
Stream Side Science

Users Guide



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Introduction

The activities in Stream Side Science bring a water focus to math, science and social studies courses. These activities help students learn basic concepts while exploring watershed and water quality issues. The activities in this program bring a water focus to math and science.

The activities in Stream Side Science bring a water focus to Junior High and High School math, science and social studies courses. These hands-on activities help students learn basic concepts while exploring watershed and water quality issues.

Each lesson plan contains background information, step by step instructions for the activity, suggestions for applying the data, and further discussion questions. Student worksheets, sampling instructions, are also provided.

What's in the water?

Students observe and list abiotic factors in specific ecosystems. Students will observe and list abiotic factors in an aquatic system and measure four of them (pH, dissolved oxygen, turbidity, and temperature).

Who Lives in the Water?

Students explore diversity and adaptation to aquatic environments by observing aquatic macroinvertebrates using the Virtual Macroinvertebrates Identification Program.

The Effects of Sewage Discharge on the DO of a Stream

The discharge of effluent from wastewater treatment plants (WWTPs) effect the health of aquatic ecosystems.

When Things Heat Up

Students learn how temperature and dissolved oxygen factors affect each other and are affected by other physical and biological conditions in a stream or lake.

What's in the water?

Purpose: To observe and list abiotic factors in specific ecosystems.

Background:

In this activity students will observe and list abiotic factors in an aquatic system and measure four of them (pH, dissolved oxygen, turbidity, and temperature).

Physio-chemical indicators of water quality include dissolved oxygen, pH, temperature, dissolved solids, and nutrients (nitrogen and phosphorus).

Materials:

- pH test kits
- Dissolved oxygen test kits
- Turbidity tubes
- Thermometers
- Copies of the student worksheet
- Copies of the chemical sampling instruction sheets
- Instruction Sheets
- Water Quality Impact posters

Documents:

- Water chemistry

Presentations:

- Water chemistry

Activity:

1. Set up a station for each factor (pH, DO, turbidity, and temperature).

At each station, provide:

- Sampling instruction sheets (if possible, laminate these!)
- The appropriate testing kit
- Samples in bottles if you are not near the stream

2. Divide the students into four groups. Explain to the students that each group will start at a different station, and rotate so they will measure all the factors.

3. Have them follow the instructions for measuring each factor found on the sampling instruction sheets.

4. Have the students record their results on the student worksheet.

Student Data sheet

ABIOTIC FACTOR	YOUR RESULTS	COMPARE YOUR RESULTS TO ALLOWABLE RANGE IN PA	DOES THE WATER MEET PA REQUIREMENTS? (Y/N)
pH	pH units	6.5 to 9.0	
Dissolved Oxygen	ppm (mg/l)	Minimum of 6.5 mg/l for cold water fisheries and 5.5 mg/l for warm water fisheries.	
Turbidity	NTUs	No Standard - US EPA has a water quality standard for turbidity that states that streams should not exceed 50 NTU	
Temperature	°Celsius	Maximum of 20 °Celsius for cold water fisheries and the maximum temperature for warm water fish is 27 °Celsius.	

ACTIVITY EXTENSIONS:

Use other water sources to compare results.

Discussion:

1. Does the stream meet water quality standards for:

Dissolved oxygen?

pH?

Temperature?

Turbidity?

2. How and why would previous weather conditions effect stream quality results?

3. What abiotic factors affect stream measurement results? How?

4. How might the following factors affect your stream analysis results?

5. Discuss the impact of the water quality parameters you measured on water quality of the stream

Dissolved oxygen?

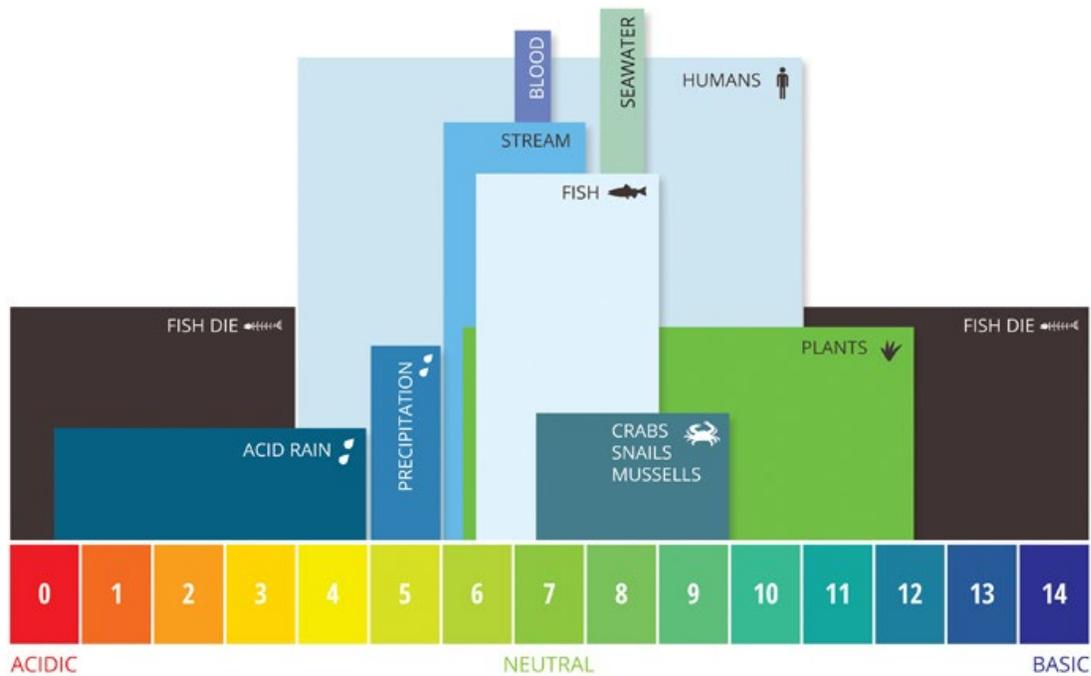
pH?

Temperature?

Turbidity?

Create posters of the following to be used in the discussion.

pH of Water



The majority of aquatic creatures prefer a pH range of 6.5-9.0.

If the pH of water is too high or too low, the aquatic organisms will die.

As pH levels move outside of the optimal pH range it can stress animal systems and reduce hatching and survival rates.

Low pH levels increase the solubility of elements and compounds, making toxic chemicals more “mobile” and increasing the risk of absorption by aquatic life

A slight change in a stream’s pH can increase the solubility of nutrients making them more accessible for plant growth.

pH levels over 9, the ammonium ion NH_4 is converted to Ammonia NH_3 , which is extremely toxic to aquatic organism.

Temperature

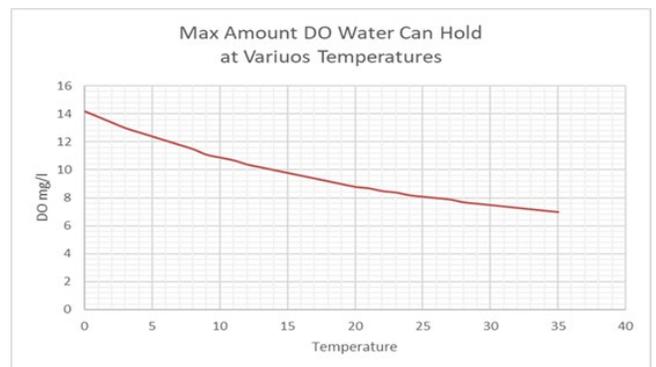


The stream temperature will vary throughout the year and through the day. Stream temperature is influenced by the amount of water feeding into the stream from underground springs, by the amount of shade, by the volume of the water itself, and by the amount of agitation.

Stream temperature affects aquatic life's sensitivity to toxic wastes, parasites, and disease, either through stress of rising water temperatures or the resulting decrease in dissolved oxygen.

Temperature

Temperature and dissolved oxygen are closely related: the warmer the water, the less dissolved oxygen.



Factors that affect stream temperature

- Air temperature: The temperature of the air above the stream
- Sunlight: More sunlight warms the water
- Land use: Impervious surfaces like parking lots and roads heat up and run off into streams
- Water depth: Deeper water is cooler
- Water quality: Dirty water absorbs more heat from the sun
- Groundwater: The amount of groundwater that enters the stream
- Vegetation: Shade from trees along the stream bank cools the water.
-

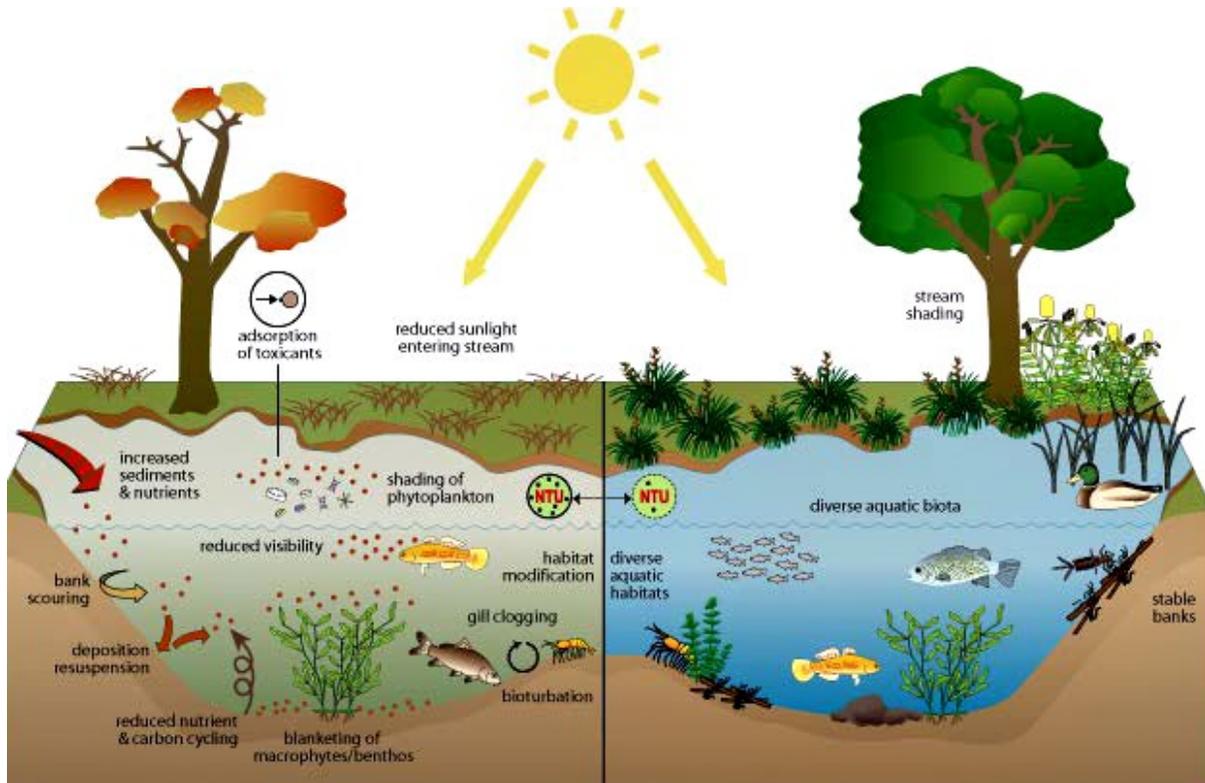
Temperature ranges of some species:

Warm water species (70 degrees F and up) largemouth bass, crappie, bluegill, carp, catfish, caddisfly

Cool water species (65 to 70 degrees F) perch, sauger, walleye, smallmouth bass, pike, muskellunge, pickerel, rock bass, stonefly, mayfly, caddisfly, water beetles

Cold water species (70 degrees F and below) trout, salmon, caddisfly, stonefly, mayfly.

Impact of Turbidity on aquatic life



Reduced sunlight: Turbidity blocks sunlight from reaching plants, which reduces their ability to photosynthesize and produce oxygen. This reduces the amount of oxygen available to aquatic life.

Clogged gills: Turbidity can clog the gills of fish and other aquatic animals, making it difficult for them to breathe.

Reduced visibility: Turbidity can make it harder for predators to find prey.

Increased acidity: Decaying organic matter in turbid water produces carbonic acid, which increases the water's acidity.

Reduced resistance to disease: Turbidity can reduce fish resistance to disease.

Altered egg and larval development: Turbidity can alter the development of fish eggs and larvae.

