was collected, dried and weighed. In both of the above experiments, the plankton content, in milligrams per liter, increased in the controls and potassium permanganate treatment. There was a decrease in the pools treated with formalin (Table IV).

TABLE IV

THE EFFECT OF VARIOUS CHEMICALS UPON THE AVERAGE WEIGHT* OF PLANKTON

	Date					
	September 6-9			*November 8-14*		
Treatment	*Before Treatment*	*After Treatment*	*Difference*	*Before Treat.*	*After Treat.*	*Difference*
Untreated Controls	11.0	13.8	+ 2.8	9.1	39.9	+30.8
15 ppm Formalin	37.8	14.0	−23.8	8.2	7.8	− 0.4
25 ppm Formalin	24.2	18.2	− 6.0	. .	. .	. .
1 ppm Methylene Blue	13.7	37.6	+23.9	. .	. .	. .
5 ppm Methylene Blue	23.1	13.8	− 9.3	. .	. .	. .
3 ppm $KMnO_4$	19.3	38.0	+18.7	12.6	23.9	+ 1.1

* Milligrams per liter.

CONCLUSION

It may be concluded from these experiments that the use of formalin in ponds having a heavy plankton bloom may cause severe oxygen depletion. It appears that this is due to the increased B.O.D. resulting from the sudden death and decay of large amounts of plankton. At higher temperatures this process occurs more rapidly and may cause a more serious problem if ponds are treated for parasite control during the summer months. In the event that it becomes necessary to treat for parasite control during the summer months, the oxygen content can be restored in small ponds by stirring with an outboard motor. In larger ponds, pumping appears to be the most feasible means of aeration. The CO_2 content can be controlled through the addition of $Ca(OH)_2$.

A STUDY OF TWO STREAMS RECEIVING DOMESTIC SEWAGE [1]

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ABSTRACT

A study involving macro-invertebrate populations, fish populations, and water quality determinations was conducted on Bicycle Path Creek and Parkerson Mill Creek, Lee County, Alabama, during a nine-month period in 1959. The streams, averaging 7.0 and 5.8 inches in depth and 10.0 and 12.8 feet in width, respectively, received domestic sewage from approximately half of the 16,000 inhabitants of Auburn, Alabama. Sewage was diverted from Bicycle Path Creek and pumped via a lift station to a sewage treatment plant located on Parkerson Mill Creek. The plant became operative about halfway through the study and the treated effluent was discharged into Parkerson Mill Creek.

Bottom organisms, which were collected at approximately two-week intervals from six stations on the two streams, were indicative of the polluted conditions, however, it was believed that not enough time had elapsed after the plant became operative for reinvasion by organisms used as indicators of unpolluted conditions. Organisms that could possibly have been classified as clean-water forms did not occur with any regularity or in significant numbers. Forms such as mayflies and stoneflies that are accepted indicators of clean waters were not found during this study.

[1] This study was part of a thesis submitted to the Graduate Faculty of Auburn University in partial fulfillment of the requirements for a Master of Science degree in Fisheries Management, June, 1960.

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Fish populations were sampled on Parkerson Mill Creek three weeks before and approximately three months after the sewage treatment plant became operative. The first samples showed that no fish were present at the first two stations, 2.0 and 3.3 miles below the sewage outfall; and only six species were found at the last station, 4.3 miles downstream from the outfall. The latter samples showed fish to be present at all three stations below the outfall with thirteen species being present at the last station, apparently as a result of improved stream conditions.

Water quality determinations clearly showed the polluted conditions of the streams and also the recovery following pollution abatement.

INTRODUCTION

With the expansion of populations and subsequent industrialization, the problem of stream pollution is becoming greater each year. Many pollutional studies have been conducted in recent years with the most intensive probably being on Lytle Creek located near Wilmington, Ohio (Gaufin and Tarzwell, 1952; 1955; 1956; Katz and Gaufin, 1952; and Gaufin, 1958).

Several studies have been made on polluted streams in the Southeast. Beck (1955; 1957) reports a system used in Florida which employs indicators of clean water rather than of polluted water. More recently, J. E. Sublette (Mimeographed. Final Report to the National Institutes of Health, Research Grant No. RG6829) has completed an ecological study of organisms associated with pollution in two Louisiana streams with emphasis placed on the midges. Davis (1960) made a rather thorough pollutional study on the Ouachita River in Louisiana.

The present study was conducted to determine the chemical quality of the water and the species composition and abundance of macro invertebrate and fish populations present in the polluted areas at the time the streams were receiving raw sewage, and to determine what changes would take place as a result of the activation of a new sewage treatment plant. The streams studies, Bicycle Path Creek and Parkerson Mill Creek, were two of the four small streams receiving raw sewage from the town of Auburn, Alabama. Approximately half of the raw sewage from Auburn's 16,000 inhabitants emptied into the two streams.

