Proceedings of the Indiana Academy of Science
(1987) Volume 97 p. 333-338.

An Assessment of Water Quality on Little and Big Duck Creeks Near Elwood, Indiana

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Introduction

This research was conducted in 1978-79 to determine the effects of discharges and surface runoff from Elwood, Indiana, on the water quality of Big and Little Duck Creeks. These results were then compared to findings of 1938. The major contributor of pollutants was wastewater from homes, industry, and an overworked sewage treatment plant. This problem has been documented by the Indiana State Board of Health, the Anderson Water Pollution Control Department, and the Madison County Health Department (2,5,6).

The first extensive survey of Big and Little Duck Creeks was conducted by the Indiana State Board of Health from 1928 to 1929 (5). At that time, the stream was used as an open sewer. This resulted not only in unpleasant appearances and offensive odors, but also created a potential health hazard.

No follow-up study has been conducted since 1938 to compare the water quality of Duck Creek above and below Elwood. It was, consequently, of interest to compare water quality changes over a 40 year period.

Description of Study Sites

Big Duck Creek drains a 36 square mile area north of Elwood (Fig. 1) The stream flows in a southwesterly direction through Elwood toward the west fork of White River. The discharge of the creek is generally low, but increases considerably below the sewage treatment plant (4).

To determine the effects of Elwood on the water quality, three stations along Big Duck Creek and two stations on its tributary, Little Duck Creek, were established.

Materials and Methods

Samples were collected during the middle of the week in the late afternoon between June 13, 1978, to January 12, 1979. Samples were analyzed for dissolved oxygen (DO), biochemical oxygen demand (BOD), suspended solids, ammonia, total coliform bacteria and hydrogen ion concentrations (pH). Sampling and analyzing was conducted as described in Standard Methods (1).

All data collected in this and the previous study were statistically analyzed. Differences in sample means for each of the six parameters measured, based on comparisons of values at each sampling location in the 1978-79 study, were determined by the use of a completely Randomized Design Analysis of Scheffe' Test for Multiple Comparisons. The student's t-test was used to determine differences of sampling means of environmental parameters from the 1938 to 1978-79 study. A probability level of 0.05 was accepted as significant.

Results

Means and standard deviations for environmental parameters for Big and Little Duck Creeks for studies conducted in 1979 and 1937 are summarized in Table 1.

