WATER POLLUTION COMPUTER PROGRAM

For this part of the lab you will be using the program **Water Pollution** by the EME Cooperation. It can be found in the computer lab in the Gen.Bio. Environmental folder. The following program will simulate various condition that will influence the amount of dissolved oxygen that occur in different bodies of water.

WATER POLLUTION

WATER POLLUTION is an interactive computer simulation consisting of two parts:

1. **Introduction:** Reviews Earth's temperature and pressure relative to water, the physical properties of water, the hydrologic cycle, factors affecting dissolved oxygen levels and fish kills, types of water pollution, biological oxygen demand, primary and secondary water treatment.

2. **Experiment:** Setting up and running water pollution experiments.

In the Experiment section, students manipulate the variables which influence water quality. Results are displayed in tables and graphs. Student activities provide basic activities to acquaint all students with various aspects of water pollution.

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OBJECTIVES

The WATER POLLUTION will help students to:

1. Understand the variables that improve and degrade water quality.
2. Determine the impact of water pollution on aquatic populations.
3. Predict the effects of manipulating one or more variables.
4. Improve data interpretation, problem-solving skills and graphing skills.
5. Evaluate hypotheses in light of experimental results.
6. Design experiments and plan a research project.

BACKGROUND

Water is a most precious resource. Living things, themselves about 70% water, depend upon water as a medium and reactant for biochemical reactions, for support and for circulation. In addition, humans use this natural resource for industrial and home use, sanitation, agriculture, recreation and to generate power.

Water is a stable molecule composed of two atoms of hydrogen to every one atom of oxygen. At sea level it vaporizes at 100°C and freezes at 0°C. Water is most dense at 4°C. During the spring and fall, as water approaches 4°C, it displaces water at lower levels. This mixes the body of water, aerating it and bringing nutrients to the surface. In the winter colder but less dense ice forms at the surface protecting organisms over wintering in the bottom waters.

Many useful substances such as oxygen, carbon dioxide and minerals, as well as

potentially harmful industrial chemicals and pesticides, dissolve in water. Dissolved oxygen in water results from the photosynthesis reaction in aquatic plants as well as water surface/atmosphere interactions. Generally, the more turbulent the water, the more dissolved oxygen it can capture from the atmosphere. Cooler water temperatures also increase the levels of dissolved oxygen in a body of water.

Dissolved oxygen levels are also dependent on the rate of decomposition of organic material. As bacteria break down organic material into a stable, inorganic form, they use up dissolved oxygen. The amount of oxygen needed for decomposition is called the Biological Oxygen Demand (BOD) and is used as an indicator of the "health" of a body of water. A high BOD indicates a high level of organic matter and an "unhealthy" condition. When dissolved oxygen levels become very low, decomposition may occur anaerobically (without oxygen). Noxious gases such as hydrogen sulfide and methane, as well as a foul appearance, are characteristic of this condition.

Humans use waterways for disposal of sewage and industrial wastes, generally reducing dissolved oxygen levels. As the levels approach 5 ppm at about 10°C, most game fish begin to suffer respiratory distress. Fish will tend to increase their respiratory rate (using up dissolved O2 faster), while getting 5-10% less oxygen as water passes over their gills at the faster rate. When dissolved oxygen levels drop below 5 ppm, a fish kill often results.

Water treatments are used to keep BOD levels low and dissolved oxygen at levels adequate to support aquatic communities. Primary water treatment involves passing water through a coarse screen, a grit chamber and a sedimentation tank to remove heavy, solid waste. This process alone reduces BOD by 35-40%. Secondary water treatment destroys harmful organisms and removes some dissolved materials. This can be done in one of two ways. The Trickling Filter Method passes water over crushed stone (1.5m deep), which captures a film of microorganisms. The film combines with oxygen and changes harmful substances into a form that can be filtered out in a sedimentation tank. Addition of chlorine further purifies the water. Remaining sludge is treated and can be recycled as fertilizer, but more frequently is dumped into the ocean. The Activated Sludge Method of secondary water treatment uses bacteria which, together with oxygen, destroy harmful microorganisms. Primary and secondary treatment combined can reduce BOD by 80-90%.

THE COMPUTER MODEL

The WATER POLLUTION program calculates dissolved oxygen and waste levels under a variety of conditions. The model displays results on a data table and a graph that plots both dissolved oxygen levels and waste concentrations against time.

Students can manipulate the following variables:

1. Body of water (Pond, Lake, Slow/Fast Rivers)	2. Water temperature (1° - 32°C)	3. Type of waste (Industrial, Sewage)
4. Dumping rate (0-14 ppm/day)	5. Type of treatment (None, Primary, Secondary)	6. Number of days (2-30)

The Data Table lists dissolved oxygen and waste in parts per million (ppm). When dissolved oxygen levels fall below 5 ppm a fish kill is indicated. The Graph plots dissolved oxygen levels (left axis) and waste levels (right axis) simultaneously. Fish kill levels are indicated.

