Our Waters Our Wastes

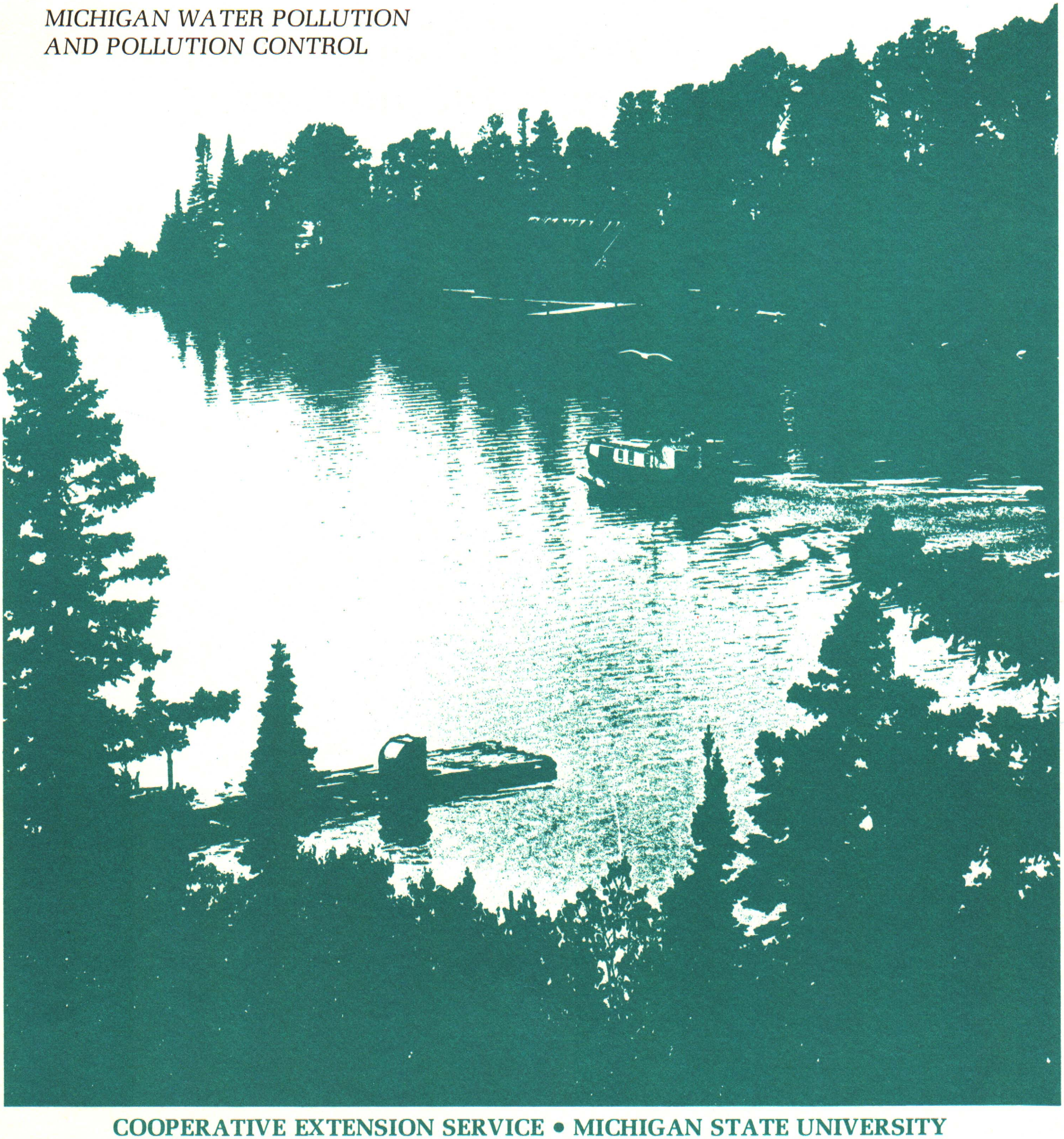
Michigan State University
Cooperative Extension Service
Ray J. White, Extension Specialist, Aquatic Ecology
Suzanne Tainter, Editor

October 1975
28 pages

OUR WATERS OUR WASTES

MICHIGAN WATER POLLUTION AND POLLUTION CONTROL

Extension Bulletin E-891
Natural Resources



COOPERATIVE EXTENSION SERVICE • MICHIGAN STATE UNIVERSITY

OUR WATERS OUR WASTES

Michigan Water Pollution and Pollution Control

RAY J. WHITE,
Extension Specialist, Aquatic Ecology
SUZANNE TAINTER,
Editor

Department of Fisheries and Wildlife
College of Agriculture and Natural Resources
MICHIGAN STATE UNIVERSITY

CONTENTS

PHOTO CREDITS

Michigan Department of Natural Resources
Cover, 2, 10, 12, 13, 14, 16, 24
MSU Department of Agriculture Engineering
2, 18, 19
MSU Department of Fisheries and Wildlife
1, 4, 6, 7, 8, 14, 17
MSU Institute of Water Research
6, 20, 22, 23

WATER QUALITY — the quality of life in Michigan depends on it. Our health, our food, many jobs, numerous leisure activities, abundant fish and wildlife all rely on high-quality water. And what would be the beauty of our state without its waters? In short, our rivers, streams, lakes and groundwater govern our well being — and that of the environment.

Four Great Lakes highlight Michigan's water resource. The waters of Superior, Michigan, Huron and Erie wash 3,200 miles of coast. Only Alaska has more deepwater shoreline. Eleven thousand inland lakes bejewel our lands. Rivers and streams wander 36,000 miles through the state. Groundwater abounds. Our freshwater resource is unequalled in the United States. The quality of this vast resource depends on us.

We are the pollution problem. Michigan's population has grown rapidly — nine million at this moment, possibly reaching 12 million before we can stabilize it. One person produces an average 120 gallons of wastewater (sewage) daily. This means we must dispose of one billion gallons of wastewater in Michigan every day.

Farming operations are becoming more intensified, complicating agricultural waste disposal, while industry, transportation and recreation are expanding. We produce and consume goods at ever-increasing rates. And our wastes are growing in complexity as well as quantity.

Streams often carry wasteloads that poison aquatic organisms. Most Michigan streams eventually carry impurities into the Great Lakes. Small rivers and streams first betrayed our out-of-sight-out-of-mind attitude to our wastes. Lake Erie showed us that size gives no immunity to shortsightedness.

Nine million people multiplied by thousands of water uses adds up to a tremendous impact on our water resources. We must combine upgraded waste treatment with population control and reduced waste production if we are to sustain and improve Michigan water quality. ■






Water Pollution

WATER IS POLLUTED when something carried in it becomes unfavorable for the life that depends on that water. Water carries dissolved gases, dissolved salts (including metals), disease organisms and heat. All are pollutants when added to water in amounts that upset the functioning of individual plants and animals or of natural communities of living things.

Some pollution acts rapidly and obviously. Spills of toxic materials kill masses of fish or poison people and livestock. Other forms of pollution act slowly and subtly. These may cause creeping deterioration of natural communities. To recognize the "illness" that is low-level pollution, we must first be able to identify lake or stream "health."

Health in any living system — one animal or an entire ecosystem — requires *proper functioning*, the *ability to cope with stress*, and *the capacity for self-repair*. Pollution hampers these activities.

We Cause Most Pollution

Pollution seldom occurs naturally. Landslides and devastating forest fires are brief and infrequent. Natural vegetation soon heals the wounds. Toxic salts seep from natural deposits in localized areas, but plants and animals in such areas are usually adapted to these conditions through centuries of exposure.

More prevalent and more persistent than natural catastrophies is pollution caused by people. People pollute (1) by promoting land erosion and unnaturally rapid precipitation runoff and (2) by adding pollutants directly to waters.

Land disturbances destroy the earth's plant mantle, which retains and recycles chemicals and water. Draining marshes, channelizing streams, excavating for buildings, roads and mines, paving streets and parking lots, tilling cropland, grazing and some logging practices — almost any major change we make in the landscape — can cause pollution.