Student Data sheet

ABIOTIC FACTOR	YOUR RESULTS	COMPARE YOUR RESULTS TO ALLOWABLE RANGE IN PA	DOES THE WATER MEET PA REQUIREMENTS? (Y/N)
pH	pH units	6.5 to 9.0	
Dissolved Oxygen	ppm (mg/l)	Minimum of 6.5 mg/l for cold water fisheries and 5.5 mg/l for warm water fisheries.	
Turbidity	NTUs	No Standard US EPA has A water quality standard for Turbidity that states that streams should not exceed 50 NTU	
Temperature	°Celsius	Maximum of 20 °Celsius for cold water fisheries and the maximum temperature for warm water fish is 27 °Celsius.	

Turbidity Conversion Chart

Turbidity Conversion Chart	
Distance from bottom of tube (cm)	NTUs
< 6	>240
6 to 7	240
7 to 8	185
8 to 9	150
9 to 10	120
10 to 12	100
12 to 14	90
14 to 16	65
16 to 19	50
19 to 21	40
21 to 24	35
24 to 26	30
26 to 29	27
29 to 31	24
31 to 34	21
34 to 36	19
36 to 39	17
39 to 41	15
41 to 44	14
44 to 46	13
46 to 49	12
49 to 51	11
51 to 54	10
54 to 58	9
58 to 60	8
Over the top	6

WATER CHEMISTRY REFERENCE TABLE

Use this table as a guide to interpret your water quality data.

WATER PARAMETER	WHAT IT MEASURES	NATURAL READING	CAUTIONARY READINGS	POSSIBLE SOURCES	REMEDIES
Water Temperature	Heat (°C)	0–34°C (32–93°F)	>32°C for most streams >24°C for cool streams >20°C for cold streams	<ul style="list-style-type: none"> • Thermal discharges • Turbid water • Solar heat • Heated runoff 	<ul style="list-style-type: none"> • Discharges adhering to regulation • Increase riparian shade • Decrease impervious surfaces
Dissolved Oxygen	Oxygen (mg/L)	5–15 mg/L >80% O ₂ saturation in Ozark streams >60% O ₂ saturation in prairie/lowland streams	<6 mg/L for cold water <5 mg/L for cool or warm water	<ul style="list-style-type: none"> • Aeration from atmospheric contact • Aeration from churning • Photosynthesis 	<ul style="list-style-type: none"> • Limit nutrients • Reduce water temperature
pH	Acidity (pH)	6.5–9.0	<6.5 >9.0	<ul style="list-style-type: none"> • Rain • Industrial pollution • Chemical spills • Decomposition 	<ul style="list-style-type: none"> • Pollution controls • pH adjustment by chemical compounds
Nitrate	Organic nutrients (mg/L)	0.0–2.0 mg/L	>2 mg/L	<ul style="list-style-type: none"> • Sewage • Industrial output • Detergents • Fertilizer • Animal waste 	<ul style="list-style-type: none"> • Increase riparian vegetation • Limit fertilizer • Properly maintain septic systems
Phosphate	Organic nutrients (mg/L)	0.0–2.0 mg/L	>2 mg/L	<ul style="list-style-type: none"> • Industrial output • Detergents • Fertilizer • Animal waste 	<ul style="list-style-type: none"> • Increase riparian vegetation • Limit fertilizer • Properly maintain septic systems
Transparency	Water clarity (cm)	Variable	Decreasing transparency measurements over time	<ul style="list-style-type: none"> • Sedimentation • Algal bloom • Watercraft traffic • Storm runoff 	<ul style="list-style-type: none"> • Sediment controls • Increase riparian vegetation

Discussion:

1. Does the stream meet water quality standards for:

Dissolved oxygen?
pH?
Temperature?
Turbidity?

*See the column of the student data sheet does the water meet PA requirements.
Considerer exploring with the students the reason(s) why the stream did not meet requirements.*

2. How and why would previous weather conditions effect stream quality results?

Often it can take hours or days for the runoff from a storm or snowmelt to reach the water and travel down the river. Therefore, previous weather may be as important as today's weather in explaining your results.

3. What abiotic factors affect stream measurement results? How?

Hot weather may result in extra snowmelt upstream and increase flows. Sunny weather may increase photosynthesis at your site, and therefore increase dissolved oxygen and pH levels. Higher flows from storms or snowmelt may increase the turbidity in your stream.

Soils in the watershed will affect the chemical composition of the runoff that reaches the stream. Topography (the steepness of the land) will determine whether the stream is steep and fast or slow and wide, which will affect dissolved oxygen and temperature.

Vegetation along the stream provides shade and protects the banks from erosion.

Land uses along the stream and in the watershed will determine what type of pollutants may enter the stream (e.g., sediment from agriculture or logging, metals and oils from roads, or fertilizers from golf courses).

4. How might the following factors affect your stream analysis results?

Seasons
From year to year
Throughout the day

5. Discuss the impact of the water quality parameters you measured on water quality of the stream

Dissolved oxygen?
pH?
Temperature?
Turbidity?

Who Lives in the Water?

Purpose: To investigate observe and quantify macroinvertebrates through observation and charting.

Summary: In this exercise, students will, using, the Virtual Macroinvertebrate Program, observe macroinvertebrates. They will record and summarize and interpret their findings.

Background: Aquatic macroinvertebrates (insects and other organisms that live in streams and ponds) display a wide range of adaptations to different aquatic conditions. Some types of macroinvertebrates are extremely tolerant of changes in temperature, flow, food, or even the presence of pollutants, while other types are so sensitive to these changes that they may die or move to other areas. In this activity, students identify the macroinvertebrates in a stream using the Virtual Macroinvertebrate Identification Program noting which types are most abundant.

Materials: Macroinvertebrate Tally sheet
Macroinvertebrate Pollution Sensitivities
Guide to Macroinvertebrates
Macroinvertebrate Survey and Assessment

Documents: Biological Monitoring
Stream side science User's Manual

Presentations: Biological Monitoring
Who Lives in the Water.

Who Lives in the Water

Introduction

Macroinvertebrates are organisms that have no backbone and are visible to the naked eye. Macroinvertebrates live their lives mostly in the water. All macroinvertebrates start their lives in the water.

Each macroinvertebrate has its own pollution tolerance. The classes of macroinvertebrates are low pollution tolerant, somewhat pollution tolerant, and high pollution tolerant (Primbas, 2005).

Macroinvertebrates that are low pollution tolerant are caddisflies, water pennies, stoneflies, and mayflies.

Somewhat pollution tolerant macroinvertebrates are dragonflies, crane flies, and damselflies.

High pollution tolerant macroinvertebrates are blackflies, aquatic worms, and midges (Primbas, 2005)

Biotic index values of macroinvertebrates can be used to determine the water quality. The Hillsenhoff's biotic index scale ranges from one to ten.

An average biotic index values ranges from 1 to 3.75 the water quality is considered excellent. An average biotic index values from 3.76 to 5 infer good water quality

An average biotic index values from 5.1 to 6.5 infer fair water quality,

An average biotic index values from 6.6 to 10.9 infer poor water quality. (Faulds, Murray, & Neville, n.d.)

Macroinvertebrates have different preferred habitats based on the water quality they need to survive:

Riffles
Stagnant
Pools
Undercut Banks

The anatomy of a stream includes habitats such as riffles, undercut banks, and stagnant pools.

Riffles are fast moving white water with a rocky bottom that is not too deep.

Undercut banks are slow moving deep waters that flow under the edge of the stream

bank. This habitat has an overhang of vegetation. When vegetation falls into the stream, it is washed downstream into stagnant pools where it stays and decomposes. (Allan, 1995).

Macroinvertebrates have different preferred habitats based on the water quality they need to survive. Many macroinvertebrates prefer or need a high dissolved oxygen level.

Many macroinvertebrates also prefer to live where the temperature is cold and the current is fast, some macroinvertebrates need or prefer warmer temperatures with less dissolved oxygen.

Macroinvertebrates such as leeches and aquatic worms are very tolerant to pollution and they do not need high dissolved oxygen levels

Student Activities

Assessment

Directions

Identify the aquatic macroinvertebrates in the Who Lives in the Water exercise presentation.

Using the Macroinvertebrate Tally Sheet identify the species and the number of organisms present.

Use the Biological Monitoring Data Assessment Sheet to record the presence and abundance of macroinvertebrate to assess the overall water quality.

Develop graphs using the data to allow for visualization of the data.

Macroinvertebrate Graphing Activity

PURPOSE: To describe and identify the quality of a stream site by analyzing the aquatic macroinvertebrates that live there.

SUMMARY: Students will learn about water quality indicators through the use of candy representing a “macroinvertebrate sample.” Sorting the candy and evaluating what is found will tell the students about the quality of the water.

BACKGROUND: Sometimes it is easy to tell if a stream is polluted. Strange colors and dead fish are often indicators of poor water quality, but biologists need to know about water quality problems long before they reach this point. Some of their most effective partners in detecting declining trends in water quality are aquatic macroinvertebrates because they respond rapidly to changes in water quality.

To evaluate the health and productivity of a stream, biologists look at the types of macroinvertebrate species who live there. Different species have different tolerance levels to pollution. If many pollution-intolerant organisms, such as stonefly or caddisfly nymphs, are present, the water quality is probably good. Although the presence of certain species indicates good water quality, the absence of these species does not necessarily indicate bad water quality. Other factors besides pollution may account for their absence.

Sensitive or Intolerant Species:

Organisms easily killed, impaired, or driven off by bad water quality; includes many types of stonefly, dobsonfly, and mayfly nymphs and caddisfly larvae.

Somewhat Tolerant Species:

Organisms with the ability to live under varying conditions may be found in good or poor quality water; includes amphipods, scuds, beetle and crane fly larvae, crayfish, and dragonfly nymphs.

Tolerant Species:

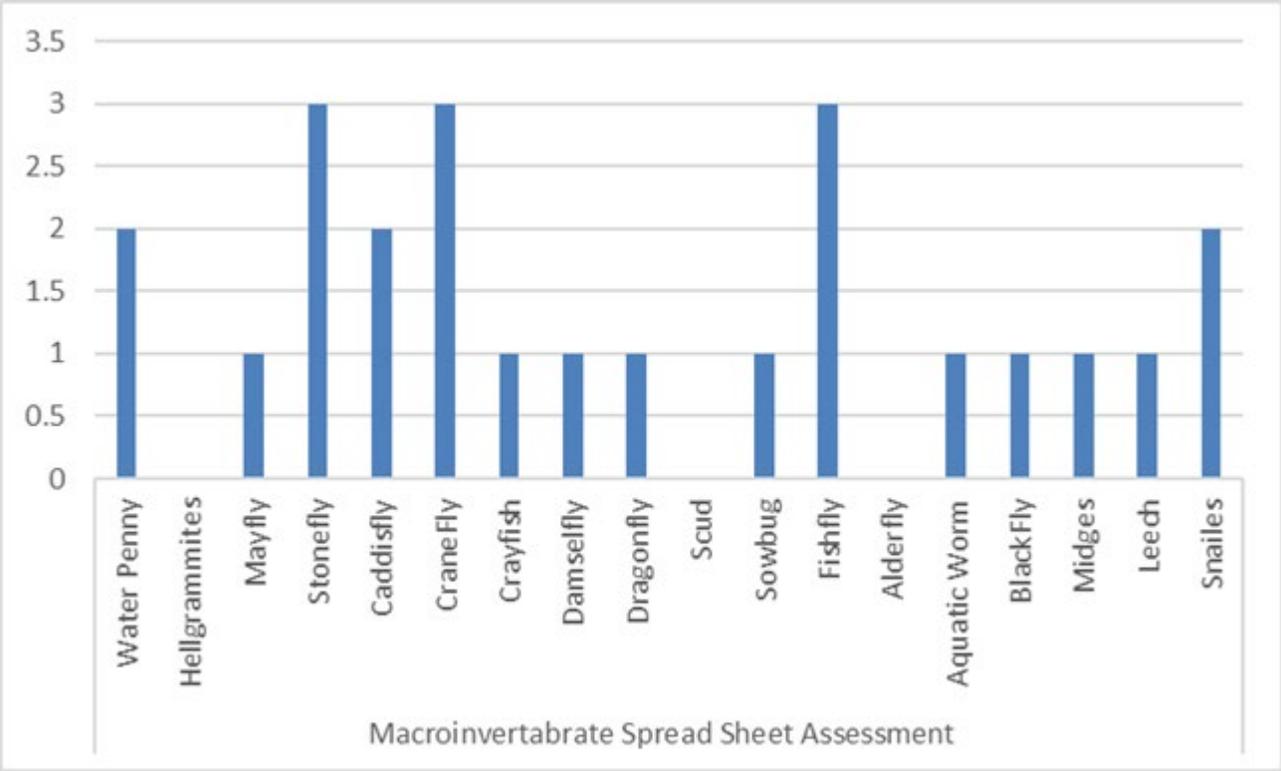
Organisms capable of withstanding poor water quality; includes most leeches, aquatic worms, midge larvae, and sow bugs.