WATER POLLUTION

1. The program concerns the effects of water pollution on aquatic life. To begin, run the INTRODUCTION for an explanation of the factors that affect water quality.

2. The Experimental section allows you to set up simulated experiments on the computer. You can investigate the effects of changing these variables:

A. Body of water (pond, lake, slow/fast river)

B. Temperature (1° - 32°C)

C. Type of pollution (industrial, sewage)

D. Dumping rate (0-14ppm/day)

E. Type of treatment (none, primary, secondary)

F. Number of days (2-30)

Activity 1

The Ketone Chemical plant is situated on a slow river whose year-round temperature remains about 18°C. The plant dumps untreated industrial waste into the river at an average rate of 12 parts per million (ppm) per day. Run this experiment for 30 days to determine:

A. What happens to the concentration of waste over time?

B. On what day does the waste concentration start to level off?

C. What happens to the concentration of dissolved oxygen over time?

D. Does a fish kill occur? If so, when? Why?

E. Compare the pollution discharge by the chemical plant to that of a town dumping 12 ppm/day of untreated sewage into the same river. Which type of waste reduces the dissolved O2 most rapidly?

F. Which pollutant is decomposed to a greater extent? Why?

Activity 2

The Flexy-Plastic Company is investigating four possible sites for a new plant: along a 14°C fast-flowing river; along a 14°C slow-flowing river; on a 14°C quiet lake; on a 14°C pond. Flexy-Plastic will dispose of an average of 12 ppm/day of untreated industrial waste directly into the water.

A. How many days does it take for the dissolved O2 level to fall below 5 ppm for:
fast river_____slow river_____lake_____pond_____

B. Which body of water retains the highest levels of dissolved O2 for the longest period of time?

C. Which plant location would be the least damaging to the environment? Why?

D. List two measures the company can take to prevent a fish kill while the plant is in operation.

1)

2)

E. Does decomposition of the plant's waste continue after the dissolved O2 level drops to zero?

Explain your answer.

Activity 3

Average seasonal temperatures of Peach Lake are:

Winter 1°C, Spring 11°C, Summer 26°C, Fall 16°C.

A. Graph the seasonal temperature vs dissolved O2 with paper provided.

B. Describe the relation between dissolved O2 and water temperature.

C. Which season would you choose to dump 10 ppm/day of untreated industrial waste to cause the least environmental damage?

D. Describe the interactions between water temperature, dissolved O2 and waste decomposition.

Activity 4

Testing the industrial waste discharge of Slick Oil Refinery shows 12 ppm/day entering the 18°C waters of a slow river.

A. Will a fish kill occur? If so, predict which day

B. Is water treatment necessary to protect the fish life? If so, which treatment?

Activity 5

Bacteria and fungi use dissolved O2 to decompose organic pollutants. The amount of O2 needed by these decomposers is called Biological Oxygen Demand (BOD). The Department of Fish and Game wants to stock fish in several fast rivers. These fish cannot tolerate a dissolved oxygen level of less than 5 ppm.

Blue River receives 8 ppm~day of secondary treated sewage. It maintains a year-round temperature of 10°C.

Tepid River receives 3 ppm/day of primary treated industrial waste. It maintains a year-round temperature of 22°C.
Narrow River receives 6 pprn/day of untreated sewage. It has a year-round temperature of 21°C.

A. Which river has the highest BOD values?

B. Which river maintains the lowest concentration of waste?

C. Which river(s) can be stocked with fish?

GLOSSARY

Biological Oxygen Demand (BOD): the amount of oxygen required to decompose the organic waste content of a body of water.

Decomposition: the biochemical breakdown of organic materials into stable, inorganic compounds by bacteria and fungi. This process may be done aerobically (with oxygen) or anaerobically (without oxygen).

Fish kill: less than 5 ppm of dissolved oxygen at 10°C results in the death of large numbers of game fish such as trout.

Industrial waste: from factories, mines, research facilities, etc.; includes salts, acids, oils, tars, greases and heavy metals.

Pollution: the undesirable alteration of the environment through human activities.

Primary Waste Treatment: removes heavy, solid waste materials through filtering; this process reduces the BOD by 35~0%.

Secondary Waste Treatment: destroys harmful microorganisms and removes certain dissolved materials by means of bacterial action. Reduces BOD by 80-90% when coupled with primary waste treatment.

Sewage: organic plant, animal and human wastes.