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AUTHOR Lantz, H. B., Jr.
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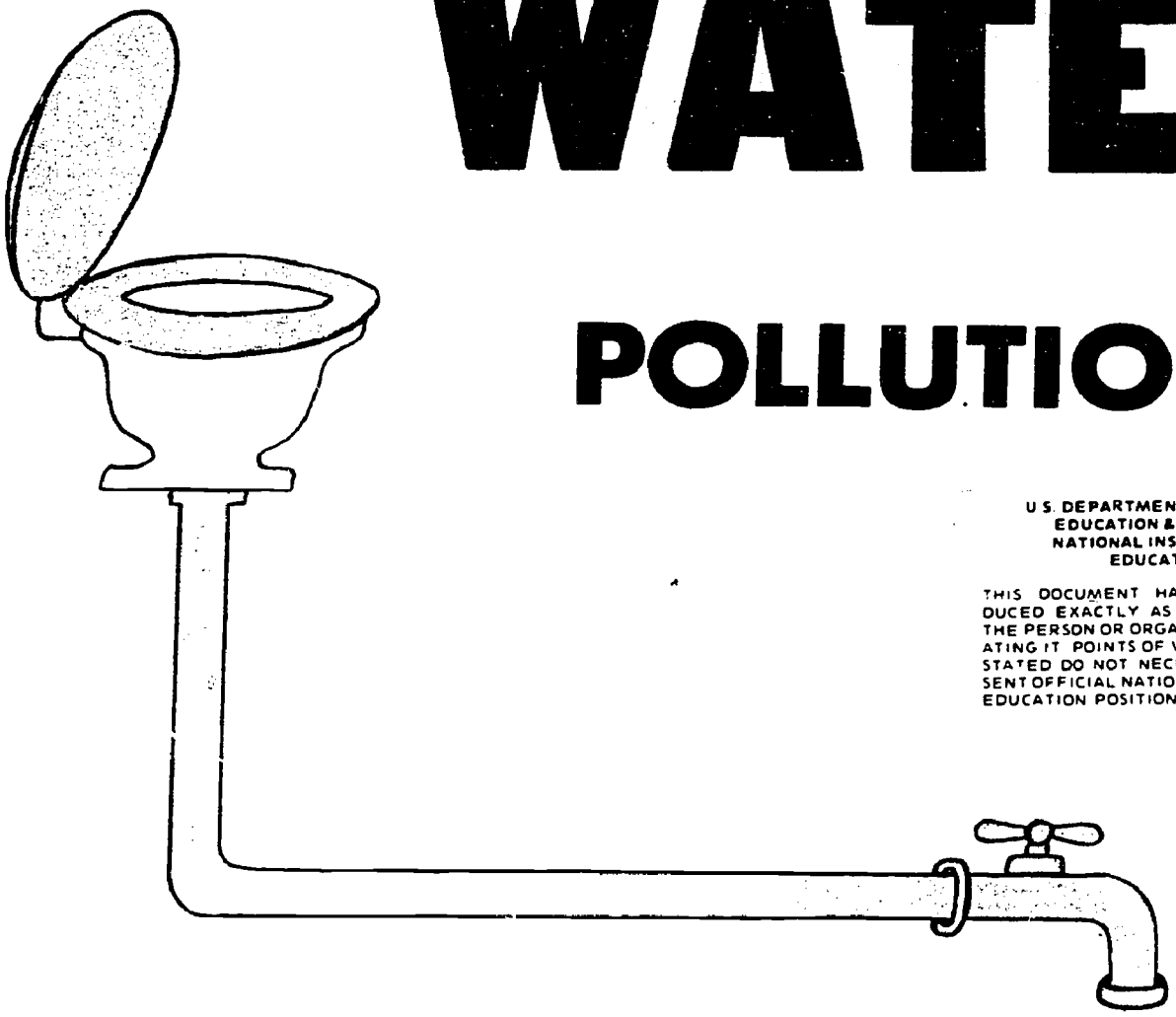
ABSTRACT

This is an introductory program on water pollution. Examined are the cause and effect relationships of water pollution, sources of water pollution, and possible alternatives to effect solutions from our water pollution problems. Included is background information on water pollution, a glossary of pollution terminology, a script for a slide script program, actions that can be taken to reduce water pollution, and a few suggested activities. The materials are designed for students at the secondary school level. (RH)

WATER POLLUTION



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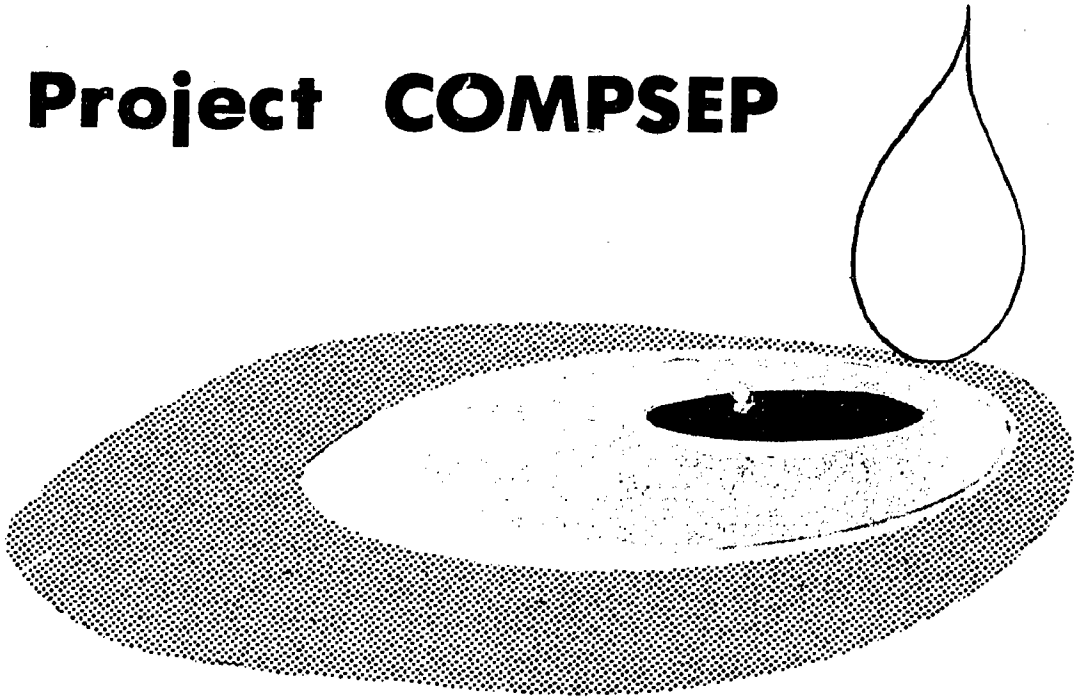

