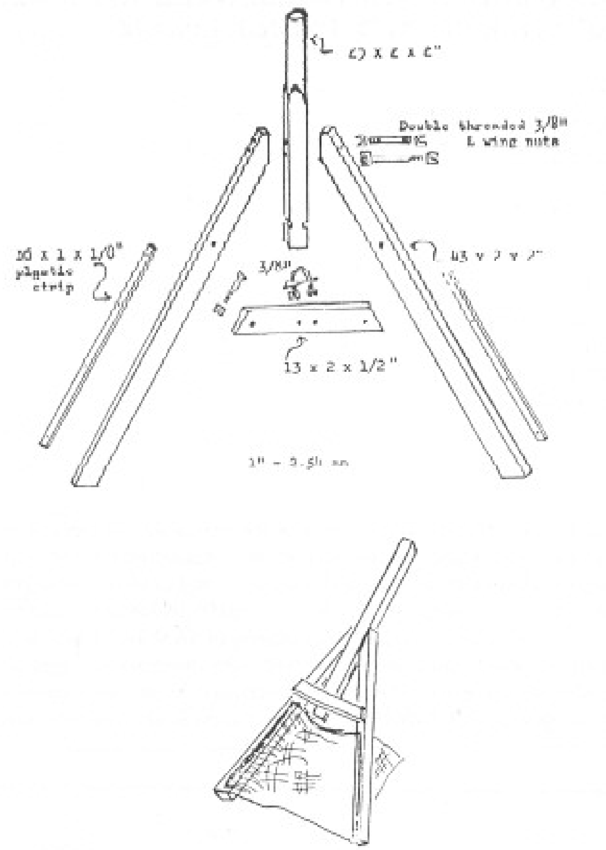

FIGURE 2. Diagram of the exploded A-frame (top) and sketch with attached netting (bottom).

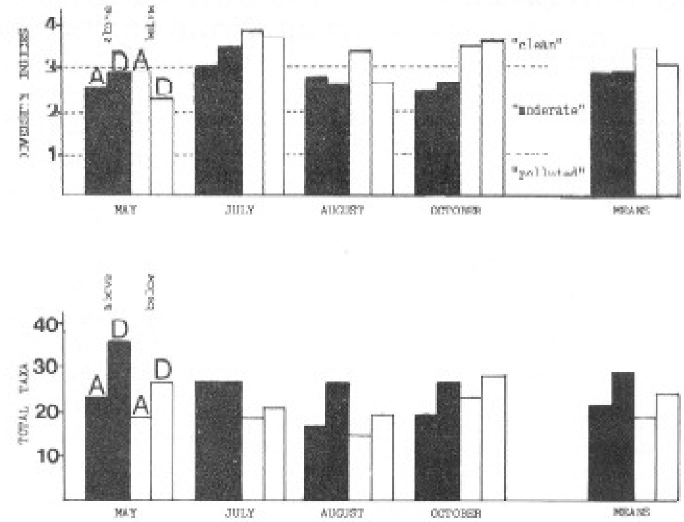

FIGURE 3. Diversity indices (top) and total taxa (bottom) for all macroinvertebrates collected each month in 1975 from the South Branch Codorus Creek, above (dark bars) and below (light bars) the municipality of Glen Rock, York County, Pennsylvania.

maximum phosphate removal and thus the resultant treatment was primarily secondary. The treated effluent was usually less than 1.0 percent of the total stream flow.

The second area was in Oil Creek, a tributary of the West Branch Codorus Creek. It measured 3 to 4 meters in width and had an approximate discharge of 10 cfs (6.7 MGD). The sewage treatment plant, located in Penn Township, served 6300 people and 17 industries. It was designed for capacity of 1.75 MGD (2.6 cfs), but effectively could handle 1.25 MGD (1.8 cfs). Its effective capacity was regularly exceeded on week days due to the increased industrial flow. As with the other sewage treatment plant, resultant treatment was usually secondary. The treated effluent was estimated at 10 — 15 percent of the stream flow.

METHODS AND MATERIALS

The study was first initiated in April, 1975, to compare the macroinvertebrate fauna above and below a small sewage treatment plant on the South Branch Codorus Creek. The only physically comparable "above" station placed the municipality of Glen Rock between stations. In May, the study was expanded to include a sewage treatment plant on Oil Creek. The final research involved macroinvertebrate sampling in the South Branch in April; macroinvertebrate and fish sampling at all station in May, June, August and October. Stations were chosen on the basis of accessibility, similarity of habitats, and minimal effects from other than the sewage treatment plants (i.e., industrial effluent or agricultural runoff between stations). Twenty macroinvertebrate collections were made on the South Branch Codorus Creek, 10 above and 10 below the municipality of Glen Rock, from April through October, 1975; and 16 collections were made in Oil Creek, 8 above and 8 below, from May through October, 1975.