PROCEDURE:

1. Distribute graph paper to each student. Have students set up a bar graph for the aquatic macroinvertebrate sample. Label the x-axis with the names of the macroinvertebrates. Label the y-axis with the number of macroinvertebrates. You can also make copies of the graph below to hand out to the students.
2. Using the Macroinvertebrate Talley Sheet Have the students count the number of each species of macroinvertebrate and graph them on the paper. Have the students try to determine the quality of the water.

BENTHIC MACROINVERTEBRATE IDENTIFICATION ACTIVITY ANSWERS

Aquatic Snails	1
Snipe flies	1
Black Fly	1
Caddisfly	1
Crain Fly	3
Crayfish	1
Dragonflies	1
Damselflies	1
Fishflies	3
Leach	1
Mayflies	1
Midges	3
Stoneflies	1
Water Penney	2
Worms	1



MACROINVERTEBRATE TALLY SHEET Assessment Exercise

Macroinvertebrate	NO.
Mayflies 	
Stoneflies 	
Caddisflies 	
Hellgrammite/Fish Flies 	
Water snipe Flies 	
Riffle Beetles 	
Water Pennies 	
Gilled Snails 	
Net Spinning Caddisflies 	
Damselflies 	

Macroinvertebrate	NO.
Crane Flies 	
Sowbugs 	
Scuds 	
Crayfish 	
Black Flies 	
Clams and Mussels 	
Midge flies 	
Lunged snails 	
Worms 	
Leeches 	
Dragonflies 	

MACROINVERTEBRATE TALLY SHEET
Assessment Exercise
Answers

Macroinvertebrate	NO.
Mayflies 	14
Stoneflies 	1
Caddisflies 	1
Hellgrammite/Fish Flies 	
Water snipe Flies 	1
Riffle Beetles 	
Water Pennies 	2
Gilled Snails 	1
Case Building Caddis 	1
Damselflies 	1
Adler Fly 	1

Macroinvertebrate	NO.
Crane Flies 	1
Sowbugs 	1
Scuds 	
Crayfish 	1
Black Flies 	1
Clams and Muscles 	
Midge flies 	4
Lunged snails 	
Worms 	1
Leeches 	1
Dragonflies 	1

Biological Monitoring Data Sheet

Record the taxa (group) represented in your sampling by either entering the number of organisms you counted

<u>Group 1 - Intolerant</u>	<u>Group 2 - Moderately Intolerant</u>	<u>Group 3 - Fairly Tolerant</u>	<u>Group 4 - Very Tolerant</u>
<input type="checkbox"/> Stonefly nymph	<input type="checkbox"/> Damselfly nymph	<input type="checkbox"/> Leech	<input type="checkbox"/> Aquatic worm
<input type="checkbox"/> Mayfly nymph	<input type="checkbox"/> Dragonfly nymph	<input type="checkbox"/> Midge larva	<input type="checkbox"/> Blood midge larva (red)
<input type="checkbox"/> Caddisfly larva	<input type="checkbox"/> Scud	<input type="checkbox"/> Planaria/Flatworm	<input type="checkbox"/> Rat-tailed Maggot
<input type="checkbox"/> Riffle Beetle	<input type="checkbox"/> Sowbug	<input type="checkbox"/> Black fly larva	<input type="checkbox"/> Left-Handed or Pouch snail
<input type="checkbox"/> Dobsonfly Larva	<input type="checkbox"/> Crane fly larva		
<input type="checkbox"/> Right-Handed or Gilled snail	<input type="checkbox"/> Clam/Mussel		
<input type="checkbox"/> Water Penny	<input type="checkbox"/> Crayfish		
<input type="checkbox"/> # of TAXA represented	<input type="checkbox"/> # of TAXA represented	<input type="checkbox"/> # of TAXA represented	<input type="checkbox"/> # of TAXA represented
<input type="checkbox"/> Weighting Factor (x4)	<input type="checkbox"/> Weighting Factor (x3)	<input type="checkbox"/> Weighting Factor (x2)	<input type="checkbox"/> Weighting Factor (x1)

Pollution Tolerance Index Rating
(Add the final index values for each group)

PTI Ratings	
Excellent	23 or More Good
Fair	17 - 22
Fair	11 - 16
Poor	10 or Less

Use the Pollution tolerance Index to compute the Pollution Tolerance Indices for the stream.

Enter the number of individuals for that Taxa in the box adjacent to the organism.
 Enter the number of Taxa represented in each sensitivity group in the box titled #of Taxa Represented.
 Sum the number of Taxa represented in each category, and enter that value in the in the Pollution Tolerance Index Rating box.

Biological Monitoring Data Sheet

Pollution Tolerance Index (PTI)

Record the taxa (group) represented in your sampling by either entering the number of organisms you counted or a ✓

Group 1 - Intolerant	Group 2 - Moderately Intolerant	Group 3 - Fairly Tolerant	Group 4 - Very Tolerant
<input checked="" type="checkbox"/> Stonefly nymph	<input checked="" type="checkbox"/> Damselfly nymph	<input checked="" type="checkbox"/> Leech	<input type="checkbox"/> Aquatic worm
<input checked="" type="checkbox"/> Mayfly nymph	<input checked="" type="checkbox"/> Dragonfly nymph	<input checked="" type="checkbox"/> Midge larva	<input type="checkbox"/> Blood midge larva
<input checked="" type="checkbox"/> Caddisfly larva	<input type="checkbox"/> Scud	<input type="checkbox"/> Planaria/Flatworm	<input type="checkbox"/> Rat-tailed Magg
<input type="checkbox"/> Riffle Beetle	<input checked="" type="checkbox"/> Sowbug	<input checked="" type="checkbox"/> Black fly larva	<input type="checkbox"/> Left-Handed or Pouch snail
<input type="checkbox"/> Dobsonfly Larva	<input checked="" type="checkbox"/> Crane fly larva		
<input checked="" type="checkbox"/> Right-Handed or Gilled snail	<input type="checkbox"/> Clam/Mussel		
<input checked="" type="checkbox"/> Water Penny	<input checked="" type="checkbox"/> Crayfish		
5 # of TAXA represented	5 # of TAXA represented	3 # of TAXA represented	0 # of TAXA represented
<input type="checkbox"/> Weighting Factor (x4)	<input type="checkbox"/> Weighting Factor (x3)	<input type="checkbox"/> Weighting Factor (x2)	<input type="checkbox"/> Weighting Factor (x1)
Pollution Tolerance Index Rating			
(Add the final index values for each group)			
13			

PTI Ratings

Excellent 23 or More

Good 17 - 22

Fair 11 - 16

Poor 10 or Less

Based on a biotic index of 13 the Assessment Stream has fair water quality the predominant taxa were intolerant and moderately tolerant species

COMPARING MACROINVERTEBRATES FROM THREE HABITATS

Using the macroinvertebrate assessment data for the following

sites Riffles

Stagnant Pools

Undercut Banks

Complete a Macroinvertebrate Assessment form for each site.

Graph, construct bar graphs for each site. Compare the information from the three sites.

Discuss your interpretation of these results

Macroinvertebrate counts for Riffles

Species	Count
Caddisflies	30
Water Pennies	24
Stoneflies	12
Mayflies	6
Craneflies	6
Hellgrammites	5
Scuds	3
Aquatic worms	3
Riffle Beetles	2
Damselflies	2
Midges	2
Dragonflies	2
Fishflies	1
Blackflies	1

Macroinvertebrate counts for Stagnant Pool

Species	Count
Caddisflies	
Water Pennies	1
Stoneflies	1
Mayflies	
Craneflies	
Hellgrammites	
Scruds	
Aquatic worms	55
Riffle Beetles	
Damselflies	
Midges	24
Dragonflies	1
Fishflies	5
Blackflies	7
Leaches	7
Dragon flies	1
Lug Snails	1

Macroinvertebrate counts for Undercut Banks

Species	Count
Caddisflies	23
Water Pennies	12
Stoneflies	3
Mayflies	17
Craneflies	3
Hellgrammites	7
Scuds	2
Aquatic worms	15
Riffle Beetles	5
Damselflies	2
Midges	
Dragonflies	1
Fishflies	5
Blackflies	7
Leaches	7
Dragon flies	2
Crayfish	1
Lug Snails	1

Discuss your interpretation of these results

Habitat Scores

Riffles

Undercut Banks

Stagnant Pool

Discussion

Discuss your interpretation of these results

Habitat Scores

Based on the biotic index scale shown above the riffle habitat has excellent water quality;

The undercut bank habitat has a good water quality.

The stagnate pool had fair water quality.

Riffles

The predominant species in the riffle habitat where; caddisflies, water pennies and stoneflies (which are highly sensitive to pollution).

Moderate pollution tolerant organisms where also found: dragonflies, fishflies, blackflies and water striders where found.

The only pollution tolerant macroinvertebrate that were found in the riffle habitat was the blackfly

Undercut Banks

The primary change from an excellent site is that there were fewer taxa of stoneflies. Mayflies will be present, but fewer taxa. Beetles should still be present. A few types of caddisflies should be present depending on the type of degradation. Freshwater mollusks where absent.

There were more caddisflies and mayflies than any other macroinvertebrate at the undercut bank habitat.

A fairly large number of water pennies. Caddisflies, mayflies and water pennies where found. They are macroinvertebrates that fall under the most sensitive category.

In addition, a large number of the macroinvertebrates found in the undercut bank habitat were aquatic worms which are pollution tolerant.

Stagnant Pool

The stagnant pool had the most pollution tolerant macroinvertebrates, a few highly sensitive and hardly any somewhat sensitive macroinvertebrates.

Findings

The purpose of this exercise was to compare macroinvertebrates found at three habitats: riffles, undercut and stagnant pool.

The comparison of the macroinvertebrates helped determine the water quality of each habitat.

The biotic index values were significantly different because the macroinvertebrates have different tolerances to pollution and nutrient levels, and different dissolved oxygen needs.

Macroinvertebrates with a higher biotic index value were found in the stagnant pools, macroinvertebrates with a lower biotic index value were found in the in the riffles, and a mix of macroinvertebrates with high and low biotic index values in the undercut banks.