MATERIALS AND METHODS

Two sample stations were located on Bicycle Path Creek and four were located on Parkerson Mill Creek (Figure 1). The dimensions and approximate locations of the sample stations in relation to the sewage outfalls are summarized below.

	Bicycle Path Ck.		*Parkerson Mill Creek*			
Sample station	B-1	B-2	P-1	P-2	P-3	P-4
Average depth (inches)	6.0	8.0	4.0	6.2	6.0	7.2
Average width (feet)	8.0	12.0	6.2	11.9	12.4	20.7
Miles below outfall	0.7	2.5	0.5*	2.0	3.3	4.3

* Station P-1 was located 0.5 mile above sewage outfall.

Both streams originate within the city limits of Auburn, Alabama, and empty into Chewacla Creek, a tributary of the Tallapoosa River. The streams, consisting of many shallow pools and rocky riffles, are located in the transition zone between the Piedmont region of eastern Alabama and the Upper Coastal Plain. The locations of the sampling stations and points of sewage introduction are shown in Figure 1.

The Surber square-foot sampler was used to collect bottom organisms during this study. Anderson's (1959 method of sorting bottom organisms using a sugar solution was used to sort the organisms but required the modification of pouring the floating animals off rapidly through a strainer using the procedure described by Lyman (1943).

To avoid hand-picking the entire number of tubifex worms per sample a method of subsampling was devised by taking one-fifth of a square-foot sample from a white enamel dissecting pan which had been marked off into ten equal parts and picking two parts at random. Since this method was designed primarily for subsampling the tubifex worms, the nonfloaters and rare organisms

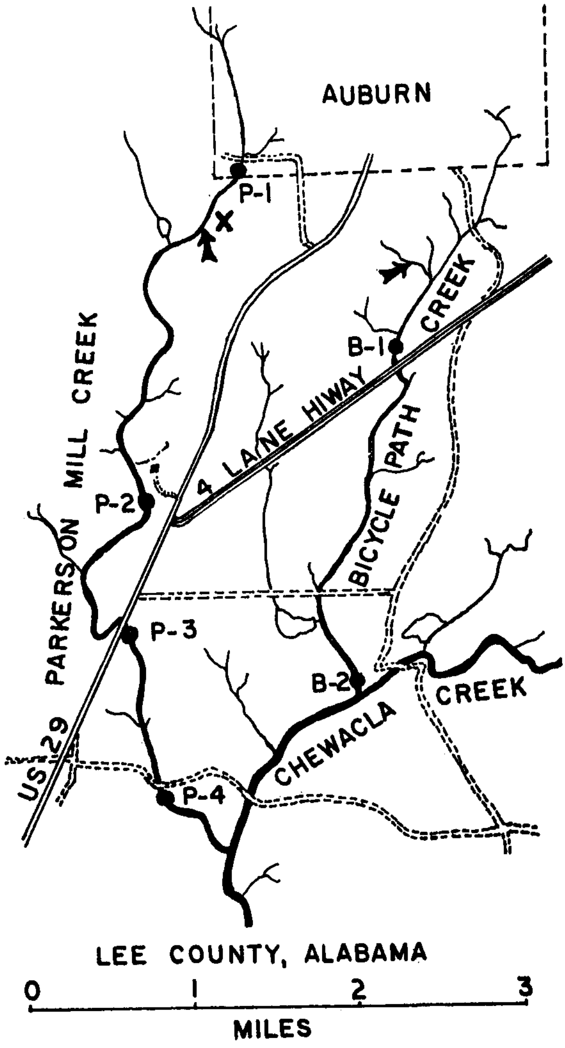

Figure 1. Map of Parkerson Mill Creek and Bicycle Path Creek and adjacent area. Sample Stations are shown by dots and the site of the sewage treatment plant shown by X. Arrows indicate points of sewage introduction into the stream.

were picked from the entire sample which accounts for some of the organisms being reported in numbers that are not multiples of five.

Fish populations were sampled on Parkerson Mill Creek using a commercial formulation containing 5 percent emulsifiable rotenone. A concentration of 20 ppm of the formulation was used to sample a section of stream 200 feet in length at each station. A seine was placed across the lower end of the sample area to prevent escapement and approximately two parts of $KMnO_4$ per part of rotenone was used below the sample area to neutralize rotenone outside the sample area.

