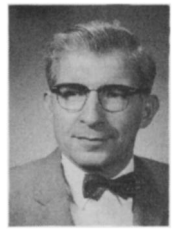
Pollutants as Input for a Food Chain

By T. C. SURRARRER

On July 7, 1970, a one-gallon glass jar was filled with chlorinated effluent from the Berea, Ohio, sewage-treatment plant. This jar was placed in good light, and the contents were aerated with a pump. After 24 hours of aeration about one quart of this fluid was siphoned into a second container and container #1 was refilled with chlorinated effluent. This process was repeated on three successive days, until container #2 was full—its contents also having been aerated continuously. A third glass jar was then begun in the same way, using fluid from the #2 and continuing the aeration. Finally, when #3 was full, a fourth container was started from #3 (refilling jars #1 and #2 as before), aerated, and filled in the same manner. (See figure.)

These four containers formed a developing ecosystem. Each day from July 1970 until the time of writing, December 1971, about one quart of fluid has been siphoned from container #4 and replaced from container #3, which was refilled from #2, which was refilled from #1. The first container was then filled again with Berea chlorinated sewage effluent.



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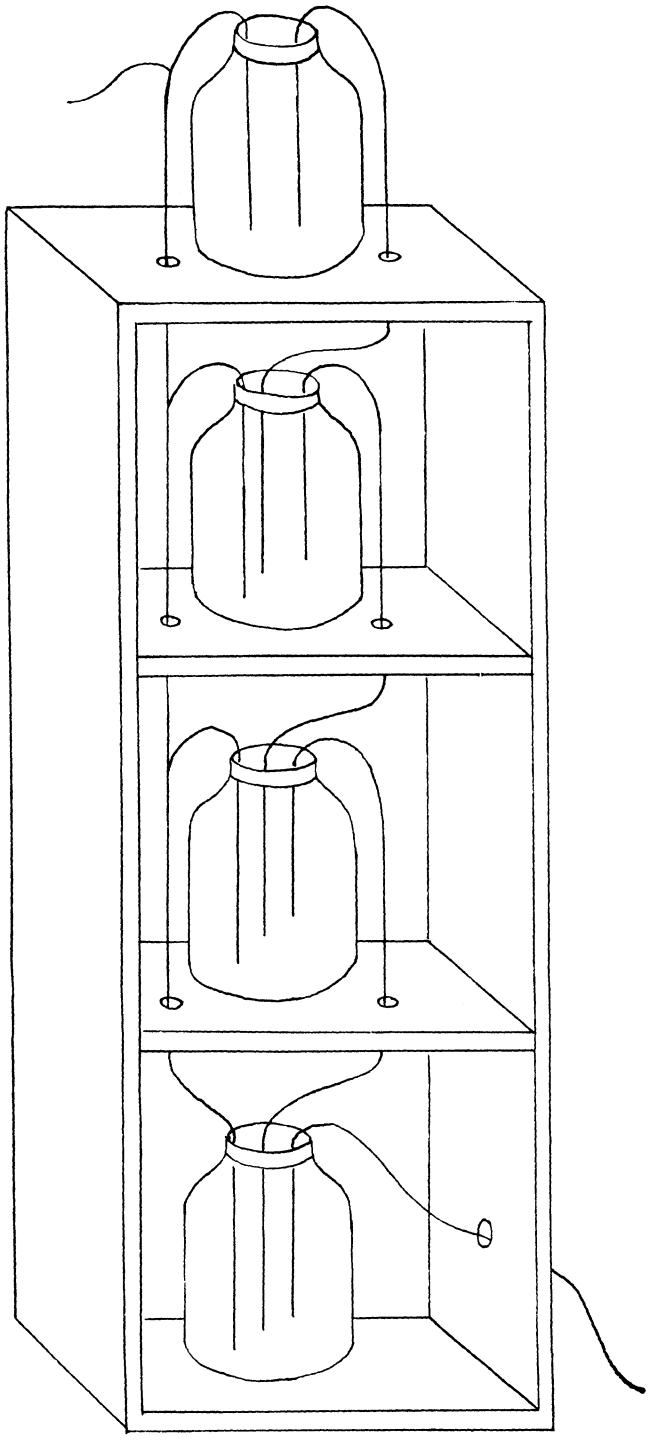
A Lush Flora and Fauna

