Macroinvertebrate Sampling and Water Quality Monitoring in Indiana

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Introduction

In 1977, the U.S. Environmental Protection Agency introduced its Basic Water Monitoring Program, which included a biological monitoring plan (15). This plan was designed to complement the states' ambient chemical monitoring programs by showing the effects of water quality on aquatic ife. In addition to existing phytoplankton and bacterial monitoring programs carried out by the states, an expanded biological monitoring program was proposed. A set of sampling stations (CORE Stations) was chosen to represent both polluted and unpolluted waters throughout the nation. Additional biological sampling at these fixed stations could then be correlated with the chemical data also collected there. Changes in water quality at these sites could thereby be more effectively monitored.

Since 1978, the Division of Water Pollution Control, Indiana State Board of Health has administered the expanded biological monitoring program in Indiana. Part of the program involves determinations of the abundance and composition of benthic macroinvertebrates in rivers. The community of macroinvertebrates in an aquatic ecosystem is very sensitive to stress, and its characteristics can often be used to detect environmental perturbations (e.g. 6). Because of the limited mobility and relatively long life spans of benthic macroinvertebrates, their community structure is a function of local environmental conditions during recent months. Macroinvertebrate sampling is especially useful in detecting infrequent perturbations that may not be discovered by periodic chemical sampling.

Macroinvertebrates were sampled in 1978, 1979, and 1980 at 19 CORE Stations in Indiana (Figure 1 and Table 1). The numbers and types of organisms pre-

Table 1. *CORE Station locations*

Stations	Name	Location	Period of Record
BD-0	Burn's Ditch at Portage	Lefty's Coho Landing	1979-80
EW-77	E. Fork White River at Williams	Williams Dam State Fishing Area	1979-80
IHC-1	Indiana Harbor Canal at E. Chicago	Dickey Road Bridge	1979-80
IWC-6.6	Indpls. Waterway Canal at Indianapolis	Confluence of Canal and White River	1978-80
KR-65	Kankakee River at the State Line	LaSalle Fish and Game Area	1978-80
KR-125	Kankakee River near Walkerton	Highway 104 Bridge	1980
M-95	Maumee River at Woodburn	Highway 101 Bridge	1979
SJR-46	St. Joseph River at South Bend	Auten Road Bridge	1979-80
SJR-78	St. Joseph River at Bristol	Town Park	1979-80
STJ-0	St. Joseph River at Fort Wayne	Tennessee Street Bridge	1979-80
TC-0.3	Trail Creek at Michigan City	Franklin Street Bridge	1978-80
WB-175	Wabash River west of Fairbanks	Breed Generating Station	1979-80
WB-207	Wabash River at Terre Haute	Fort Harrison Boat Club	1980
WB-292	Wabash River near Lafayette	Granville Bridge on CR 700W	1978-79
WB-301	Wabash River at Lafayette	Highway 26 Bridge	1979
WB-426	Wabash River at Bluffton	Highway 316 Bridge	1978-80
WR-48	White River at Petersburg	Highway 61 Bridge	1979-80
WR-205	W. Fork White River at Centerton	Henderson Ford Bridge	1978-79
WR-350	W. Fork White River near Winchester	U.S. Highway 27 Bridge	1979-80