Two macroinvertebrate samples were collected concurrently. One sample by field picking from materials kicked into an A-frame net (described below) and the other by laboratory picking material kicked into a D-frame net (Benfield and Cairns, 1974).

Denoncourt and students had been using a kick technique into an A-frame net followed by field picking of macroinvertebrates. This gear was not described in the literature and was a particularly successful method of sampling most habitats in the assessment of the total macroinvertebrate fauna. The A-frame was modified from a suggestion in Spear (1967) who described a split-bamboo rod with crossbars and minnow netting for one-man collection of fishes. Stauffer had used a technique learned at the Center for Environmental Studies at Virginia Polytechnic Institute. It utilized three minutes of kicking into a standard D-frame dip net obtainable from biological supply houses (Benfield and Cairns, 1974). This method was developed after reading Frost *et al.* (1971) and Krenshaw *et al.* (1968). Discussion of the two kick techniques led to comparison of the advantages and disadvantages of each.

Our A-frame net was constructed of two by two inch (50 mm x 50 mm) lumber with hardwood crossbar and handle (Fig. 2). We used plankton netting (0.8 x 0.4 mm) cut and sewn to form a conical net with a front opening shaped as a truncated isoceles triangle approximately 0.7 meters high and 1.0 meters across the base. A canvas or nylon hem (75 to 100 mm wide) was sewn to all edges. Sides of the net were attached with a 25 x 3 mm plastic strip and screws.

The A-frame was used to sample in riffles and runs as well as in pools, backwater and under banks. It was scooped through areas of minimal water flow after thorough agitation by the collector. Macroinvertebrates were then hand-picked in the field from (8 — 10) kick samples taken in all available habitats until it was concluded further sampling would not change the relative abundance of organisms collected. Specimens were preserved in 60 percent isopropanol.

The D-frame dip-net method required total preservation of all material taken in three minutes of kicking. The specific D-frame samples in this study contained the total combined material from nine, 20-second kick samples taken as much as possible from the same habitats as the A-frame. The total D-frame samples were preserved in 60 percent isopropanol and later washed and hand separated (laboratory picking) with the aid of water, sugar, and magnesium sulfate flotation. Macroinvertebrates were usually identified to the generic level with the aid of Pennak (1953), Usinger (1971) and Edmundson (1959).

Data from the A-frame samples, from the D-frame samples, and from the combined samples were examined on the basis of total taxa,