Overall sensitive macroinvertebrates had the highest percent at the riffle and undercut bank habitat, and pollution tolerant has the highest percent at the stagnant pool

Displays and Handouts

MACROINVERTEBRATE TALLY SHEET
Assessment Exercise

Macroinvertebrate	NO.
Mayflies 	
Stoneflies 	
Caddisflies 	
Hellgrammite/Fish Flies 	
Water snipe Flies 	
Riffle Beetles 	
Water Pennies 	
Gilled Snails 	
Net Spinning Caddisflies 	
Damselflies 	

Macroinvertebrate	NO.
Crane Flies 	
Sowbugs 	
Scuds 	
Crayfish 	
Black Flies 	
Clams and Mussels 	
Midge flies 	
Lunged snails 	
Worms 	
Leeches 	
Dragonflies 	

Biological Monitoring Data Sheet

Record the taxa (group) represented in your sampling by either entering the number of organisms you counted

<p><u>Group 1 - Intolerant</u></p> <p><input type="text"/> Stonefly nymph </p> <p><input type="text"/> Mayfly nymph </p> <p><input type="text"/> Caddisfly larva </p> <p><input type="text"/> Riffle Beetle </p> <p><input type="text"/> Dobsonfly Larva </p> <p><input type="text"/> Right-Handed or Gilled snail </p> <p><input type="text"/> Water Penny </p> <p><input type="text"/> # of TAXA represented</p> <p><input type="text"/> Weighting Factor (x4)</p>	<p><u>Group 2 - Moderately Intolerant</u></p> <p><input type="text"/> Damselfly nymph </p> <p><input type="text"/> Dragonfly nymph </p> <p><input type="text"/> Scud </p> <p><input type="text"/> Sowbug </p> <p><input type="text"/> Cranefly larva </p> <p><input type="text"/> Clam/Mussel </p> <p><input type="text"/> Crayfish </p> <p><input type="text"/> # of TAXA represented</p> <p><input type="text"/> Weighting Factor (x3)</p>	<p><u>Group 3 - Fairly Tolerant</u></p> <p><input type="text"/> Leech </p> <p><input type="text"/> Midge larva </p> <p><input type="text"/> Planaria/ Flatworm </p> <p><input type="text"/> Black fly larva </p> <p><input type="text"/> # of TAXA represented</p> <p><input type="text"/> Weighting Factor (x2)</p>	<p><u>Groups 4 - Very Tolerant</u></p> <p><input type="text"/> Aquatic worm </p> <p><input type="text"/> Blood midge larva (red) </p> <p><input type="text"/> Rat-tailed Maggot </p> <p><input type="text"/> Left-Handed or Pouch snail </p> <p><input type="text"/> # of TAXA represented</p> <p><input type="text"/> Weighting Factor (x1)</p>
--	--	--	--

Pollution Tolerance Index Rating
 (Add the final index values for each group)

PTI Ratings	
Excellent	23 or More Good
Fair	17 - 22
Poor	11 - 16
	10 or Less



Guide to Aquatic Macroinvertebrates: The Basics

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Riffle Beetle Larva



- Small crunchy, comma shaped body, up to 1/2 inch
- 3 pairs of segmented legs
- Gills and 2 hooks on posterior end

Riffle Beetle Adult



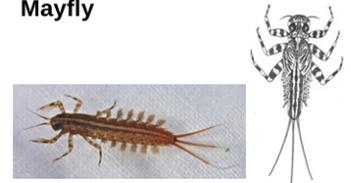
- Oblong beetle shape, long antennae
- Small, 1/16 - 1/8 of an inch
- Walks slowly underwater, doesn't swim on surface

Water Penny



- Flat saucer-shaped body
- 3 tiny pairs of legs on the underside
- Up to 1/2 inch

Mayfly



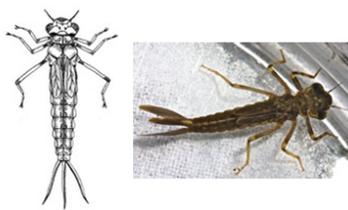
- Feather or leaf-like gills on the abdomen
- Typically has 3 tails (can have 2)
- 3 pairs of segmented legs

Stonefly



- Long antennae
- 2 tails
- No gills on abdomen
- 3 pairs of segmented legs

Damselfly



- 3 broad oar-shaped tails
- Long, narrow body with no gills on abdomen
- 3 pairs of spindly segmented legs

Common Net Spinning Caddisfly



- Head and first three thoraxes are hardened
- 2 fleshy, hairy hooks on the posterior
- 3 pairs of segmented legs
- Gill tufts on abdomen

Case-making/Free living Caddisfly



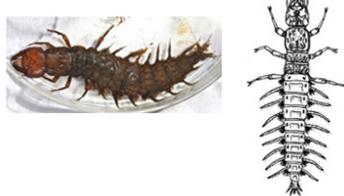
- May have a case constructed of sand, gravel, leaves or twigs
- Hardened head with grub-like soft body
- 3 pairs of segmented legs with hooks on the posterior

Dragonfly



- Oval/round abdomen (may be wider than it is tall)
- Large eyes
- 3 pairs of segment legs

Dobsonfly (Hellgrammite)



- 8 pairs of fleshy appendages on abdomen
- Cotton-like gill tufts between appendages
- Large pinching jaw

Fishfly



- 8 pairs of fleshy appendages on abdomen
- No gill tufts
- Forked posterior with 2 fleshy tails

Alderfly



- 7 pairs of fleshy appendages on abdomen, no gill tufts
- One long thin branched tail



Guide to Aquatic Macroinvertebrates: The Basics



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Midge



- Uniformly wide, segmented body
- Distinct head
- Pair of prolegs behind the head and at the posterior
- Up to 1/4 inch

Crane Fly



- Plump, caterpillar-like, segmented body
- 4 fingerlike lobes at the posterior
- 1/2 - 1 inch

Black Fly



- Bowling pin shaped body
- Distinct head with one proleg directly underneath
- Up to 1/4 inch

Water Snipe



- Soft, fleshy body with tapered ends
- Caterpillar-like legs
- 2 feathery 'horns' at the posterior

Crayfish



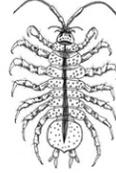
- Lobster-like body
- Two large claws near the head
- 1/2 - 5 inches

Scud



- Shrimp-like body, no hard covering
- Long antennae
- 7 pairs of legs
- Swims quickly on its side

Sowbug



- Oblong body
- 2 pairs of antennae, one longer than the other
- Armor-like appearance

Clams & Mussels



- Fleshy body enclosed between two-hinged shells
- 1/8 - 5 inches

Gilled Snail



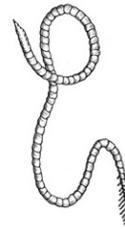
- Shell opens to the right when holding the shell with the narrow end pointing up and the opening facing you
- Has an operculum (thin plate covering the shell opening)

Lunged Snail



- Shell opens to the left when holding the shell with the narrow end pointing up and the opening facing you
- No operculum
- Shell might be in a coiled shape

Aquatic Worm



- No distinct head
- No legs
- 1/4 - 2 inches

Leech



- Worm-like segmented body
- Both ends have suckers
- 1/4 - 2 inches

Flatworm (Planaria)

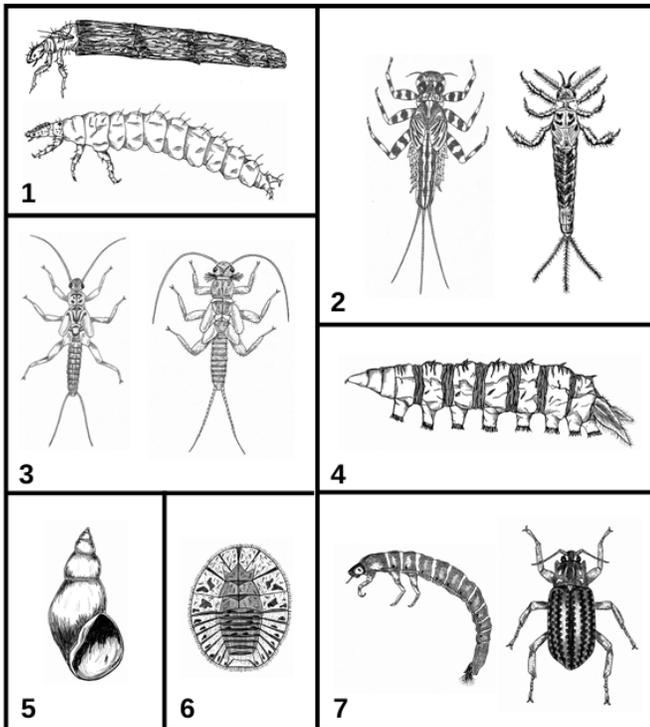


- Soft elongated body
- Triangular shaped head with eyes on top

Aquatic Macroinvertebrate Identification & Pollution Sensitivities

Sensitive to Pollution

These organisms are sensitive to pollution and indicate good water quality.



1 Most Caddisflies: Order Trichoptera. Up to 1", 6 hooked legs on upper 1/3 of body, may be in stick, rock, or leaf case, no gill tufts on abdomen, intolerant of impairment.

2 Mayfly: Order Ephemeroptera. ¼" – 1", plate-like or feathery gills on abdomen, 6 hooked legs, 2 or 3 long hair-like tails, tails may be webbed together, very intolerant of impairment.

3 Stonefly: Order Plecoptera. ½" – 1 ½", 6 legs with hooked tips, antennae, 2 hair-like tails, no gills on abdomen, very intolerant of impairment.

4 Watersnipe Fly: Order Diptera. ¼" – 2", body plump and maggot-like, caterpillar-like "legs" along body, feathery "horns" on end, intolerant of impairment.

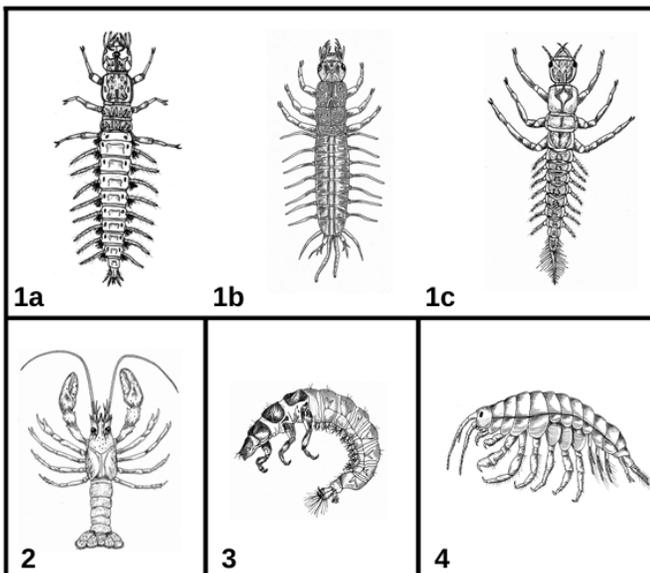
5 Gilled Snails: Class Gastropoda. Up to ¾", shell opening covered by a thin plate called an operculum, with helix pointed up shell opens to the right, intolerant of impairment.

6 Water Penny: Order Coleoptera. ¼" – 1", disk-like oval body with 6 small legs and gill tufts on underside, intolerant of impairment.

7 Riffle Beetle: Order Coleoptera. Small black beetle crawling on streambed OR comma-like brown "crunchy" body with 6 legs on upper 1/3 and possibly gill tuft on back end, intolerant of impairment.

Less Sensitive to Pollution

These organisms are somewhat sensitive to pollution and indicate fair water quality.

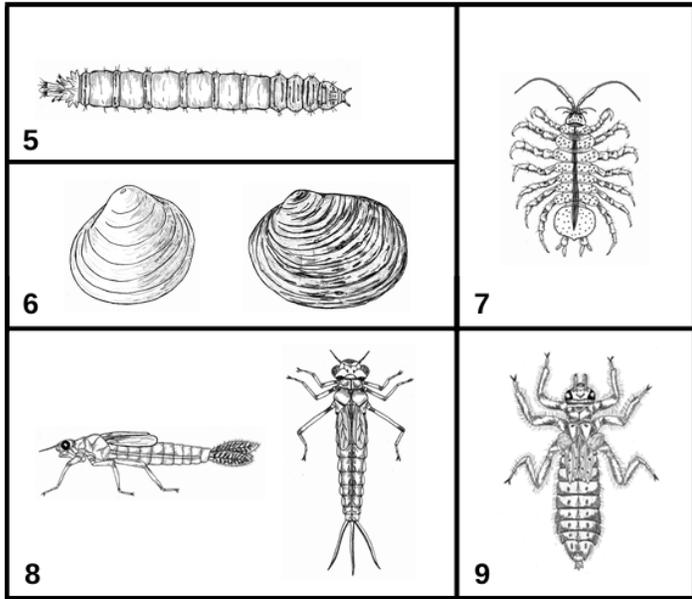


1 Hellgrammite, Fishfly, and Alderfly: Order Megaloptera. ¾" – 4", 6 legs, large pinching jaws. **a)** 8 pairs of fleshy appendages along abdomen with gill tufts, 2 hooks on tail end, **b)** 8 pairs of fleshy appendages along abdomen without gill tufts, 2 tube-like appendages on tail end, **c)** 7 pairs of fleshy appendages without gill tufts, 1 single spiky tail; somewhat tolerant of impairment.

2 Crayfish: Order Decapoda. Up to 6", 2 large claws, 8 legs, resembles a small lobster, somewhat tolerant of impairment.

3 Common Netspinners: Family Hydropsychidae. Up to ¾", 6 hooked legs on upper 1/3 of body, 2 hooks at back end, white gill tufts on underside of abdomen, somewhat tolerant of impairment.