Water quality determinations were made employing techniques described in American Public Health Asociation (1955) and "Methods of Water Analysis" (Swingle, Unpublished). The analyses were conducted in the field using the field water analysis kit described by Swingle and Johnson (1953). Water samples were collected using a Kemmerer Sampler which was operated by placing it in the water parallel to stream flow and closing it by hand after a sufficient time had elapsed for several changes of water to have flowed through it. No analyses were conducted while the streams were flooded. Hydrogen ion concentrations were determined in the field using a portable Beckman pH meter.

RESULTS AND DISCUSSION

A. Physical-Chemical Factors

Dissolved oxygen normally ranged between 2.0 and 3.0 ppm at Station B-1 of Bicycle Path Creek prior to the sewage being diverted to Parkerson Mill Creek in early June, and ranged above 7.0 ppm after the sewage was diverted. Due to pump failure at a lift station, sewage was reintroduced into this stream for a period of 7-9 days during late September and analysis on October 1 showed no D.O to be present; however, the next sampling visit on October 12 showed D.O concentrations had returned to normal.

The D.O. concentrations at Station B-2 showed no effects of the sewage diversion or of the reintroduction of the sewage. Normal concentrations at this station ranged between 8.0 and 10.0 ppm.

Prior to activation of the sewage treatment plant, normal D.O concentration for Parkerson Mill Creek ranged near 8.0 ppm at Station P-1, between 1.0 and 2.0 ppm at Station P-2, 3.0 to 4.0 ppm at Station P-3, and 5.0 to 6.0 at Station P-4. Within five weeks after the plant became operative, all stations had concentrations above the 5.0 ppm level that Ellis (1935) deemed necessary to support a mixed fauna of warmwater fishes and other aquatic animals in streams.

Concentrations of CO_2 at Station B-1 of Bicycle Path Creek was near 10 ppm before the sewage was diverted and decreased to range near 2 ppm after diversion. Concentrations increased to 21.7 ppm when the sewage was reintroduced but returned to normal by the next sampling date. Concentrations at Station B-2 remained fairly constant at slightly below 1.0 ppm with the only significant fluctuation occurring when the sewage was reintroduced in late September.

Normal CO_2 concentrations at the various stations on Parkerson Mill Creek prior to sewage treatment ranged near 3.0 ppm at Station P-1, between 9.0 and 10.0 ppm at Station P-2, near 7.0 ppm at Station P-3, and near 5.0 ppm at Station P-4. After activation of the sewage treatment plant, however, there was a general decline in CO_2 concentration during the remainder of the study with all stations having concentrations between 1.0 and 2.0 ppm on the last sampling date.

Ammonia concentrations normally ranged below 0.5 ppm at both stations on Bicycle Path Creek, however, analyses for NH_3 were not started until after the sewage had been diverted and a scouring flood had washed most of the sludge beds away. The reintroduction of the sewage into the stream in late September caused an increase in concentration to 20.0 ppm. at Station B-1 and to near 4.0 ppm at Station B-2, but concentrations had returned to normal at both stations on the next sampling date.

On Parkerson Mill Creek, NH_3 concentrations ranged from 5.0 to 12.0 ppm at the stations below the sewage outfall prior to the treatment plant becoming operative, and ranged near 3.0 ppm after activation of the plant. Station P-1 above the outfall had a range of from 0.2 to 0.6 ppm NH_3.

Hydrogen ion concentrations from the stations on Bicycle Path Creek ranged from pH 6.5 at Station B-1 to pH 8.3 at Station B-2. The range at the stations on Parkerson Mill Creek was pH 6.2 to pH 7.6. In general, the pH was slightly more acid in the more heavily polluted areas.

Alkalinity was present only in the form of bicarbonates during the entire study except on one occasion where a concentration of 3.0 ppm carbonates was found at Station B-2. Normal bicarbonate concentrations ranged near 40.0 ppm on Bicycle Path Creek. The stations below the sewage outfall on Parkerson Mill Creek had a normal bicarbonate range of near 130.0 ppm before sewage treatment plant activation which decreased to range near 60.0 ppm after plant activation. Bicarbonate concentrations at Station P-1 generally ranged near 60.0 ppm throughout the study.

Temperature ranged from about 22 to 28° C. during most of the study, however, during the last two months, it decreased to a low of 7° C.

B. Biological Factors

1. *Macro-invertebrate Populations*

The logarithm of the numbers of bottom organisms were used to graphically present the relationship of the number of organisms from each station on Parkerson Mill Creek (Figure 2). Rainfall, which appeared to be the most important factor affecting the fluctuation in numbers of organisms, is also plotted on Figure 2. During March, 7.79 inches of rain virtually washed the stream bed clean and resulted in a decreased number of organisms during late April. The organisms had again become abundant on the next sampling date, May 29, however, scouring floods occurred during the next four days and the decrease in organisms was evident through early July. Surber (1936) found that it was about seven weeks after erosional floods before bottom organisms again became abundant.