We add wastes directly through either *point sources* or *diffuse sources*. Point sources inject pollutants at specific locations. Examples are outlets from urban wastewater treatment plants, industries and feedlots. Diffuse sources are harder to recognize, therefore often harder to remedy. They include soil and fertilizer runoff from cropland and lawns, biocide drift (especially pesticides or herbicides) and seepage from septic tank systems.

Kinds of Pollutants

Industrial wastes are often complex. They may contain numerous chemicals: oils, acids, dissolved salts and metals. Many add unhealthy heat. Michigan's three largest industrial discharges are cooling water, food processing wastes and auto manufacturing wastes.

Agricultural wastes are primarily organic matter: plant and animal tissues or excrement. The U.S. Department of Agriculture estimates that U.S. farm animals will produce about 2 billion tons of wastes this year. Unless we keep these wastes out of our waters we face serious water pollution problems.

Municipal sewage is also mostly organic matter. Disease bacteria and viruses are special worries with human wastes. Phosphate detergents can as much as double phosphorus levels in municipal sewage. Thus, municipal sewage is the single largest source of phosphorus in our waters. Urban runoff water often contains as many pollutants as sewage — lawn fertilizers, leaves, ashes, pet droppings, road salt, tire grindings, oils and drippings from machinery, as well as contaminants washed out of air by rain.

Soil erosion also pollutes. Soil particles carry pesticides and nutrient chemicals. The sediment itself clogs and smothers aquatic areas. Sediment is by volume our greatest pollutant. Building and highway construction and some farming practices often lead to unnecessary soil loss. Removing river bank and lakeshore vegetation also contributes to erosion. ■

Pollution Sources — raw sewage discharge; trash pile on Lake Michigan shøre; livestock wastes; storm water; soil erosion; industrial discharge.

DEBRIS ON LAKE ERIE SHORE — sign of abuse. Still, a lake or stream with no evidence of dead fish would not necessarily be free of pollution.

Pollution Effects

OIL COATED ducks, dead fish, closed swimming beaches, canoe paddles heavy with slime and weeds — we remember the effects of water pollution that kill wildlife or interfere with our pleasures. Water pollution has other less obvious effects every bit as detrimental to our waters.

Water pollution affects aquatic organisms in three major ways: *it poisons, it changes the water environment* and *it disrupts ecosystem processes.* Pollution can kill (lethal effects) or have many lesser (sublethal) effects. It can change the types of plants and animals that live in a river or lake.

Rivers, lakes and streams are more than water. Each is an *ecosystem,* an interrelated complex of animals, plants and nonliving chemicals — dissolved gases, dissolved salts and solid particles. Driven by energy from the sun, the ecosystem constantly cycles the chemicals which serve as nutrients for the plants and animals.

The nutrients, mainly phosphorus, nitrogen and carbon, together with oxygen and hydrogen, are cycled among the organisms. Green plants, including algae, use sunlight to make their own food by the process of *photosynthesis.* As they grow, plants tie up nutrients in tissue. Animals eat plants, and the nutrients form animal tissues. Bigger animals eat the smaller animals. Bacteria decompose dead plants and animals releasing nutrients to the water, and the cycle begins again.

Bacteria consume all organic matter, including wastes people add to waters. They use oxygen in the process. Oxygen is replenished to water by photosynthesis and by contact with air at the lake or stream surface. If great quantities of wastes are added to water, bacteria use oxygen faster than it is replaced. Then dissolved oxygen diminishes, and animals suffer.

Aquatic Life Requirements

Animals living in aquatic environments share many of the basic requirements of land animals. They need oxygen, water, food, shelter and, if the population is to endure, successful reproduction. In addition, aquatic animals die when temperature is above or below certain levels, and they thrive only within a very narrow temperature range. When a pollutant interferes with these essentials, it can mean disaster for aquatic life.

Safe Levels

Practically any substance in large enough doses will be lethal, even substances common in the environment such as oxygen and carbon dioxide. But, when determining a safe level for a toxicant or poisonous substance, we must do more than find a level that does not kill the organism. A safe level must have no sublethal effects. It must not interfere with the animal's food supply, its breeding habitat or its behavior. It should not increase the abundance of disease organisms, nor should it make the animal more susceptible to disease or predation. Animals in the wild often have all they can do to cope with natural environmental stresses. Added hardship from a pollutant can tip the balance between survival and death.

Other factors enter into the effects of pollutants on organisms. Rarely is only one pollutant present. Some toxicants are *synergistic* — more potent in combination than would be the total effect if both pollutants occurred at the same time but acted alone. Environmental conditions alter sensitivity to toxicants. For example, copper is more toxic to fish in soft water than in hard water. The animal's life stage also makes a difference. Coho salmon fry are killed by DDT at levels that seem to have no effect on adult salmon.

Some Pollutants

MAN-MADE CHEMICALS

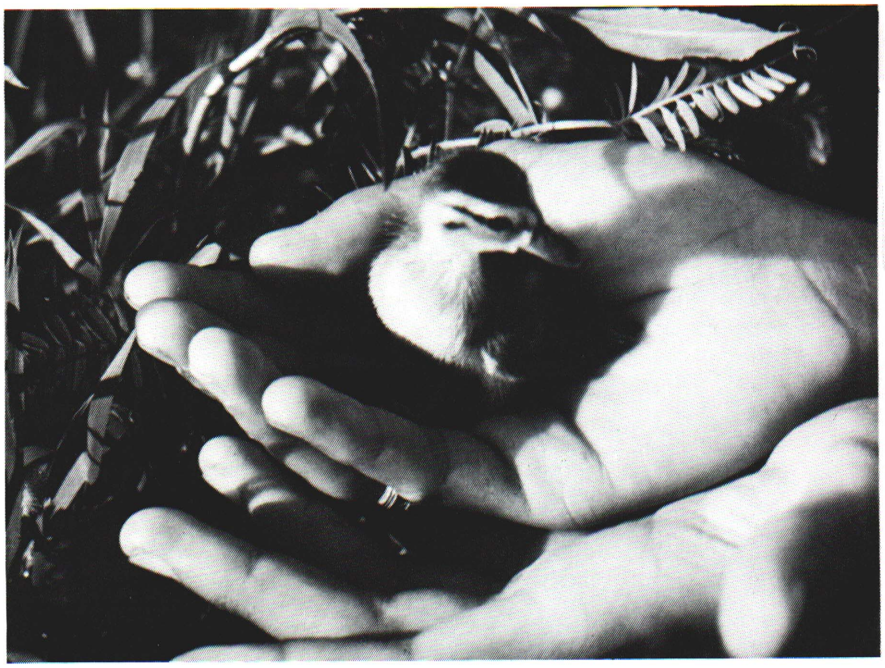
Man-made chemicals, often developed to kill pests, also kill aquatic organisms. Where the killing is not immediate, they have insidious effects that end in premature death. DDT interferes with the ability of fish to adjust to temperature changes. The herbicide 2, 4-D reduces the natural resistance of fish to some parasites.

A grave problem with persistent chemicals is *biomagnification*. For example, animals retain and concentrate pesticides from tissues of organisms lower on the food chain which they have eaten. Scientists trace population declines in fish-eating birds such as osprey, peregrine falcons and herring gulls to accumulated DDT. The DDT causes reproductive failure by interfering with calcium metabolism. The birds lay eggs with abnormally thin shells that break when the birds incubate them.

Humans eat high on the food chain, but like other mammals they excrete DDT more readily than birds. We know little about the impact on human health of DDT and the chemically-similar PCBs (polychlorinated biphenyls), widely used industrial chemicals. Accumulated levels of these chemicals forced restrictions on commercial sale of Lake Michigan salmon, chubs and lake trout. DDT use is now banned in the Lake Michigan watershed and all PCB discharges stopped. DDT and PCB concentrations in these fish are now apparently declining.

METALS, SALTS, ACIDS AND OILS

We know mercury-contaminated fish endanger human health. Mercury damages nerve tissue, paralyzes and kills. The State of Michigan halted discharges of mercury in 1970 when levels higher than those allowed by the U.S. Food and Drug Administration were discovered in fish from Lake St. Clair. Other metals, salts, acids and oils, from such activities as clearing icy roads, manufacturing, mining, shipping and irrigation may destroy aquatic life, interfere with natural stream purification, corrode water treatment equipment, and raise the cost of waste treatment.



