

The Ecology of **WASTEWATER:**

PART OF A TOTAL INTEGRATING SYSTEM

By Marion T. Hall

All living things, including man, and all human activities on the surface of the earth, including all of our technology, industry, and agriculture, are dependent on the great interwoven cyclical processes followed by the four elements that make up the major portion of living things and the environment: carbon, oxygen, hydrogen, and nitrogen. All of these cycles are driven by the action of living things: green plants convert carbon dioxide into food, fiber, and fuel; at the same time, they produce oxygen, so that the total oxygen supply in our atmosphere is the product of plant activity. Plants also incorporate inorganic nutrients into food stuffs. Animals, basically, live on plant-produced food; in turn they regenerate the inorganic materials—carbon dioxide, nitrates, and phosphates—which must support plant life. Also involved are myriads of microorganisms in the soil and water.

Altogether this vast web of biological interactions generates the very physical system in which we live: the soil and the air. It maintains the purity of surface waters and, by governing the movement of water in the soil and its evaporation into the air, regulates the weather. This is the environment. It is a place created by living things, maintained by living things, and, through the marvelous reciprocities of biological evolution, is essential to the support of living things. It constitutes a huge, enormously complex living machine—the ecosphere—and every human activity depends on the integrity and proper functioning of that machine. Without the photosynthetic activity of green plants there would be no continuing supply of oxygen for our smelters and furnaces, let alone to support human and animal life. Without the action of plants and animals in aquatic systems, we can have no pure water to supply agriculture, industry,

and the cities. Without the biological processes that have gone on in the soil for thousands of years, we would have neither food crops, oil, nor coal. This machine is our biological capital, the basic apparatus on which our total productivity depends. If we destroy it, our most advanced technology will come to naught, and any economic and political system which depends on it will flounder. Yet, recognition of this major threat to the integrity of this biological capital has never been a factor in establishing a tax base, especially in urban centers. That social strategy smacks of a sinister form of Russian roulette.

Every environmental effort we make requires that we look at the environment as a total integrating system, a unit, and when one part of the system is disturbed, the impact on other parts must be dealt with realistically and favorably for the health of the total system. For example, resource management and utilization requires that the by-products, often pollutants, be dealt with also as resources, that is, recycled. The planning activities of the greater community become closed-systems planning—correcting past mistakes wherever feasible, but particularly looking to the future—and are the province of the people and their governing bodies.

OXYGEN! SUPPLY AND DEMAND IN WATER MANAGEMENT

As we confront the problems of water management, it becomes apparent that there is too much demand and not enough supply of oxygen in our waterways because of man's activities. Both lakes and rivers have a phenomenal capacity to purify themselves. Sunlight bleaches out and breaks down some pollutants; others settle to the bottom and stay there, where in the bottom muds they are slowly rendered harmless by the action of anaerobic bacteria. Others are consumed by beneficial microorganisms. These water borne bacteria and fungi need oxygen, which is therefore vital to self-

purification of waters. The oxygen that sustains bacteria as well as fish and other organisms is replenished in part by natural aeration from the atmosphere—but primarily from life processes (photosynthesis) of aquatic green plants.

Trouble starts when demand for dissolved oxygen exceeds the supply. Large quantities of organic pollutants such as sewage alter the balance and overload the waterway. The overload is like a poison: it renders the entire cleansing system ineffective. One wishes that the waterway cleansed itself up to the point of the overload, but, instead, it becomes a mere carrier of wastes. Bacteria feeding upon the pollutants multiply and consume the oxygen. Organic debris accumulates. Anaerobic areas develop in the waters too, where microorganisms that can live and grow without oxygen decompose the settled and settling solids. This incomplete breakdown of organic matter produces foul odors. Species of fish sensitive to oxygen deficiency can no longer survive. Chemical, physical, and biological characteristics of a stream are altered, and its water becomes unusable for many purposes without extensive and expensive treatment.

WATER POLLUTION

Water pollution today is very complex in its composition, and is getting more so. In polluted streams and lakes there are hundreds of different contaminants: bacteria; fungi; viruses; pesticides; weed killers; phosphorus from fertilizers; detergents; municipal sewage; trace amounts of metals, even the dangerous heavy metals; acid from mine drainage and from industrial and natural particulate fallout; organic and inorganic chemicals, many of which are so new that we do not know their long-term effects on human health; and traces of drugs.

A distinction is often made between industrial and municipal wastes, but they are difficult to separate because many industrial plants discharge



their wastes into municipal sewer systems. As a result, what is referred to as municipal waste is also industrial waste. About 40 percent of all wastewater treated by municipal sewage plants comes from industry. Industry's contribution to water pollution is sometimes measured in terms of "population equivalent." In the United States pollution from organic industrial wastes similar to sewage in strength is now considered to approximate that produced by a population of 200 million.