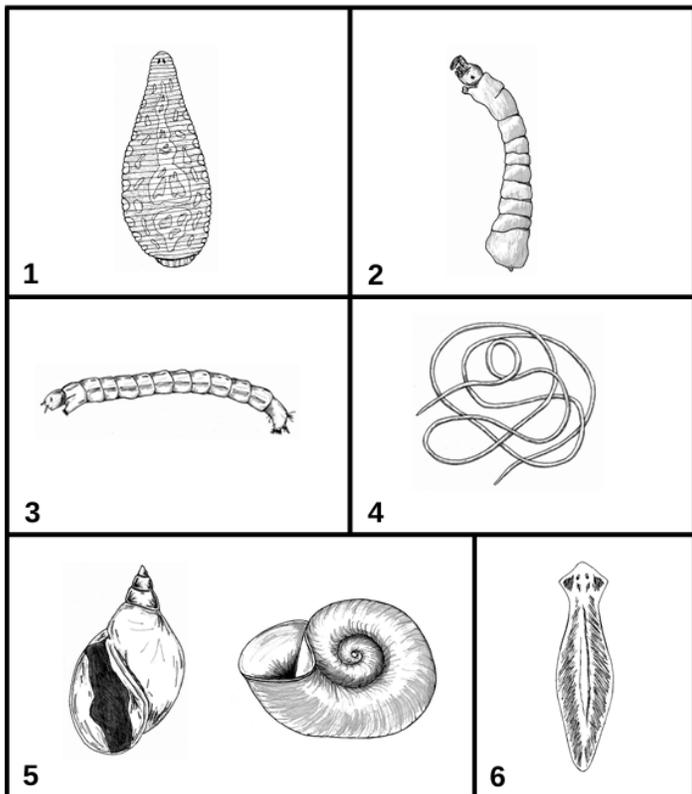
4 Scud: Order Amphipoda. ¼", white to gray, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp, somewhat tolerant of impairment.



- 5 Crane Fly: Order Diptera.** $\frac{1}{4}$ " – 2", bodies plump and maggotlike, caterpillar like "legs" along body, four lobes one end, tolerant of impairment.
- 6 Clams and Mussels: Class Bivalvia.** Up to $\frac{3}{4}$ ", fleshy body enclosed between two clamped together shells (if clam is alive, shells cannot be pried apart without harming clam), somewhat tolerant of impairment.
- 7 Sowbug: Order Isopoda.** $\frac{1}{4}$ " – $\frac{3}{4}$ ", gray oblong body wider than it is high, more than 6 legs, long antennae, somewhat tolerant of impairment.
- 8 Damselfly: Order Odonata.** $\frac{1}{2}$ " – 2", large eyes, 6 hooked legs, large protracting lower jaw, 3 broad oar-shaped tails, somewhat tolerant of impairment.
- 9 Dragonfly: Order Odonata.** $\frac{1}{2}$ " – 2", large eyes, 6 hooked legs, large protracting lower jaw, wide oval to round abdomen, somewhat tolerant of impairment.

Pollution Tolerant

These organisms are tolerant to pollution and indicate poor water quality.



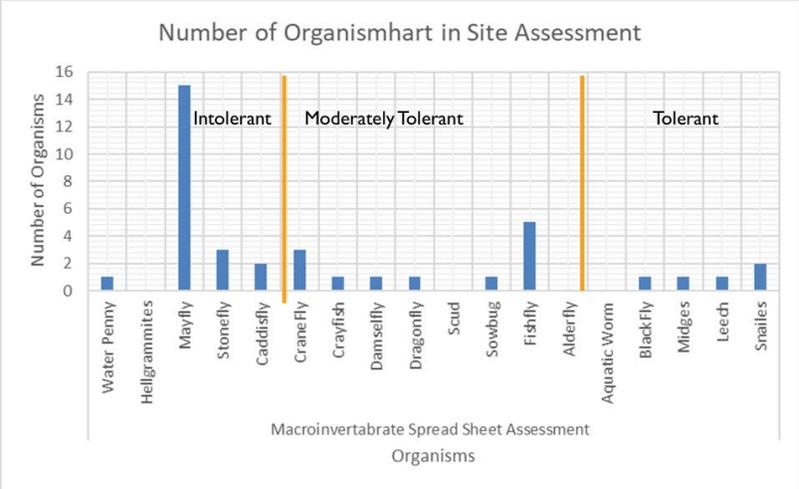
- 1 Leech: Order Hirudinea.** $\frac{1}{4}$ " – 2", segmented body, suction cups on both ends, tolerant of impairment.
- 2 Black Fly: Family Simuliidae.** Up to $\frac{1}{4}$ ", end of body wider (like bowling pin), distinctive head, sucker on end, tolerant of impairment.
- 3 Midges: Family Chironomidae.** Up to $\frac{1}{4}$ ", distinct head, worm-like segmented body, 2 leg-like projections on each side, often whitish to clear, occasionally bright red, tolerant of impairment.
- 4 Aquatic Worm: Class Oligochaeta.** $\frac{1}{4}$ " – 2", can be very tiny; thin, wormlike body, tolerant of impairment.
- 5 Lunged Snails: Class Gastropoda.** Up to $\frac{3}{4}$ ", no operculum, with helix pointed up shell opens to the left, tolerant of impairment.
- 6 Flat Worm: Family Planariidae.** Up to $\frac{1}{4}$ ", soft body, may have distinct head with eyespots, tolerant of impairment.

Charts and Graphs

Charts and Graphs

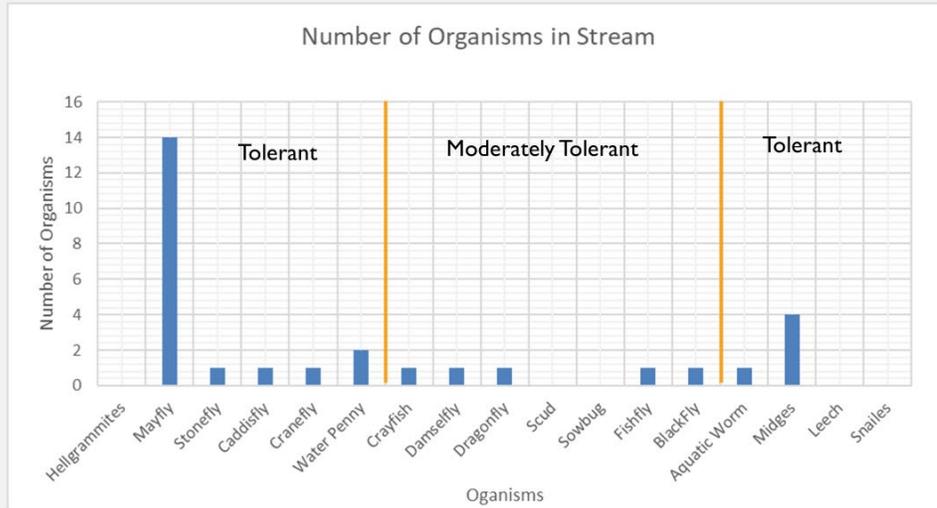
Macroinvertebrate Assessment

WHO LIVES IN THE WATERBENTHIC MACROINVERTEBRATE IDENTIFICATION ACTIVITY ASSESSMENT



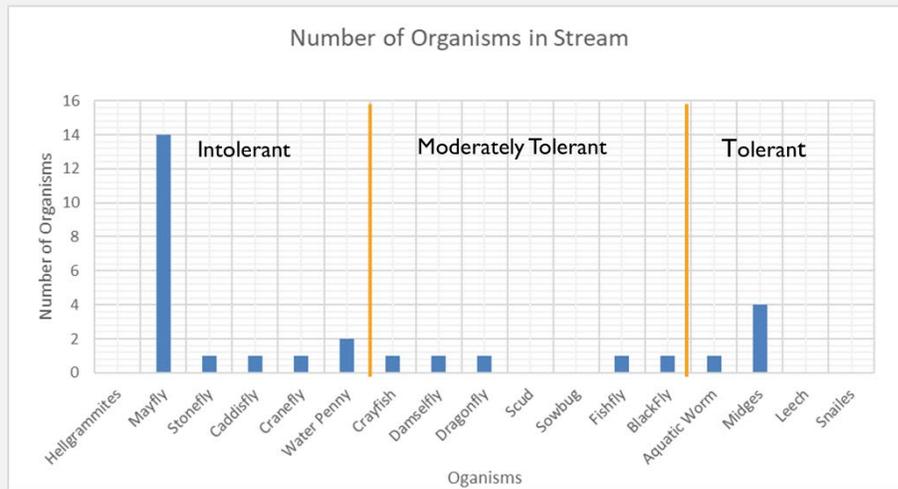
Macroinvertebrate Assessment - Riffles

COMPARING MACROINVERTEBRATES FROM THREE HABITATS RIFFLE



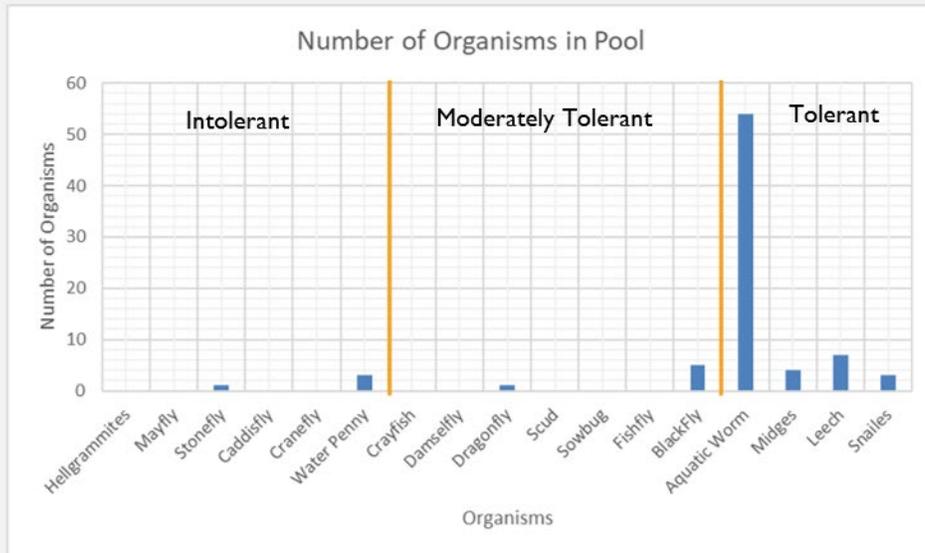
Macroinvertebrate Assessment - Undercut Bank

COMPARING MACROINVERTEBRATES FROM THREE HABITATS UNDERCUT BANKS



Macroinvertebrate Assessment -Pool

COMPARING MACROINVERTEBRATES FROM THREE HABITATS STAGNATE POOL



Wetland Vs Stream Macroinvertebrates

Purpose: To investigate various biomes through observation and comparison of the diversity of life, in particular, the specific number of species, biomass, and type of organisms.

Summary: In this exercise, students will use data from to compare macroinvertebrate living in a stream Vs a wetland site.

Activity: Construct a graph comparing the macroinvertebrate living in a stream Vs a wetland site.