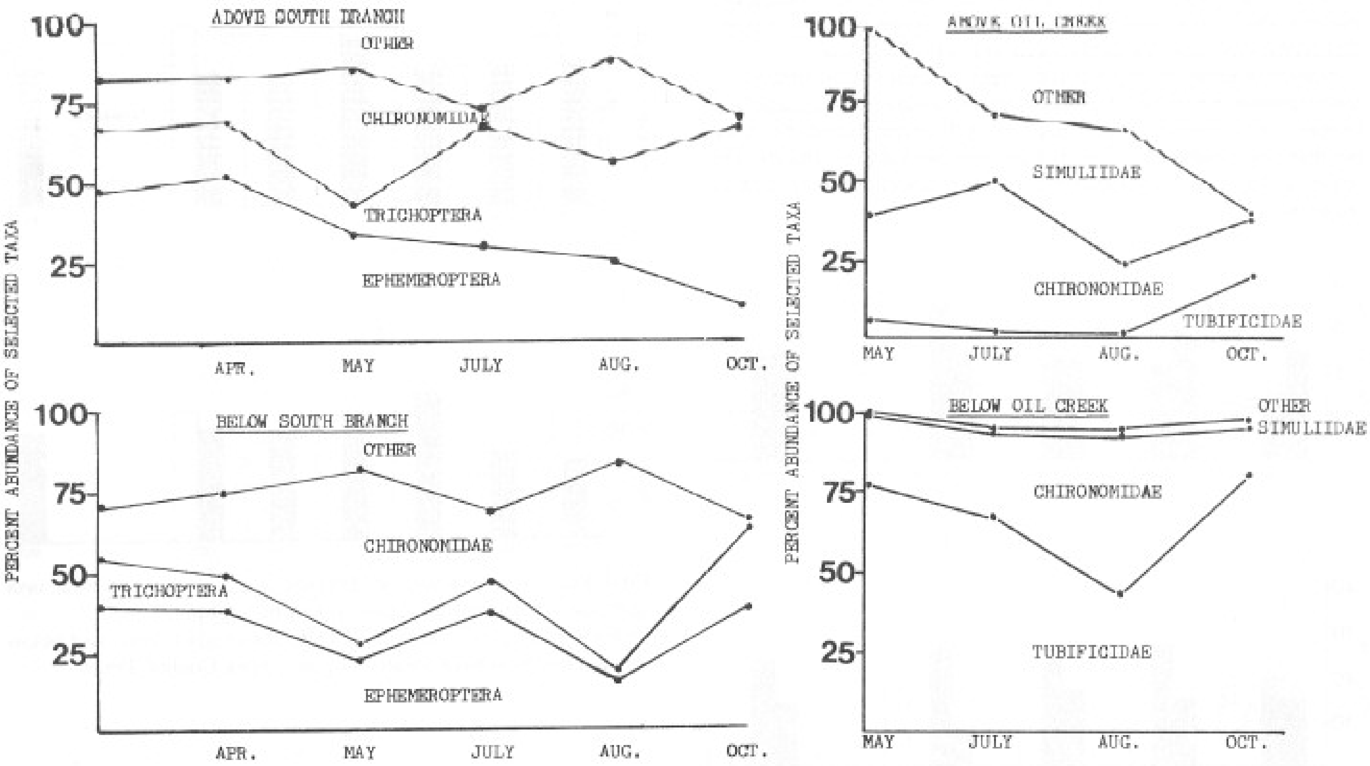

FIGURE 4. Percent abundance of selected macroinvertebrate taxa taken each month in 1975: 1— from the South Branch Codorus Creek, above (top, left) and below (bottom, left) the municipality of Glen Rock and 2— from Oil Creek, above (top, right) and below (bottom, right) a sewage treatment plant; York County, Pennsylvania.

relative abundance and seasonal variation of predominate taxa, indicator organisms, and species diversity indices. Species diversity indices were calculated with the formula suggested in Weber (1973). The magnitude of diversity indices for organic pollution as suggested in Wilhm and Dorris (1968) were used: 3 or higher indicates "clean" waters, between 1 and 3 indicates "moderate pollution", and less than 1 indicates "polluted" waters. Limitations to this method were discussed in Denoncourt and Polk (1975). However, it was a useful tool for the assessment of organic enrichment in the Codorus Creek drainage. The extensive raw data were not included in the paper, but are available upon request.

Fishes were collected by electroshocker from approximately 100 meters of stream length. This included pools, riffles, runs and undercut bank. large specimens were identified, measured, counted and released; others were preserved in 10 percent formalin and data taken in the laboratory. The number, size groups and relative abundance of each species was recorded.

Selected physicochemical parameters were measured coincident with each faunal collection: dissolved oxygen with a model 57 YSI, pH and carbon dioxide with a hach field kit, and temperatures with the YSI and Taylor field thermometers. A 24-hour study of water temperature and dissolved oxygen was conducted at stations in Oil Creek on 22 - 23 August, but not in the South Branch because preliminary data suggested minimal differences.

RESULTS — SOUTH BRANCH CODORUS CREEK

Seventy-one taxa were identified among 3,999 specimens at the above station and 56 taxa among 1,556 specimens at the below station. The total taxa for combined techniques was greater at the above station in all months except October, means were 31 taxa above and 28 taxa below (Fig. 3, bottom).

Ephemeroptera (primarily *Baetis, Caenis, Ephemerella, Stenonema,* and *Tricorythodes*), Trichoptera (*Cheumatopsyche* and *Hydropsyche*), and Chironomidae made up 66 to 89 percent of the total specimens in all seasons at both stations (Fig. 4, left). Ephemeroptera and Trichoptera were more abundant at the above station (44 to 70 percent versus 18 to 55 percent below) except in October when the abundance at both stations was similar (68 versus 66 percent). In addition, more Annelida and Chironomidae were collected below, while more Plecoptera (*Acroneuria, Neophasganophora, Isoperla, Peltoperla*) were collected above.

More taxa were consistently found in D-frame samples (Fig. 5, bottom). These ranged from 27 to 37 (mean 29.5), while A-frame samples contained 17 to 27 (mean 22.0) at the above station; 21 to 29 (mean 24.5) and 15 to 23 (mean 18.0), respectively, at the below station. A mean of 14 taxa (10 to 19) were taken in D-frame samples that were not taken in A-frame samples. However, a mean of 7.1 taxa (3 to 10) were found only in A-frame samples. A wider variety of Diptera (*Tipula, Hexatoma, Antocha, Tabanidae, Empididae, Chironomidae,* and *Simuliidae*) and Trichoptera were found in D-frame samples; more Odonata (*Boyeria, lanthus, Ophiogomphus, Dromogomphus, Cordulegaster,* and *Agrion*) and Megaloptera (*Nigronia* and *Sialis*) in A-frame samples.