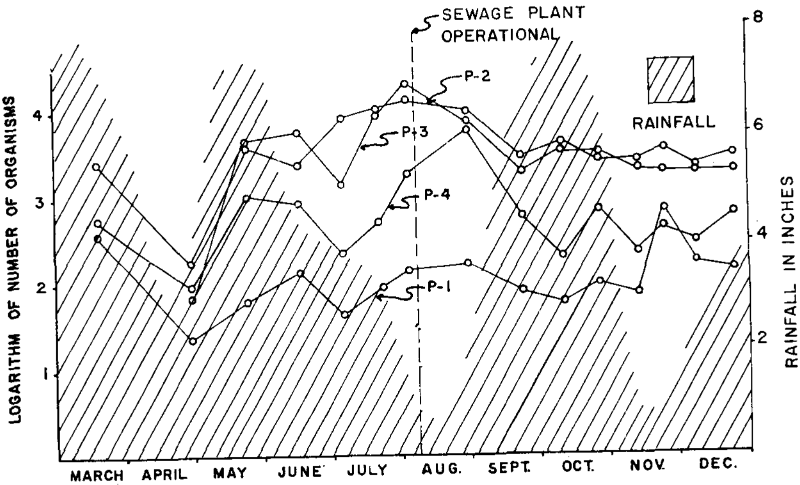

Figure 2. Logarithms of the numbers of organisms found at the various stations on Parkerson Mill Creek from March 15 through December 23, and rainfall in inches from March through December, 1959.

Organisms reached a peak of abundance during August which had only 0.73 inches of rain recorded for the month. Although only 5.93 inches of rain fell during September, 2.22 inches was recorded for one day which would account for the decrease in numbers of organisms during September and October. No scouring floods occurred during the rest of the study and little change was noted in the concentrations of organisms except at Station P-1 where an increase during late November was apparently due to an accumulation of organic material. Temperature decreased to 8° C. at three stations on Parkerson Mill Creek during December; however, it had no apparent effect on the numbers of organisms.

A list of the organisms and their frequency of occurrence is presented in Table I. *Tubifex* appeared in almost every sample taken during the study. *Helobdella* was present consistently through all seasons as was *Physa* and *Cricotopus*. *Pisidium* and *Procladius* first appeared in May and occurred at random during the rest of the study. *Anatopynia dayri* was present from April through October. *Tendipes riparius,* a form usually associated with pollution, was found through August 29, and occurred in only one sample after that. *Phycoda alternata* was not found after the sewage plant became operative and *Tubifera,* the rat-tailed maggot, was found twice in extremely polluted areas of the streams. *Polypedilum* appeared very abruptly in mid-June and occurred

TABLE I

A LIST OF SPECIES COLLECTED FROM BICYCLE PATH CREEK AND PARKERSON MILL CREEK AND THE NUMBER OF STATIONS AT WHICH THEY OCCURRED FROM MARCH 15 THROUGH DECEMBER 21, 1959

	3–15	4–39	5–25	6–16	7–4	7–20	8–3	8–29	9–23	10–11	10–25	11–13	11–25	12–8	12–21
Tubifex sp.	4*	5*	6	6	5	5	6	6	6	6	6	5*	6	6	6
Physa sp.	–	2	2	2	4	3	3	6	3	3	3	0	1	1	0
Helobdella sp.	2	3	2	3	3	3	2	4	4	3	2	3	4	2	2
Psidium sp.	0	0	2	2	1	2	1	1	1	2	2	1	2	0	2
Procladius sp.	0	0	1	0	1	1	2	2	1	2	0	0	0	2	1
Cricotopus sp.	–	1	1	1	2	1	4	3	0	0	0	1	0	1	1
Anatopynia dayri	0	1	1	4	2	3	3	6	2	1	1	0	0	0	0
Tendipes riparius	2	5	5	3	2	1	1	2	0	0	0	1	0	0	0
Psycoda alternata	2	2	1	0	0	1	1	0	0	0	0	0	0	0	0
Tubifera sp.	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Polypedilum sp.	0	0	0	5	2	3	3	5	3	2	3	3	1	1	1
Tendipes decorus	0	0	0	0	0	0	1	1	0	1	3	0	1	1	0
Lumbriculidae	0	0	0	0	0	0	0	0	0	2	1	0	2	3	4
Dugesia sp.	0	0	0	0	0	0	0	1	2	0	1	1	1	1	1
Nanocladius sp.	0	0	0	0	0	0	0	0	0	3	3	0	2	4	1
Tendipes plumosus	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
Simulium sp.	0	0	0	0	0	2	0	1	0	1	0	0	0	1	0
Tanytarus sp.	0	0	0	0	0	0	0	1	0	1	0	0	1	1	0
Haliplus sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Crangonyx gracilis	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
Ferrissia sp.	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0
Ceratopogonidae	0	0	2	1	0	0	0	1	0	0	0	0	0	0	0
Erioptera sp.	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1
Hydrosyche sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Lemna sp.	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
Argyra albicans	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Limnophila sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Pentaneura sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Cryptochironomus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
T. (Limnochironomus)	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0