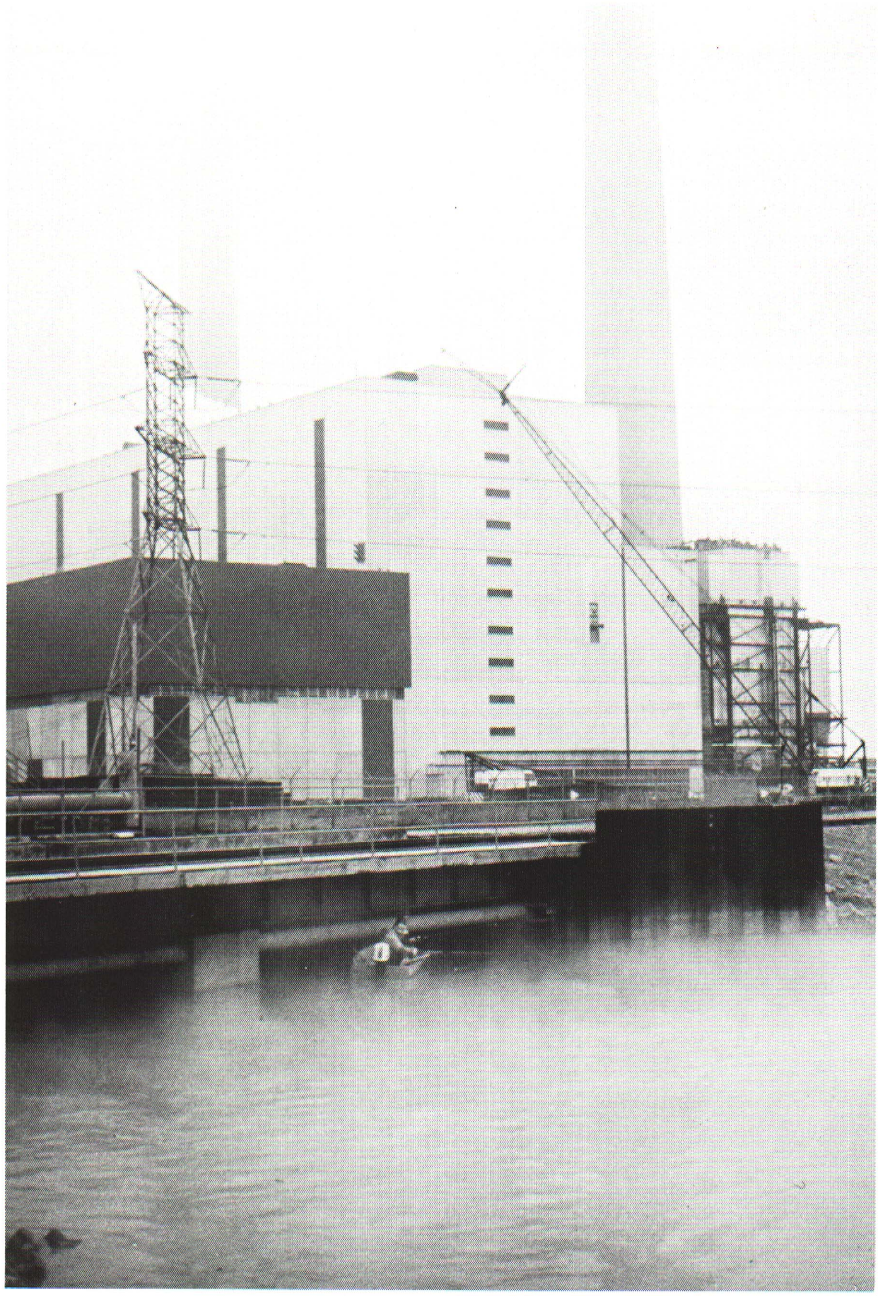
Young wildlife is especially vulnerable to pollution from chemicals such as mercury, pesticides and industrial chemicals.

HEAT

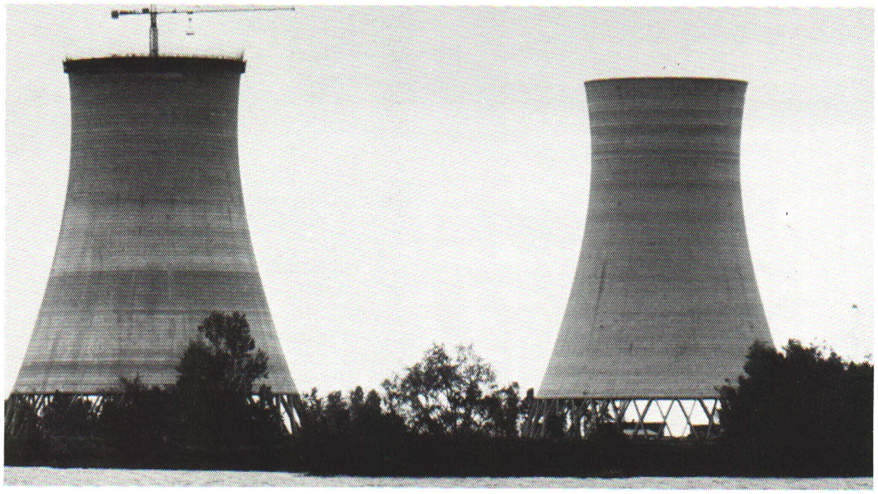
Thermal pollution can stress an entire ecosystem. Abnormal heat throws ecosystem events out of *synchrony;* for example, fish eggs may hatch before their food supply is available. Heat stresses food organisms. Daphnia (water fleas) live only one-fourth as long in water near 80°F as in water at 50°F. As temperature rises, fish become more active and use oxygen faster. But the ability of water to hold dissolved oxygen decreases. Aquatic communities are adapted to the particular oxygen supply and temperature of their habitats. If we raise the temperature, we may change the community. Rough fish such as carp are adapted to warm water. Tolerant of low oxygen conditions found in polluted situations, carp tend to replace such fishes as trout and cisco which require cold water with high oxygen content.

SEDIMENT

Something as seemingly harmless as soil can also be detrimental to aquatic life. Soil particles carry with them dangerous chemicals and organic matter, but the sediment itself is also harmful. It makes water turbid or cloudy. This interferes with sunlight transmission necessary for photosynthesis. And it hinders fish that hunt food by sight. Sediment smothers bottom-dwelling organisms and buries breeding sites. It fills stream pools. When sediment reduces water depth, and water is more exposed to summer sun and winter cold, water temperature becomes more extreme. Sediment pollution particularly threatens streams in agricultural areas.



Electrical generation plants are the largest users of water for cooling. This is often discharged back into lakes or streams (above). Cooling towers (below) put excess heat in air instead of water.



ORGANIC WASTES

Organic wastes reduce the amount of oxygen available to aquatic life. This can be so severe it suffocates fish outright, or oxygen can hover at a level just low enough to prevent good growth. The oxygen-depleting potency of organic wastes is expressed as BOD (biochemical oxygen demand). BOD tests measure how much oxygen organisms need to digest wastes in the water.

