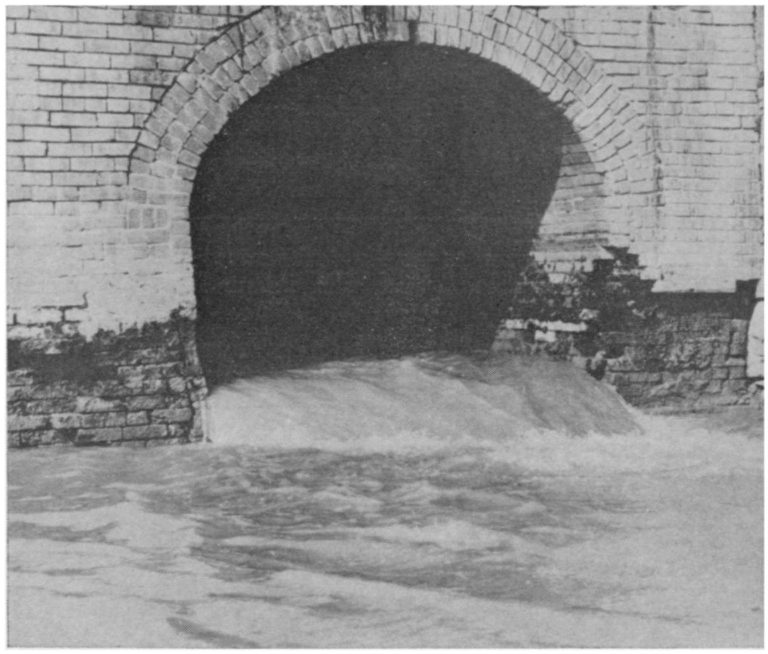
Eutrophication speeded by man



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A storm sewer: Waste into a river feeds plant growth.

Lakes age under natural conditions but man has accelerated the process. Reversal can demand heroic measures

by Richard H. Gilluly

Lakes always die. Their life span is determined by the physical, chemical and biological conditions to which they are subject.

Lakes begin by being oligotrophic—nearly sterile—with clear, clean water. Gradually silt and nutrients are added. Some of the nutrients come from minerals leached from the sides and bottom of the lake or from organic materials. Silt, other minerals and organic materials come from streams supplying the lake. Eventually the nutrients stimulate increased plant growth, and the character of animal life in the lake changes.

In time the mass of new mineral and biological material fills the lake and it becomes a marsh. From marshes, lakes finally become solid land. The whole process is called eutrophication. Without man's interference, the time span for eutrophication is measured in tens of thousands of years or longer, depending on individual conditions.

Man, by adding his nutritive wastes to lakes, has compressed the process, sometimes into the space of a few years. The classic case is Lake Erie, where the process of eutrophication has indeed been immensely accelerated. But many other lakes, in North America and all over the world, have also become eutrophic because of man's activities. Fortunately, the process is very often reversible; several area report progress.

Burke Photo

Dr. Hasler: Wisconsin lakes show signs of improvement as sewage is diverted.

Eutrophication is a complex process, varying from lake to lake in its character, rates and causes. But in most eutrophic bodies of water in the United States, the limiting nutrients are compounds of phosphorus or nitrogen, with phosphorus apparently the more important contributor in most cases.

A limiting nutrient is one that acts as an accelerator or decelerator of eutrophication as its amounts are increased or decreased. All other essential nutrients exist in sufficient quantities for more or less unlimited growth, and the limiting nutrient becomes the controlling factor.

Although phosphorus is usually the limiting nutrient in North American lakes, sometimes nitrates play the key role, as is apparently the case in Lake Tahoe, on the California-Nevada border. Sometimes nitrogen and phosphorus act together as limiting nutrients. "Nitrogen and phosphorus are the main elements causing eutrophication in Lake Erie," says Dr. Frank K. Wilkes of the Federal Water Quality Administration research division in Washington, D.C. He adds, however, that organic materials are also sometimes suspected of being the key nutrients.

Scientists use certain standard parameters to gauge the degree of eutrophication in a body of water. Because of the key role nitrogen and phosphorus play, the amounts of these two substances provide a frequently used guideline.

Because stimulation of plant growth is a prime effect of eutrophication, the amount of chlorophyll in a lake is another commonly used parameter, as is a simple measurement of the weight of plant growth per acre. The number of plant cells per milliliter of water is

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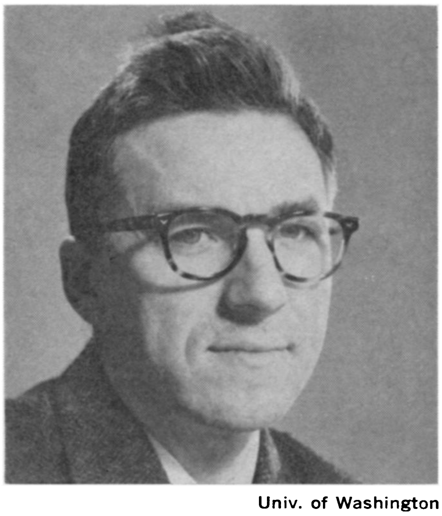
Rivers pour wastes, including nutrients, into Cleveland Harbor and Lake Erie, speeding the eutrophication process.



Univ. of Washington

Dr. Edmondson: Phosphorus indicted.

another guide. One of the oldest devices for gauging eutrophication is the Secchi Disk, a 20-centimeter white disk that is lowered into water on a calibrated line. The distance it can be seen through the water measures water clarity, which decreases sharply in a eutrophied lake. Productivity measurements detect the amounts of respiration and photosynthesis in a lake, or the amount of carbon 14 uptake into algal cells.