The quality of wastewater is often measured in terms of its biochemical oxygen demand (BOD), or the amount of dissolved oxygen that is needed by bacteria to decompose the waste. Wastewater with much higher BOD content than sewage is produced by certain industries, for example, leather tanning, beet-sugar refining, and meat-packing. But industry also contributes a vast amount of non-degradable, long-lasting pollutants, such as inorganic and synthetic organic chemicals that impair the quality of water. All together, manufacturing activities, transportation, and agriculture probably account for about two-thirds of all water pollution.

Industry also produces an increasingly important pollutant of a different kind—heat. Power generation and some manufacturing processes use great quantities of water for cooling, and it goes back into streams warmer than it came out. Power plants discharging masses of hot water can raise a stream's temperature by ten to twenty degrees in the vicinity of the plant's outlet. Warmer water absorbs less oxygen and this slows down decomposition. Fish cannot regulate their body temperatures, and the additional heat upsets their life cycles; for example, fish eggs hatch too soon. Some scientists have estimated that in a few years the United States will be producing enough wastewater and heat to consume, in dry weather, all the oxygen in all twenty-two river basins in the United States—obviously with disastrous effects.

SEWAGE TECHNOLOGY: PRIMITIVE AND SIMPLISTIC

How clean do we want our waterways to be? Rivers and lakes in America serve two conflicting purposes—they are used both as sewers and as sources of drinking water for over 100 million Americans, a situation which should concern a civilized society. That's why the new water-quality standards for interstate streams already set in various states rely on criteria established by the U.S. Public Health Service and Public Law 92-500, Federal Water Pollution Control Act Amendments of 1972. In all, the PHS lists fifty-one contaminants or characteristics of water supplies that should be controlled. The problem is that there are thought to be many substances in drinking water that are not on the list, not being measured, and not being identified. The American system of dealing with wastes is to mix, blend, dilute, and transport, usually via stream, so that the sewage plant operator doesn't even know what he is treating. With nearly 1,000 new or modified chemicals on the market every year and about 30,000 new chemicals already in use in industrial and agricultural processes, it isn't easy for understaffed PHS programs to track new pollutants. Systematic identification and detailed analysis of pollutants is just beginning. Only a few years ago the PHS established its first official committee to evaluate the effects of insecticides on health because of the hue and cry from Rachel Carson's *Silent Spring*.

Many water treatment plants are hopelessly outmoded. They were designed for a simpler, less crowded world. About three-fourths of them do not go beyond disinfecting water with chlorine. That kills bacteria but does practically nothing to remove pesticides; herbicides; other organic and inorganic chemicals, especially heavy metals; and viruses from the water we drink.

A survey by the PHS in the early 1970s shows that most waterworks operators lack formal train-

ing in treatment processes, disinfection, microbiology, and chemistry. The men are often badly paid. Some of them in smaller communities have other full-time jobs and are only part-time water-supply operators. The survey, encompassing eight metropolitan areas from New York City to Riverside, California, to the State of Vermont, so far has revealed that in seven areas about 9 percent of the water samples indicated bacterial contamination. Pesticides were found in small concentrations in many samples. In some, trace metals exceeded PHS limits. The level of nitrates, which can be fatal to babies, was too high in some samples. By 1970 the PHS had found that nearly sixty U.S. communities, including some large cities, could be given only "provisional approval" for the quality of their water-supply systems. The PHS has warned that the United States is "rapidly approaching a crisis stage with regard to safe drinking water" and is courting "serious health hazards." Numerous crises have already erupted concerning the quality of drinking water in urban areas, particularly along major rivers.

Clearly, there will have to be enormous improvement in both the treatment of water we drink and the treatment of water we discard. This would have the great advantage of making our waterways better for swimming and fishing as well as more aesthetically enjoyable. Actually, it is more rational not to put poisons in the water in the first place. The sane way to keep our drinking water safe is to have industry, agriculture, and municipalities stop polluting water with hazardous substances. Some of this could be accomplished by changing manufacturing processes and recycling wastewater inside plants. The wastes can sometimes be retrieved at a profit.