WATER POLLUTION

by

H. B. Lantz, Jr.

June, 1975

Orange County
ESEA, Title III Project
H. B. Lantz, Jr., Director

TITLE III ENVIRONMENTAL EDUCATION CENTER
Orange County High School
Orange, Virginia 22960

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Introduction

> "Our water resources, more perhaps than any other, illustrate the interaction of all parts of the environment and particularly, the recycling process that characterizes every resource of the ecosystem--Everything that man injects into the biosphere--chemical, biological, or physical--can ultimately find its way into the earth's water. And these contaminants must be removed, by nature or man, before that water is potable."
>
> Charles C. Johnson, Jr. Assistant Surgeon General of the United States

Three out of four people in the United States get their drinking water from public supply systems. In 1969, a Federal study found half of these systems substandard. Health specialists are increasingly concerned about neutralizing toxic substances and viruses when natural water purification fails. We are finally realizing that there are limits to natural purification - that our nation's waters cannot indefinitely absorb an endless avalanche of waste.

If you feel that there is no problem of water pollution, then examine these startling facts:

1. Our Great Lakes (particularly Erie and Michigan) are almost dead.
2. Water pollution is about six times as great today at it was in 1900.
3. A farmer piled his wheat and oats along a stream and sprayed the crops with dieldrin, a poisonous pesticide. Rain washed the dieldrin into the stream and 2,200 fish died.
4. The Cuyahoga River, which flows through Cleveland, caught fire and burned, damaging two railroad bridges.

The list is endless! These are not just isolated examples.

This introductory program of water pollution examines the cause and effect relationships of water pollution, sources of water pollution, and possible alternatives to effect solutions for our water pollution problems. The program consists of background readings, a slide script presentation, a glossary of terms, and water pollution activities.

Additional copies of this booklet are available through the ESEA Title III Office, Orange County High School, Orange, Virginia 22960.

Sources of Water Pollution[1]

Sewage - The increase in the amount of sewage being dumped into our water supply is staggering. The amount of sewage solids dumped each year has increased 70% since 1940. Each year we dump 18 billion pounds of sewage into our nation's waters.

The sewage load imposed on our water resources is extremely high and is likely to become even higher in the next few years.

In 1900, U.S. cities dumped untreated sewage equivalent to an amount produced by a population of 24 million.

By 1980, U.S. cities could be dumping untreated sewage equivalent to an amount produced by a population of 114 million if better sewage treatment facilities are not constructed.

Even more effective sewage treatment may not completely solve the problem. While advanced sewage treatment facilities can remove many of the dangerous chemicals and bacteria from the waste, these facilities produce a large amount of sludge as a by-product. Sludge is the solid matter removed from the waste water. While waste treatment facilities produce cleaner water, they also produce greater and greater quantities of sludge. Sludge disposal is becoming a serious problem. As an example, Chicago must find ways to dispose of approximately 1000 pounds of sludge each day.

1. About half of the sludge from Chicago is shipped to agricultural areas for use as fertilizer.
2. About half of the sludge is buried in the ground. According to city officials, the land now used for disposal will no longer be available within 2 years.

If the population continues to increase at the present rate, the problem of sewage treatment and disposal is almost certain to become more serious.

During rainy weather, approximately 3% to 5% of the annual sewage in the United States washes into streams untreated. Old-fashioned, inadequate sewage systems in many of our cities overflow during heavy rains allowing the sewage to by-pass the treatment plants.

Radioactivity - Pollution by radioactive material is new but increasingly serious and dangerous. Nuclear testing and other nuclear activities have spread radioactive contaminants throughout the world. Radioactive elements are often called the "universal water pollutant" because there may be few areas in the world left where both surface and ground water do not contain some radioactive contaminants. Almost everyone is exposed to some radioactivity since these elements can be consumed directly from water or from contaminated food. Fortunately, the number of radioactive elements absorbed by man from water is still relatively small. How-

ever, with the present increase in nuclear activities, the problem could become far more serious. As yet, we have been unable to find ways to remove radioactive pollutants. Most of the existing water treatment plants in the world are equipped to filter out only municipal and industrial wastes. Because the effects of radioactivity on the human body are so serious, radioactive pollution could become a frightening problem.

Cancer-Producing Chemicals

1. Cancer-producing chemicals, like arsenic, beryllium, and chromium, may be found in the drinking water of some industrial communities.
2. Benzpyrene, a cancer-causing chemical, has been found in oysters and barnacles living in water contaminated by fuel oil from ships.

Because of the large increase in the chemical waste produced by agriculture and industry, there has also been a large increase in the number and variety of cancer-producing agents, or carcinogens, which enter the water supply. Petroleum wastes from ships, chemical factories, and oil refineries produce a variety of carcinogens in our streams and rivers. Hydrocarbon fallout from coal and oil heating equipment often settles on the surface water supply. Radioactive fallout from nuclear weapons testing and other nuclear activity further adds to the variety of carcinogens to which we are exposed. Run-off from fields and forests which have been sprayed with insecticides and pesticides enters the streams, rivers, reservoirs and subterranean seas of groundwater which provide us with drinking water. As pesticides and other chemicals are added to the ground and surface water, there is a serious danger that cancer-causing chemicals are also being added.

With the continued growth of cities and industry it is likely that the dangers of cancer from contaminated drinking water will also increase.

Heat - One of the least well known but increasingly important water pollutants is heat. Water is used for the cooling of equipment and products during manufacturing. Great quantities of cold water are drawn from rivers, used for cooling, and then returned to the channels as hot water. Power plants which use large amounts of water for this purpose can raise the water temperature in the area of the plant by 10 to 20 degrees.

1. Warm water absorbs less oxygen. With less oxygen in the water, natural waste treatment processes are slowed.
2. The life cycles of fish and other marine life are upset because of their inability, as cold blooded animals, to control their body temperatures. This means that the heat may kill the fish or prevent them from reproducing.

Oil - One of the newest and most serious water pollutants is oil. Recent disasters have focused the attention of many people on the dangers of oil pollution.

1. Wrecks of oil tankers have allowed tons of crude oil to pollute coastal waters and beaches. Birds, fish, and other forms of marine life have been killed in large numbers.
2. Oil leaks from offshore drilling equipment have also seriously contaminated coastal waters and beaches. After a recent series of oil leaks in California waters, dead whales began to wash up on the beaches. Many biologists attributed the deaths of these magnificent mammals to the oil disasters.

