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Investigation of the Streambed Oxygen Demand of Fourche Creek, Pulaski County, Arkansas

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answered. The fact that these experiments usually use containers which are being recycled (such as half-gallon milk cartons) adds to the development of the concept of recycling. Setting up these experiments which they have designed has enabled these students to apply the scientific method of investigation to a problem in which they are interested, and recycling materials and energy has been emphasized. If the group can be encouraged to see the value of recycling other materials such as aluminum cans and see some glimpse of the relationship of such recycling to plants and plant communities, then more of the total material-energy picture can be included in discussions.

The third Outdoor Lab experience deals with the traditional sampling methods by which plant communities can be described. The botany students have had some experience in keying out trees on other parts of the campus arboretum, using Moore (1972); hence, they are able to identify the trees within the wooded area of the Outdoor Lab rather quickly. During the laboratory period, the modified point-quarter method (Smith, 1980) is used in sampling of the trees. The plant community is named in terms of the importance values assigned to the trees, a value based on the percentages of dominance, frequency, and density of the trees. Discussion of other sampling possibilities enables the students to form some concepts dealing with the techniques of quantifying other aspects of the ecosystem.

During the fourth session, the emphasis is on the time-space relationships of this plant community with others. Succession is observed in the various seral stages present in a proposed Nature Reserve, an area extending beyond, yet included in the Outdoor Lab area. Back at the bench circle, a discussion of relationships in time and space of these examples of plant communities with the worldwide view is usually quite rewarding. This discussion includes looking at a sheet dealing with activities relating to lifestyle, including hobbies and work, as these activities relate to the environment (in terms of polluting or maintaining it), to the economy and energy (in terms of cost and use of materials and energy), and to each student. Hopefully, the discussion which follows will spark some questions dealing with each student's relationship to the whole and thoughts concerning the student's reactions to these basic problems. Is the grassy community really "a prairie remnant"? If so, does that make it more valuable as part of a Nature Reserve or Outdoor Lab for the UCA campus? How can it be preserved and yet used to best advantage? Should students be concerned about the environment? about plant communities? about recycling materials? about energy shortages and alternative sources? These questions, hopefully, change to the more valuable and life-long questions for each student: What concerns do I have about these things? and what can I do about these concerns?

Having the Outdoor Lab on the UCA campus has been a most valuable asset for teaching these ecological concepts to various classes. With the increased emphasis on environmental education in our state and the development of outdoor-lab facilities in the various public school systems in Arkansas, it becomes even more important that the colleges and universities develop such on-site facilities for students. Students in general, not just the botany students, need to receive training in environmental awareness, to develop a knowledge of some of the relationships and dependencies on our "Spaceship Earth", in order to become part of the solution to problems and not part of the problems.

LITERATURE CITED

MOORE, DWIGHT M. 1972. Trees of Arkansas. Third Edition. Arkansas Forestry Commission; Little Rock, Arkansas.

MOORE, JEWEL E. 1974. Multi-use of the campus environment in the teaching of botany. Proc. Ark. Acad. of Sci. 28:45-46.

SMITH, ROBERT LEO. 1980. Ecology and field biology. Third Edition. Harper and Row; New York.

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AN INVESTIGATION OF THE STREAMBED OXYGEN DEMAND OF FOURCHE CREEK, PULASKI COUNTY, ARKANSAS

In recent years Fourche Creek has been the site of numerous investigations (ADPC&E, 1974a,b; Bryant and Terry, 1979; U.S. Army CoE, 1972). The stream has a history of consistently low D.O. values. Previous five-day BOD's collected indicated that neither the carbonaceous nor nitrogenous demand, nor a combination of the two, was sufficient to account for the low D.O. concentrations measured (ADPC&E, 1974a).

In a modeling report by Bryant and Terry (1979), it was hypothesized that the benthic deposits exerted a significant demand on the oxygen in the overlying water. The primary purposes of this study were to compare S.O.D. values derived experimentally with those derived from the model and, if possible, define the effects on the stream's ecosystem.