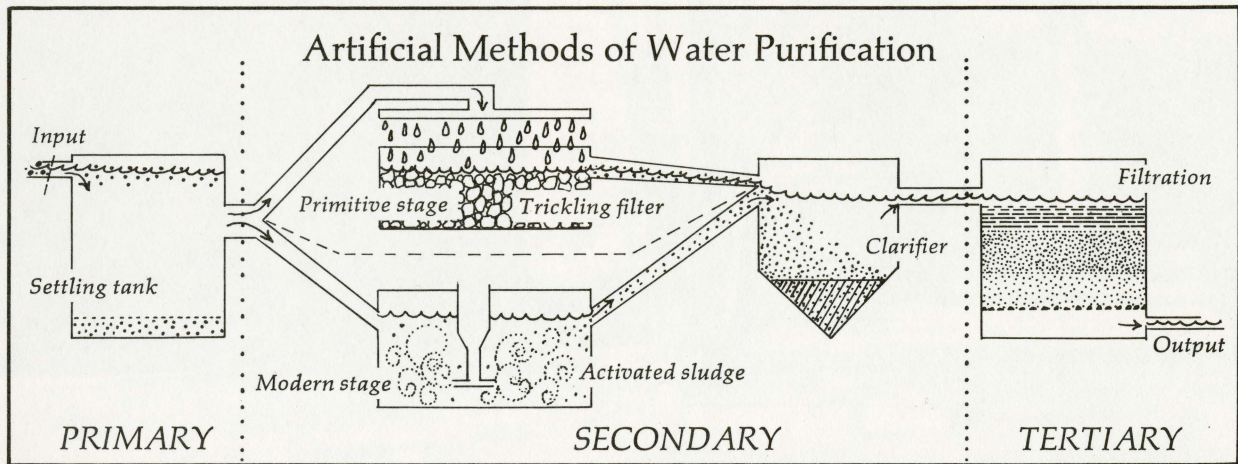
BOD ON THE ROCKS:

A TOAST TO A PRIMITIVE SYSTEM

A great deal of industrial and municipal wastewater now undergoes some form of treatment. So-

called *primary treatment* is merely mechanical. Large floating objects such as sticks are removed by a screen. The sewage then passes through settling chambers where filth settles to become raw sludge. Primary treatment removes about one-third of the gross pollutants. About 30 percent of Americans served by sewers live in communities that provide only this much treatment. Another 62 percent live in communities that carry treatment a step beyond, subjecting the effluent from primary processing to *secondary treatment*. In this age of exact science, secondary treatment looks very old-fashioned. The effluent flows, or is pumped, onto a "trickling filter," a bed of rocks three to ten feet deep. Bacteria normally occurring in sewage cover the rocks, multiply, and consume most of the organic matter in the wastewater. This is similar to the aerobic half of the processes of a natural marsh. A somewhat more modern version is the activated sludge process, in which sewage from primary settling tanks is pumped to an aeration tank. Here, in a speeded-up imitation of what a stream does naturally, the sewage is mixed with air and sludge saturated with bacteria. It is allowed to remain for a few hours while decomposition takes place. Properly executed secondary treatment will reduce degradable organic waste by 90 percent. A *tertiary treatment* sometimes follows involving removal of any remaining suspended solids and the addition of chlorine to the water to kill up to 99 percent of disease germs.

Secondary treatment in the U.S. municipalities within the next five years and its equivalent in most industrial plants is a principal objective of the current war on pollution. But today that kind of treatment isn't good enough. Widespread use of secondary treatment will cut the amount of gross sewage in the waterways, but will not reduce the subtler, more complex pollutants. The effluents will contain dissolved organic and inorganic contaminants. Among the substances that pass largely



unaffected through bacterial treatment are salts, certain dyes, acids, persistent insecticides and herbicides, heavy metals, viruses, and many other harmful pollutants.

Technical narrowness or lack of thinking about all the possible consequences of a process, has often been the curse of twentieth-century applied science and technology. Today's sewage plants generally do not remove phosphorus and nitrogen from wastewater, but turn the organic forms of these nutrients into mineral forms that are *more* usable by algae and other plants. Overgrowths of algae and other aquatic plants then rot to recreate the same problem of oxygen-consuming organic matter that the sewage plant was designed to control in the first place. The multibillion-dollar program to treat wastewater merely in the same old primitive way is myopic and insulting to our ingenuity. So far, sewage technology is inadequate and represents substantial failure on the part of the government, technical education, and the private sector to solve the problems. The original decision to dump wastes—human, animal, and industrial—into lakes and rivers was disastrous. The further decision to mix human sewage and industrial wastes compounded the disaster. Properly treated human sewage makes a valuable ferti-

lizer and can be used to grow both food and fiber crops. Mixtures of sewage and industrial wastes contain poisons and can only be used to grow fiber crops (lumber, wood pulp, etc., for packing excelsior and paper). When industrial wastes are kept separate from sewage systems, some of these wastes may be reclaimed or used as resources in by-product industries. It is important to know that wastes can become resources with proper planning and management.

Progress has been made. Pennsylvania State University did research to develop a Land Irrigation Wastewater Treatment System. Sheaffer and Bauer of Chicago utilized aspects of this system in developing a model recycling sewage system for Muskegon, Michigan, in 1973. These systems utilize effluent and sludge to grow crops resulting in excellent quality runoff, percolation, and stream water. They work at their best where there is a lot of vegetated land for the number of people.

Another approach is through fine media filtering of effluent—tertiary treatment—as in an exemplary plant at South Lake Tahoe, California. The point is that different situations require different solutions. We need to apply more imagination, experimentation, and ingenuity, instead of the same old-fashioned textbook solutions.