Oil released from wrecks or leaks may float on the surface and travel many miles from the point of origin. This is why the government of Canada was so concerned when an oil company sent a giant tanker through the Arctic Ocean to the new Alaskan oil fields. Canadians were worried that an accident would cause great harm to their northern coast.

Other oil pollution may occur in rivers in the vicinity of industries processing or using large quantities of oil.

Oil polluted water
may be highly flammable,
is likely to be unsafe for home use,
may kill most animal and plant life along the banks,
is smelly, dirty, and ugly.

Detergents - Have you every turned on your kitchen faucet and found foam bubbling out into your glass?

Have you ever seen a river or lake turned into a highway of white foam?

An increasingly large number of people have.

The widespread use of detergents has added many difficulties to the job of the sanitary engineer. Detergents are very long-lived, man-made cleaning chemicals. Bacteria and other natural processes often fail to break down and consume many of the chemicals now used. These chemicals pass through the fine filters in water treatment plants and eventually enter our water supply.

In parts of New York City, foam from detergents appeared in the sinks on the seventh floor of some buildings.

Fifteen-foot billows of foam poured out of the tap at a water treatment plant in Chanute, Kansas.

The Minnesota State Department of Health estimates that half of the 54,000 wells in the Minneapolis-St. Paul area are contaminated with chemicals from detergents.

Nearly 1,000 bodies of well water have been examined in a 13-state area. Nearly 40% of the wells studied showed some evidence of contamination by detergents.

Foam is extremely disagreeable. It is an insult to the nose, throat, and eyes.

The chemicals in detergents pollute our waters. In order to reduce the amount of detergents in the water supply, some manufacturers have changed the chemicals in their detergents. The new detergents can be broken down more easily by bacteria and water treatment. These detergents are said to be biodegradeable.

While manufacturers have been able to control some of the foam, most have not been able to eliminate the phosphates in their detergents. Enriched by phosphates, green algae growth is encouraged in many bodies of surface water. These algae show up as a smelly scum on the water.

Other Chemicals - While a glass of water contaminated by detergent may be visibly offensive, water polluted by a number of new chemicals may appear colorless, tasteless, odorless, and generally safe.

APPEARANCES MAY BE DECEIVING!

1. A lethal dose of radioactive material could enter the water supply and not be detected.
2. Small quantities of DDT may be consumed in the drinking water without the person being aware of the danger.

Hundreds of completely new chemicals are added to the American market each year. There are new abrasives, food and fuel additives, insecticides, herbicides, petroleum by-products, and plastics.

For every new contaminant identified in the water supply, there may be many more that are neither known nor identified!

Water pollution is very complex today and is becoming more complicated all the time. With over 500 new or modified chemicals added to the market each year, it is almost impossible for the Public Health Service to identify and control chemical contaminants.

1. Many people may be happily quenching their thirst with polluted water containing an appalling variety of harmful agricultural and industrial chemicals.
2. Most of the man-made chemicals are new. The long-term effects of these chemicals on human health is not known. The human body has never had to tolerate these chemicals before.
3. Many of the newer chemicals are difficult to filter out or break down. Even secondary water treatment often fails to eliminate many of the chemicals from the water supply. For example, present water treatment facilities do not remove nitrogen and phosphorus compounds from the water supply. The organic form of these plant nutrients is often changed into a mineral form during treatment. This form is even more usable as a nutrient by algae.

We may not be aware of all the dangers from newer chemical wastes. However, we can be certain that continued dumping of chemical wastes into the water supply will lead to disastrous consequences.

Fertilizer - One of the most serious 20th-century water pollutants is fertilizer. During the past 50 years, farmers have added more and more chemical nutrients to the soil in an attempt to produce more crops on the same amount of land.

The farmers have been very successful:

1. The crop yield per acre is higher than ever before.
2. Less time and fewer men than ever before are required to produce enough food for our fast growing population. But...
3. Fertilizers have added a serious new burden to our already over-burdened water supply.

Most fertilizers used in agriculture contain large amounts of phosphates and nitrogen. Nutrients such as these cause farm crops to grow larger and more quickly. Unfortunately, these nutrients have the same effect on algae, plankton, and other forms of plant life found in water. Once the nutrients enter the surface water, they cause the plant life to grow and multiply rapidly. As the plant life thrives and expands, more and more of the oxygen in the water is consumed. Fish which thrived before may begin to sicken and perish. Fish requiring less oxygen may multiply. Eventually, as the dissolved oxygen in the water is decreased, most of the fish and plant life in the water will disappear.

Untreated sewage is also a source of added nutrients. As with most pollution problems, there is no single cause of the "death" of a lake. We are facing a crisis because we have many, many different sources of pollution.

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[1]Lavaroni & O'Donnell. "Sources of Water Pollution," Water Pollution: Addison-Wesley Publishing Company, 1971. pp. 27-34.

Water Pollution Disasters[1]

Cholera Epidemics - Over the centuries, cholera (CAHL-er-ah) epidemics have threatened almost every civilization. This disease causes severe vomiting and diarrhea within 2 or 3 days after infection. The victim then collapses into a delirium and finally into a coma. Within 1 day after the first indication of illness, the person can be dead.

In 1832, a cholera epidemic struck the city of New York. People died from the dread disease by the thousands. The people were so frightened that over one-fourth of the population fled the city in panic. Victims had to be buried in mass open graves.

Only one year earlier a similar epidemic raged through London. Thousands of people fled the city to avoid the disease and the mob violence which broke out. Before the epidemic was halted, over 50,000 people had died. Again in 1848, 1853, and 1865, London was struck by cholera epidemics.

Efforts to stop cholera epidemics were to no avail until one doctor, John Snow, suggested that the disease might be spread by impure water. Dr. Snow had reached his conclusion after careful observation of the areas where the disease was most common. Acting on his suggestion, a well which supplied water to a large part of the city where the disease was present was closed. Within a short time the epidemic was halted in that part of the city. Later epidemics in other areas were also traced to the water supply. Then came the discovery that the disease could be prevented by purifying the drinking water. By 1886, cholera and most other water-borne diseases, such as typhoid fever, were no long serious threats. Dr. John Snow will long be remembered as one of the first persons to point out the serious health hazards which can result from water pollution.

The Oyster Tragedy - Raritan Bay is a body of water located between Staten Island, New York and Sandy Hook, New Jersey. It used to be famous for the quality of the oysters which thrived in its waters. As late as 1880, over 10% of the oysters eaten in the United States grew in Raritan Bay. People often wrote about the quality of the oysters which grew in these waters.

Shellfish no longer survive in Raritan Bay. By 1917, the oyster beds had virtually disappeared. Sewage and other waste had been dumped into the bay and into the streams which fed the bay. A flourishing industry had been killed, a source of seafood was destroyed, and another body of water became an open "cesspool."