* No samples were collected from Station P-3 on March 15 and from Station B-1 on March 15, May 29, and November 13.

during the rest of the study. *Tendipes decorus,* an oligochaete of the family Lumbriculidae, *Dugesia* and *Nanocladius* appeared after the sewage treatment plant became operational, however, they appeared to be tolerant of polluted conditions; therefore, it is doubtful that they could be used as indications of improved stream conditions.

Occurrence of the remaining species was infrequent and at random. The possibility that some of them washed into the creek from tributary streams was not ruled out although only one or two of the small branches entering the creeks had any measurable amount of flow.

Eleven species of bottom organisms were found at Station P-1 during the study (Table II). *Tubifex* occurred in every sample and was always the most abundant organism at this station. Although station P-1 was above the sewage outfall, it still received runoff from dairy barns and hog pens and could thus be classified as slightly polluted. *Tendipes riparius* was present during April, May, and June and *Cricotopus* occurred from late April to late August. The greatest number of species occurring on any one sampling date was seven species on August 29. The other species collected from this station did not seem to follow any pattern.

Twelve species of bottom organisms were collected from Station P-2 (Table III). Since this station was the first one below the sewage outfall, only species that could tolerate extremely polluted conditions were found prior to sewage treatment. *Tubifex* occurred in every sample from this station and *Tendipes riparius, Psycoda alternata,* and *Tubifera* occurred prior to sewage treatment with *T. riparius* occurring once about three weeks afterwards. *Anatopynia, Polypedilum, Nanocladius,* and an oligochaete of the family Lumbriculidae occurred somewhat regularly during the latter part of the study while the remaining species occurred at random.

Fifteen species of bottom organisms were collected from Station P-3 (Table IV). *Tubifex* was present in every sample and *Helobdella* was present in every sample but one. *Tendipes riparius* occurred regularly through August 29 and *Anatopynia* occurred from June 16 to September 23. *Psycoda alternata* occurred in April, July, and August, prior to sewage treatment. *Polypedilum* was present from July through the remainder of the study and *Physa* was present from July through October. *Nanocladius* and Lumbriculidae were present during the latter part of the study. The remaining species appeared at random throughout the study.

The conditions appeared to be much more suitable for a greater variety of organisms at Station P-4 as shown by the fact that 19 species were collected from this station (Table V). *Tubifex, Helobdella, Physa* and *Pisidium* occurred regularly throughout the study at this station while *Polypedilum* occurred from July 4 through December 8 and *Dugesia* was present from August through December. *Cricotopus* occurred from June 16 through August while *Procladius* and *T. decorus* occurred only during August. *T. riparius* was present through July 4, and the remaining species appeared without any pattern of occurrence.

A significant change in the numbers of *Tubifex* was noted at Station B-1 (Table VI). The first sample on May 25 showed the highest number of worms taken at the station during the study. The next two samples showed a decrease to a number which ranged at a fairly constant level until the sewage was reintroduced in late September. The worms reached a peak of abundance again approximately one month after the sewage was reintroduced but the numbers had again decreased by December. *Physa* occurred somewhat regularly from June through December, *Polypedilum* was present through July and August and *Anatopynia* was present during June, July and August. The remaining species appeared at random. *Tubifera* occurred once on October 11 at this station after the sewage was reintroduced in late September.

A total of 24 species was collected at Station B-2 during the study (Table VII). The most significant thing about the organisms found at this station was the decline in numbers of *Tubifex* after the sewage was diverted and the great variety of species found here. *Tubifex* appeared in every sample while *Helobdella, Pisidium,* and *Procladius* appeared regularly although not on every sample date. *Physa* and *Anatopynia* occurred regularly during the first part of the study. The remaining eighteen species occurred at random with several species occurring only once.