A serious effort has been made to seed these four containers with a lush flora and fauna—the hypothesis being that the success or failure of organisms in the system is limited only by their environmental requirements. The flora and fauna were collected, by means of tow nets, from the east branch of Rocky River, on which Berea is situated. Small amounts have been seeded into each of the four jars. Larger forms, such as hydras, flatworms, segmented worms, snails, clams, crustaceans, and insect larvae, have been placed in the containers in an effort to find organisms able to succeed on the effluent input. Fish, placed in containers #3 and #4, are the only chordates in the system.

It is evident that the perfection of this miniature ecosystem mirrors the return of all matter through nature's cycles to its original state. Such a system, however, results in numerous population spikes that cannot stay in equilibrium unless there is a continuous harvest of the excess populations. This problem is common to all dynamic complexes. The stability of the system is further dependent on the varieties of organisms in the system that will interact, resulting in cycles of populations. The dynamics of such a multiple system are almost infinite.

A simple monocellular population is quickly established in the first container, with reasonable success for some flatworms, some annelids, and some gastropods. In general, the conditions in containers



Four-jar synthetic ecosystem. Container #1 is at top, container #4 at bottom. The line at left, with connections into all jars, is the aeration tube from a pump. Lines at right are siphons downward from one jar to the next; the final output siphon is from #4.

#1 to #4 become gradually more compatible for the more complex organisms. It is possible to establish populations of small multicellular organisms, such as hydras, rotifers, cladocerans, ostracods, and tubificids, on adequate populations of smaller forms.

The green plants must be encouraged in the populations of both the monocellular and the multicellular organisms: they recycle the nitrates and phosphates back into protoplasm and also produce oxygen for the aerobic flora and fauna.

It is essential that the particulate material be kept in suspension, because many of the small crustaceans are equipped with mandibles that crush the small particles caught by the maxillae and guide them into the gullet. By keeping the particulate material in suspension it is also made available to the filter-feeders. The ultimate in filter-feeders is the bivalve mollusks, whose ciliated mantle cavity and gill surface direct the particulate material, guided by the oral palps, to the gullet. This provides an easy way of removing suspended solids. The bivalve *Spherium* seems to be able to reproduce effectively in jars #2 and #3.

Snails are prolific in all jars, and many species are good scavengers. Fish will feed on a great variety of things: filamentous algae, higher aquatic plants, flatworms, snail eggs, snails, annelids, crustaceans, and fish of other kinds. A fish in jar #3 did quite well without any supplemental food for several months. Fish do well in #4, but because of their numbers they require supplemental food.

Advantages of the System

This ecosystem provides a way to study easily a complex system within a general lecture room or in a laboratory with limited facilities. The gross physical conditions can be controlled without a great outlay of money, space, or equipment. The temperature of such a system is as controllable as the temperature of the space in which the observations are being made. Dissolved oxygen can be controlled by the rate of areation through regulation of a small pump. The pH can be easily checked and adjusted. A relatively constant input and output can be maintained. Complete chemical analysis of the input and output is possible, and specific efficiencies can be determined. The fauna and flora can be controlled by cultural methods, and the bioassay of specific organisms can be checked within reasonably controlled physical conditions.

By keeping the particulate materials in suspension it is possible to prevent an anaerobic mass from accumulating on the bottom of the jars. The finely divided material that silts to the bottom of the jars is a rich biota that has a high biologic oxygen demand (BOD). The demand for oxygen probably would exceed the amount of oxygen that could penetrate the mass; therefore this material, if permitted to settle, would likely become anaerobic. This is the very phenomenon that developed in the millions of years of geologic time: organic materials accumulated in the low places, either as a result of the materials produced on the spot or that which was swept into the low places. The BOD was in excess of the oxygen available. Thus have developed swamplike environ-

ments, which accumulate sulfur-liberating compounds that give rise to "bad air." It was in places like these that the mastodons became mired—to produce pollutants that must have smelled like many of our present streams.