Mississippi River Fish Kill - During 1963, an estimated 5 million fish washed up on the banks of the Mississippi River. The sight and smell of dead fish along the banks provided frightening evidence of man's wanton disregard for his water supply.

Thousands of minnows, catfish, buffalo fish, shad, and drum went into convulsions as they fought to maintain an upright position in the poisoned water. Some fish jumped into boats, onto shores, and against stationary objects. Stomachs and intestines were distended and expanded by gases and liquids. Bleeding skin and internal organs further told the gruesome story of water pollution. After weeks of hearings and inquiries by the Public Health Service, it appeared that unwise use of insecticides was responsible for most of this destruction.

The Ohio River - For over three decades, the Ohio River has been the only river in the United States which was polluted from its very source. Most rivers begin life as clean fresh water. Only after the water moves away from clear mountain streams is it polluted. The Ohio River is denied these pure beginnings since it is formed by the junction of two large rivers, the Allegheny and the Monongahela (mon-on-gah-HE-lah). These two rivers join at Pittsburgh, Pennsylvania. The Allegheny and the Monongahela bring together waters which have already been polluted by industries and communities upstream. To this pollution is added waste discharged by Pittsburgh, an urban area of over 1,400,000 people. Thus, the Ohio River starts life dirty, polluted, and unsafe. As the river meanders 981 miles to Cairo, Illinois, it is further abused by a continuous flow of sewage and chemicals.

Virus Epidemics - Virus-caused diseases such as hepatitis (HEP-ah-tight-us) may be spread through polluted water. Viruses are extremely small organisms found in both air and water. While adding chlorine appears to kill most of the bacteria found in water, it generally does not kill viruses. Chlorination does seem to lengthen the time required for growth of the viruses in the human body, but it usually fails to destroy them.

The number of cases of hepatitis is increasing. In December, 1956, 83 people out of a population of 3,000 in one area of New York State were stricken with infectious hepatitis. Even though the water in this area was chlorinated, the infection was probably transmitted through the water supply. In 1954, 50,000 cases of infectious hepatitis were reported in the United States. By 1962, 73,000 cases were reported.

The increase in infectious hepatitis has caused many physicians to wonder what other virus-caused diseases are being passed through the water supply. Some epidemics of polio may have resulted from water pollution. Polio viruses, viruses which cause respiratory and eye disease, and viruses which cause flu-like symptoms may be transmitted through our water supply. Our wanton dumping of municipal and industrial sewage and waste may be providing ideal conditions for the growth and transmission of virus-caused diseases.

Disease Bacteria - Throughout history, epidemics and plagues have created fear and panic in many area of the world. Not until 1848 did physicians suspect that the disease-carrying bacteria were

contained in polluted water. Since that time, epidemics of diseases such as cholera and typhoid have been almost eliminated by water purification techniques. Through the use of chlorine and mechanical treatment techniques, Public Health officials reduced the typhoid death rate in the United States to 1 per 100,000 people by 1940.

However, while bacteria in the water supply to homes and municipalities can be controlled, the amount of bacteria in open bodies of water is difficult to control. As rivers and lakes become increasingly polluted, the natural processes of purification are slowed down or halted. In time, serious epidemics could be caused by the use of untreated surface water. Many bodies of water have been declared unsafe for swimming because of the presence of disease-carrying bacteria. In 1969, Monterey Bay, a small bay off the coast of California, was closed for swimming because of typhoid-causing bacteria in the water.

Eutrophication - As the amount of algae and other plants growing in a lake increases, the lake becomes a bog. Lake Erie is an example of an aging lake which may eventually fill up with plant life. Then, after many thousands of years, it will probably become dry land.

This natural process of eutrophication (YOU-tro-feh-kay-shun), or enrichment with nutrients, has been enormously speeded up by man's activities. Nitrogen and phosphate fertilizers have been washed off the land into the lakes and streams. These nutrients have caused plant life to grow much more rapidly than normal. Eventually, the plant life will deplete the oxygen supply which is so necessary for the decomposition of wastes. Gradually, perch, trout, bass, and other desirable species of fish will be replaced by less desirable species such as carp and buffalo fish. In time, no fish will be able to survive in the water. And swimming, boating, fishing, and other water activities will be impossible.

Recreation - Our oceans, rivers, streams, and lakes provide many valuable opportunities for recreation. These bodies of water are used for water skiing, fishing, swimming, boating, and skin diving. Most of us need to get away from the pressures of our busy lives. Unfortunately, because of increased pollution, our opportunities for water sports and recreation are becoming fewer and fewer.

Some of our ocean beaches are coated with ugly black oil. These beaches, and the water nearby, may not be safe for swimming.

Many of our finest rivers, which once provided hours of enjoyment to fishermen and sportsmen, are now useless.

1. Shad runs on the Hudson River once attracted hundreds of sportsmen. There are very few shad left in the Hudson River.

2. Salmon fishing in Maine is no longer a favorite sport. The Androscoggin, Penobscot, and the Kennebec Rivers are full of pulp from the local paper mills.
3. For many years, trout and salmon became more and more scarce in Lake Washington. Finally, community action stopped sewage dumping in the lake. Now there is a chance the fish may start to grow there again.
4. The Mississippi River has always been a favorite spot for fishermen. Recently, 50 million catfish, victims of water pollution, washed up on its shores.
5. Few fish are now able to survive in Lake Erie, the Potomac River, the Ohio River, and many other bodies of water.
6. Because of disease-causing bacteria and viruses, many bodies of water are no longer safe for swimming. An increasing number of beaches have signs posted indicating that the water is dangerous.
7. Boating on many bodies of water has become impossible or unsafe because of floating debris and excessive plant growth.
8. Skin diving may become less enjoyable as pollution reduces the amount of sea life which can be observed and photographed.

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[1]Lavaroni & O'Donnell. "Pollution Disasters," Water Pollution: Addison-Wesley Publishing Company, 1971. pp. 35-40.

GLOSSARY OF POLLUTION TERMINOLOGY

Aesthetic - relating to things which are pleasing to the senses, especially those things which are beautiful.

Algae - usually microscopic, chlorophyll-containing water plants. Filamentous algae form green, "mossy" growths on submerged objects. Some types of oceanic algae form large, grass-like plants.

Anaerobic decomposition - decomposition which takes place in the absence of oxygen. Methane gas and hydrogen sulfide are products of this decomposition. The smell of rotting eggs is due to hydrogen sulfide.

Bacteria - microscopic single-cell plants which are found in soil, water, organic matter or in the bodies of plants and animals. Some are pathogenic, but most are not.