Table II

A List of Species, the Dates of Collection and the Numbers of Organisms Collected Per Square Foot from Station P-1 of Parkerson Mill Creek

	3–15	4–29	5–25	6–16	7–4	7–20	8–3	8–29	9–23	10–11	10–25	11–13	11–25	12–8	12–21
Tubifex sp.	390	13	35	128	40	88	183	425	75	35	95	70	630	155	135
T. riparius	0	1	3	5	0	0	0	0	0	0	0	0	0	0	0
Cricotopus sp.	0	9	20	0	3	0	35	15	0	0	0	0	0	0	0
Physa sp.	0	0	4	0	0	0	0	1	0	0	0	0	0	0	0
Polypedilum	0	0	0	0	0	0	15	25	0	0	0	0	0	0	0
Helobdella	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0
Anatopynia	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0
Ceratopogonidae	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Dugesia	0	0	0	0	0	0	0	0	1	0	0	0	5	0	0
Nanocladius	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0
Lumbriculidae	0	0	0	0	0	0	0	0	0	4	0	0	0	10	2

Table III

A List of Species, the Dates of Collection and the Numbers of Organisms Collected Per Square Foot from Station P-2 of Parkerson Mill Creek

	3–15	4–29	5–25	6–16	7–4	7–20	8–3	8–29	9–23	10–11	10–25	11–13	11–25	12–8	12–21
Tubifex sp.	2550	145	3850	2375	7875	9750	13250	9225	2755	3700	2950	1995	1800	1875	1800
T. riparius	0	38	40	0	0	0	0	30	0	0	0	0	0	0	0
Lumbriculidae	0	0	0	0	0	0	0	0	0	20	15	0	15	20	10
P. alternata	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0
Helobdella	0	0	0	0	0	0	0	0	55	0	0	0	0	0	0
Tubifera	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Anatopynia	0	0	0	0	0	0	0	70	5	45	5	0	0	0	0
Polypedilum	0	0	0	0	0	0	0	15	15	0	0	0	5	5	0
Physa	0	0	0	0	0	0	0	10	1	0	0	0	0	0	0
Lemnae	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Procladius	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0
Nanocladius	0	0	0	0	0	0	0	0	0	15	5	0	0	30	0

TABLE IV

A LIST OF SPECIES, THE DATES OF COLLECTION AND THE NUMBERS OF ORGANISMS COLLECTED PER SQUARE FOOT FROM STATION P-3 OF PARKERSON MILL CREEK

	3–15	4–29	5–25	6–16	7–4	7–20	8–3	8–29	9–23	10–11	10–25	11–13	11–25	12–8	12–21
Tubifex sp.	–	21	4350	5575	1315	9750	18750	6500	1805	3450	2800	2325	3000	1925	2725
T. riparius	–	37	90	50	15	75	10	180	0	0	0	0	0	0	0
Lumbriculidae	–	0	0	0	0	0	0	0	0	0	0	0	10	20	5
P. alternata	–	2	0	0	0	10	25	0	0	0	0	0	0	0	0
Helobdella	–	6	10	25	10	20	15	85	0	50	75	20	220	10	30
Anatopynia	–	0	0	15	30	115	520	155	10	0	0	0	0	0	0
Polypedilum	–	0	0	0	0	5	0	20	30	10	10	5	5	0	5
Physa	–	0	0	0	10	20	20	60	5	10	5	0	0	0	0
Procladius	–	0	0	0	0	0	0	0	5	0	0	0	0	0	5
Nanocladius	–	0	0	0	0	0	0	0	0	0	5	0	15	20	0
Ferrissia	–	0	0	0	0	5	0	0	0	0	0	0	0	0	0
T. plumosus	–	0	0	0	0	5	0	0	0	0	0	0	0	0	0
Crangonyx	–	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Cricotopus	–	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Pisidium	–	0	0	0	0	0	0	0	0	0	0	0	0	0	10

TABLE V

A LIST OF SPECIES, THE DATES OF COLLECTION AND THE NUMBERS OF ORGANISMS COLLECTED PER SQUARE FOOT FROM STATION P-4 OF PARKERSON MILL CREEK

	3–15	4–29	5–25	6–16	7–4	7–20	8–3	8–29	9–23	10–11	10–25	11–13	11–25	12–8	12–21
Tubifex	540	48	775	675	0	0	1000	4500	55	65	75	95	160	160	450
T. riparius	35	26	190	5	5	0	0	0	0	0	0	0	0	0	0
Lumbriculidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
P. alternata	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helobdella	10	4	15	120	145	270	315	705	495	110	550	90	245	95	150
Anatoypnia	0	0	0	0	0	10	15	95	0	0	0	0	0	0	0
Polypedilum	0	0	0	0	5	120	40	55	5	10	20	5	0	15	0
Dugesia	0	0	0	0	0	0	0	30	20	0	10	5	0	0	5
Physa	0	15	65	10	25	70	50	5	0	5	5	0	5	0	0
Procladius	0	0	0	0	0	0	320	15	0	0	0	0	0	0	0
Nanocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	15	5
Pisidium	0	0	16	20	0	3	10	0	15	5	5	5	5	0	0
Cricotopus	0	0	0	5	45	15	5	5	0	0	0	0	0	0	0
T. decorus	0	0	0	0	0	0	10	5	0	0	0	0	0	0	0
Simulium	0	0	0	0	0	11	0	90	0	0	0	0	0	5	0
Argyra albicans	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
Ferrissia	0	0	0	0	5	0	0	0	0	0	0	0	5	0	0
Erioptera	0	0	0	20	0	0	0	0	0	0	0	0	0	0	4
Ceratopogonidae	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