All species diversity indices suggested upper "moderate" to "clean" waters relative to organic pollution for both stations, following the categories in Wihlm and Dorris (1968) (Fig. 5, top). Those based upon combined data had mean values of 2.98 (2.71 to 3.57) above and 3.27 (2.45 to 3.98) below (Fig. 3, top). A comparison of species diversity indices between the two types of samples (field versus laboratory sorting) showed little variation; mean difference 0.1 above and 0.34 below with the greatest difference 0.75.

A total of 1,405 fishes representing 20 species were taken in the combined collections; 699 specimens and 16 species above, 706 specimens and 17 species below (Table 1). *Anguilla rostrata* (1 specimen), *Clinostomus funduloides* (2) and *Micropterus salmoides* (2) were taken only above; *Notropis hudsonius* (20), *N. spilopterus* (4), *Noturus insignus*

(4) and *Lepomis cyanellus* (3) were taken only below. *Rhinichthys cataractae* and *Salmo trutta* were more common above, *Pimephales notatus* and *Catostomus commersoni* were more common below. Generally, more species and biomass were present below.

Water temperatures were usually slightly higher below. Otherwise, little variation in physicochemical parameters was observed: dissolved oxygen was 8.5 ppm or greater, pH 7.3 to 8.0, carbon dioxide 1 to 5 mg per liter, and conductivity slightly higher below (Table 1). The amount of flow at the below staton was slightly higher than above due to a small tributary.

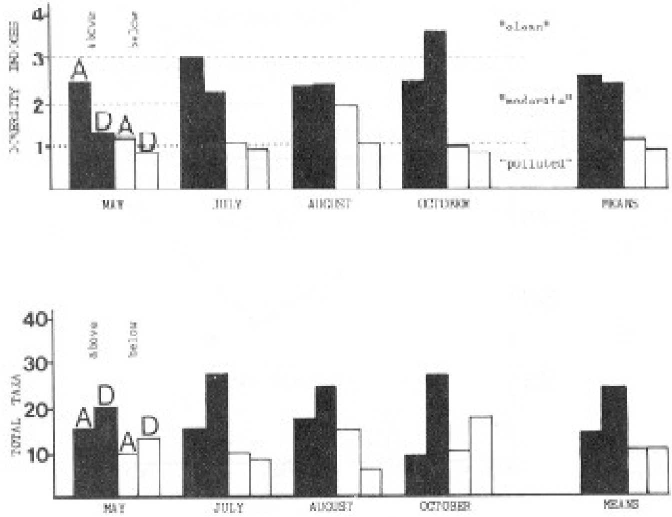

FIGURE 5. Comparison of diversity indices (top) and total taxa (bottom) of macroinvertebrates taken by "A-frame" and "D-frame" kick samples in 1975 from the South Branch Codorus Creek, above (dark bars) and below (light bars) the municipality of Glen Rock, York County, Pennsylvania.

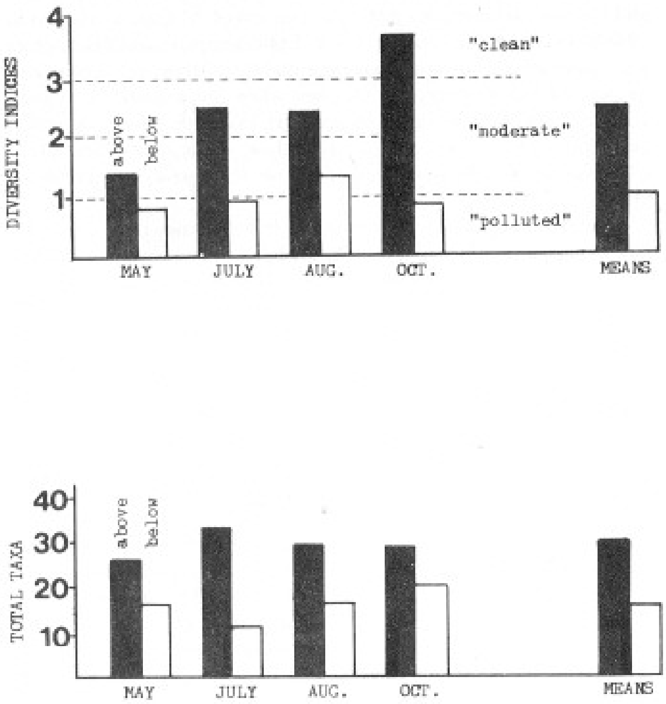

FIGURE 6. Diversity indices (top) and total taxa (bottom) for all macroinvertebrates collected each month in 1975 from Oil Creek, above (dark bars) and below (light bars) a sewage treatment plant, York County, Pennsylvania.