Biochemical oxygen demand - the amount of oxygen (expressed in parts per million of oxygen) that is required to oxidize the oxidizable materials in a liter of water.

Biocide - a substance formulated to kill certain living things. Insecticides, herbicides, fungicides and nematocides are examples of biocides.

Biodegradable - capable of being decomposed by living things. Sugar, milk, meat, excrement, blood and cellulose are common examples.

Carnivorous - meat eater.

Chlorinated hydrocarbon - substance containing carbon, hydrogen and chlorine. In this sense, one of many insecticides such as DDT, dieldrin, benzene hexachloride, etc.

Chlorination - the disinfection of water by means of chlorine.

Coliform bacterium - type of bacterium which is found in the colon (large intestine) of animals (some also live in plants, some are free-living).

Cooling tower - a chimney-like device in which an updraft evaporates water, thus cooling it.

Denature - to alter the structure of a substance.

Detergent - synthetic organic compound which is chemically different from soap, but resembles it in its ability to emulsify oils and hold dirt in suspension.

Dissolved oxygen - that oxygen held in solution. It is not the oxygen of the water molecule. Bubbles of dissolved oxygen (and other gases) form on the bottom of a pan of water as the water is heated.

Ecology - the study of plants and animals and their relationships to each other and to their environments. Environmental biology.

Enzyme - any one of a series of complex organic substances which regulate the rate of chemical reactions in living things.

Estuary - that part of a river's mouth which is subject to the effects of the sea's tides. The zone where salt water and fresh water mix.

Euthrophication - the process of fertilizing a body of water, thus encouraging algae growth. Often referred to as enrichment.

Food chain -a sequence of organisms in which each uses the next lower member as a food source.

Fry - newly hatched fish.

Half life - the time required for one-half of the atoms of an element to disintegrate.

Hard detergent - a detergent which is resistant to assimilation by bacteria.

Heavy metal - high density metals such as copper, cadmium, zinc, nickel, mercury and chromium.

Herbicide - a substance formulated to kill unwanted plants.

Hydrologic cycle - the process by which precipitation replaces water which evaporates from the earth's surface.

Indicator organism - an animal or plant with specific habitat requirements. By its presence or absence in a habitat it indicates the quality of the habitat.

Inert - having no chemical or biological activity.

Insecticides - a substance formulated to kill insects.

Invertebrate - an animal without a backbone (insects, crustaceans, etc.).

Isotope - any of two or more forms of a chemical element, nearly identical in properties, but differing in atomic weight.

Larva - the immature form of insects which have complete metamorphosis.

Mayfly - an aquatic insect belonging to the order Ephemeroptera.

Metabolic rate - the rate at which energy is expended in the body.

Midge - a small mosquito-like insect (Order - Diptera, principally Family - Tendipedidae or Culicidae).

Nitrate - a compound containing the NO_3 radical.

Nymph - the immature form of insects which have incomplete metamorphosis.

Parts per million - abbreviated ppm. One ppm would be a milligram of a substance dissolved in one liter (1000 grams) of water.

Pathogenic -capable of producing disease.

pH - a measure of acidity or alkalinity. Values run from 0 to 14 with 7 representing neutrality. Numbers less than 7 represent increasing acidity. Numbers greater than 7 represent increasing alkalinity.

Photosynthesis - the formation of carbohydrates in chlorophyll-containing plant tissues which are exposed to light. Oxygen is liberated in the reaction.

Pollutant - any substance which lowers the quality of the receiving water (or air, soil, etc.).

Primary sewage treatment - process by which solid materials are removed from sewage (usually by settling or filtration).

Putrescible - capable of rotting.

Renewable resource - a resource capable of replenishing itself. Living things, soil and water are renewable resources. Coal, oil and mineral ores are non-renewable.

Respiration - chemical processes by which substances are oxidized within living cells to provide energy.

Secondary sewage treatment - process by which decomposable soluble substances are removed from sewage (usually by bacterial action).

Soft detergent - a detergent which can be assimilated by bacteria.
Solvent - a substance (usually a liquid) capable of dissolving other substances.
Species diversity - the degree of variability among the species present in an area.
Sphaerotilis bacteria - a type of bacteria which produce slime.
Synergism - the cooperative action of two or more pollutants (the word means to work together).
Tannin - complex, water-insoluble, brownish substances of plant origin (tea owes its color to tannins).
Thermal - pertaining to heat.
Water table - the upper limit of the portion of the ground which is wholly saturated with water. In a sandy lake region the water table is usually at about the same level as the lake surfaces.

Water Pollution

Water Pollution is a slide-script program that can be used as an introduction for students to the problems associated with one of our natural resources - water. It deals with sources of water pollution and the effect of pollutants on all living things. The majority of the slides are concerned with one river that is probably most familiar to the students of Orange County - the Rapidan River. Additionally, slides of the Potomac River are included.

This slide-script program is applicable in grades 4-12, as well as adult audiences. This presentation will require approximately 45 minutes to an hour.

Slide Script: Water Pollution

1. Title Frame - Water Pollution

   No narration

2. Spaceship Earth

   As viewed from outer space, the earth appears as a blue oasis in the dark, vastness of our solar system. Blue - because about three quarters of our planet is water. Water is to life, as we know it, the determining or limiting factor, for no known organism can function and survive without it.

3. Lake

   Water takes the form of the container it is found in. This could be a container as large as a lake, as we see here...

4. River

   or in faster moving bodies such as rivers. The United States is indeed fortunate in that it is blessed with the largest freshwater lakes in the world, and one of the largest river systems.

5. Volcano

   One type of water is subterranean or underground. This subterranean water is evidenced in the form of steam from volcanos, or if one digs deeply into the earth, he will find a water saturated zone known as the water table, which supplies many wells in our area. Even though this water is deep within the earth it still is susceptible to pollution.

6. Ocean

   The great abundance of water on earth is somewhat misleading, for about 3/4's of all water on earth is unusable for inland

life. Why? Salt water can not be safely consumed.

7. Drop of Water

For human usage we like our water to be odorless, colorless, almost tasteless, and cool. But, water of this type is getting more difficult to find as time goes on.

8. Boy Floating in the Great Salt Lake

There are some places where water is more salty than the oceans. The Great Salt Lake of Utah has no outlets and salts continue to enter the lake from surrounding mountains until now this water is seven times more salty than the oceans.

9. Swamp

There really is no such thing as pure water in nature. This is due to the ability of water to dissolve many things. Therefore, the color of water in nature may vary greatly. Water in a swamp, for example, may be extremely dark due to the great amount of organic material in it. However, this water is not necessarily polluted, even though it is not absolutely clear.