Lake Sebasticook in Maine, a highly eutrophic lake, for example, had total nitrogen levels, in one measurement, of nearly two milligrams per liter and total phosphorus of 1.33 milligrams per liter. The cell count in Lake Sebasticook is about 200,000 per milliliter—compared to 50,000 to 100,000 in an average eutrophic lake and 100 in a highly oligotrophic lake.

Parts of Lake Tahoe in the Sierra Nevada Mountains in California and Nevada are still highly oligotrophic. In these areas, total nitrogen is in the range of 10 micrograms per liter and total phosphorus three to four micrograms per liter. Secchi Disk measurements can range from two inches in a highly eutrophic lake such as Lake Sebasticook to as much as 40 meters in clear oligotrophic mountain lakes.

The parameters provide clues to the kinds of damage done by eutrophication. The sheer volume of plant material reduces living space in lakes for other organisms, particularly valuable game and commercial fish. The nature of the plant growth is often of as much concern. Blue-green algae form foul-smelling scums on lake surfaces and along shorelines. Aerobic bacteria consume oxygen in the process of decaying the algae and other plant material. Thus, the level of dissolved oxygen decreases and the lake is less able to support the game fish that generally require more oxygen than the hardier carp and other trash fish that replace them.

Some of the blue-green algae are poisonous to man and animals, causing contact dermatitis in swimmers, for example. Other algae cause a foul smell or taste in drinking water drawn from lakes.

Eutrophication is not confined to lakes. A similar process occurs in rivers, notably slow, sluggish ones such as the lower Potomac, or rivers that have been extensively dammed, such as the Ohio and parts of the Missouri.

Any body of water has a limit beyond which it can no longer assimilate nutrient materials without eutrophication. The limit is controlled by variables such as the rate of flow-through, the purity of the source of water, the depth—eutrophication accelerating greatly as a lake grows shallower, partly because of

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Presence of pollution and eutrophication makes recreational use hazardous.

the availability of sunlight for photosynthesis in shallower waters—and the rate at which organisms die and release nutrients they had locked up while alive.

These factors often have profound effects on the ability of a lake to recover from eutrophication. Lake Washington in Seattle, for example, began to show signs of serious eutrophication in the 1950's, as a result of the addition of 20 million gallons of sewage annually from the growing population around the lake. Residents, spurred by the League of Women Voters, passed a $121 million bond issue to build an entirely new sewage system. The system—completed in 1968—collects wastes from all around the perimeter of the lake and releases them after treatment into Puget Sound where a four-times-a-year water turnover allows assimilation.

"The lake is back to its condition in 1950 now," says Dr. W. T. Edmondson of the University of Washington. "Prompt action headed off trouble before it really got bad."

Man had a lot of help, however. Lake Washington is a deep lake, about 240 feet at its deepest. Its rate of flushing is not particularly rapid, about one-third of its volume a year. But the water entering it is from particularly pure mountain snow-melt sources. Incidentally, says Dr. Edmondson, "phosphorus turned out to be the dominating problem, algae growth being in direct proportion to phosphorus." He adds that treated sewage alone adds a large amount of phosphorus, but that detergents may nearly double this. Situations like this are the reason for the current thrust to get detergent companies to remove phosphates from their product, since these phosphates are the largest single apparent source of nutrient phosphorous.

"This is generalizable to most places, and the move to change detergents has a lot of sense to it," says Dr. Edmondson.

There is a caution, however. Nitrogen also is a nutrient and the likeliest candidate as a replacement for the phosphates in detergents is a nitrogen compound: nitrilotriacetate (SN: 4/25, p. 408).

Detergent manufacturers, warns Dr. Arthur D. Hasler of the University of Wisconsin, should move very slowly in substituting nitrogen compounds for phosphates until thorough ecological studies have been made.

Dr. Hasler says Lake Monona and other lakes near Madison, Wis., have recovered less dramatically than Lake Washington, but that changes that have taken place since sewage was diverted elsewhere and some plant life physically removed have been significant. But slowing progress has been the fact that water entering the lakes is already enriched from the highly productive agricultural land around Madison. Dr. Hasler says the flow-through time—which is more rapid for the Wisconsin lakes than for Lake Washington—is less important than the rate at which phosphorus is precipitated into bottom sediments from which it is released only very slowly. Dr. Hasler agrees that phosphorus is a critical element in eutrophication. He says this is particularly frustrating in Madison, where nearly every house has a water softener, and high levels of phosphates in detergents are not really necessary.

Dozens of solutions to eutrophication have been suggested and many tried. In the view of some scientists, some have actually intensified the problem. Killing of algae by copper sulfate at Madison lakes, for example, simply makes the algae available for decay and ultimately makes the problem worse, according to Dr. Hasler. He suggests instead the actual removal—or cropping—of plant life in eutrophied lakes.

The most obvious approach—the one taken at Lake Washington and the Madison lakes—is to divert sewage or other nutrients entering a waterway, or to remove nitrogen and phosphorus from sewage through tertiary treatment. Another ecological approach that has been proposed is dredging of bottom sediments when there is a major interchange of nutrients between the sediments and waters above. Biological controls are yet another approach: snails, for example, have been used to harvest weeds in some southeastern states. Dr. Charles C. Goldman of the University of California at Davis will experiment with a unique solution in Lake Tahoe this summer. He plans to learn whether crayfish, which thrive in eutrophic waters, may be able to tie up nutrients for long periods and slow their recycling.

But the problem is further complicated by political, economic and social considerations. Lake Tahoe, which in some areas is showing signs of eutrophication, is under the control of 70 different political subdivisions in two states. Lake Erie, with an immense population in the two nations surrounding it, poses even greater problems. The technical means exist to halt or reverse eutrophication, but the outlook is for slow progress. □