Fourche Creek extends 30 miles (48.6 km) from its sources in northeastern Saline County, Arkansas, to its confluence with the Arkansas River in Pulaski County. The sources lie in the eastern edge of the Ouachita Mountains at an elevation approximately 600 feet above mean sea level (Fig. 1). Figure 2 is a schematic diagram of the Fourche drainage showing locations of tributaries and major municipal and industrial effluents relative to its confluence with the Arkansas River. The main stem also receives runoff from springs, timberland, pastureland and residential areas (USACE Environmental Assessment Report, 1972). Table 1 contains data regarding the sampling sites.

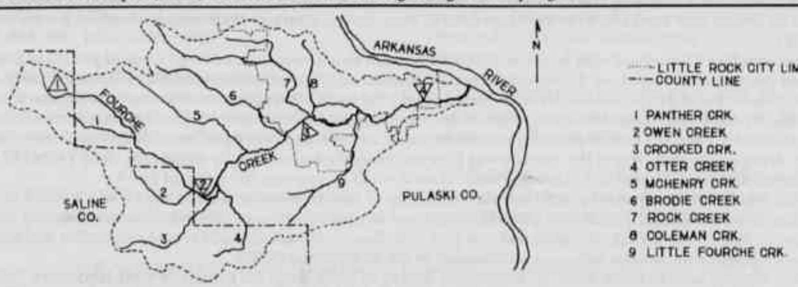

Figure 1. Map of Fourche Creek drainage showing sampling sites and major tributaries.

Table. 1 Sampling sites of Fourche Creek, February-August 1979 (location is distance upstream from its confluence with the Arkansas River.

Site	Location	Substrate	Mean Depth (m)	Mean Width (m)
1	46.2 km	sand, gravel, cobble, some bedded shale and quartz	0.1	5.5
2	33.2 km	cobble, boulders, some sand, heavy vegetation	0.1	6.8
3	19.4 km	silt and sand layered with detritus	0.09	8.3
4	7.3 km	silt and sand layered with detritus, some oils	0.6	5.2

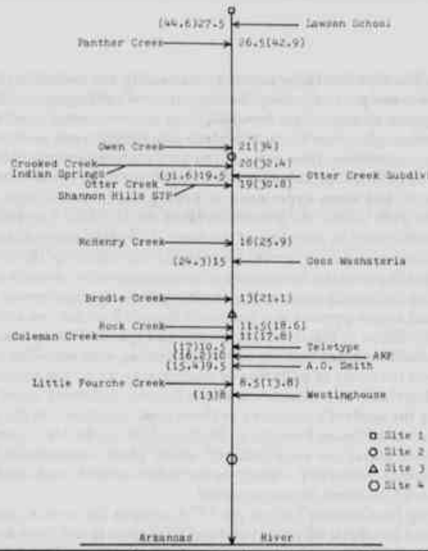

Figure 2. Schematic of Fourche Creek drainage indicating the major tributaries and waste effluent sources. Numbers are miles (km) from the confluence with the Arkansas River.

For each sampling period, pH, specific conductance, D.O. and water temperature were determined in the field according to the methods given in USGS (1979). In addition to the collection of field parameters, surface water and sediment samples were collected, chilled and taken to the laboratory for analyses. Water samples were analyzed for fecal coliform and streptococcus bacteria and five-day BOD. The sediment was measured for COD, total kjeldahl nitrogen (ammonia plus organic nitrogen), total ammonia nitrogen, total nitrate and nitrite nitrogen and total phosphorus. All laboratory procedures were in accordance with USGS (1979).

In addition, minimal disturbance sediment samples were collected and analyzed for S.O.D., which is defined as the D.O. uptake from the overlying water by benthic materials and/or organisms. The demand results mainly from the reduction of biologically oxidizable material and the respiration of micro- and macro-organisms, but inorganic chemical oxidation reactions may also contribute to the demand. The major micro-demand is generally due to bacterial and fungal respiration, whereas the macro-demand is by both surface-dwelling and burrowing organisms (Butts and Evans, 1977). Periphyton may also contribute significantly in some aquatic environments.

Several methods to measure S.O.D.'s are available (Bowman and Delfino, 1978); however, the technique outlined by Nolan & Johnson (1977) was used in this study. This technique involves carefully removing the top 5-8 cm of bed material, transporting it with minimal disturbance to the laboratory and placing it in a closed-system respirometer. The sediment in the S.O.D . chamber was 2.5 cm deep with 0.069 m^2 of surface, and 24 1 of unbuffered aerated, demineralized water was circulated through the system with a peristaltic pump. Dissolved oxygen was recorded as the system was operated at $21 \pm 2°C$ for 24 hours. The part of the curve where oxygen consumption versus time was constant was used for calculating the S.O.D. rate. A control was run without sediment and the correction made in the calculation. One to three samples from each site and date were run, and to reduce individual variation, the mean value of each series was used as the S.O.D. during that sampling period.