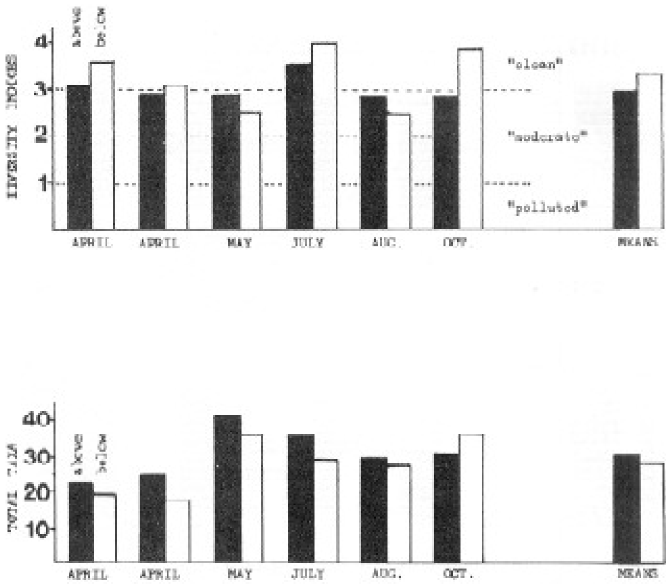

FIGURE 7. Comparison of diversity indices (top) and total taxa (bottom) of macroinvertebrates taken by "A-frame" and "D-frame" kick samples in 1975 from Oil Creek, above (dark bars) and below (light bars) the sewage treatment plant, York County, Pennsylvania.

RESULTS — OIL CREEK

Sixty-one taxa were identified among 6,903 specimens at the above station; 36 taxa among 27,587 specimens at the below station. The total taxa for combined data was always greater at the above station in all months. The mean values were 29.5 above and 16.25 below (Fig. 6, bottom).

The dominant taxa above were Simuliidae, Empididae, Chironomidae, and Tubificidae; Simuliidae and Chironomidae were the most abundant in all months (65 percent to 91 percent) except October when Tubificidae reached 20 percent (Fig. 4, right). Tubificidae and the Chironomidae (particularly red Chironomus), totaled 95 percent to 99 percent in all the below samples.

D-frame samples always contained more taxa at the above station: 20 to 28 (mean 24.5) versus 9 to 18 (mean 14.5) for A-frame samples. The total taxa for the below station were: 6 to 17 (mean 10.75) for D-frame samples and 9 to 15 (mean 10.75) for A-frame samples (Fig. 7, bottom). The D-frame samples contained a mean number of 9.6 taxa (2 to 20) not found in A-frame samples; while A-frame samples contained a mean of 5.1 taxa (2 to 11) not found in D-frame samples. A wider variety of Diptera (Simuliidae, Chironomidae, Empididae, Ceratopogonidae, Tabanidae, *Tipula, Antocha, Tubifera*) and Trichoptera (*Chimarra, Hydropsyche, Cheumatopsyche*) were found in D-frame samples, while more Odonata were taken from the A-frame samples. Also, larger numbers of Annelida, Tubificidae and Lumbricidae, were taken in the D-frame samples.

Species diversity indices (Fig. 6, top) suggested "moderate" waters relative to organic enrichment for the above station: mean 2.50 (1.46 to 3.73). Those for the below station were indicative of "polluted" waters: mean 1.01 (0.82 to 1.39). Diversity indices based upon either A-frame or D-frame samples gave similar results (Fig. 7, top).

A total of 257 fishes representative of 6 species were taken in the combined 8 collections: 222 specimens and 6 species above, 35 specimens and 3 species below. More species and specimens were consistently taken above. *Pimephales notatus* and *Rhinichthys atratulus* were taken only above along with twice as many *Semotilus atromaculatus*. More *Lepomis cyanellus* were taken below (Table 2).

TABLE 1

Number of fishes collected and associated physicochemical parameters measured from May through October 1975 in the South Branch Codorous Creek, above and below Glen Rock, York County, Pennsylvania