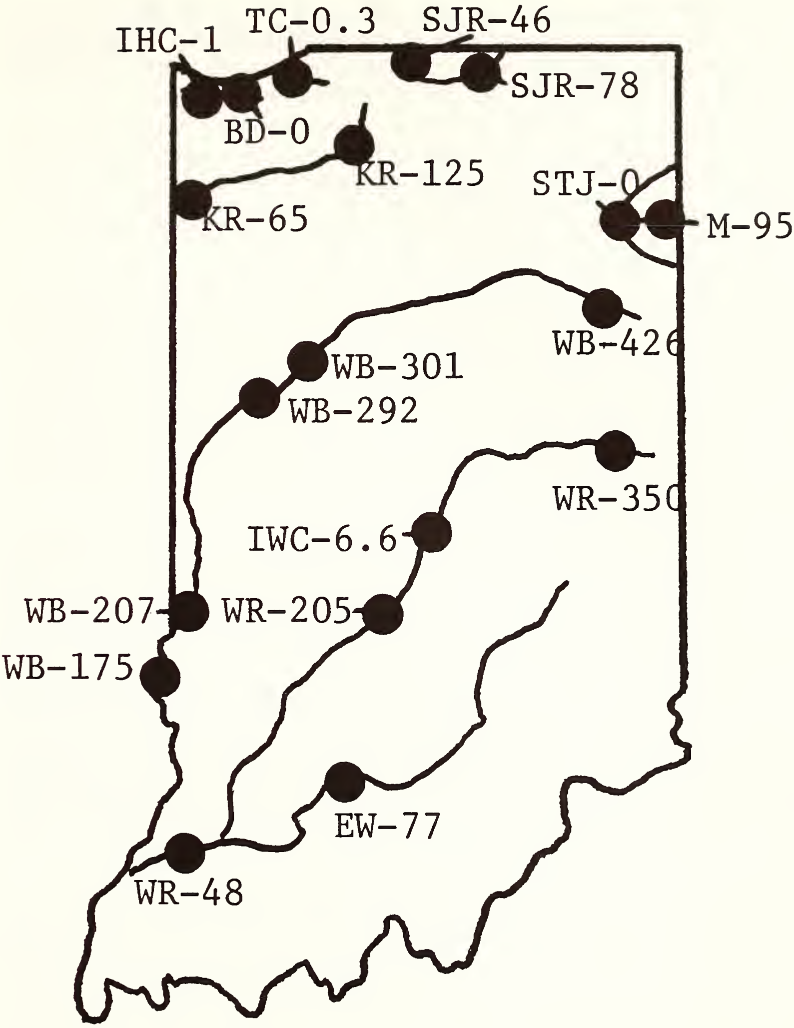

FIGURE 1. *Indiana CORE Stations.*

sent, species diversities, similarity coefficients, and community trophic structures were examined to provide indications of recent water quality at each site. Results were compared with chemical measurements of water quality published elsewhere (8, 9, 10).

Methods

Macroinvertebrates were collected on modified Hester-Dendy artificial substrate samplers (4). These samplers provide a standard substrate on which macroinvertebrates may colonize during a given exposure period. The confounding effects of substrate differences are thereby eliminated, so that data from different stations can be compared.

The samplers were either suspended from floats or tied to immovable objects within areas of permanent flow at a depth of 1 meter. Three samplers tied closely together were placed at each sampling location. Each year they were set out during late July or early August and recovered 4-6 weeks later.

After removal from the river, samplers were placed in trays with a small amount of water and disassembled. Each sampler plate and spacer was carefully scraped clean with a knife. The organisms and water were then poured over a U.S. Standard No. 30 sieve (0.595 mm openings), and the retained material was preserved in 70% N-propanol. Macroinvertebrates were sorted and identified to the lowest possible taxon in the laboratory.

The number of taxa present and their relative abundance were used to calculate the Shannon-Weaver Diversity Index (14) at each station during each year. Genus-level identifications were used for all groups except chironomids, which were identified only to family. Because identifications were not made to the species level, the computed index values are not comparable to those used by Wilhm (16) to classify water quality. Communities with average index values greater than 1.4 were considered to have high diversity, whereas average index values lower than 1.0 indicated low diversity communities, often associated with pollution-related stress.

The organisms collected were assigned to tolerant, facultative, and intolerant categories, according to their ability to survive in waters polluted by sewage. The presence of intolerant organisms at a station indicates waters with low concentrations of sewage-related pollutants. Organisms collected during this study that were considered pollution-intolerant are shown in Table 2.

An autotrophy index for each station was calculated by dividing the number of herbivorous individuals present by the total sample size. An abnormally large proportion of herbivores suggests that periphyton is abundant and often indicates nutrient-enriched waters (11). Chemical monitoring (8, 9, 10) showed that median nutrient concentratons at the CORE stations were about 2.5 mg/1 NO_3-N and 0.15 mg/1 total phosphorus. A t-test was used to determine whether herbivores were more abundant at stations with higher average nutrient concentrations.

TABLE 2. *Pollution-intolerant organisms collected during the study.*

Name	Reference
Plecoptera	1, 6
Trichoptera	
Macronema spp.	6, 13, 17
Brachycentrus spp.	5, 6, 17
Polycentropus spp.	1, 6
Ephemeroptera	
Stenonema interpunctatum	12, 13
Stenonema exiguum	1, 12
Ephemerella spp.	6, 17
Coleoptera	
Ancyronyx variegata	2, 6
Macronychus glabratus	2, 6

A Bray-Curtis Similarity Coefficient (3) was calculated for station pairs upstream and downstream from Fort Wayne, South Bend-Elkhart, Lafayette, Terre Haute and Indianapolis. This coefficient ranges between 0 and 1, so that sample pairs with a coefficient of 1 are identical and those with a coefficient of 0 have no similarities. Samples from each station pair should have high similarity coefficients if water quality is similar.