Individual S.O.D. measurements are given in Table 2, and mean S.O.D. values and other parameters are given in Table 3. The variation in values was probably due in part to the disturbance of the sediment during collection and filling of the respirometer. Some variation may also be attributed to natural variation in sediment composition patterns. One would expect slight variation at a given site, more at different sites on a stream and still more between streams. Butts and Evans (1977) determined that S.O.D. values vary greatly among streams. After studying several streams in Illinois, they estimated values of 0.27 $g/m^2/day$ for relatively clean streams to 9.3 $g/m^2/day$ for heavily polluted streams.

Fourche Creek has a history of low oxygen concentration (Fig. 3). Water quality data collected during this study (Table 3) support the ADPC&E (1974a) findings that whole-water components were not the primary cause of the low D.O. values. The stream had a moderate pH (6.8 to 7.4) with the exception of pH 7.8 at Site 1 on 20 March. Low alkalinity (ADPC&E, 1974a) and conductance values (Table 3) indicate a relatively unbuffered system.

Five-day BOD values between two and five should not have a significant demand on the stream's D.O. Neither the bacterial counts nor the nitrogen and phosphorus values are unusually high. Low trace metal concentrations (ADPC&E, 1974b) should minimize the inorganic chemical oxidation reactions. Thus, the measured wasteloads do not account for the low D.O. values.

Sediment samples collected during this study (Table 3) indicate that deposited material is the major contributing factor in the D.O. sag as was hypothesized by Bryant and Terry (1979) in the calibration of their model, although their estimated values were somewhat higher than those actually measured.

Downstream from Site 2 Fourche Creek begins to meander, the fall rate decreases, and large areas of pools are present. As the velocity decreases, reaeration decreases and sediment deposition increases. Bottom organics and sediment COD's increased more than ten times within an eight-mile (13 km) reach (Table 3). Sediment COD's increased from 2500 to 99,500 mg/kg whereas the total bottom kjeldahl nitrogen increased from 160 to 1770 mg/kg during the August sampling. Within this same reach the D.O. concentration decreased from 9.1 to 4.0 mg/1 (Fig. 3). The high D.O. values at miles 5.0 and 0.5 in 1979 probably are not representative of the lower Fourche because the points of measurement were at the confluence of two dredged channels where the velocity was high and reaeration undoubtedly significant. Fifty yards (46 m) upstream from Site 4 the stream was pooled, and the sediment was black silty sand. Here the S.O.D. rate was twice that at Site 4.

The ADPC&E report (1974b) showed a small population density of benthic invertebrates at Sites 2 and 3 which probably could not exert a heavy S.O.D. Since several chemical parameters generally increased in concentration or intensity downstream, and bacterial counts increased (with the exception of Site 1), the S.O.D. probably was due to a combination of bacterial and fungal respiration and oxidation of organics with, perhaps, the organics exerting the greater influence as indicated by the downstream COD's.

The authors wish to thank the U.S. Geological Survey in Little Rock for the use of their laboratory facilities and collecting equipment.

Table 2. S.O.D. rates (g/m²/day) in Fourche Creek, Pulaski County, Arkansas, 1979.

Date	Site 1	Mean	Site 2	Mean	Site 3	Mean	Site 4	Mean
13 Feb	1.27 1.87 2.47	1.87						
16 Feb			2.65 1.19 1.37	1.74				
17 Feb					1.38 1.96	1.67		
20 Mar	1.58 1.87	1.72						
13 Jul							1.61	1.61
17 Jul					2.55	2.55		
1 Aug	2.24 0.50 1.67	1.47						
3 Aug			0.83 1.82	1.32				
17 Aug							3.35 3.10	3.22

Table 3. Water quality data for Fourche Creek, Pulaski County, Arkansas, 1979.