	23 May		18 July		22 August		12 October	
	above	below	above	below	above	below	above	below
Number of Species	11	13	10	12	12	14	12	14
Number of Specimens	165	147	130	198	259	178	145	188
Salmo trutta	—	—	1	—	3	—	1	1
Campostoma anomalum	6	—	7	7	3	4	1	1
Clinostomus funduloides	1	—	—	—	—	—	1	
Exoglossum maxillingua	2	3	4	7	6	6	5	3
Notropis analostanus	—	—	—	—	2	3	—	6
Notropis cornutus	4	2	—		2	2	—	4
Notropis hudsonius	—	6	—	6	—	2	—	6
Notropis procne	1	2	—	12	—	5	2	2
Notropis spilopterus	—	4	—	—	—	—	—	—
Pimephales notatus	—	2		17	—	7	2	3
Rhinichthys atratulus	71	65	47	59	102	58	87	108
Rhinichthys cataractae	55	5	22	8	65	19	14	13
Semotilus atromaculatus	4	5	10	21	14	10	10	20
Catostomus commersoni	14	43	24	38	34	37	3	7
Hypentelium nigricans	2	3	4	7	17	12	12	7
Noturus insignis	—	1	—	—	—	3	—	—
Lepomis cyanellus	—	—	—	3	—	—	—	—
Micropterus salmoides	—	—	—	—	2	—	—	—
Etheostoma olmstedi	5	1	10	13	9	10	7	7
Anguilla rostrata	—	—	1	—	—	—	—	—
Water Temperature (°C)	16.5	19.0	23.0	18.0	20.0			
Dissolved oxygen (ppm)	11.0	10.0	9.2	8.9	9.4	9.8	8.5	9.0
pH	7.5	8.0	7.8	7.8	7.5	7.7	7.3	7.3
Carbon dioxide Conc. (mg/L)	0–5	0–5	0–5	0–5	0–5	0–5	0–5	0–5
Conductivity (mohms/cm)	—	—	115	128	105	115	—	—

TABLE 2

Number of fishes collected and associated physicochemical parameters measured from May through October 1975 in Oil Creek, above and below the sewage treatment plant, York County, Pennsylvania.

	23 May		18 July		22 August		12 October	
	above	below	above	below	above	below	above	below
Number of Species	3	—	3	2	3	3	4	3
Number of Specimens	12	—	66	3	55	10	89	22
Carassius auratus (goldfish)	1	—	—	—	—	—	—	—
Pimephales notatus (bluntnose)	—	—	—	—	1	—	—	—
Rhinichthys atratulus	—	—	24	—	36	—	48	—
Semotilus atromaculatus	10	—	40	2	18	7	34	11
Catostomus commersoni	1	—	2	—	—	1	5	5
Lepomis cyanellus	—	—	—	1	—	2	2	6
Water Temperature (°C)	18.5	24.0	19.5	23.3	19.5	24.0		
Dissolved oxygen (ppm)	7.5	6.5	7.6	5.8	8.6	0.6	8.0	8.0
pH	7.5	7.5	7.8	7.5	7.8	7.6	7.5	7.9
Carbon dioxide Conc. (mg/L)	10–15	10–15	10–15	10–15	5–10	15–20	5–10	5–10
Conductivity (mohms/cm)	—	—	405	495	325	560	—	—

Water temperatures were 3.8 to 5.5 C higher at the below station (Table 2). Conductivity was also higher below (405 versus 495 in July, 325 versus 560 in August), while dissolved oxygen was usually lower. The pH varied from 7.5 to 7.9, carbon dioxide 10 to 20 mg/1.

The 24-hour survey of dissolved oxygen and temperature variation, taken on 22-23 August, coincided with a period of high air temperatures. Results reflected the combined effects of high temperature and high organic load. The dissolved oxygen was 7.4 ppm or more (80+ percent saturation) at the above station; while it was less than 1.0 ppm (10 percent or less) below (Fig. 8).

ADDITIONS

One fish species (Rosyside dace, *Clinostomus funduloides* Girard) and 31 taxa of macroinvertebrates were added to the known fauna of the Codorus Creek drainage. The macroinvertebrates included 2 caddis fly families (Hydroptilidae and Phryganeidae), 2 beetle families (Chrysomelidae and Curculionidae), the sow bug *Lirceus*, 3 stonefly genera *(Isoperla, Nemoura* and *Peltoperla)*, 6 mayfly genera *(Blasturus, Caenis, Paraleptophelebia, Pseudocloeon, Tricorythodes* and *Iron)*, 2 dragonfly genera *(Dromogomphus* and *Lanthus)*, the damselfly *Lestes*,