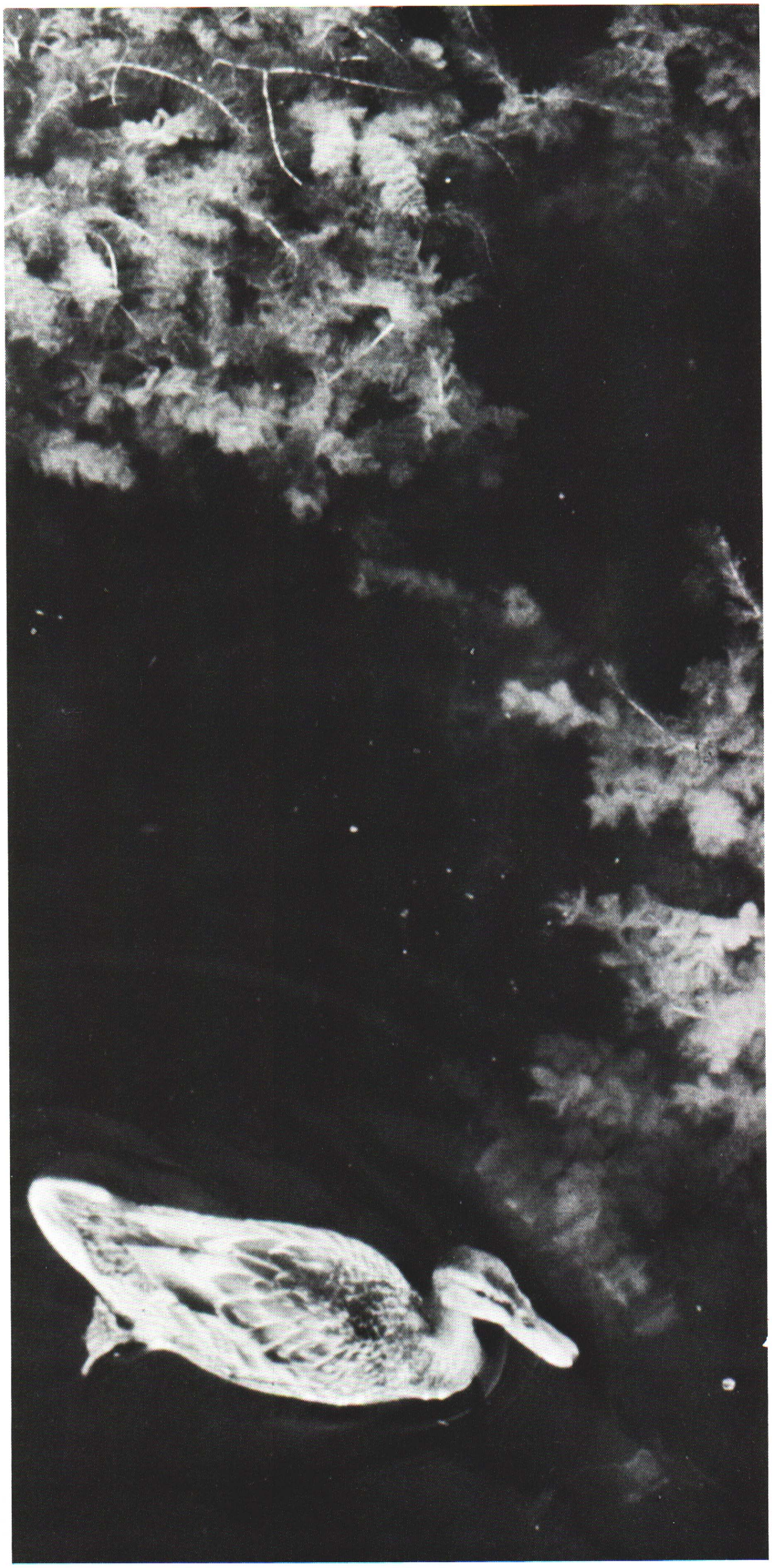
Heavy coatings of organic matter accumulate on stream bottoms as sludge blankets. Unsightly masses of gray, white, pink, yellow or brown "sewage fungus" coat objects. Pollution-tolerant organisms such as sludge worms, rattailed maggots and blood worms replace more sensitive bottom organisms.

Decomposition of organic wastes releases nutrient chemicals to the water.

NUTRIENT CHEMICALS

Nutrient chemicals affect aquatic life by stimulating lush plant growth. Bacteria decomposing this excessive plant matter strip the water of dissolved oxygen. Furthermore, nutrients are rereleased to the water to stimulate more plant growth. Algae blooms interfere with other plant growth. Algae can make the water turbid and produce unpleasant tastes and odors. Removal of off-tastes increases the costs of drinking water treatment.

The kinds of pollution that stimulate aquatic plant growth interact in the process of *eutrophication* — overenrichment of lakes and streams. It is a nuisance we create for ourselves. ■



Nutrients produce abundant weeds.

Heavy weed growth and algae combine to threaten the usefulness of small lakes (above). The Great Lakes are not immune. Algae in a severely enriched Lake Erie embayment (right).

Eutrophication

Michigan's Number One Lake Problem

EUTROPHICATION is the process of nutrient enrichment of lakes, streams and ponds. Wastes and fertilizers pour, seep and erode into waters, adding unnatural concentrations of nutrients. Phosphorus is usually the key chemical. The nutrients produce a superabundance of algae and rooted plants. Eutrophic lakes are literally overfed.

Eutrophication is one of the subtle forms of pollution. It builds gradually. But when it reaches visibility, a sometimes sudden turning point, we become painfully aware of it.

Piles of scum and slime build up on rocks and beaches. Leafy aquatic plants flourish. Blue-green algae blooms die and rob the water of oxygen as they rot. The water turns unpleasant shades of green or brown, gray or yellow and may taste and smell obnoxious. Rough fish replace more desirable kinds. Eventually weeds and sediment fill the lake completely. It is no longer a lake but a bog marsh. Not even Lake Erie, though it's 240 miles long and 50 miles wide, is immune to this process.

Through the centuries, lakes gradually fill with sediment. In most lakes the bulk of the sediment is decaying plants and some mineral soil. Without human interference, the filling proceeds at an almost imperceptible pace.

Between occasional episodes of filling and enrichment after forest fires and landslides, Michigan lakes healed and remained virtually stable for thousands of years — until modern human settlement. Now lakes suffer incessant overenrichment.

Overenrichment stems from sewage treatment plant discharges, septic system seepage, runoff from lawns and fields and erosion. Phosphorus-saturated soils no longer remove phosphorus from septic tank effluents. Scientists know that phosphorus passes into lakes through some Michigan soils from as far away as 300 feet. To protect water quality, septic systems should be located in suitable soil at least 300 to 400 feet from lakes, much farther away than many are located.

The best way to deal with eutrophication is to reduce nutrient inflow. Scientists consider phosphorus the nutrient to control in most cases, partly because it is more readily curbed than other major nutrients. Carbon and nitrogen are available to aquatic plants through water contact with air as both occur in atmospheric gases. Overabundant phosphorus usually results from human activities. Phosphorus inflow can be cut if we will exert the effort.

Reducing phosphorus inflow to lakes has dramatic results. Lake Washington in Seattle, Lake Monona in Madison, Wisconsin, and several German lakes all recovered from severe eutrophy because concerned people removed major nutrient inputs to these lakes, primarily sewage discharges. Scientists were surprised at how rapidly the lakes recovered. For instance, in only three years Lake Washington's algae problem was less severe than it had been in 60 years. Rapid improvement occurs because lakes tie up phosphorus in lakebed mud. This takes phosphorus out of circulation, allowing lakes to recover, once new phosphorus inputs are reduced.

Eutrophication is the No. 1 problem facing Michigan lakes. The Department of Natural Resources recently determined that about one fourth of Michigan's largest inland lakes are eutrophic. Lake Erie, until recently, was considered "dead." ■

Michigan Water Quality

Where are the Problems?

MICHIGAN illustrates the impact of population on water quality. From the Upper Peninsula to the southern Lower Peninsula, population increases and water quality deteriorates. The Upper Peninsula is sparsely populated. It is forested rather than agricultural, and water quality tends to be good.

In the agricultural and industrial southern half of the Lower Peninsula, over half of the state's people live on one tenth of the land area. Water quality is correspondingly poor.

The northern half of the Lower Peninsula has water intermediate in quality. Recreational pressures are mounting in this area. Seventy million people live within a day's drive of northern Michigan. Grand Traverse County had 40 subdivisions in 1960 and 900 in 1970. Most hug the shores of its 82 inland lakes and Lake Michigan.

Water quality in the Great Lakes shows this same relation to human activities. The upper Great Lakes — Superior, Michigan, Huron — overall have high quality water. Shore areas and bays where people and industry have concentrated show deteriorating water quality.

Superior, the largest and least populated of the lakes, is the least affected by human activities. Thus far, its pristine waters have endured abuses from shipping, mining, lumbering and municipal wastes.