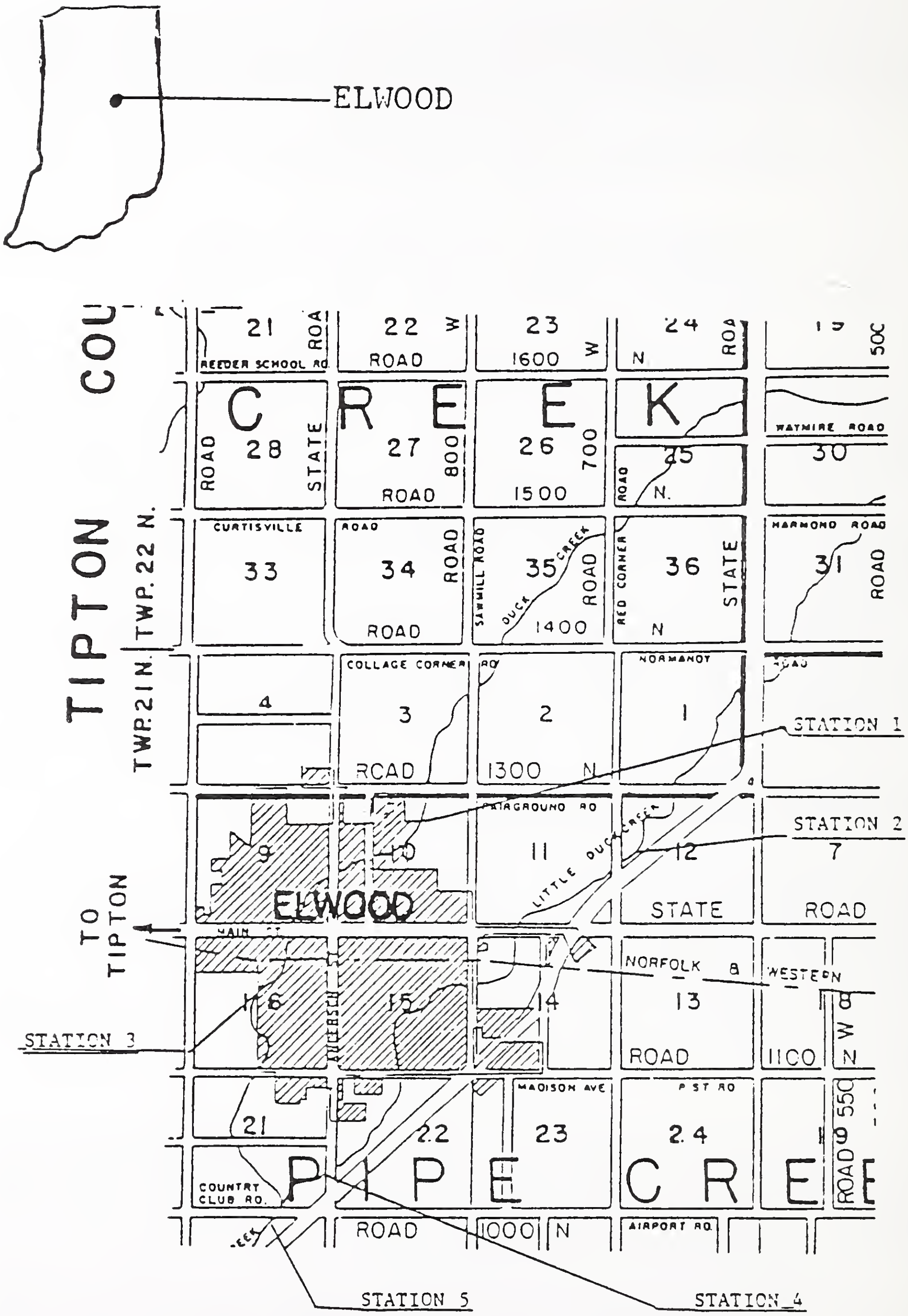

Figure 1. Location of Study Sites.

The mean DO concentrations at Station 1 of Big Duck Creek were higher (9.1 mg/1) than the remaining reaches of Big Duck Creek. A similar trend was observed for Station 2 on Little Duck Creek.

Aeration of the still, shallow portions of the streams, photosynthesis of aquatic plants and low concentrations of BOD may be responsible for the high DO in the upstream areas (Table 1).

TABLE 1
Means and Standard Deviations (SD) for Dissolved Oxygen Concentrations (DO) Hydrogen Ion Concentrations (pH), Biochemical Oxygen Demand (BOD), Suspended Solids (SS), Total Coliform Bacteria (TCB-colonies X10³/100ml), and Ammonia Concentration (NH_3) of Little and Big Duck Creek from June 13, 1978, to January 12, 1979. All mean values are expressed as mg/l with the exception of pH and TCB.

	Stations				
	1	2	3	4	5
Parameter			1978-79		
DO	9.1 ± 3.3	7.04 ± 4.2	5.1 ± 4.3	6.9 ± 3.1	5.4 ± 2.9
pH	8.2 ± .20	8.0 ± .21	7.8 ± .30	7.9 ± .30	7.9 ± .14
BOD	2.5 ± 1.9	5.6 ± 4.7	5.8 ± 2.9	4.2 ± 2.7	7.3 ± 2.8
SS	5.8 ± 4.3	3.8 ± 3.1	10.6 ± 10.4	6.8 ± 5.2	9.4 ± 9.5
TCB	13.1 ±18.2	38.8 ±41.5	310.4 ±272.8	17.7 ±23.5	20.8 ±22.0
NH_3	0.81± 0.66	0.29± 0.21	0.37± 0.20	0.20± 0.21	0.53± 0.65

Station 3 had the lowest mean DO concentration (5.1 mg/l). This oxygen level was probably reduced by the higher BOD which was observed at this sampling location. Wastewater storm overflow, urban runoff and untreated household wastewater discharges were the most probable sources of oxygen-depleting wastes affecting this segment of Big Duck Creek.