	Site 1			Site 2		Site 3		Site 4	
	13 Feb	20 Mar	1 Aug	16 Feb	3 Aug	17 Feb	17 Jul	13 Jul	17 Aug
pH	7.4	7.8	---	7.5	7.4	6.8	6.9	7.0	---
Temperature (°C)	3.0	---	---	7.0	---	5.0	26.0	25.5	---
D.O. (mg/l)	12.8	---	---	11.6	---	12.6	4.8	3.7	---
Specific Conductance (umhos)	111	239	200	98	103	82	92	120	---
Sediment C.O.D. (ug/kg dry wt.)	4100	---	2500	---	2700	13000	99500	36500	---
5-day B.O.D. (mg/l)	1.6	2.8	3.9	2.0	1.2	1.3	5.0	5.0	---
Mean S.O.D. (g/m²/d)	1.87	1.72	1.47	1.74	1.32	1.67	2.55	1.61	3.22
Fecal Coliforms (colonies/100 ml)	1800[a]	4400[a]	---	22[a]	78[a]	500	290	1100	---
Streptococci (colonies/100 ml)	1100	1200[a]	---	10[a]	---	124	310	360	---
Sediment TKN (mg/kg of N)	3.2	---	170	---	160	1000	1770	260	---
Sediment NH_3-N (mg/kg of N)	2.3	---	0.0	---	0.0	12	6.9	0.0	---
Sediment NO_3-N (mg/kg of N)	0.0	---	3.9	---	0.0	0.0	4.6	3.6	---
Sediment P (mg/kg of P)	---	---	430	---	88	---	450	543	---

[a]Estimate.

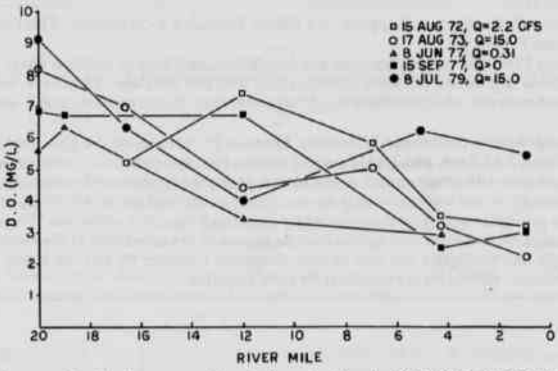

Figure 3. Summer dissolved oxygen values in Fourche Creek, 1972-1979. (ADPC&E, 1974a,b)

LITERATURE CITED

ARKANSAS DEPARTMENT OF POLLUTION CONTROL AND ECOLOGY. 1974a. Water pollution control survey of the Arkansas River Basin, Vol. I, Sources of Pollution, pp. 146-171.

ARKANSAS DEPARTMENT OF POLLUTION CONTROL AND ECOLOGY. 1974b. Water pollution control survey of the Arkansas River Basin, Vol. II, Effects of pollution on receiving waters, pp. 715-719, 885, 890, 1030, 1038, 1040.

BOWMAN, G. and J. J. DELFINO. 1978. Sediment oxygen demand techniques: A review and comparison of laboratory and *in situ* systems. Unpubl. mimeo presented at the Third Annual Meeting of the Wisconsin Chapter American Water Resources Association, Oshkosh, WI, 23 Feb 1979, 27 pp.

BRYANT, C. T. and J. E. TERRY. 1979. Water quality modeling of selected streams in Pulaski and Saline counties, Arkansas. Unpubl. mimeo, 26 pp.

BUTTS, T. A. and R. L. EVANS. 1977. The art and science of measuring sediment oxygen demand in the field. Unpubl. mimeo presented at AMSA-MSD Water Quality Conf., Chicago, 20-22 Apr 1977, 25 pp.

NOLAN, P. M. and A. F. JOHNSON. 1977. Sediment oxygen demand investigation of St. Croix River, Maine, U.S.A. and New Brunswich, Canada. Mimeo report to U.S. Environmental Protection Agency, 23 pp.

U.S. ARMY CORPS OF ENGINEERS. 1972. Environmental assessment report on Fourche Bayou Basin in Pulaski and Saline counties, Arkansas, 43 pp.

U.S. GEOLOGICAL SURVEY. 1979. Techniques of water resources investigation, Book 5, Ch. A-1, methods for determination of inorganic substances in water and fluvial sediments, 626 pp.

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