Lake Huron also has high water quality except for Saginaw Bay, which is three times as eutrophic as the rest of the lake.

Lake Michigan, however, shows serious deterioration. One reason is its watershed — all the area that drains into the lake. It is more populated, industrial and agricultural than the Superior and Huron watersheds. Another reason is that wastes are less readily flushed from this lake. Water entering Lake Michigan today will still be there 30 to 100 years from now. Over the last 100 years the chloride concentration doubled, and sulfites tripled in the lake. At present, severe eutrophication is limited to Green Bay and the Chicago area. If we continue to add nutrients at present rates, even this vast and deep lake will likely follow the pattern of shallower Lake Erie.

Erie is the most beset by municipal and industrial inputs of any of the Great Lakes. Almost 12 million Americans live close to its shores. In the western basin, which receives half the nutrient input, enrichment has led to increased turbidity. Municipal water supplies require costly treatments to remove tastes and odors caused by algae. Pollution-tolerant organisms have replaced previous bottom dwellers. Valuable fishes have declined severely, rough fish taking their place. Every summer the lake has a dead spot, totally bereft of oxygen and inhabited only by certain bacteria. Lake Erie ended our delusion that these vast inland seas could absorb unlimited waste loads. ■

Recreational demands on our water resources will be among the most difficult to satisfy as the Michigan population continues to grow.

What's Being About

Enforcement

IT IS THE RESPONSIBILITY of the Michigan Department of Natural Resources (DNR) to stop water pollution, prevent it and clean up already polluted waters in Michigan. The DNR subdivision charged with this task is the Bureau of Water Management.

Since Michigan's early start in pollution control in 1934, most efforts have been aimed at point source discharges — municipal treatment plants and industrial facilities. Var-

The secchi disk gives an indication of water transparency. It is lowered into the water until no longer visible and a depth reading taken. This is one of the measurements taken on Michigan lakes by the DNR's Inland Lakes Section.

Done It?

Virtually all Michigan streams empty into the Great Lakes. The Kalamazoo River carries its burden of sediment into Lake Michigan.

ious state and federal regulations are enforced by the DNR.

One regulation requires that, by 1977, municipal treatment plants must be capable of removing 80% of phosphorus in their wastes. The cleansing act forbids the sale of laundry products that contain more than 8.7% phosphorus. Together, these requirements should significantly reduce phosphorus inputs from municipal sources.

The heart of the DNR program to reduce industrial discharges is the National Pollutant Discharge Elimination System (NPDES) created by the 1972 Federal Water Pollution Control Act. This program supersedes a similar permit program which Michigan instituted in 1948. Permits individually tailored to each plant limit the types and amount of discharges and set schedules for compliance. If demonstrated interest warrants it, the DNR must hold public hearings before granting a permit.

Another aid in the industrial cleanup campaign is Michigan's unique "truth in pollution" act. All industries must report their byproducts and wastes. From this information, the DNR can anticipate pollution problems.

The DNR uses scheduled monitoring programs, surprise plant visits and surveys by boat and helicopter to keep track of waste disposal. All industries pay fees to offset surveillance costs.

As an incentive to upgrade industrial waste treatment, the state gives tax exemptions for construction of waste treatment plants. And to insure that both industrial and municipal treatment plants are operating efficiently and correctly, the state trains and certifies treatment plant operators.

Besides regulating continuous discharges from industrial plants, the DNR enforces a regulation designed to minimize water pollution from accidents — the Pollution Incident Prevention Plan. Companies storing hazardous materials such as oil and salt must have DNR-approved plans that specify storage conditions and accident cleanup plans. All incidents must be reported to the DNR.

Encouraging Results

Ultimately, pollutants discharged to Michigan waters reach the Great Lakes, as the entire state lies in the Great Lakes drainage basin. Many of Michigan's water pollution control programs improve water quality in the Great Lakes by cleaning up the streams that feed them. It is in these streams that we are making headway in the battle against water pollution.

The Detroit River, Lake Erie's main tributary, shows great improvement. State programs have cut chloride inputs in half and reduced phosphorus by almost two thirds. Oil once claimed 40,000 ducks a year. It now kills less than 100. Last spring the DNR planted trout and salmon in the river.

In 1967 the Hersey River had a sewage loading that drove dissolved oxygen levels to nearly zero three miles downstream from Reed City. The municipal treatment plant was upgraded to comply with new regulations. Now the river again supports trout.

The Tittabawassee River receives wastes from the city of Midland and a chemical company. A very substantial improvement in the biological quality of the river is a result of the company's pollution abatement program. It put in cooling towers for heat, pond diversions for waste spills and upgraded general waste treatment.

The Raisin River was once devoid of aquatic life for 5 miles downstream from Adrian. The river now shows improved quality since waste inputs from storm sewers, and municipal and industrial discharges were reduced.

The Kalamazoo River still shows biological degradation for 5 miles between Kalamazoo and Otsego; but 20 years ago, degradation extended 34 miles. Additional improvements are expected as scheduled wastewater treatment improvements are carried out.

Aid for Ailing Lakes

Michigan's inland lakes are given special attention by one section of the DNR Bureau of Water Management. The *Inland Lakes Monitoring Program* surveys Michigan lakes to pinpoint existing problems and provide information for lake management programs. The survey shows Michigan lakes receive almost 100 kinds of industrial and municipal discharges. The Inland Lakes section enlists the aid of lake associations in a self-help program. Local residents take samples and relay results to the DNR.

Reducing Diffuse-Source Pollution

As point-source discharges are brought under control, the DNR is increasing efforts to regulate diffuse-source pollution. The 1972 *Soil Erosion and Sedimentation Act* is helping them regulate erosion. This act requires permits for all significant earth changes except agriculture. It will help the DNR prevent incidents such as the Kidd Creek fish kill where tons of soil from a Traverse City shopping center construction site washed into the creek, killing thousands of fish. The law exempts agriculture, but farmers have a vested interest in conserving topsoil. They can work out conservation plans with the Soil Conservation Service and MSU County Extension Agents.

Storm water is a diffuse source getting more attention as municipal effluents are improved in quality. Storm runoff contains nutrients, metals and other substances that can make it as serious a pollutant as raw sewage. In many cities, storm and sanitary sewers are combined. During storms, part of the water, including some raw sewage, bypasses the wastewater treatment plant and discharges directly to streams or lakes. Separating sewers is expensive but necessary. As an alternative, communities hold such overflow, sending it through the treatment plant during low flow periods. This has the advantage of treating the storm water as well as the sewage. ■

Without strict regulations preventing any waste discharge from boats, water quality can be seriously degraded. Chlorination controls disease problems but does not prevent overenrichment or oxygen depletion. Holding tanks or incinerators are necessary to prevent pollution.

Wastewater Treatment

Assisting Natural Processes

MOST WASTE TREATMENT processes provide controlled conditions to speed natural purification processes. Many industrial wastes resist, even hamper, conventional treatment and must undergo pretreatment. Following pretreatment many industrial effluents are discharged to municipal treatment plants for further processing.

Human wastes are handled by individual septic tanks or by treatment plants. The septic tank-soil absorption field is more economical for sparsely populated areas such as lake developments. In the tank, bacteria break down organic matter, and solids settle. Then the liquid portion flows to the drain field. Treatment effectiveness depends on soil conditions. The soil must filter out remaining organic matter, nutrients and bacteria.

About one third of Michigan's residents maintain septic tank systems. The other two thirds of Michigan homes are connected by sewers to a waste treatment plant. About 40% of Michigan's municipal wastes receive at least secondary treatment.

Sewers collect wastewater from homes and businesses and deliver it to the waste treatment plant. Primary treatment is mechanical. Screens catch sticks, rags and other solid matter. Sand and grit settle out in a grit chamber, and organic matter settles to the bottom of a sedimentation tank as raw sludge. The liquid part is chlorinated and discharged to receiving waters (lakes and streams) or given secondary treatment.