10. Cloud

Water is constantly moving, either as a liquid or as a gas. Each day of the year water is "pumped" out of the oceans, streams, lakes, and ponds by a natural pump--our sun--and released into the air to form clouds.

11. Precipitation on Tree

The water that forms the clouds is soon recondensed into a liquid and falls to earth as rain, thus completing the water cycle.

12. Bird Flying Over Water

It is true that in some of our larger cities there is a shortage of water, but in many cases, it is a shortage of good quality water. As time marches on, water of good quality is becoming more difficult to find. Why is that?

13. Polluted Water

You may not recognize it, but for the most part this is water. But it is unusable to us due to pollution and is therefore lost as a water source.

14. Polluted Water Sign

Often times, water becomes so polluted that it is not only unfit to drink, but also is unfit to even swim and play in.

Beaches have been closed and abandoned and left only to the few forms of life that can now live there.

15. Sewage Treatment Plant Dumping Sewage Into Stream

One of the major sources of water pollution is sewage. Each year we dump 18 billion pounds of sewage into our nation's waters.. With increasing populations, this is likely to become even higher in the next few years. Sewage treatment plants are expensive and have not received priority from the tax dollar. Many plants are outdated and inefficient.

16. Waste Being Dumped Directly into Stream

Sewage treatment plants may clean the sewage once, twice or three times. However, most have only secondary treatment. Unfortunately, sewage may not be treated at all in some of our more rural environments before it enters a stream.

17. Waste Being Dumped on Ground

In some cases, wastes may even be transported in trucks and then dumped in some other location. Nevertheless, run-off following a rain will carry much of this material into nearby streams.

18. Blood Pouring from Pipe Into Stream

Until recently, organic wastes from slaughterhouses were dumped into our streams. Today state and federal regulations have stopped much of it.

19. Hog Lot

Another form of organic material entering streams is animal sewage. Run off from hog and other livestock lots adds much material to streams to be decomposed by bacteria. Agriculture wastes account for a large percentage of our water pollution problems locally.

20. Duck

Even large populations of waterfowl contribute to water pollution. Waterfowl habitats are decreasing each year causing the birds to congregate in the remaining wildlife areas. Whenever, animal populations are concentrated their waste products accumulate and contribute to water pollution.

21. Fertilizers

Not only organic fertilizers, but also chemical fertilizers contribute to water pollution. Fertilizers enable plants to grow better on land and will do likewise in water. Combined with organic wastes, a pond will become very enriched and plants will flourish.

22. Algae Covered Pond

Algae will often completely cover such a pond. Once a body of water reaches this point, it is for all purposes dead.

23. Landfill

Even organic wastes in a poorly designed and constructed landfill can contribute to water pollution. As water leaches through the landfill it carries with it much organic matter. The water then reaches the water table and thus pollutes even our underground water.

24. Dead Fish

What does all of this add up to? Unfortunately, dead aquatic life is the end result of all this. All this organic matter that gets into water is decomposed by bacteria

25. Methane Gas Bubbles

and robs the water of life giving oxygen. Also, as a result of this decomposition, methane gas is produced. With bubbling methane present, as in this close-up, water may no longer look like water.

26. Fish Coming to Surface

Organic matter and even algae itself can deplete oxygen in water. Dying algae falls to the bottom and is decayed by bacteria. Fish living in such conditions will often indicate their need for oxygen by coming to the surface.

27. Polluting Industry

Look closely at this photograph. Several forms of pollution are evident--air and water. Industrial water pollution is a type that most people are aware of.

28. Mining Company Dumping Wastes

Beside the deep, clear waters that inspired Longfellow to write "By the shore of Gitchee Gumee", a waterfall of taconite tailings from the Reserve Mining Co. spills into Lake Superior at the rate of 20 million tons a year. Conservationists are outraged, but the company says the grime is harmless.

29. More Water Pollution

Rainbow of filth reaching to Gitchee Gumee.

30. Mercury

Metals also contaminate and poison our waters. They come from

industry and automobile exhausts. Liquid metal mercury is the best known of the metals. Its presence in water has accounted for numerous fish kills across the nation.

31. Strip Mining

At first glance, this photograph might remind you of the moon. But, it is not. It is an area of strip mining! Strip mining is usually the most economical method to mine many minerals, but is also the most devastating to the environment.

32. Strip Mining

Because drainage patterns are disturbed, water can usually be found standing in strip mines. Upon examination, the water would probably appear clean, though no life is present. However, water that has percolated through strip mined soils is usually acidic, too acidic for aquatic life.

33. Detergents

Although detergents have been a great step forward in the war against dirty clothes, it was becoming apparent in some areas that a greater problem was emerging--removing the detergents from streams.

34. Suds on River

Detergents contain chemical compounds known as phosphates and nitrates. These two compounds often stimulate algae growth and thus indirectly bring about water pollution. However, there is hope here, for many detergents are now biodegradable. This means that bacteria found naturally in water can decompose and get rid of these detergents.

35. Glass of Soapy Water

How would you like to turn on your faucet and get a glass of soapy water?

36. Biocides

Insecticides and pesticides are another serious threat to water supplies. Run-off from fields and forests which have been sprayed enters streams, reservoirs, and underground seas. The best known pesticide is DDT. It is a very persistent killer and remains in the ecosystem for years. Animals in the most remote parts of the world have been found to contain DDT in their tissue.

37. Oil Spill

One of the newest and most serious water pollutants is oil. Oil pollution may occur on a large scale, such as oil tanker

wrecks or offshore drilling leakages, or on a smaller basis, such as a river in the vicinity of industries processing or using large quantities of oil.

38. Oil Slick

Oil polluted water may be highly flammable, is likely to be unsafe for home use, may kill most animals and plants along the banks, is smelly, dirty, and ugly.

39. Nuclear Power Plant

Pollution by radioactivity is new but increasingly serious and dangerous. Nuclear testing and other nuclear activities have spread radioactive contaminants throughout the world. At this point, we are not aware of all the consequences of radioactivity, nor have we been able to find ways to remove radioactive pollutants. Because the effects of radioactivity on the human body are so serious, radioactive pollution could become a frightening problem.

40. Steam Rising from Water

One of the least well known but increasingly important water pollutants is heat. Water is used for the cooling of equipment and products during manufacturing. Great quantities of cold water are drawn from rivers, used for cooling, and then returned to channels as hot water. Power plants which use large amounts of water for this purpose can raise the water temperature in the area of the plant by 10 to 20 degrees. Warm water absorbs and holds less oxygen than cold and upsets the life cycles of fish and other aquatic life.

41. Auto Corpes Along River

Another form of water pollution is the direct result of depositing "worn out" automobiles and other pieces of machinery and equipment along waterways. This slide needs little explanation.