Discussion: answer the discussion Questions

MACROINVERTEBRATE TALLY SHEET

Stream

Macroinvertebrate	No of Organisms
Mayflies 	20
Stoneflies 	
Caddisflies 	5
Hellgrammite 	
Water snipe Flies 	
Riffle Beetles 	
Adler Fly 	
Snails 	
Net Spinning Caddisflies 	
Damselflies 	

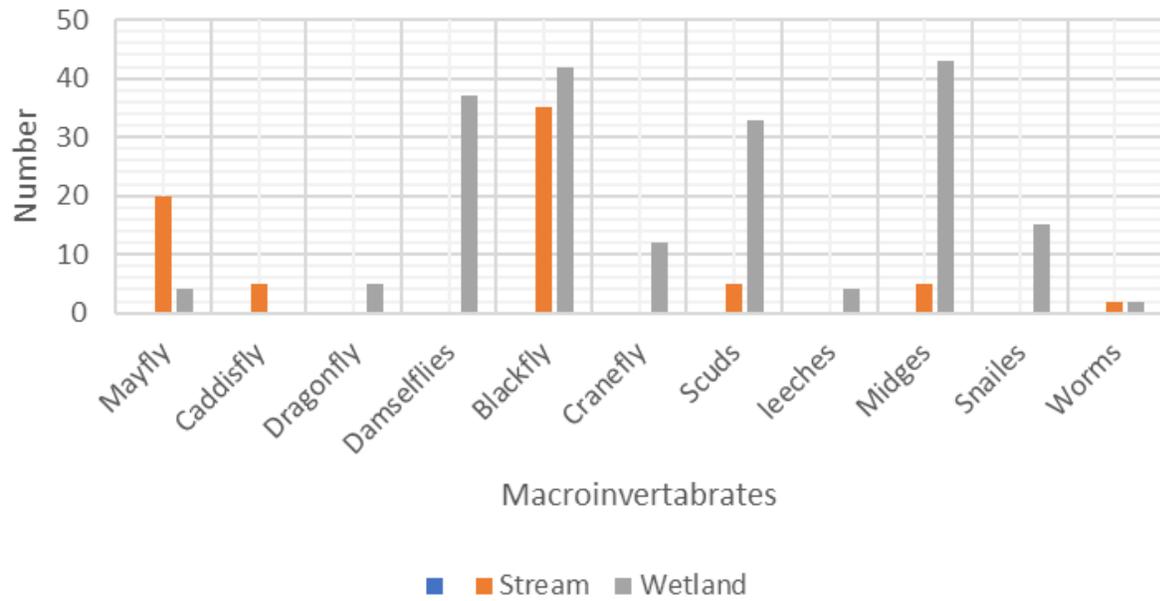
Macroinvertebrate	No of Organisms
Crane Flies 	
Sowbugs 	
Scuds 	5
Crayfish 	
Black Flies 	35
Clams and Mussels 	
Midge flies 	5
Worms 	2
Leeches 	
Dragonflies 	

MACROINVERTEBRATE TALLY SHEET
Wetlands

Macroinvertebrate	No of Organisms
Mayflies 	4
Stoneflies 	
Caddisflies 	
Hellgrammite 	
Water snipe Flies 	
Riffle Beetles 	
Adler Fly 	
Snails 	15
Net Spinning Caddisflies 	
Damselflies 	37

Macroinvertebrate	No of Organisms
Crane Flies 	12
Sowbugs 	
Scuds 	33
Crayfish 	
Black Flies 	42
Clams and Mussels 	
Midge flies 	43
Worms 	2
Leeches 	4
Dragonflies 	5

Macroinvertebrates Stream Vs Wetland



Discussion:

1. Were there some types of organisms found in both biomes and other types of organisms not found in one or the other?

2. What features of those habitats might have caused these differences?

Discussion: Answers

1. Were there some types of organisms found in both biomes and other types of organisms not found in one or the other?

The most obvious difference in large macroinvertebrates in a wetland is the presence of dragonfly and damselfly larvae. These are rarely found in moving streams because they require emergent vegetation such as cattails for resting, and for laying their eggs. You may also find considerably more swimming beetles (Order Coleoptera) or boatmen and backswimmers (Order Hemiptera) in a wetland than in a stream, because they do better in still water.

Zooplankton are also typically found in wetland ponds. Look for Daphnia and other microscopic animals swimming in the water.

Animals found in moving water may be more stream lined or have adaptations for clinging to rocks compared to animals who live in still water. They may be less streamlined and have adaptations for swimming.

2. What features of those habitats might have caused these differences?

The most obvious difference between the two habitats is flow. Water slowly moves through a wetland, but there is not any measurable velocity. Materials settle in these conditions, typically resulting in a soft, mucky bottom rather than the rocky bottom of many fast streams.

Standing water may warm up faster than running water, resulting in changes in oxygen. Both systems have standing plants and mats of plants that cover some of the surfaces, but a pond/wetland is much more likely to have an abundance of suspended single celled plants (algae).

REFERENCES

- Allan, D.A. (1995). Stream Ecology. Netherlands: Kluwer Academic Publishers Environmental quality Primbas, Angela. (2005). Save Our Stream.
- Faulds, A.F., Murray, C.M., Neville, K.N. Leaf Pack Experiments Stream
- Hilsenhoff, W.L. 1987. An Improved Biotic Index of Organic Stream Pollution. Michigan Entomology Society 20(11):9-13

The Effects of Sewage Discharge on the DO Levels of a Stream

- Purpose:** To investigate observe the effects of sewage discharges on a stream.
- Summary:** Students will be introduced to Stream Zones.
Students will be introduced to the DO Dag curve.
Students will be introduced to the Streeter – Phelps Equation, and how it is utilized in the process discharge permitting to assess the impact of a waste water discharge on the dissolved oxygen levels of the receiving stream.
Using data provided students will, using the DO Sag Program determine the DO level at the critical point, and is distance downstream from the discharge point.
They will use the results to determine if the discharge meets DEP Water Quality Standards.
- Materials:** DO Sag Program Excel
DO Sag Program web based
- Documents:** Stream Side Science User's Manual
Oxygen sag Curve Computations
- Presentation:** The effects of Sewage discharges on the DO Sag of a stream

Oxygen Sag Curve

By far the most important characteristic determining the quality of a river or stream is its dissolved oxygen, DO (measured in mg/L).

While saturation is rarely achieved, a stream can nonetheless be considered healthy as long as its dissolved oxygen DO exceed 5 mg/L.

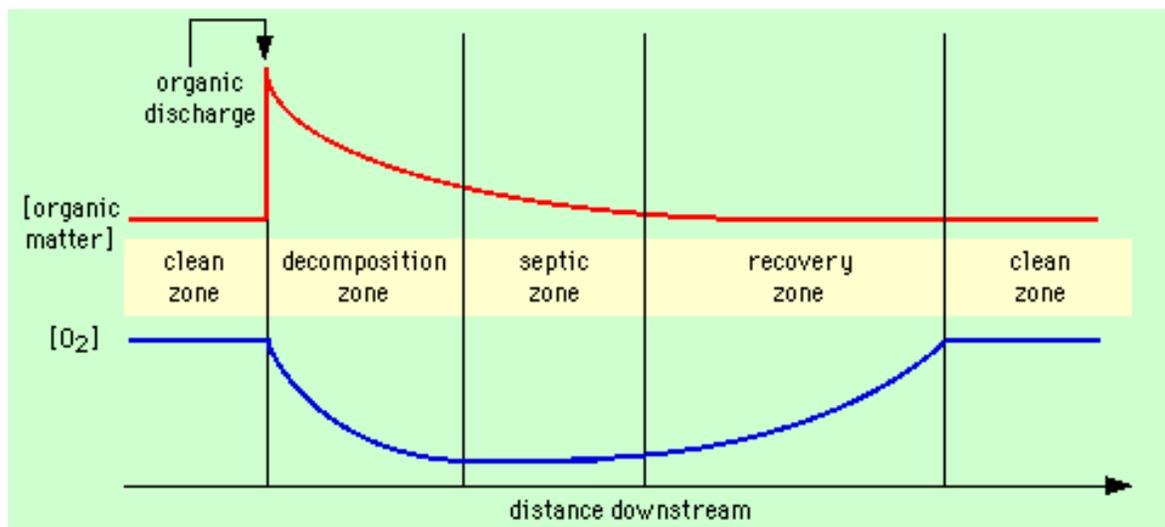
Below 5 mg/L, most fish, especially the more desirable species such as trout, do not survive.

The discharge of a sewage effluent in a stream produces a biochemical oxygen demand. This oxygen demand causes an oxygen deficit, or oxygen shortage. The greater the oxygen deficit, the greater the rate of natural oxygen replenishment from the atmosphere into the stream.

Two concurrent processes of oxygen consumption and oxygen replenishment produce an oxygen sag curve.



An oxygen sag curve graphically represents the changes in dissolved oxygen levels in a body of water, typically a river or stream, following the addition of organic pollutants.

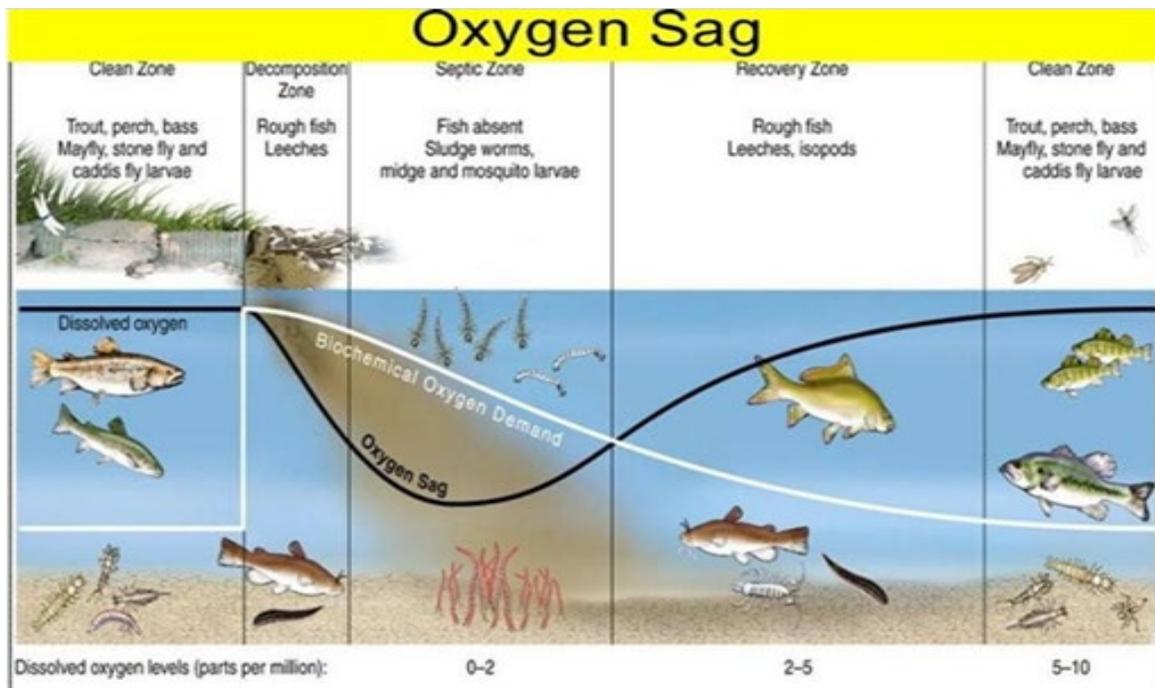


An oxygen sag curve is a graph that shows how the concentration of dissolved oxygen in a body of water changes over distance from a point of pollution. The curve is created by plotting the concentration of dissolved oxygen against the distance downstream from a sewage outlet or other pollutant source.

The curve shows a sag, or drop, in dissolved oxygen levels due to the increased demand for oxygen by microorganisms that consume oxygen as they decompose organic pollutants. The curve then recovers downstream as the rate of oxygen replenishment increases.

The oxygen sag curve shows different zones as the water flows from the pollution source, including:

- **Clean zone:** The dissolved oxygen level is high
- **Decomposition zone:** The dissolved oxygen level drops
- **Septic zone:** The dissolved oxygen level drops
- **Recovery zone:** The dissolved oxygen level recovers
- **Final clean zone:** The dissolved oxygen level returns to high



Oxygen Sag Curve

Streeter–Phelps equation

The Streeter–Phelps equation derived by H. W. Streeter, a sanitary engineer, and Erle B. Phelps a consultant for the U.S. Public Health Service, in 1925, based on field data from the Ohio River.

The Streeter – Phelps equation is used in the study of water pollution and as a water quality monitoring tool. The Streeter-Phelps equation is used to set discharge limits for sewage by calculating the potential "oxygen sag" in a river downstream from a discharge point, allowing regulators to determine the maximum amount of biochemical oxygen demand (BOD) that can be released without causing critically low dissolved oxygen

levels, which are harmful to aquatic life; essentially, it helps set limits to ensure the river can adequately reoxygenate after receiving the sewage effluent.

Modeling the Oxygen Sag Curve:

The equation mathematically describes the decline in dissolved oxygen concentration (due to organic matter decomposition) followed by a recovery as the water reoxygenates downstream from a pollution source, creating a "sag curve."

The equation takes into account factors like the initial dissolved oxygen concentration, the rate of deoxygenation (related to BOD), the rate of reaeration (dependent on water velocity and turbulence), water temperature, and stream characteristics.

By analyzing the calculated sag curve, regulators can identify the "critical point" where the dissolved oxygen concentration reaches its lowest level, allowing them to set discharge limits that prevent this level from falling below a predetermined standard for aquatic life protection.

How it works:

Environmental data like stream flow, temperature, BOD concentration of the sewage effluent, and the deoxygenation and reaeration rates are inputted into the Streeter-Phelps equation.

The equation calculates the dissolved oxygen concentration at different distances downstream from the discharge point, creating the oxygen sag curve.