Results and Discussion

A summary of macroinvertebrate collections between 1978 and 1980 is given in Table 3. Macroinvertebrate samples at IHC-1, TC-0.3, BD-0, and WR-205 generally had low community diversities and never contained pollution-intolerant organisms. These stations had chronic low dissolved oxygen concentrations (<5 ppm) and/or high total ammonia nitrogen concentrations (>1 ppm) during the 3-year period (8, 9, 10). Macroinvertebrate communities at M-95 and WR-350 likewise appeared stressed, but chemical sampling did not corroborate this. Further study is needed to determine the source of stress at M-95. Unstable flows rather than unfavorable water quality may have been responsible for stressed communities at the headwater station WR-350, since small streams are far less stable than large ones (7). Though pollution-intolerant organisms were always collected at KR-65, community diversity was notably low there. The channelized nature of the whole Kankakee River watershed in Indiana may be responsible for this low diversity, since channelization greatly reduces macroinvertebrate habitat.

The effects of nutrient enrichment in rivers was also observed in macroinvertebrate communities. A high population density generally indicates some form of nutrient enrichment, either anthropogenic or by the natural enrichment occurring with increasing stream order (7). When average population densities at each station were subjected to a t-test, significantly higher ($p < .05$) densities existed at stations where average nutrient concentrations were greater than 2.5 mg/1 NO_3-N and 0.15 mg/1 total phosphorus (see Table 3). However, there was no significant difference in the percentage of herbivorous macroinvertebrates at these stations. Therefore, the autotrophy index could not be used to indicate nutrient enrichment.

Stations immediately upstream and downstream from Fort Wayne, South Bend-Elkhart, Lafayette, Terre Haute, and Indianapolis make it possible to evaluate the effects of these urban areas on macroinvertebrate communities. Bray-Curtis Similarity Coefficients for these station pairs are shown in Figure 2. Above and below Lafayette and Terre Haute, the samples were remarkably similar, suggesting that there was little effect from wastewater discharges in these areas. Samples downstream from Fort Wayne and Indianapolis, however, had lower community diversities, and pollution-intolerant organisms were always absent. Bray-Curtis Similarity Coefficients also show that the upstream-downstream communities were different. Pollution sources near these urban areas may have been responsible for the changes, especially at Indianapolis, where stressful conditions were chronic. An intermediate situation existed in the South Bend-Elkhart area, where pollution intolerant organisms were present downstream but community diversities were slightly lower and fewer taxa were present. Reasons for the low degree of similarity between upstream-downstream communities on the St. Joseph River are not clear, but may be related in part to flow variations caused by 2 hydroelectric dams between the sampling stations.

Water quality, as measured by macroinvertebrate response to stress and nutrient enrichment as well as by chemical sampling, was high at stations SJR-78,

TABLE 3. *Summary of macroinvertebrate collections, 1978-1980. Average values are computed from data for the period of record of each station (See Table 1). Symbols under "intolerant organisms" column are: A = always* absent, *P = always* present, *A/P = sometimes present. Stations marked with * had average nutrient concentrations greater than 2.5 mg/1 NO_3-N and 0.15 mg/1 total phosphorus (8, 9, 10).*

Sta.	Dominant family	Intolerant Organisms	No. of taxa		% herbivores		Diversity		No./sampler	
			average	range	average	range	average	range	average	range
BD-0	Chironomidae	A	5.7	4-7	5	0-8	0.90	0.13-1.45	96	12-289
EW-77	Hydropsychidae	P	10.1	8-11	23	11-30	1.57	1.36-1.82	664	489-1031
IHC-1	Tubificidae	A	1.8	0-5	0	0	0.01	0-0.03	450	0-1200
* IWC-6.6	Hydropsychidae Heptageniidae	A/P	9.9	7-12	36	19-56	1.47	1.07-2.04	726	78-1807
KR-65	Hydropsychidae	P	7.9	4-11	11	2-22	0.74	0.57-1.04	232	18-477
KR-125	Heptageniidae	P	7.3	5-9	66	63-88	1.11	0.98-1.20	79	71-93
* M-95	Heptageniidae	A	5.0	4-6	76	64-89	0.67	0.44-0.93	71	45-113
SJR-46	Chironomidae Hydropsychidae	A/P	7.3	5-9	3	1-4	1.00	0.59-1.47	620	202-1011
SJR-78	Hydropsychidae	A/P	9.7	6-13	9	3-15	1.47	1.00-1.78	1333	39-3026
STJ-0	Heptageniidae	A/P	6.7	5-10	60	28-77	1.06	0.76-1.30	221	108-384