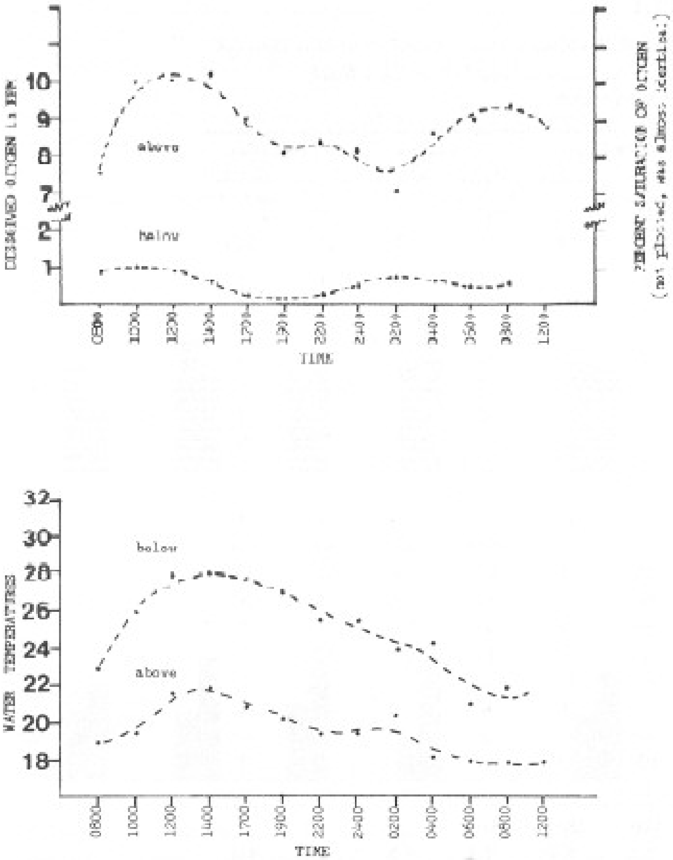

FIGURE 8. Variation in dissolved oxygen (top) and water temperature (bottom) in Oil Creek above and below the sewage treatment plant, York County, Pennsylvania.

2 caddis fly genera *(Pycnopsyche* and *Psychomyia),* 7 beetle genera *(Agabus, Bidessus, Dytiscus, Gyrinus, Cymbiodyta, Enochrus* and *Hydrophilus)* and 5 fly genera *(Antocha, Chrysops, Hexatoma, Tabanus* and *Tubifera).*

DISCUSSION

A comparison of total taxa revealed a consistent trend in all months: more taxa were taken at the above than at the below stations. The deviation at Glen Rock in October was attributed to the September flood, caused by hurricane Eloise. Although there were always less taxa below at Oil Creek, the highest total for this station was recorded in October.

Organisms typical of "clean waters" and of organically enriched waters were taken at all stations. However, more taxa considered indicative of "clean" waters were taken in the South Branch; specifically genera of Plecoptera, Emphemeroptera, and Trichoptera. Effects of organic enrichment at the below station were suggested by the reduced variety of these taxa; a mean of 3 more taxa per collection was taken at the above station. In contrast, Tubificidae and red Chironomus were abundant at the below station in Oil Creek where Plecoptera, Ephemeroptera, and Trichoptera were either absent or taken in low numbers (3 percent of less). The latter distribution of taxa was given in Gaufin and Tarzwell (1952) for areas below sources of organic pollution.

Although Resh and Unzicker (1975) discuss the disadvantages of indicator orders or families, and emphasize the importance of species identification, we felt there were definite "indicator communities" at all stations. Gaufin and Tarzwell (1956) emphasized association (= communities) of "tolerant" or "intolerant" forms and their relative abundance, rather than species, for the assessment of water quality. We preferred this method because of problems associated with identification to species (and even genus) and conflicting information about tolerances. A combination of taxa (= communities) tolerant of high organic load and low oxygen characterized the below station in Oil Creek, while communities intolerant of these conditions characterized the above station in the South Branch Codorus Creek. Macroinvertebrate communities at the below station in the South Branch and at the above station in Oil Creek suggested decreased water quality with the presence of fewer intolerant organisms.

Fish communities showed similar trends to that indicated by macroinvertebrates. Higher diversities of fishes were present in the South Branch, while lower numbers and lower diversities in Oil Creek reflected the effects of organic enrichment upon food diversity and water quality.

Comparison of species diversity indices (DI) with "indicator organisms" revealed contradictions. A higher mean DI was recorded at the below station in the South Branch where fewer "clean water forms" were taken (22 taxa versus 33 above). A more accurate assessment of water quality was associated with tolerances of organisms and specifically community groups. The DI's in Oil Creek compared favorably with conditions suggested by "indicator organisms". However, changes in taxa and their relative abundance were not reflected. In October, total taxa at the above station in Oil Creek decreased, several new taxa were taken, and the DI increased due to a more even distribution of numbers in each taxa. The overall biological interpretation of conditions had not changed. These contradictions in evaluation tools strongly suggested that more than one method was necessary for realistic conclusions.