One secondary treatment, the trickling filter method, feeds the effluent through a bed of stones where a scum of bacteria digests the organic matter. More common today is the activated sludge process. Air and bacteria-laden sludge are mixed with the effluent and circulated in large tanks. The bacteria digest the organic matter. The solids are allowed to settle, and the effluent chlorinated and discharged.

The amount of chlorine sometimes necessary to disinfect the effluent may poison warmwater fish. The U.S. Environmental Protection Agency (EPA) recently expressed concern that the chlorine may combine with other chemicals in wastes to form compounds dangerous to human health. Alternative disinfection methods are under study.

Though it greatly reduces organic matter (BOD), secondary treatment leaves nutrients dissolved in the effluent. Advanced treatment is necessary to remove phosphorus as required by law. One process uses pickling liquor, an iron waste from steel manufacturing. The iron combines with the phosphorus, and this compound settles out of the effluent.

This clarification process is only one form of tertiary, or advanced, treatment. Tertiary treatment greatly raises the cost of wastewater treatment, but more thorough wastewater treatment is essential to protect water quality as our wastes grow more plentiful and complex.

Researchers are constantly seeking more effective — but simpler and less expensive — ways to treat wastewaters. Reverse osmosis is an experimental process that is potentially cheap, simple and produces high-quality water. Reverse osmosis separates water from wastes by forcing water through special membranes, leaving the wastes on the other side.

All wastewater treatments have two end products — the liquid effluent and the sludge. Effluent is most commonly discharged to lakes or streams.

Sludge Handling

One fourth to one half of a treatment plant's operating costs and capital are spent on sludge disposal. Various methods digest, thicken, dry, burn or bury sludge. Some produce useful products that help offset disposal cost.

Wastewater treatment assists natural processes. Some bacteria that decompose organic wastes use oxygen from the water. Oxygen is replenished through aeration as water is tossed by wind or tumbles over rocks and logs. Aeration also takes place in a wastewater treatment plant.

Digestion is usually the first step in sludge treatment and disposal. Sludge is allowed to decay naturally in heated tanks or in lagoons. Digestion stabilizes organic matter and helps control odors and disease organisms.

Digested sludge is 90 to 95% water. The next step removes as much water as possible. This is done by heat or suction or sludge is spread on sand beds to dry.

The final step is disposal of the dried material. Incineration can create air pollution and ultimately — through wind and rain action — water pollution. And it leaves ash. Sludge buried in landfills may leach into streams or groundwater. Both of these methods waste the nutrients in dried sludge.

Milwaukee sells dried sludge as fertilizer. Other cities use it as soil conditioner on roadways, parks and other public areas.

But drying is expensive. In areas where land is readily available, applying digested but wet sludge to land is the cheapest disposal method. Chicago pumps digested sludge to southern Illinois where it heals strip mining wounds.

The irony of wastewater treatment and disposal is that we spend money and energy to get rid of "wastes" that contain plant nutrients, and then spend money and energy to put these same nutrients in chemical fertilizers for our lawns and fields.

Accordingly, land disposal of both sludges and liquid effluents, even raw wastewater, is receiving increasing attention. Michigan State University is among the institutions studying land disposal and other innovative ways to treat and dispose of wastes without degrading land or water.

Land Disposal

Land disposal, long used for agricultural wastes, is now becoming popular for disposing of municipal and industrial wastes. Vegetation and soil organisms break down wastes and recycle nutrients spread onto the earth. This living filter treats wastes physically, chemically and biologically. Total surface area of the particles in one ounce of soil can equal six acres. The soil particles hold back micro-organisms and, to some extent, chemicals. Importantly, phosphorus is tenaciously held by the soil. Soil micro-organisms break down the wastes; then plants grown on the land take up the nutrients. Plants can be harvested, removing nutrients from the area and putting them to use.

If we apply more wastewater and nutrients than the plants can use, the chemicals may leach into the groundwater. Nitrate, a form of nitrogen in chemical fertilizers and made from ammonia in animal wastes, is a dangerous water contaminant. It causes disease and death in humans and livestock.

The kind of soil determines how effectively soil filters wastes. Coarse, sandy soils have rather large spaces between particles allowing water to pass through rapidly. If water moves too fast, or if there is too little soil between the surface and the groundwater, wastes may be carried into the groundwater. Water passes slowly through fine-textured clay soils. Puddles are apt to form on the surface of such "tight" soils, aggravating runoff and erosion problems and creating health hazards. ■

New Strategies for

MSU Research: Land Disposal, Animal Waste,

WASTEWATER TREATMENT methods have failed to keep pace with demand. We need to evaluate traditional methods and develop new options and strategies for managing our wastes. Michigan State University is undertaking such research with efforts concentrated on *land disposal, animal waste handling* and *recycling municipal wastewater.*

Land Disposal Questions

Land provides another place to treat and revitalize wastewaters, but land resources can be abused, also. To dispose of urban wastes and large concentrations of animal wastes on land, we must know the characteristics of sludges, liquid effluents and animal manures. To protect soil and underlying groundwater, we must know where every waste constituent goes. What is tied up in crops? Are any chemicals leached to the groundwater? Are salts and metals building up in the soil? Urban wastes contain more salts and metals than agricultural wastes. These substances may damage soil, retard crop growth and poison plants and animals.

Studies by MSU scientists are providing information on land disposal. Researchers are applying simulated municipal effluent to agricultural land at high rates. They monitor drainage water, look at materials held by the soil and measure the nutritive value of the crops harvested from that land. This tells them what happens to substances in the effluent.

In another experiment, a specifically designed soil mound is spread with wastes which trickle down through the soil layers. The soil removes most phosphorus, nitrogen, dangerous micro-organisms and organic matter. Information from the mound will help predict the processes, soils and conditions necessary to remove phosphorus. Other researchers study movement of chemicals in an MSU campus watershed. By monitoring runoff to the stream, they are learning how erosion and runoff contribute to water pollution, particularly pollution by pesticides.

Runoff ponds keep animal wastes out of our lakes and streams.

Animal Waste Problems

For centuries, farmers pastured their livestock and in other ways returned wastes to the fields. Today we raise animals in lots, pens and barns, and we mechanize livestock and poultry operations. This increases waste handling, treatment and disposal problems.

MSU specialists in animal husbandry, poultry and dairy sciences and agricultural engineering study animal waste characteristics and methods of waste storage, transport, treatment and disposal. Their objective is to upgrade current waste-handling practices, develop new methods and find ways to convert wastes to useful products.

Fourteen MSU farms, ranging from

Waste Management

Recycling

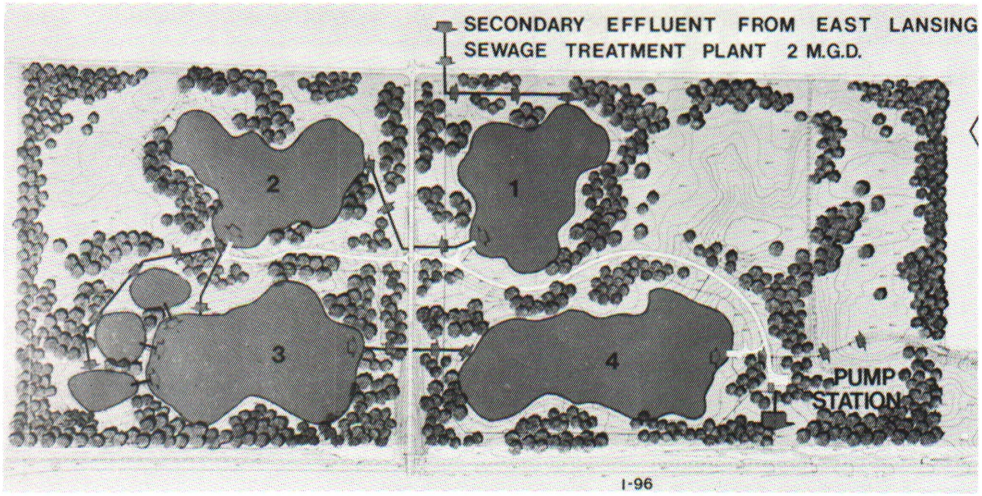
Wastes are applied to land plots with various surfaces — grasses, corn stuble and others. By monitoring water from the plots at the collection points below, researchers can determine how effective the various surfaces would be for preventing water contamination by wastes.

open lots to totally confined operations, provide sites for evaluating present waste handling practices and structures. Researchers compare practices such as daily scraping and hauling with scraping and storing, looking at how well they conserve nutrients and the labor involved. They are looking at the effectiveness of run-off ponds and other structures to contain wastes and prevent water pollution.