Extrapolating to Natural Systems

This closed but highly dynamic ecosystem provides a place to ask and perhaps solve some complex environmental problems. Observations and deductions resulting from the study of this minature system might be applied to a natural ecologic unit consisting of a drainage system and its included land mass. Ecology is the interplay of the land mass with its overlying air, its water supply and drainage, and all living organisms, including their end products, both natural and fabricated. Such a defined unit could be studied exhaustively and thus become a model for multiple units anywhere. For example, much might be accomplished by first improving the quality of the small streams by effective management of private or public property at the headwaters of the large drainage systems. If many of the small units could be improved, then with the accumulated know-how a progressive improvement might be extended to the larger rivers.

Acknowledgment.—The figure is by Karen Davenport.

PYRETHRINS FOR OUTDOOR USE

Pyrethrins—common household insecticides derived from flowers of the chrysanthemum family—are among the safest insecticides known to man. Though they've proven effective in household bug bombs, their rapid breakdown in sunlight has previously prevented their use in forest insect control. But chemists have recently developed a new formulation that keeps the insecticide active for about 48 hours. At this point, unlike DDT and other chlorinated hydrocarbon insecticides, it breaks down into harmless components and disappears.

NATIONAL SYMPOSIUM SLATED

A National Symposium on Methods of Learning Environmental Science will be held at Northeastern Illinois University, Chicago, 2–3 November. Workshops will be concerned with innovative programs on learning environmental science in elementary and secondary schools and in colleges. Student participation will be considered. Abstracts (100 words) of papers should be submitted by 15 May to Musa Qutub, symposium chairman, Earth Science Dept., Northeastern Illinois University, Bryn Mawr at St. Louis Ave., Chicago 60625.

YCC . . . from p. 149

A theme for each week drew attention to a specific part of the environment. This was supplemented by field trips to the life zones (Upper Sonoran to Arctic–Alpine) that exist from Colorado Springs (elevation 1,830 m) to the summit of Pikes Peak (4,300 m), which is about 7 km, air-line, from the city. The corps members also visited a fire tower, recreation places, and timber-management sites. They were given a brief introduction to each trip; then, in the field, they made the measurements of air and soil temperatures and of tree heights, diameters, and ages, and they learned to name the plants and estimate their abundance. They were encouraged to reach their own conclusions about proper management techniques, and they tried these out on the professionals who accompanied them on the trip.

Weeks of Self-Discovery

Parents commented on the decided changes of character that occurred in their sons and daughters. Calmness, confidence, and enthusiasm replaced restlessness, hopelessness, and cynicism. The effect of the program is best summarized in the words of a very thoughtful enrollee. Mitch Corwine, who had shoulder-length hair and real questions about the "establishment" at the beginning, said at the end of the program: "This has been the most fascinating and rewarding summer in my life. I want to thank the people who created and supported the Youth Conservation Corps for giving me the opportunity to prove to a great number of people that I am as good as anybody else." (P.S.: Mitch kept his long hair.)

For me, it was the best program and summer I've ever spent in my 12 years in the U.S. Forest Service. You science teachers are lucky: you get to work with the kids for nine months; I have them for less than three!

Acknowledgments.—Fig. 1 photo is by Phil Arkow, *Colorado Springs Sun;* fig. 2 by *Colorado Springs Gazette Telegraph.* The remaining photos are from U.S. Forest Service files: fig. 3 and 4 by Dennis Lynch, fig. 6 and 7 by Julian Ludwig.

LITTERING DOESN'T PAY

Keep America Beautiful, Inc. reports that a 10-year-old South Carolina anti-litterbug helped catch a robber. The boy saw a motorist toss paper out of his car window, so he wrote down the license number and retrieved the litter. In the litter was part of a check from a local department store that had been robbed earlier in the day. Armed with the check fragment and the license number, the police nabbed the suspect, who turned out to be wanted in three other holdups as well.