By comparing the calculated oxygen levels to water quality standards, regulators can set discharge limits for the sewage treatment plant to ensure the dissolved oxygen in the river remains within acceptable levels.

A dissolved oxygen level of 4 mg/L is generally recommended.

When the level drops below 2.0 mg/L, some aquatic animals may become distressed or die from suffocation. The Streeter Phelps equation calculates the dissolved oxygen concentration at different distances downstream from the discharge point, creating the oxygen sag curve.

By comparing the calculated oxygen levels to water quality standards, regulators can set discharge limits for the sewage treatment plant to ensure the dissolved oxygen in the river remains within acceptable levels.

"BOD reduction rate constant" the constant "k"

The Streeter Phelps equation also calculates "BOD reduction rate constant" the constant "k", that represents the rate at which Biochemical Oxygen Demand (BOD) decreases over time in a water body, essentially indicating how quickly organic matter is being decomposed by microorganisms and consuming oxygen in the process; it is typically expressed as a value per unit time (e.g., per day) and is used in calculations to predict the oxygen depletion in a water system based on its initial BOD level.

The BOD rate constant is high for the raw sewage ($K = 0.35 - 0.7$ per day) and low for the treated sewage ($K = 0.12 - 0.23$ per day),

To calculate BOD (Biochemical Oxygen Demand) using the decay constant, you use the formula:

$$\text{BOD}(t) = L * (1 - e^{(-k * t)}) \text{ where:}$$

$\text{BOD}(t)$: is the BOD at a specific time "t".

L: is the initial BOD

k: is the BOD decay constant

t: is the time elapsed.

$$\text{BOD}(t) = L0 * e^{(-k * t)}$$

$$\text{BOD}(5 \text{ days}) = 60 \text{ mg/L} * e^{(-0.62 * 5 \text{ days})}$$

$$\text{BOD}(5 \text{ days}) = 60 \text{ mg/L} * e^{-3.4}$$

$$\text{BOD}(5 \text{ days}) = 60 \text{ mg/L} * e^{-3.4} = 17$$

$$\text{BOD}(5 \text{ days}) = 60 \text{ mg/L} - 17 = 43$$

$$\text{BOD}(5 \text{ days}) = 43 \text{ mg/l}$$

Activity Oxygen Sag Curve

Directions

1. Enter the data from the table into an Excel spread sheet.
2. Plot the DO and BOD levels versus the distance downstream of a point source of pollution.

Distance from Point source (miles)	DO	BOD
0	8.6	2
1	4.0	36
2	2.0	18
3	2.0	9
4	3.0	4.5
5	4.0	3.0
6	5.0	2.0
7	6.0	2.0
8	7.0	2.0
9	8.0	2.0
10	8.0	2.0

DO Sag Calculations

INSTRUCTIONS

Using the data for DO Sag Curve of untreated wastewater, primary treated wastewater and secondary treated wastewater of your choice. inset the data into the **Yellow** Input Data Cells of the Spread sheet Oxygen – Sag Curve Computations.

https://people.wou.edu/~taylors/es476_hydro/DOSAG.xls

OXYGEN-SAG CURVE COMPUTATIONS						DOSag.xls
Streeter-Phelps Relations; see Box 10-6.						S.L.Dingman
						Physical Hydrology, 2nd Ed.
Input Data			Computed Values			
Stream	Discharge, qu		m^3/s	BOD, $Bu =$		mg/L
	Width, B		m	DO =		mg/L
	Depth, Y		m	$Tu =$		C
	Velocity, U	#DIV/0!	m/s			
STP	Discharge, qw		m^3/s	BOD, $Bw =$		mg/L
	$Tw =$		C	DO =		mg/L
Parameters	$B(0) =$	#DIV/0	mg/L	$T(0) =$	#DIV/0	C
	$k_1 =$!	1/day	$k_2 =$!	1/day
	$k_1 =$	#DIV/0	1/s	$k_2 =$	#DIV/0	1/s
		!			!	
		#DIV/0!			#DIV/0!	

A table similar to this one will appear.

Highlight the three columns

In Charts select Scatter Smooth Lines Top Row Third Chart The

DO Sag curve will appear

Right Click on chart

Under chart elements select and label the following Axis

Axis titles Chart Title

Gride Lines

Najor Horizontal Major

Vertical Minor Horizontal

Minor Vertical

	m	mg/L	mg/L
0	8.60	9.53	9.53
1000	6.61	9.53	9.53
2000	5.58	9.53	9.53
3000	5.14	9.53	9.53
4000	5.06	9.53	9.53
5000	5.18	9.53	9.53
6000	5.41	9.53	9.53
7000	5.71	9.53	9.53
8000	6.02	9.53	9.53
9000	6.33	9.53	9.53
10000	6.63	9.53	9.53
11000	6.92	9.53	9.53
12000	7.18	9.53	9.53
13000	7.42	9.53	9.53
14000	7.64	9.53	9.53
15000	7.83	9.53	9.53
16000	8.01	9.53	9.53
17000	8.17	9.53	9.53
18000	8.31	9.53	9.53
19000	8.44	9.53	9.53
20000	8.56	9.53	9.53
25000	8.97	9.53	9.53
30000	9.21	9.53	9.53
35000	9.35	9.53	9.53
40000	9.43	9.53	9.53
42000	9.45	9.53	9.53
44000	9.46	9.53	9.53
46000	9.48	9.53	9.53
48000	9.49	9.53	9.53
50000	9.49	9.53	9.53
60000	9.52	9.53	9.53
70000	9.52	9.53	9.53
80000	9.53	9.53	9.53

Problems

1. The Streeter-Phelps Equation Un Treated Effluent BOD 180 mg/l

25 million gallons per day (mgd) (1m³/sec) of domestic sewage is discharged into a stream.

The flow rate of the stream is 250 cubic feet per second (cfs) (3.5m³/s).

The velocity of the stream is approximately 3 miles per hour. (0.02 m/s).

The temperature of the sewage is 21 °C.

The Temperature of the Stream is 15° C.

The Wastewater temperature is 20 °C

The BOD₅ of the wastewater is **180 mg/l**.

The BOD of the stream is 1 mg/l, The DO of the sewage is 0 mg/l The DO of the stream is 9.2 mg/l.

2. The Streeter-Phelps Equation Primary Treated Effluent BOD 60 mg/l

25 million gallons per day (mgd) (1m³/sec) of domestic sewage is discharged into a stream.

The flow rate of the stream is 250 cubic feet per second (cfs) (3.5m³/s).

The velocity of the stream is approximately 3 miles per hour. (0.02 m/s).

The temperature of the sewage is 21 °C.

The Temperature of the Stream is 15° C.

The Wastewater temperature is 20 °C

The BOD₅ of the wastewater is **60 mg/l**.

The BOD of the stream is 1 mg/l,

The DO of the sewage is 0 mg/l The DO of the stream is 9.2 mg/l.

3. 25 million gallons per day (mgd) ($1\text{m}^3/\text{sec}$) of domestic sewage is discharged into a stream.

The flow rate of the stream is 250 cubic feet per second (cfs) ($3.5\text{m}^3/\text{s}$).

The velocity of the stream is approximately 3 miles per hour. (0.02 m/s).

The temperature of the sewage is $21\text{ }^\circ\text{C}$.

The Temperature of the Stream is 15° C .

The Wastewater temperature is $20\text{ }^\circ\text{C}$

The BOD_5 of the wastewater is **25 mg/l** .

The BOD of the stream is 1 mg/l ,

The DO of the sewage is 0 mg/l

The DO of the stream is 9.2 mg/l .

Questions:

1. What is the dissolve Oxygen at the critical point for each of the scenarios?
At what downstream distances does it occur.

BOD 180 mg/l
BOD 60 mg/l
BOD 25 mg/l

2. Using the data from the Sag Curve for Thompson Run discharge of 60 mg/l BOD complete the following table.

Distance from Point Source m	Distance mi	DO mg/l
0	0	
1000	0.6	
3000	1	
5000	2	
7000	4	
9000	5	
10000	6	
13000	8	
15000	9	
19000	12	
42000	26	

3. Determine the BOD at the following distances downstream from the Point source Discharge with a BOD of 60 mg/l BOD. Use a k value of 0.62/day.

Distance from Point Source m	Time Days	BOD mg/l
0	0	
1000	0.6	
3000	1	
5000	2	
7000	4	
9000	5	
10000	6	
13000	8	
15000	9	
19000	12	

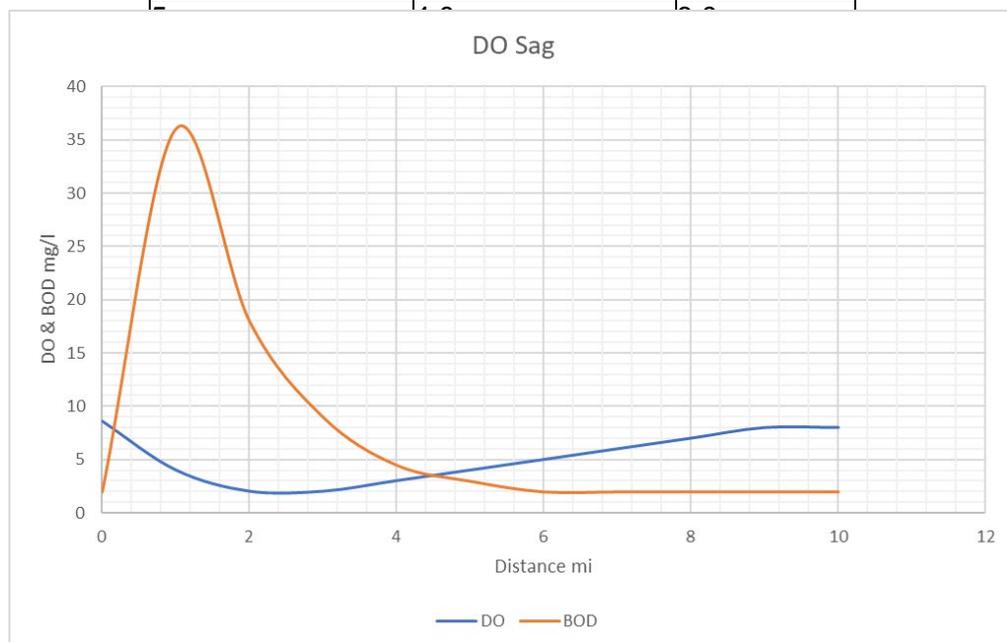
Answers

Oxygen Sag Curve

Directions

1. Enter the data from the table into an Excel spread sheet.
2. Plot the DO and BOD levels versus the distance downstream of a point source of pollution.

Distance from Point source (miles)	DO	BOD
0	8.6	2
1	4.0	36
2	2.0	18
3	2.0	9
4	3.0	4.5



The Streeter-Phelps Equation Un Treated Effluent BOD 180 mg/l

25 million gallons per day (mgd) (1m³/sec) of domestic sewage is discharged into a stream.

The flow rate of the stream is 250 cubic feet per second (cfs) (3.5m³/s).

The velocity of the stream is approximately 3 miles per hour. (0.02 m/s).

The temperature of the sewage is 21 °C.

The Temperature of the Stream is 15° C.

The Wastewater temperature is 20 °C

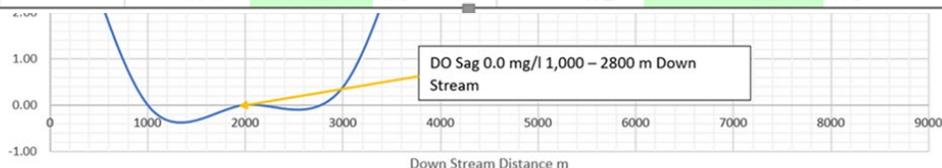
The BOD₅ of the wastewater is **180 mg/l**.

