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# TENNESSEE'S EAST FORK POPLAR CREEK: A BIOLOGICAL MONITORING AND ABATEMENT PROGRAM

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In May, 1985, a Biological Monitoring Program was developed for East Fork Poplar Creek (EFPC) in eastern Tennessee, United States. This stream originates within the Oak Ridge Y-12 Plant that produces nuclear weapons components for the Department of Energy. Water and sediment in the stream contain metals, organic chemicals, and radionuclides from releases that have occurred over the past 45 years. Effluents discharged from the Y-12 Plant enter the stream near its headwaters; further downstream the creek also receives urban and some agricultural runoff and effluent from the City of Oak Ridge's Wastewater Treatment Facility (WTF). Classified uses of EFPC, as designated by the Tennessee Department of Environment and Conservation, include growth and propagation of fish and aquatic life, and recreation, including fishing and swimming. Primarily because of elevated concentrations of mercury, fishing and swimming in EFPC have been prohibited since November, 1982.

The biological monitoring program was developed under mandate of the National Pollutant Discharge Elimination System (NPDES) permit as an alternative approach to compliance with water quality standards. The monitoring program has two major objectives: first, to determine if the effluent limitations established for the Y-12 Plant, as stipulated in the NPDES permit, protect and maintain the classified uses of the stream; and second, to document environmental improvements from the implementation of a water pollution control program at the Y-12 Plant. This program seeks to eliminate direct discharges of wastewaters to EFPC and to reduce inadvertent release of pollutants.

The biological monitoring program includes four major tasks: (1) ambient toxicity testing; (2) bioaccumulation studies; (3) biological indicator studies; and (4) ecological monitoring of stream communities, including periphyton, benthic macroinvertebrates, and fish. Biological conditions are monitored at six sites on EFPC ranging from kilometer 24.4 near the headwaters to kilometer 6.3 near the mouth. A site on Brushy Fork, a stream just north of Oak Ridge, is used as a reference.

Ambient (instream) toxicity was monitored through the use of 7-day static-renewal tests that measured the survival and growth of fathead minnow (*Pimephales promelas*) larvae and the survival and reproduction of a microcrustacean (*Ceriodaphnia dubia*). Full-strength water from EFPC within the Y-12 Plant boundary was frequently toxic to *Ceriodaphnia*, but less frequently toxic to the minnow larvae. Chlorine has been identified as an important toxicant in upper EFPC.

Water samples from six sites in EFPC downstream from the Y-12 Plant boundary were tested eight times with both species during a 2-year period (October, 1986 through October, 1988). These sites were ranked by the number of times they were "best" or "worst" for each species. The results of the ranking procedure revealed no longitudinal pattern to water quality in the creek based on either fathead minnow growth or *Ceriodaphnia* fecundity in 7-day tests.

Water samples collected for use in the ambient toxicity tests were routinely analyzed for conductivity, pH, alkalinity, hardness, total residual and free chlorine, and temperature. Water temperature was recorded at each site as the sample was collected; all other measurements were made in the laboratory within 3 h after sample collection. The influence of effluent from the Oak

Ridge WTF on chemical conditions in EFPC was easily detected based on measurements of conductivity, alkalinity, and total residual chlorine. The sum of the Pearson correlations between ranked values for conductivity, alkalinity, and hardness, subtracted from 3.0 provided a useful measure of the degree to which stream sites were chemically perturbed. For pristine streams on the Oak Ridge Reservation this index ranges from 0.2 to 0.4 (i.e., high correlations occurred consistently between conductivity, alkalinity, and hardness). The index's values for EFPC sites were not less than 1.5 and exceeded 2.0 within the Y-12 Plant boundary and at the site just downstream from the Oak Ridge WTF.

Both the Y-12 Plant and the Oak Ridge WTF release nutrients that enhance algal growth in EFPC. Periphyton community studies indicated that physical and/or biotic factors may contribute to the differences in algal biomass, production, and condition among the EFPC study sites. In upper reaches of EFPC, periphyton are strongly influenced by chlorine, while periphyton just below the Y-12 Plant accumulate metals (such as Hg and Cd) that may be transferred to higher trophic levels by grazers.

Bioaccumulation studies indicate that fish from EFPC have elevated concentrations of mercury compared to fish from a reference stream (30% of the EFPC fish exceeded the FDA tolerance limit of 1 $\mu$g/g). Mean concentrations of mercury in redbreast sunfish were highest near the Y-12 Plant and decreased steadily with distance downstream. Linear regression analysis of mercury concentrations in redbreast sunfish vs. time indicate that mercury contamination in this species has increased a small but statistically significant amount since monitoring began in May 1985 (average increases at the various sampling sites were from 0.2 to 0.8 $\mu$g/g). A pattern similar to that described for mercury also was evident for PCBs. From studies using caged Asiatic clams, the upper reach of EFPC has been identified as an important source of PCBs. The clam studies also indicated the presence of low levels of PAHs in EFPC.

Bioindicators of fish health revealed a downstream gradient of increasing fish health. Fish from the lower reaches of EFPC showed improvement in health over the study period but the health of fish from the upper reaches has not improved. Bioindicator responses indicate that decreased health of fish from EFPC was due primarily to toxicant exposure. Higher concentrations of detoxification enzymes, metallothioneins, DNA damage, and liver somatic index were observed in EFPC fish. In addition, reproductive impairment was observed in fish collected near the Y-12 Plant but not in fish collected ≥4 km farther downstream.

Instream monitoring of benthic macroinvertebrates indicate that species richness, diversity, density, biomass, and production were lowest at upstream sites. All of these parameters gradually increased with distance downstream. Although effluents released from the Y-12 Plant may account for the observed degradation of macroinvertebrate communities, the specific constituents causing the impacts have not yet been identified. The impacts probably result from a combination of several factors, such as elevated temperature, sublethal concentrations of one or more toxicants, episodic releases of toxicants, excess nutrients, organic loading, and/or siltation.

Instream monitoring also indicated that fish populations in EFPC are in poor condition, although some downstream recovery was observed. The Index of Biological Integrity (IBI) ratings for the upper reaches of EFPC were low but indicated slight improvement through time (i.e., upper reach ratings have increased from very poor to very poor bordering on poor). At downstream sites the IBI rating was very poor to poor initially, but showed steady improvement over the two-year sampling period. The slight improvements in the IBI ratings were supported by increases in the number of darter species, occurrence of intolerant species, and number of lithophilic spawners in lower EFPC.

The biological monitoring program has been effective in identifying contaminants of concern and providing information on contaminant spatial and temporal distribution and effects. Biological monitoring has provided a successful and innovative alternative to water quality standards and/or toxicity testing during the initial stages of environmental restoration.

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