TABLE 3.—Continued

Sta.	Dominant family	Intolerant Organisms	No. of taxa		% herbivores		Diversity		No./sampler	
			average	range	average	range	average	range	average	range
TC-0.3	Chironomidae	A	5.0	3-8	4	0-9	0.58	0.23-1.26	255	11-588
* WB-175	Hydropsychidae	A/P	8.8	7-9	12	9-14	1.43	1.32-1.56	1494	1041-2072
* WB-207	Hydropsychidae	P	8.0	7-9	11	11-12	1.35	1.31-1.40	1322	1111-1502
* WB-292	Hydropsychidae	P	9.0	7-10	10	7-15	1.29	1.16--1.51	1047	615-1656
* WB-301	Hydropsychidae	P	9.7	9-10	11	8-15	1.46	1.33-1.57	1800	1244-2188
* WB-426	Heptageniidae	A/P	10.3	6-13	35	13-69	1.38	1.01-1.56	359	93-626
* WR-48	Hydropsychidae	P	8.2	6-12	18	8-42	1.39	0.86-1.72	887	447-1567
* WR-205	Chironomidae	A	6.0	4-10	40	37-43	0.86	0.41-1.49	115	63-173
WR-350	Chironomidae	A	3.9	1-6	22	0-44	0.74	0-1.05	20	5-35

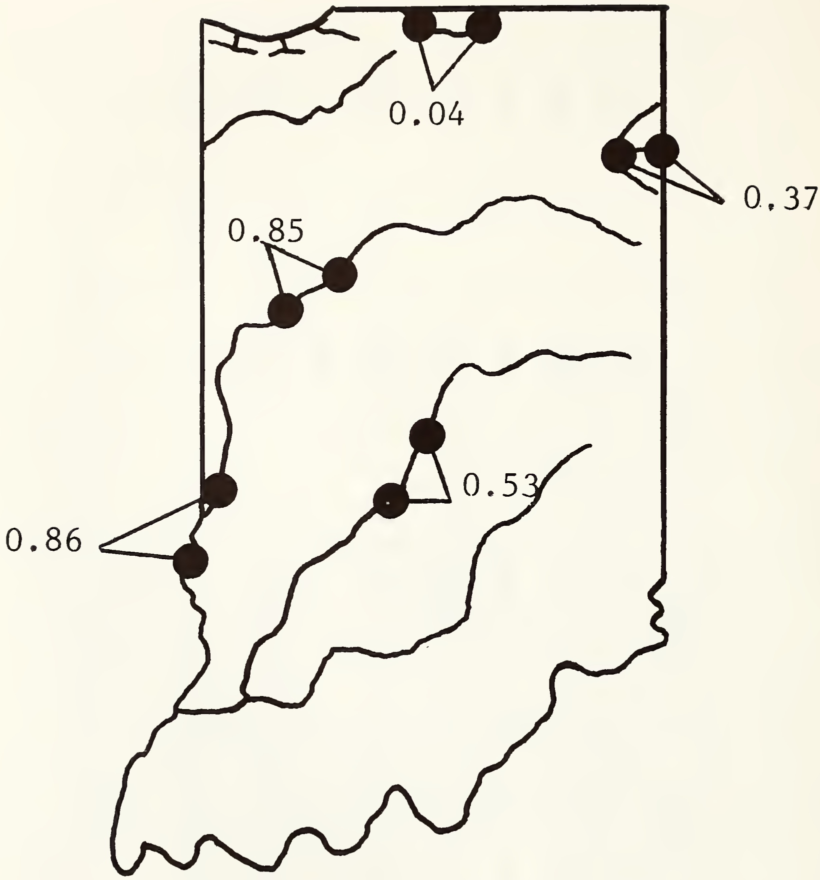

FIGURE 2. *Bray-Curtis Similarity Coefficients.*

KR-125, KR-65, and EW-77. Poor water quality was measured at IHC-1, BD-0, TC-0.3, M-95, and WR-205. Insufficient data exist to demonstrate whether water quality improved or deteriorated at any particular station during the period of study.

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