42. Forest Fire

Water pollution may be caused directly by man, as we have already seen, or it may be created indirectly as a result of forest fires....

43. Clearing of Land

or land development.

44. Siltation of Pond

Both forest fires and land development strip the land of its vegetative cover, thus making the land highly vulnerable to

soil erosion. With rains the run-off becomes much greater and carries with it our precious soil, often heavily loaded with fertilizer. The result is increased siltation to fill in bodies of water, clog the gills of fish and other marine life, and destroy bottom conditions of ponds where much of the aquatic life breeds and reproduces.

45. Flooded Town

Some authorities believe that river channels, polluted with garbage, silt, and solid waste have increased the likelihood of flooding. When the natural channel becomes filled the river flows at higher levels than normal. When heavy rains occur a river is more likely to overflow its banks.

46. River By Papermill

Paper mills contribute substantially to water pollution. Before this northern mill was made to clean up, it was dumping not only chemicals but wood chips and bark into the river.

47. Barge on River

Because natural water channels have been filled with debris, it is necessary to dredge some rivers to allow barge traffic to move along our waterways.

48. Trout

Fish vary in their ability to live in polluted water. Usually our most desirable game fish have a low tolerance to polluted water and die. Trout, as seen here, soon die if water becomes polluted at all.

49. Bass

Other fish, such as bass, can tolerate more dirty water. Rough fish such as carp and catfish can live in even dirtier water.

50. Dead Carp

But, even carp cannot live if the water becomes too polluted.

51. Biologist at Work

In an effort to better detect water pollution and its source, biologists are at work around the world collecting water samples...

52. Biologists in Boat

that can be brought back to the boat...

53. Biologists in Lab

or to the water laboratory, where it will be determined what are the living and non-living parts of the water.

54. Fresh Water Clams

However, one does not have to be a trained water ecologist to learn how to detect pollution. Some organisms will indicate water conditions by their presence or absence. For instance, fresh water clams will soon die if the water in which they live becomes polluted. Therefore, if clams can be found in a stream, it indicates clean water.

55. Caddisfly

The larvae of the caddisfly is another clean water indicator organism. It builds its home on the underside of rocks. The home may be composed of sticks or small pebbles cemented together.

56. Midge

Another insect, the midge, can live in very polluted water. It can live in clean water quite well also, but finding the midge and not caddisflies in a body of water may indicate water pollution.

57. Midge Larvae

The immature form of the midge is not a handsome organism.

58. Young Biologist on Stream

If a biologist can distinguish between the differences of a caddisfly and midge larva, he has a method of determining water quality. This young biologist is preparing to lower a device that will get a mud sample of the lake bottom.

59. Emptying Mud Sample

The sample is poured into a series of sieves and washed.

60. Examination of Contents

Following the washing, the contents are examined. The organisms found will help him to identify the condition of the water.

61. Checking a Stream

By placing a stream sampler downstream from the point where someone stirs up the stream bottom organisms of that habitat may be captured.

62. Examining Stream Samples

Again, the organisms present indicate the quality of the water.

63. Large Number of Fish

Perhaps you once knew of a good fishinghole, but due to pollution the fishing is not good anymore. We can't afford to lose more of our precious water to pollution, for there is a bottom for every barrel. The choice is yours - we can have this.....

64. Dead Fish

or this! We cannot treat water without regard, for water is life!

What Can Be Done to Stop Water Pollution

1. Governmental Action

Governmental action is required for the prevention and correction of water pollution. Through new laws, enforced by water pollution control agencies, federal, state, and local governments are attempting to solve the many water problems facing our nation.

Federal - Recent laws passed by the national government established the Federal Water Pollution Control Administration. They also provide additional funds for construction of sewers and waste treatment plants and other funds for research on improved sewer systems. The federal government can also

1. enforce laws against pollution,
2. assist in establishing water quality standards,
3. develop water programs covering entire river basins, and
4. provide specialists and technical assistance to states and communities.

States - All states have now formed water pollution control agencies. They have also passed laws to assist the agencies in their work. Like the federal agencies, state agencies can provide additional funds, administer laws, collect data on statewide pollution problems, and provide specialists and other assistance to local communities.

Local - Water pollution often begins in local communities and therefore must be controlled by these same communities. Local governments and other members of the community must work to provide

1. more up-to-date and adequate sewer systems,
2. more effective water treatment facilities, and
3. effective laws and regulations to control water pollution

2. Planning and Zoning

Some of the dangers of water pollution might be reduced by

better planning. Industries requiring large amounts of water and dumping large amounts of waste should be built far apart. Better separation of industries might allow natural water purification processes to work. Zoning would also insure that chemicals which join to form dangerous poisons are not dumped into the same water. Some wastes (radioactive materials) should not be dumped at all. Activities which could be dangerous in case of accidents should be constructed far from areas where people live and work. Can you think of other problems which would be solved by limiting cities, industries, and farms to certain zones?

Prohibit Certain Activities - Certain activities such as offshore oil drilling may have to be closely controlled if we wish to have clean water in the future. If an industry or activity

1. uses too much water,
2. dumps too many dangerous chemicals, or
3. is dangerous in case of accidents,

the industry or activity may have to be prohibited. We may not wish to live without certain products but we may have to if we wish to survive.

Elimination of Products - If we are unable to control the pollution caused by the manufacturing and disposal of certain products, we may find it necessary to eliminate or restrict the offending products. Some products, such as strong detergents, radioactive materials, and toxic chemicals are probably too dangerous, difficult, and expensive to control at the present time. While we may enjoy some of the advantages offered by these products, we may have to make a choice between life and death. We cannot continue to dump deadly chemicals into our drinking water.

Regulation of Effluents - Laws and regulations which force polluters to pay the costs of clean-up should be passed. If a municipality, industry, or farm unit dumps a large amount of contamination in the water supply, it should be made to share the later cost of making the water safe again. If the pollutants dumped by an industry, city, or farm cannot be treated successfully, then regulations preventing the disposal of that waste should be passed. Do you think large polluters would stop dumping untreated wastes if they had to pay the clean-up costs?

Taxes - Very probably, the task of cleanup will be done by government. This means that we will pay for it with our taxes. The fairest way to do this is to tax people or industries heavily when they pollute. This would mean that they would have to charge more for their products and would be a powerful reason to cut down on their pollution. An industry's taxes could be cut if they installed special equipment to cut down on pollution. This would mean that they could produce their products at a lower cost and probably sell more. Thus, it would now be profitable not to be a polluter.

Individual Action - All of us can do things ourselves to help solve our serious water pollution problems. While we are using

our rivers, streams, and lakes for boating, swimming, and picnicking, we can stop dumping litter, garbage, and other wastes in the water. We can share our ideas about water pollution with others in our community.