TABLE VI

A LIST OF SPECIES, THE DATES OF COLLECTION AND THE NUMBERS OF ORGANISMS COLLECTED PER SQUARE FOOT FROM STATION B-1 OF BICYCLE PATH CREEK

	5–25	6–16	7–4	7–20	8–3	8–29	9–23	10–11	10–25	11–25	12–8	12–21
Tubifex	11730	4375	1875	2375	185	1750	1455	4375	10720	7025	300	1175
Helobdella	0	0	0	0	0	0	30	0	0	5	0	0
Polypedilum	0	0	5	5	15	5	0	0	0	0	0	0
Anatopynia	0	10	80	0	0	130	0	0	0	0	0	0
Physa	0	5	20	45	0	10	1	1	5	0	10	0
Procladius	0	0	25	145	0	0	0	0	0	0	5	0
Cricotopus	0	0	0	0	35	0	0	0	0	0	55	0
Tubifera	0	0	0	0	0	0	0	5	0	0	0	0
Erioptera	0	0	0	0	0	0	0	0	1	0	0	0
T. decorus	0	0	0	0	0	0	0	0	5	0	0	0
Nanocladius	0	0	0	0	0	0	0	0	0	15	30	0
T. plumosus	0	0	0	0	0	0	0	0	0	0	5	0
T. (Limnochironomus)	0	0	0	0	0	0	0	0	0	0	5	0

TABLE VII

A LIST OF SPECIES, THE DATES OF COLLECTION AND THE NUMBERS OF ORGANISMS COLLECTED PER SQUARE FOOT FROM STATION B-2 OF BICYCLE PATH CREEK

	3–15	4–29	5–25	6–16	7–4	7–20	8–3	8–29	9–23	10–11	10–25	11–13	11–25	12–8	12–21
Tubifex	4500	3000	685	365	60	35	1000	7	55	35	55	45	65	15	30
Helobdella	10	5	0	10	235	10	0	10	10	5	0	5	10	0	0
T. riparius	10	35	15	0	0	0	0	0	0	0	0	35	0	0	0
Polypedilum	1	0	0	0	0	0	0	0	0	0	5	5	0	0	0
P. alternata	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crangonyx	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Physa	0	1	0	0	25	0	20	2	0	0	0	0	0	0	0
Anatopynia	0	1	5	10	0	25	45	2	0	0	0	0	0	0	0
Lemnae	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
Pisidium	0	0	15	15	40	5	0	1	10	5	5	0	5	0	5
Procladius	0	0	90	0	0	0	60	5	0	5	0	0	0	10	0
Ceratopogonidae	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0
Simulium	0	0	0	0	0	40	0	0	0	10	0	0	0	0	0
Cricotopus	0	0	0	0	0	0	5	1	0	0	0	10	0	0	0
Tanytarsus	0	0	0	0	0	0	0	4	0	10	0	0	15	105	0
Pentaneura	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Haliplus	0	0	0	0	0	0	0	0	10	0	0	0	0	0	5
Argyra	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Nanocladius	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
T. decorus	0	0	0	0	0	0	0	0	0	5	70	0	10	5	0
Hydrosyche	0	0	0	0	0	0	0	0	0	0	0	5	0	5	0
Dugesia	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Limnophila	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Cryptochironomus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5

2. *Fish Populations*

Fish populations were sampled at each station from July 19-22, approximately 3 weeks before the sewage treatment plant became operative; and from October 31 through November 3, approximately 3 months after the plant became operative (Table VIII).

The first samples showed no fish to be present at Stations P-2 and P-3. Station P-1 had 2 species and 41 individuals present and Station P-4 had 6 species represented by 46 individuals.

The samples taken after the plant activation showed fish to be present at all stations below the sewage outfall but none at Station P-1. Due to the small size of the stream at this station, it is not surprising that no fish were found here. They apparently migrated downstream after conditions became favorable below the outfall. Station P-2 had 4 species and 8 individuals and P-3 had only 1 individual present. Station P-4 had 13 species represented by 86 individuals.