When manure is spread on frozen fields, it often washes into streams with melting snow and spring rains. Researchers are determining what practices a farmer must follow to prevent pollution from this source.

A completely closed-circuit, waste-handling system is being studied on an MSU swine farm. Several times a year, wastes are flushed from the barn to a lagoon. Here, water is biologically purified. Clean enough to drink, the water is then pumped back to the barn to be used again for flushing. The system uses a minimum of water and has no outflow.

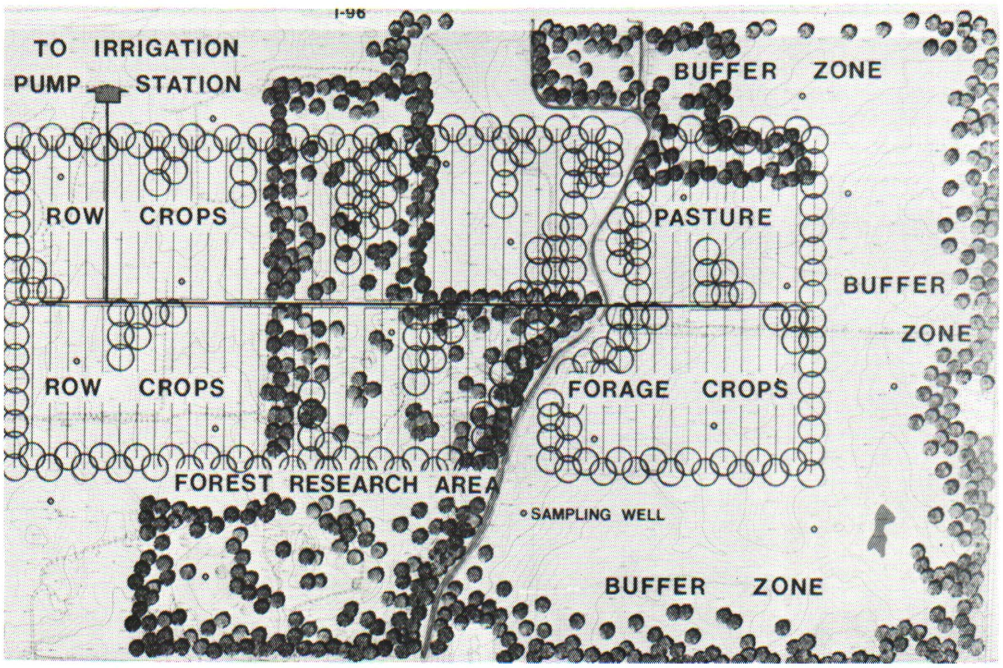
Other researchers are finding ways to reuse wastes. Poultry scientists at MSU have been leaders in this field for ten years. Poultry wastes are dried and fed to livestock. Undigested food, hormones and enzymes give the wastes food value. Researchers have raised beef, swine, broilers, laying hens and fish on diets partially made up of poultry wastes. Poultry wastes also make good garden fertilizer. ■



MSU WATER QUALITY
Management Facility

Secondary effluent is pumped from East Lansing sewage plant to Lake No. 1 and flows by gravity through Lakes 2, 3 and 4. Biological processes in the lakes remove nutrients from the effluent. Water from any of the lakes with varying amounts of nutrients can be piped under I-96 to irrigation research plots.

The WQMP started operating in 1974. The U.S. Environmental Protection Agency, the State of Michigan, and the Rockefeller, Kresge and Ford Foundations provided construction money. The university provides land, staff and other resources. The project has the full cooperation of the city of East Lansing.



Using the "Wastes" in Wastewater

Municipal Wastewater Recycling

THE LARGEST wastewater treatment endeavor at MSU is the Water Quality Management Project (WQMP) conducted by the MSU Institute of Water Research. Beyond being a tertiary treatment process, the project purposes to ease food and energy crises. Biological systems purify water by removing nutrients in forms that can be recycled. This conserves nutrients. Moreover, it saves energy compared to complex chemical and mechanical processes used in conventional treatment.

The $2.3 million outdoor laboratory is located on 500 acres of the MSU campus. Its system of lakes, marshes, forests and fields are providing hard facts on recycling wastewater into useful products.

The four lakes, each about 6 feet deep, have a combined surface area of 40 acres. Three experimental marshes are an acre each. Cropland and forest plots totalling 150 acres are equipped for spray irrigation.

The Aquatic System

The project wastewater undergoes primary and secondary treatment at the East Lansing Sewage Treatment Plant. Each day, about 2 million gallons of effluent are pumped 4½ miles to the first lake. From this point on, aquatic plants and algae take up nutrients from the water. Flowing through the chain of lakes and marshes, the water becomes progressively cleaner. And on reaching the fourth lake, project officials expect it to be suitable for fishing and boating. Plans call for chlorinating and diverting some of this water to a swimming pool.

Plants grow rapidly in the nutrient rich water. Harvested plants are fed to livestock or worked into the soil to fertilize crops. Dried plants are used in animal feeds. The plants have a nutritive value similar to alfalfa.

Nutrients will also be recycled through the lake fish populations. A sport fishery will be created in Lake Four. Fish farming — growing marketable, high protein fish such as catfish — is a possibility for the other lakes. Questions on fish farming in northern climates and the effect of fish on the lakes are yet to be answered.

Marshes, which trap nutrients entering natural lakes, may be effective nutrient filters. They also form suitable wildlife and waterfowl habitat.

Land Treatment

South of the lakes system is the terrestrial site. Here wastewater is sprayed on a variety of plant communities — old fields, row and forage crops and woodlands. Researchers carefully record the effects of spraying on these areas. They vary the amount and quality of the water sprayed on the plants. They can use water from any of the lakes or wastewater direct from the East Lansing treatment plant.

When irrigation water percolates through the soil to the groundwater, a further type of recycling occurs — groundwater recharge. This is recycling of the major wastewater component — water. Recharge could be important to a city such as East Lansing which draws heavily on groundwater.

Research

The WQMP is not so much a processing plant as primarily a *research and demonstration* facility where re-

Spray irrigation continues through the winter at a slower rate.

searchers can learn how to operate such a system and show others how they might do the same in their communities.

This project is to develop the combinations of lake and land treatments necessary for water renovation and reuse of nutrients. MSU has the diversity of scientists to fully exploit this facility. Researchers from crop and soil sciences, economics, fisheries and wildlife, forestry, limnology, microbiology, nutrition, parks and recreations, sanitary engineering and other fields conduct projects that answer questions such as:

How much wastewater can we safely apply to various crops and soils?

How does spraying affect animals in the area?

How can we minimize public health hazards?

Do frogs and insects carry significant amounts of nutrients out of the system?

How does winter cold affect project functioning?

What recreational activities are compatible with recycling systems?

How much land will be required for communities using such systems?

Initially, the investigators mapped and inventoried the lake and terrestrial sites. They surveyed birds, mammals, worms, soils, vegetation, groundwater and other parts of the system to provide background information on the aquatic and terrestrial systems. With this pretreatment survey, researchers will be able to compare developing conditions.

As a service to all researchers, the IWR maintains a body of data useful in any research project on the site. Fifty chemical characteristics of wastewater, water circulation data and weather information are some of the measurements kept in a computerized storage system. The IWR also monitors deep wells to guard against groundwater contamination.

Demonstration

Another purpose of this project is to demonstrate what sort of neighbor a wastewater recycling system makes. The lakes have no objectionable odors, and the area will be landscaped like a park with trees and shrubs typical of southern Michigan. The project has already demonstrated recreational possibilities. The area was opened to cross-country skiing in 1975. The system could be used for playing fields or parks or any of the open spaces essential to the health of urban areas.