The DO concentrations at Stations 2 (7.0 mg/l) and 4 (6.9 mg/l) located on Little Duck Creek were still high. This was surprising since malfunctioning household on-site sewage disposal systems were observed discharging into Little Duck Creek.

The DO levels decreased at the downstream Stations 3 and 5. This may have been caused by agricultural runoff and the introduction of oxygen-demanding waste from the town.

Results from this study show that the mean DO concentration in the upstream region of Station 1 was 4 mg/l higher in 1978-79 than in 1937. The 1938 report by the Indiana State Board of Health indicates that this part of Big Duck Creek

TABLE 2
Means and Standard Deviations for Dissolved Oxygen Concentrations (DO), Biochemical Oxygen Demand (BOD), Suspended Solids (SS) and Total Coliform Bacteria (TCB-colonies X10³/100ml) of Little and Big Duck Creek from August 29, 1937, to September 23, 1937. All mean values are expressed as mg/l with the exception of TCB.

	Stations				
	1	2	3	4	5
Parameter			1937		
DO	5.0 ± 3.8	7.1 ± 3.6	0.4 ± 0.9	7.3 ±3.2	0.06±0.2
BOD	18.9 ±25.4	2.8 ± 1.7	354.7 ± 20.13	40.2 ±2.8	—
SS	54.2 ±31.6	110.5 ±47.4	185.6 ± 144.3	40.07±7.8	—
TCB	3.90±45.842	.055± .052	1835.70±3485.00	.30±0.40	1000.00±0000

experienced low flow such that the stream often reached pool stage (5). It was also indicated that mud in the channel was occasionally stirred up in a hog wallow upstream. This condition was improved by 1979 when the hog wallow was eliminated and the stream flow was increased due to changes in agricultural drainage.

Station 2 was above all known sources of pollution in 1937, except for agricultural runoff and the DO levels were similar in both periods.

In the downstream portion from Stations 1 and 2, the DO levels were noticeably lower during the 1937 investigation. The inner city mean DO level in 1937 was 0.4 mg/1 as compared to 5.1 mg/1 in 1978-79. A similar difference occurred at Station location 5 below Elwood, where the mean DO level in 1937 was a barely detectable 0.06 mg/1 while in 1978-79 it was 5.40 mg/1. The most obvious reason for the improvement in DO may be because Big Duck Creek is no longer being used as an open sewer as it was 40 years ago.

Station 1 had the lowest mean BOD (2.5 mg/1) of all 5 Stations. This may be due to this station being above major sources of organic pollution. At Station 2, the mean BOD was considerably higher (5.6 mg/1) and may have resulted from the application of animal manure on the fields near the stream.

Station 3 had a higher BOD (5.8 mg/1) than the upstream water of Big Duck Creek. As was mentioned before, faulty household sewerage systems and a municipal sewer overflow probably provided the organic waste.

Station 5 had the highest BOD level (7.3 mg/1). This was most likely due to the inner city wastewater discharges, as well as effluent from the Elwood sewage treatment plant.

The 1978-79 study showed a 16 mg/1 decrease in BOD at Station location 1. This decrease was probably due to the elimination of the hog wallow. BOD levels were significantly lower in 1978-79 at Station 2 as compared to the 1938 study, even though land use had not changed much in that time.

The mean BOD concentration at Station 3 was 354 mg/1 in 1937 compared to only 5.8 mg/1 in 1978-79, because of effluents from several tomato canneries, as well as raw domestic sewage at that time. These wastes are no longer a part of the organic load on this portion of the stream.