October deviations in macroinvertebrate taxa, diversity indices and to a lesser extent fishes, were observed in both drainages. These were more obvious at the below stations and were greater in Oil Creek. Changes in substrate occurred at all stations, but were also more dramatic in Oil Creek. These changes were believed the result of the September flooding caused by hurricane Eloise. A total of 12.85 inches of rain was recorded for the Oil Creek drainage from 22 to 26 September. Oil Creek below the sewage treatment plant had almost a total covering of *Sphaerotilus* and silt for one-quarter mile in July and August. On October 12, most *Sphaerotilus* was gone and most rubble was clean of silt and periphyton. An increase in total taxa was recorded and suggested an improvement in water quality.

Results from the two sampling methods suggested laboratory sorting was a better qualitative method than field sorting. More taxa were consistently found from the D-frame samples, while the diversity indices showed little variation. The D-frame method of sampling (which could have been used with the A-frame) used less field time, perhaps a total of 10 to 15 minutes per collection while the A-frame method (essentially field sorting) used at least 2 to 3 man-hours. The D-frame method allowed sampling of more stations in the same time period. Collector bias was also minimized with the D-frame method because field picking was not employed. Unintentional bias may have affected the field picking from A-frames. Many Diptera, such as Empididae larvae, were collected at all stations, but never taken with the A-frame. They were small, moved little and were undoubtedly well camouflaged. Field picking, however, did have the advantage of reducing laboratory time. If organisms were separated into vials, minimal laboratory time was necessary to prepare the samples for identification. Often more than 4 to 5 man hours were required to thouroughly sort some D-frame samples and prepare them for identfication, even though washing and flotation were used. The smaller D-frame did not have the versatility of the larger and stronger A-frame. The latter was used more effectively in deeper waters and in slower waters. This was probably the reason that larger numbers of Odonata were taken.

The fact that both methods took organisms not collected by the other suggested that combined data gave a more complete assessment. It was our conclusion that under most conditions, field time is extremely critical. Therefore, we would presently recommend laboratory sorting after either the D-frame or A-frame were used.

Seasonal variation in numbers and relative abundance of aquatic insects must take into consideration the emergence of nymphs into adults. This was undoubtedly one of the reasons for variation in the realtive abundance of genera of Emphemeroptera in the South Branch. The genus *Emphomorella* was particularly dominant in April and May, *Tricorythodes* and *Caenis* in July, and *Baetis* in August. Chironomidae, usually abundant in most months, showed a drastic decrease in October. This latter was considered more an effect of the flood, caused by hurricane Eloise, than the emergence of taxa. The flood was also believed responsible for other variations in Oil creek, although emergence may have played a part. Simuliidae decreased at the above station, while Chironomidae decreased at the below station in October. These taxa were easily carried by high waters. Tubificidae, on the other hand, effected less by drifting (Larimore, 1974), remained abundant throughout the seasons. Increase in *Chironomus* in July and August at the below station was believed associated with the combined effects of high temperature and increased growth of aquatic fungi in these months with the resultant decrease in available oxygen.

CONCLUSIONS

Macroinvertebrate and fish communities below the two sewage treatment plants contained increased abundance of forms tolerant of organic enrichment and decreased abundance and diversity of intolerant forms. This was more dramatic in Oil Creek where the treated effluent constituted a larger percent of the stream flow.

The effects of organic enrichment were noted on the basis of relative abundance of predominant organisms, "indicator communities", total taxa and, to a lesser extent, diversity indices. Water quality in the South Branch Codorus Creek appeared far better than Oil Creek on the basis of high diversity of "clean water" macroinvertebrates and a diverse fish community.

Each sewage treatment plant appeared to have a definite effect: that on Oil Creek one of degradation, seasonally acute; that on the South Branch Codorus Creek one of moderate enrichment with suggested increased productivity of fishes. Increased organic load on the South Branch may harm what was found to be fair to marginal trout waters.

Laboratory sorting of total field samples was the more efficient research method on the basis of field time and minimal bias. Each method, field sorting and laboratory sorting, produced taxa not found by the other. However, diversity indices and relative abundance of predominant taxa were similar.

Relative abundance of organisms and "indicator communities" were better tools for the assessment of water quality relative to organic enrichment than speies diversity indices, although all were useful.

ACKNOWLEDGMENTS

Acknowledgment is given to Wayne A. Potter for assistance with diversity calculations; Anne G. Cincotta, Charles E. Denoncourt, Donat G. Denoncourt and George A. Jenkins who aided with field and laboratory aspects; Edward R. Brezina and James Ulanoski of the Pennsylvania Department of Environmental Resources who helped with identification of macroinvertebrates; John W. Lockwood and John T. Bosley for information relative to their respective sewage treatment plants. The cooperation of all members of the Pennsylvania Fish Commission is appreciated.

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