If many more people become concerned about the problem, we may be able to find some solutions. We can try to learn more about the pollution problem. It is important that we have facts so that we can suggest better solutions to the problems. Everyone can find out whether their community has an adequate sewer system, sewage treatment, and plans for future improvements in the system. Finally, we can contact our federal, state, and local water pollution control agencies to find out what is being done and how we can help individually to solve the water pollution problem.

Activities

1. Put the same amount of tap water in two glasses. Put a thermometer in each glass to read temperature. Place one glass on a window sill at room temperature. Place the other glass in a refrigerator. Allow the glasses to remain undisturbed for one hour.

   At the end of one hour, observe both glasses. Note any differences.

   > Were bubbles found on the sides of either glass? Which one? What kind of gas formed those bubbles, do you think? What causes the bubbles to form?

   Fish need oxygen to live in the water. Waterfalls and rapids mix oxygen with the water as it flows down a stream. Gases, such as oxygen, tend to remain dissolved in the water longer if the water is cool. When water is warmed, the gases bubble out, as with the tap water on the window sill.

   This is also why an opened coke will go flat if left in a warm room for several minutes.

2. Fill three jars with distilled water. Use distilled water purchased from a local store. Now label the jars A, B, and C. Put a tablespoon of detergent in jar A. Put a tablespoon of fertilizer in jar B. Leave jar C as it is. Stir the water in jars A and B in order to make a solution. Stir until there are no solid particles remaining.

   In all three jars, pour an ounce of pond water. Even if you live in a city, you can find a supply of this water. You may have to go to a park or nearby lake. Collect a sample of water with algae living in it and bring it to class. The algae in your sample may look like tiny green spots or may be a green scum from the surface of the ponds. A quart jar full should be

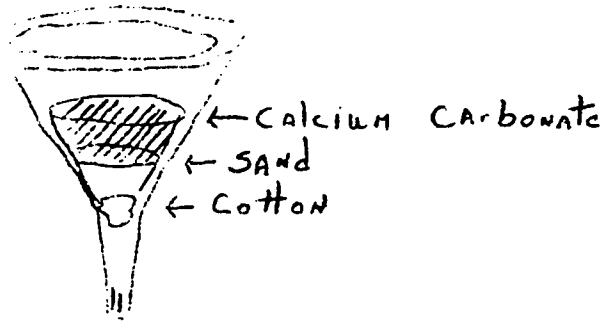
plenty.

Set your jars aside for 2 weeks. At the end of this time, compare the three jars.

a. Which jar shows the greatest growth of algae? Read the label on the detergent and fertilizer boxes to see how much phosphate is contained in each of the products.
b. Which jar contains the highest amount of phosphate?

Compare the color of the water before it was poured into the filter with the color of some unfiltered water.

a. Describe the difference between the filtered and unfiltered water.
b. Now, make a colored picture to show the difference.



Construct a second filter just like the first. However, this time put a layer of crushed chalk on top of the sand. Now run some polluted water through this filter into a second jar. You now have two samples of filtered water. One sample has been filtered through sand and the second sample through calcium carbonate and sand. Add 2 tablespoons of pond water to each of the samples of filtered water.

c. Which sample should show the greatest amount of algae growth in 2 weeks? Explain your answer.
d. What does this experiment show you about what man must do in order to recycle water for reuse?
e. Why is it more difficult to filter water today than 30 years ago?
f. How is man using water differently today than he did 20 or 30 years ago?

Activities # 3 and 4 are adapted from a booklet entitled "Water Pollution" by Charles W. Lavaroni et al. Addison-Wesley Publishing Company, Inc., 1971.

3. One way to get phosphates out of water is by adding calcium. You can observe the effect of calcium on phosphates in the following demonstration.

Once again, use your three jars. Put distilled water in each of the jars. Leave jar A as a control.

In jar B, add calcium. Regular school chalk is made of a calcium compound. Take some chalk and crush it. Add about a tablespoon of ground calcium to the water. Stir until it becomes a solution.

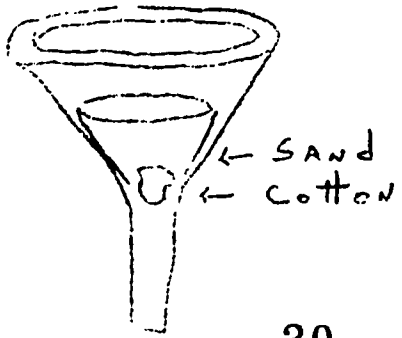
Now put a tablespoon of a phosphate detergent or fertilizer in both jar B and jar C.

a. What happens of jar B containing the calcium?
b. How is what happens in jar B different from what happens in jar C?

Now put some of your pond water into jars B and C. Allow the jars to set out for 2 weeks.

c. Which jar shows the greatest growth of algae?
d. How does it compare with other samples?

4. Try this experiment to see how water can be filtered "naturally." Put some tap water in a jar. Add some dirt, bits of leaves and other materials. Stir it so that you have some polluted water. Now add some phosphate. Use the fertilizer or detergent which caused the highest amount of algae growth in your previous experiments. Construct a simple filter similar to that shown in the picture. Put some cotton in the funnel and then pour on a layer of sand. Now slowly pour some of the polluted water through your filter.



5. For an additional six activities see "Workshop-in-a-Box, Environmental Science, Grades 1-6"(Available through your school library). These are excellent, inexpensive activities for water pollution awareness.

Bibliography of Audiovisuals

Filmstrips (Available through ESEA Title III Office)

1. The Cloudmaker - Grades K-3.
2. Water Cycle Circus - Grades K-3.
3. Animals of Sea and Shore - Elementary
4. The Muddy Raindrops - Elementary
5. The Invasion of the Sludges - Elementary
6. Life in a Pond - Elementary - Jr. High
7. Water for Tomorrow - Set of 3 filmstrips. Grades 6-12.
8. The Pond - Grades 4-12.
9. The Salt Marsh - Grades 4-12.
10. The Everglades - Grades 4-12.
11. Water Conservation Today - Jr. - Sr. High
12. Water Pollution - A Complex Problem - Secondary
13. Fresh Water from the Sea - Secondary
14. Measuring Water Pollution - Secondary

Films (Available through ESEA Title III Office)

1. Lorax - Elementary.
2. Water for All Living Things - Elementary
3. World in a Marsh - Elementary

For a description of the above films see the audiovisuals listing available through this office.

Books (Available through ESEA Title III Office)

1. Lavaroni & O'Donnell. Water Pollution. Addison-Wesley Publishing Company, Inc., California, 1971.