Dr. Walter N. Mack samples lake water for viruses as part of an IWR research project on virus removal by the WQMP processes.

In principle, the Water Quality Management Project is an uncomplicated system. Communities that cannot afford tertiary treatment plants may be able to use this type of system or parts of it. The land outlay is considerable, but the cost may be offset by the area's multiple uses.

If such systems are to serve as alternatives to conventional treatments, they must have full public confidence. This project can help build that trust. Citizens and public officials can visit the facility to find out first hand how a recycling system operates.

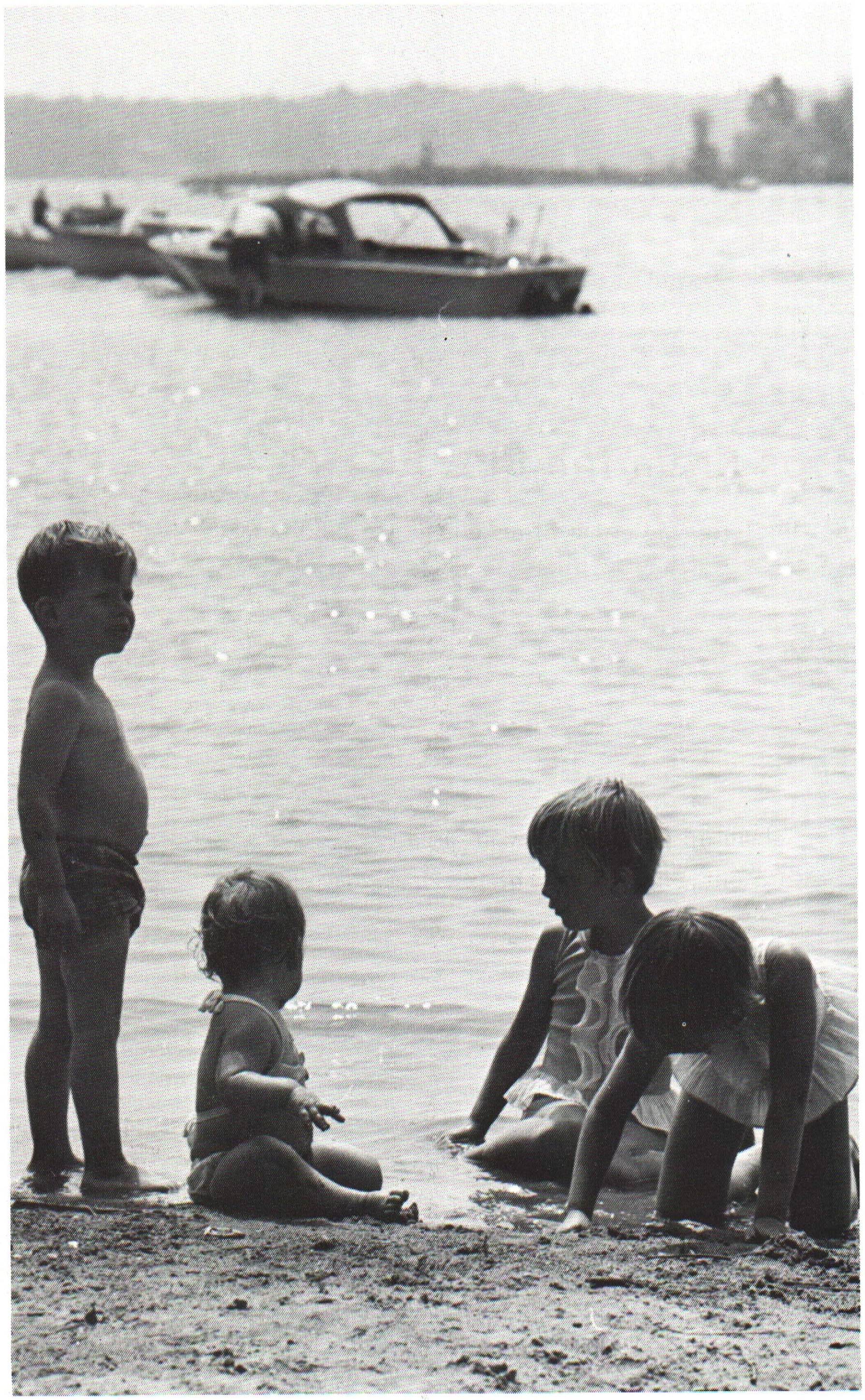
This process is no panacea. No one method will solve all sewage treatment problems. But the MSU Water Quality Management Project and other systems that handle wastes in ways that enhance rather than degrade resources will be important parts of future waste management. ■

The WQMP is used as a teaching facility as well as a research lab. These students are taking bottom samples on the lakes.

As the population in the Great Lakes area grows, the quality of our waters will deteriorate unless we take new approaches to waste management. Waste control programs need to be integrated to insure wise use and proper protection of all our resources — air, land and water.

Environmental protection authorities and innovative waste treatments will not solve waste pollutions problems. We must make the personal effort to curb waste output and support pollution control efforts.

Our activities create water pollution and our actions must halt and prevent it. The future of the Great Lakes, the quality of our inland waters, and the quality of life in Michigan depend on it. ■



What You Can Do:

- Dispose of used oil, leaves and trash in ways that keep them out of storm sewers.
- Use lawn and garden chemicals wisely.
- Conserve water. Ease the burden on the wastewater treatment plant or septic system.
- Keep septic tanks and drain fields functioning properly.
- On your lake or river property, maintain a natural vegetation buffer to trap runoff and retard erosion.

Tips From the EPA

- Don't litter. Refuse often ends up in lakes or streams.
- Speak out for clean water. Vote for clean water. Vote yes on bonding programs for wastewater treatment.
- Find out the facts on water pollution in your area. If you have a strong pollution control program support it; if it is weak insist it be strengthened.
- Find out if any citizen organizations have water clean up programs in your area.
- Find out how you can help. Some possibilities: Lake Michigan Federation, League of Women Voters, Michigan Lake and Stream Associations, Inc., Save Lake Superior, Sierra Club, Trout Unlimited, and many others.

If you are:

a builder — make control of surface runoff water a regular part of every project.

a farmer — always manage land so that nothing washes away with rains or melting snow.

an industrialist — add waste treatments or consider process changes that "engineer" pollution control into regular production processes.

a boat owner — never dump any wastes overboard; insist on proper waste handling facilities at docks.

Resources

MSU Cooperative Extension Publications:

MSU Bulletin Office, P.O. Box 231, East Lansing, MI 48824

E 718 *Inland Lakes – Analysis and Action.* J. K. Fulton and E. W. Say

E 577 *Sewage Disposal Questions and Answers.* J. E. Vogt and J. S. Boyd

E 720 *Whose Responsibility – Livestock and Poultry Wastes.* Robt. L. Maddex

U.S. Government Publications:

Supt. of Documents, U.S. Government Printing Office, Washington, D.C. 20402

Don't Leave It All to The Experts. US Environmental Protection Agency 1972 ($.55)

A Primer on Water Quality. Swenson and Baldwin; U.S. Geological Survey ($.50)

A Primer on Waste Water Treatment. Federal Water Quality Administration 1971 ($.55)

What You Can Do About Water Pollution. Federal Water Pollution Control Administration 1968 ($.15)

Others:

The Algal Bowl — Lakes and Man. John R. Vallentyne, Department of the Environment Fisheries and Marine Service, Ottawa, Canada. 1974 Available from: Information Canada, Ottawa, Canada ($3.60)

A Citizen's Guide to Clean Water. Izaak Walton League of America, Suite 806, 1800 Kent St., Arlington, VA 22209

Cleaning Our Environment: The Chemical Basis for Action. American Chemical Society, Washington, D.C. 1969 ($2.75, paperback)

For materials on state water quality regulations contact:

Division of Information and Education, Department of Natural Resources, Stevens T. Mason Building, Lansing, MI 48926

Cooperative Extension Service Programs are open to all without regard to race, color, or national origin. Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Gordon E. Guyer, Director, Cooperative Extension Service, Michigan State University, E. Lansing, MI 48824.

1P – 10:75 – 7 M – WP – 50¢.