BOD levels at Station 4 in 1937 were significantly higher (40 mg/1) than those measured in 1978-79 (4.2 mg/1). Apparently, Little Duck Creek was used to carry away domestic waste in 1937. Suspended solids levels (SS) were low at the upstream stations. The highest levels were determined at Station 3 in 1978-79. Apparently, addition of city effluent to the already existing load of soil particles increased the SS concentration.

Suspended solids levels in 1937 were significantly higher as compared to 1978-79 at all stations. The most probable reasons for these differences include higher levels of erosion in 1937 and discharges of raw sewage together with other organic wastes from a hog operation located north of Elwood abutting Big Duck Creek.

Total coliform bacterial (TCB) counts were significantly higher at Station 3 (310 x 10^3/100 ml) in 1978-79 than at any other station. This sampling location was affected by a wastewater overflow immediately upstream and also received wastewater from household sewer systems. At Station 5 total coliform bacterial counts were only a fraction (20.8^3 x 10/100 ml) of the concentration level found at Station 3. The reason for this difference may be due to chlorination of wastewater at the sewage treatment plant.

Total coliform bacterial counts were lower at Stations 2 and 4 in 1937 than in 1979. This was apparently due to limited development along Little Duck Creek at that time. However, the bacterial count was ten times higher in 1937 than in 1979 at Station 3. This was probably due to untreated industrial and household waste.

Mean ammonia levels did not increase significantly within the city. Station 3 exhibited a mean level of 0.27 mg/1. Station 4 had a similar level of 0.20 mg/1. The relatively low concentrations of ammonia at these stations were probably due to the limited time available for ammonia production from organic matter.

Station 5 on Big Duck Creek exhibited a mean ammonia concentration of 0.53 mg/1. This higher value was probably due to ammonia in the effluents from the sewage treatment plant.

No ammonia determinations were made in 1937, consequently, no comparison could be made. Generally, the pH levels varied little from station to station.

Conclusion

When the upstream and downstream stations were compared, a definite decrease in water quality was noted. The DO concentrations decreased as the water flowed through the city. The BOD increased in the downstream area because of increased organic loadings.

Elwood increased the SS level of Big Duck Creek. Agricultural and urban runoff together with untreated sewage significantly increased SS within the inner city region. Dilution by treated sewage, as well as, cleaner water from Little Duck Creek helped to reduce the suspended solids level in the downstream location.

Relatively high ammonia concentrations were observed in the upstream portions of the creeks. This was apparently related to farm practices. The higher readings of ammonia were noted after animal manure was spread on the fields along the stream. The downstream levels were also high. This was probably due to ammonia in the effluents from the sewage treatment plant. In contrast, only small changes in the hydrogen ion concentration were observed along the creek.

Total coliform bacteria increased in the center of town because of a sewer bypass into the creek. Below Elwood the concentration of bacteria decreased due to dilution with disinfected effluents from the sewage treatment plant.

Except for a noticeable increase in BOD and ammonia, the Elwood sewage treatment plant effluent together with water from Little Duck Creek appeared to improve Big Duck Creek's condition as it left the city to join White River.

Significant differences between parameters in 1937 and 1978-79 were observed. Results of this study indicate a significant improvement in water quality of Big Duck Creek since 1937. This included significant decreases in biochemical oxygen demand, suspended solids, total coliform bacteria and increases in dissolved oxygen. This was probably due to the concentration of Elwood's wastewater collection system and sewage treatment plant in the 1940's. However, there was still degradation of water quality within the city due to untreated wastewater discharges. Consequently, emphasis should be placed on the inner city problem.

Acknowledgments

The authors appreciate the assistance from the Anderson Water Pollution Control staff, the Madison County Health Department, the Sanitary Engineering Division of the Indiana State Board of Health and Dr. Clyde Hibbs of the Department of Natural Resources, Ball State University.

This project was funded partially by the Indiana Academy of Science.

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