The presence of fish at Stations P-2 and P-3 and the increased number of species and individuals at P-4 found on the second sampling date was attributed to the improved conditions brought about by the activation of the sewage treatment plant. None of the fish from the study were of harvestable size although it appeared that the stream was capable of producing harvestable size fish at the lower station. Only one carnivorous individual, a largemouth bass, was found during the study and as a result no attempt was made to compute population values (Swingle, 1950). This bass was a 4-inch specimen collected from P-4 on the latter sampling date and since this species is considered highly sensitive to pollution (Katz and Gaufin, 1952), presence of this fish was probably the result of improved conditions at this station.

SUMMARY

1. Water quality determinations showed that Parkerson Mill Creek had conditions favorable for supporting fish populations within five weeks after activation of the sewage treatment plant, and due to scouring floods, within one week for Bicycle Path Creek after the sewage was diverted.
2. Erosional floods appeared to be the most important factor affecting the fluctuation in numbers of the bottom organisms.
3. Temperature did not seem to affect the numbers of bottom organisms.
4. The activation of the sewage treatment plant had no apparent effect on the numbers of organisms at the various stations on Parkerson Mill Creek during this study, however, a significant decrease occurred in the numbers collected from Bicycle Path Creek after the sewage was diverted.
5. There was an increase in the number of species after the sewage diversion and plant activation; and the stations located farther away from the sewage outfall had the greatest number of species.
6. Of the 30 species of bottom organisms collected during this study, only four, *Tubifex, Tendipes riparius, Psycoda alternata,* and *Tubifera* were found to be tolerant of extremely polluted conditions. All but *Tubifex* disappeared after the sewage treatment plant became operative.
7. *Helobdella, Physa, Cricotopus, Pisidium, Polypedilum, Procladius,* and *Anatopynia* occurred with regularity at Stations P-2 and P-3, and at Station B-1 after the sewage was diverted; and since they were somewhat tolerant of polluted conditions but not found in the grossly polluted zones, they were classified as facultative. *Nanocladius, Dugesia, Tendipes decorus,* and an oligochaete of the family Lumbriculidae appeared after the sewage treatment plant became operative, however, since they also appeared to be slighly tolerant of pollution, their appearance was assumed to be seasonal and they too were considered to be facultative.
8. It appeared that not enough time had elapsed after sewage diversion and/or plant activation for reinvasion by organisms used as indicators of clean water. Forms that could possibly have been used as clean water indicators did not occur with regularity or in sufficient numbers to justify their use. Also, infrequency of sampling and lack of knowledge of the life histories of certain organisms contributed to the uncertainty of their classification. Mayflies and stoneflies, which are accepted indicators of clean waters, were not found during this study.

TABLE VIII

A LIST OF SPECIES, DATES OF COLLECTION, AND NUMBERS OF FISH COLLECTED FROM THE VARIOUS STATIONS ON PARKERSON MILL CREEK

Species	*Station P-1*		*Station P-2*		*Station P-3*		*Station P-4*	
	Date of Collection		*Date of Collection*		*Date of Collection*		*Date of Collection*	
	7-19-59	10-31-59	7-20-59	11-2-59	7-20-59	11-3-59	7-22-59	11-2-59
Semotilus atromaculatus (Creek Chub)	36	0	0	0	0	0	1	0
Pimephales promelas (Fathead Minnow)	5	0	0	0	0	0	5	0
Gambusia affinis (Mosquito Minnow)	0	0	0	0	0	0	20	16
Ictalurus natalis (Yellow Bullhead)	0	0	0	0	0	0	11	0
Campostoma anomalum (Stoneroller)	0	0	0	1	0	0	2	2
Lepomis macrochirus (Bluegill)	0	0	0	3	0	0	7	6
Chaenobryttus coronarius (Warmouth)	0	0	0	3	0	0	0	0
Notropis sp. (Shiner)	0	0	0	1	0	0	0	1
Notropis bellus (Blackfin Shiner)	0	0	0	0	0	1	0	14
Micropterus salmoides (Largemouth Bass)	0	0	0	0	0	0	0	1
Ericymba buccata (Silverjaw Minnow)	0	0	0	0	0	0	0	1
Hybopsis amblops (Bigeye Chub)	0	0	0	0	0	0	0	1
Notropis venustus (Blacktail Shiner)	0	0	0	0	0	0	0	38
Notropis longirostris (Longnose Shiner)	0	0	0	0	0	0	0	2
Notropis sp-1	0	0	0	0	0	0	0	1
Notropis sp-2	0	0	0	0	0	0	0	1
Notropis Cornutus (Common Shiner)	0	0	0	0	0	0	0	1

9. Fish populations were not found at the first two stations below the sewage outfall prior to the treatment of sewage, but were found at all stations below the outfall approximately three months after the treatment plant was activated.

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