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BIOMONITORING - A FINAL METHOD TO MEASURE POLLUTION ABATEMENT,(U)
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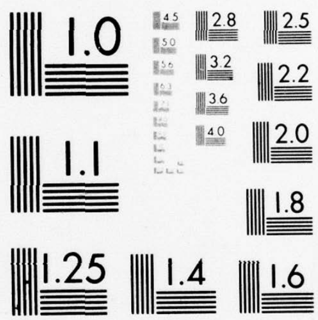

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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*BENDER & ROBINSON

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(6) BIOMONITORING - A FINAL METHOD TO MEASURE
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JUN 1978

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The final goal of the Army's water pollution abatement program is to protect aquatic plants and animals by maintaining conditions favorable to life in the nation's waterways. Although most of this work involves monitoring chemical and physical characteristics of water, pollution is essentially a biological problem in that its primary effects are on living things. Therefore, it is appropriate to measure the success or failure of a pollution control system by monitoring the responses of aquatic plants or animals to the treated wastewater. Biological monitoring, or biomonitoring, of a treated effluent or waste stream thus provides the ultimate evaluation of pollution abatement. Legislators recognized the basic need for such monitoring by requiring in Public Law 92-500 (1972) that biomonitoring be conducted on all waste discharges. A biomonitoring system is now being tested at Radford Army Ammunition Plant (RAAP) in southwestern Virginia for just this purpose.

Biological monitoring is not a new concept. In the 19th century, coal miners used canaries to warn them when the air contained toxic gases. When the canary fainted, miners left the shaft for clean air above ground. Over twenty years ago, Rachel Carson in her book Silent Spring interpreted the death of birds and other wildlife as a symptom of the effects of pesticides on the environment. Each year the scientific literature contains numerous studies of organisms possessing either extreme tolerance or extreme sensitivity to environmental pollutants. Tolerant species are abundant in the

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presence of a contaminant, while sensitive plants and animals may disappear even when only small quantities of a pollutant are present.

Any aquatic organism, whether a fish, a clam, or a worm, will respond in some measure to the collective effects of all factors in its environment. This response may be survival and prosperity or illness and eventual death. One response, as demonstrated by early physiologists, showed that fish will use more oxygen when they are under prolonged stress. Later it was found that the "breathing rate," that is, the rate at which water is pumped over the gills, changes when a fish is exposed to stress. We have combined the early physiological discoveries with contemporary technology to develop a system to measure that change.

The biomonitoring system consists of: a series of special tanks in which the "breathing rates" are measured; a wastewater distribution and dilution system; and a mini-computer to collect, store, and analyze the data. The entire system, with holding tanks and a diluter, is housed in a trailer, so that the system can be moved to any location.

Although the theory of the biomonitoring system is complex, the operation and maintenance are relatively simple. A portion of the plant effluent after final treatment is diverted to the water distribution system in the trailer. Water is delivered in a constant flow to eight test tanks each of which contains one fish. River water is delivered to four other tanks which serve as controls. The fish swims between two electrodes, and muscular contractions associated with "breathing" are measured by a change in potential, which is caused by a bioelectrical current from contractions of the jaw and opercular muscles. Before the testing begins, normal "breathing rates" are determined for each fish from measurements taken over a period of five days. During testing, "breathing rates" are determined for 15-minute intervals and each count is compared to normal "breathing rates" for that fish. When the fish are exposed to a sublethal toxic condition, the "breathing rate" changes. If six of the eight test fish have a significant increase in "breathing rate," an alarm is sounded.

The changes in "breathing rates" correlate directly to conditions which can occur when an acid spill, system upset, or other problem occurs on a manufacturing line. The alarm advises the plant manager that the quality of the waste stream has deteriorated and he must take appropriate action. Although the system cannot identify the pollutant, it provides a warning more rapibly than conventional water quality monitoring and at a fraction of the cost.

Many Army production facilities have large containing ponds that can hold treated wastewaters for several days. After the alarm is sounded, the wastewater could be impounded in lieu of discharge. The pollutants can be identified by chemical analysis and additional treatment can be applied. Continuous information from the biomonitoring system provides a tool that enables management to recommend additional wastewater treatment when necessary.

In Europe and Africa, biomonitoring systems are being used to assay drinking water taken from large rivers polluted by industrial discharges. If fish, which are more sensitive to pollutants than man, show no signs of toxicity after exposure, the water is pumped into the drinking-water reservoirs.

Although the United States has no biomonitoring systems in practical use today, passage in 1977 of the Toxic Substance Control Act and Toxic Substance Act by the United States Congress should encourage their development. Under these laws all manufacturers will be required to demonstrate that their wastewaters do not have a toxic, mutagenic, or persistent effect upon the aquatic organisms in the receiving waters. Some industries are spending up to one million dollars to develop toxicological data for each compound present in their wastewater. The price for these data is high but, even so, the results may not apply to wastewaters of variable and complex composition such as those from ammunition plants. Therefore, a continuous evaluation is also needed. Ultimately, biomonitoring may become the final test of the adequacy of wastewater treatment and the method to safeguard environmental quality.