The BOD of the stream is 1 mg/l,

The DO of the sewage is 0 mg/l

The DO of the stream is 9.2 mg/l

OXYGEN-SAG CURVE COMPUTATIONS				DOSag.xls	
Streeter-Phelps Relations; see Box 10-6.				S.L.Dingman	
				<i>Physical Hydrology</i> , 2nd Ed.	
Input Data		Computed Values			
Stream	Discharge, $qu =$	3.5 m ³ /s	BOD, $Bu =$	1.1 mg/L	
	Width, $B =$	122 m	DO =	9.2 mg/L	
	Depth, $Y =$	1.5 m	$Tu =$	15 C	
	Velocity, $U =$	0.02 m/s			
STP	Discharge, $qw =$	1 m ³ /s	BOD, $Bw =$	180 mg/L	
	$Tw =$	25 C	DO =	5 mg/L	
Parameters	$B(0) =$	40.86 mg/L	$T(0) =$	17.22222222 C	
	$k_1 =$	0.86 1/day	$k_2 =$	0.26 1/day	
	$k_1 =$	9.93E-06 1/s	$k_2 =$	3.02E-06 1/s	



The Streeter-Phelps Equation Primary Treated Effluent BOD 60 mg/l

25 million gallons per day (mgd) (1m³/sec) of domestic sewage is discharged into a stream.

The flow rate of the stream is 250 cubic feet per second (cfs) (3.5m³/s).

The velocity of the stream is approximately 3 miles per hour. (0.02 m/s).

The temperature of the sewage is 21 °C.

The Temperature of the Stream is 15° C.

The temperaturee of he waste water is 20 °C

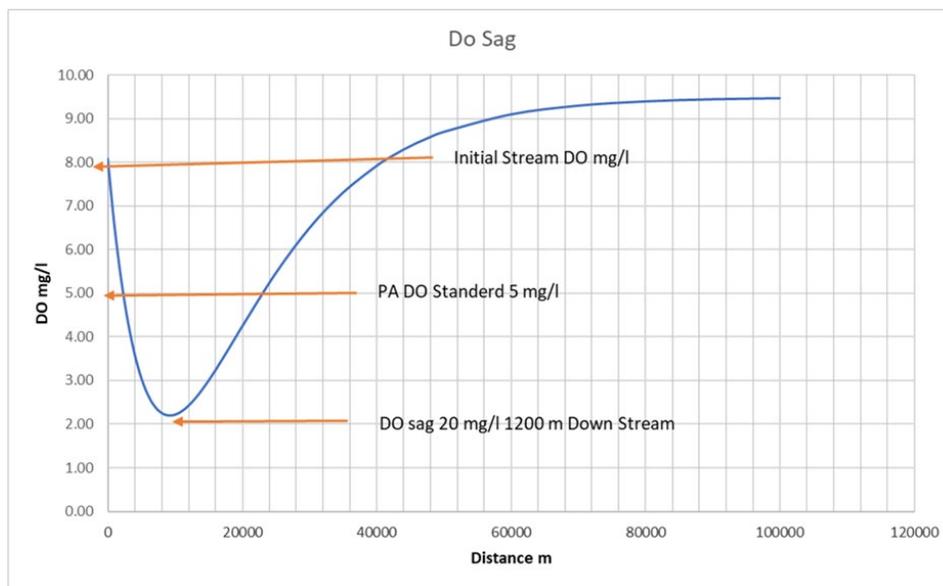
The BOD5 of the sewage is **60mg/l**.

The BOD of the stream is 1 mg/l,

The DO of the sewage is 0 mg/l

The DO of the stream is 9.2 mg/l

	Input Data	Computed Values
Stream	Discharge, $q_u =$	2 m ³ /s
	Width, $B =$	10 m
	Depth, $Y =$	2 m
	Velocity, $U =$	0.10 m/s
STP	Discharge, $q_w =$	0.5 m ³ /s
	$T_w =$	25 C
Parameters	$B(0) =$	13.60 mg/L
	$k_1 =$	1.16 1/day
	$k_1 =$	1.34E-05 1/s
	$k_2 =$	7.23E-06 1/s
	BOD, $B_u =$	2 mg/L
	DO =	9.6 mg/L
	$T_u =$	16 C
	BOD, $B_w =$	60 mg/L
	DO =	2 mg/L
	$T(0) =$	17.8 C
	$k_2 =$	0.63 1/day



The Streeter-Phelps Equation Treated Effluent BOD 25 mg/l

25 million gallons per day (mgd) ($1\text{m}^3/\text{sec}$) of domestic sewage is discharged into a stream.

The flow rate of the stream is 250 cubic feet per second (cfs) ($3.5\text{m}^3/\text{s}$).

The velocity of the stream is approximately 3 miles per hour. (0.02 m/s).

The temperature of the sewage is 21°C .

The Temperature of the Stream is 15°C .

The 20°C

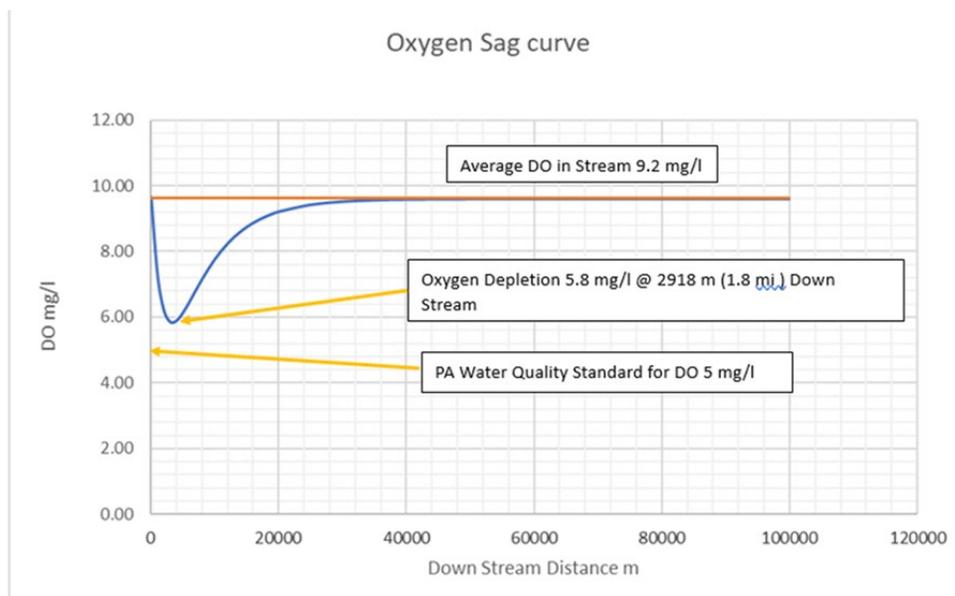
The BOD5 of the sewage is **25 mg/l**.

The BOD of the stream is 1 mg/l,

The DO of the sewage is 5 mg/l

The DO of the stream is 9.2 mg/l

OXYGEN-SAG CURVE COMPUTATIONS				DOSag.xls	
Streeter-Phelps Relations; see Box 10-6.				S.L. Dingman	
				<i>Physical Hydrology</i> , 2nd Ed.	
		Input Data	Computed Values		
Stream	Discharge, q_u =	3.5 m^3/s	BOD, B_u =	1.1 mg/L	
	Width, B =	122 m	DO =	11 mg/L	
	Depth, Y =	1.5 m	T_u =	15 C	
	Velocity, U =	0.02 m/s			
STP	Discharge, q_w =	1 m^3/s	BOD, B_w =	25 mg/L	
	T_w =	25 C	DO =	5 mg/L	
Parameters	$B(0)$ =	6.41 mg/L	$T(0)$ =	17.22222222 C	
	k_1 =	0.86 1/day	k_2 =	0.26 1/day	
	k_1 =	9.93E-06 1/s	k_2 =	3.02E-06 1/s	



Problems

Answers

BOD 180 mg/l DO 0 mg/l at 2,00 meters
 BOD 60 mg/l DO 2.0 mg/l at 9236 meters
 BOD 25 mg/l DO 5.8 mg/l at 400 meters

Distance from Point Source m	Distance from Point Source mi	DO mg/l
0	0	8
1000	0.6	6.5
3000	1	4.3
5000	2	3.0
7000	4	2.4
9000	5	2.2
10000	6	2.2
13000	8	2.6
15000	9	3.0
19000	12	4.0
42000	25	8.0

Distance from Point Source m	Distance from Point Source mi	Time Days	BOD mg/l
0	0	0	60
1000	0.6	1	56
3000	1	2	53
5000	2	3	49
7000	4	4	45
9000	5	5	41
10000	6	6	38
13000	8	8	32
15000	9	9	35
19000	12	11	28
42000	25	26	0

When Things Heat Up

Purpose: To relate the physical and chemical properties of water to a water pollution issue.

Summary: In this exercise, students will measure the temperature and dissolved oxygen of a stream and discuss what this information can tell us about possible pollution problems.

Background: During this activity students will investigate two properties of water in a stream – the temperature and the concentration of dissolved oxygen in the water. Students will explore how natural influences, human activities and pollution may cause these parameters to change.

Temperature and oxygen were chosen for this activity because they are easy to measure, the causes of change are both varied and easy to understand, and also the two properties are related to each other. Fish and other animals living in water can be harmed by high temperatures and low oxygen concentrations.

As water gets warmer the “saturation concentration” for oxygen gets lower – in other words the warmer the water, the less oxygen it can hold. Therefore, when water temperatures increase, fish are often hit with a double whammy of low oxygen as well.

Materials:

Documents: Stream side Science Manual
When Things Heat Up Student

Presentations: None

High temperatures or low dissolved oxygen are not necessarily a sign of a pollution problem in the stream. Temperatures change throughout the seasons and will also vary from year to year.

During warm drought years as opposed to wet years, temperatures in most streams will be higher during the summer because of lower flows and warmer air temperatures.

Therefore, the first thing to consider is whether you're just observing natural changes in a stream. Stream standards allow for occasional violations because of this natural variation.

Dissolved oxygen will be lower if the temperature is higher, and vice versa.

Human activities can increase the temperature in a stream.

Humans can affect the temperature of rivers by discharging heated water. Industrial or energy plants often produce heated water as a byproduct. Also, when we modify the stream banks (riparian area) and reduce the amount of canopy cover, we can have a direct impact on stream conditions without ever dumping in a pollutant.

Example: Discharge water from energy plants and from some other industrial plants may be considerably warmer than the stream it discharges to. This type of "thermal pollution" is considered a point source (it travels from a source to a stream through a pipe or ditch). Your students should consider any such sources in their community. Many other human activities affect water quality through indirect means. Urban development, agricultural areas and logging areas may all result in removal of riparian vegetation along a stream. When the shade from these plants disappears, the stream is exposed to more sunlight and heats up. Therefore, your problem may just be some "brush clearing" activities upstream of your site.

Human activities can have decreased oxygen in a stream.

Oxygen can only get into water from the surface (mixing with the atmosphere) or from oxygen produced by plants in the water. Oxygen in water is consumed by animal and plant respiration, during various chemical reactions, and during the decay of organic material. Humans can have a profound effect on how much decaying material is in a stream.

Grass clippings, runoff from feedlots, and debris from logged areas are just a few of the sources of material which will ultimately decay in the water and in doing so, use up oxygen. In a rapidly moving stream, the water usually mixes with the atmosphere enough to replace this oxygen. In a pooled up or very slow-moving stream, especially if it's warm, oxygen can be used up very quickly.

NOTE: Dumping nutrients into water (e.g., from yard fertilizers), can stimulate plant growth in a stream or lake. When these plants die, you may also see a drop in oxygen.

The time of day when measuring oxygen Concentration in a stream makes a difference

We often forget that plants not only create oxygen, but also use it for their cell metabolism. During the night, plants do not photosynthesize but still use oxygen. In streams that have become congested with an overabundance of living plants, oxygen may be very high during the day, but can be extremely low just before dawn because of plant uptake.

Temperature

What is Temperature?

Temperature is the measure of how much heat energy water contains. A stream's temperature is affected by the season, the source of water, the geographic area of the stream, the shape of the channel and whether the stream is shaded. Most aquatic organisms require a specific temperature range, and many of our sport fish require cold water.

Temperature must be measured in the field. The temperature will change if the water is collected and stored, and will not reflect the true value at the site.

Discussion Questions for Temperature:

Groundwater entering a stream will affect its temperature.

Groundwater is usually colder than surface water and therefore it would probably cool the stream. Because the temperature of groundwater doesn't fluctuate much throughout a year, a stream with a major groundwater component may show less seasonal variability than a stream fed entirely by surface runoff.

Different land uses affect stream temperature.

The major influences on temperature in a stream are exposure to the sun, and exposure to heated surfaces. Any activity that causes a stream to become shallower and wider (this can happen when too much sediment enters a stream) will cause the stream to heat more rapidly.

When trees along the banks are removed, the loss of shading can cause the stream to heat up.

Water that is diverted (such as for irrigation) and then returned to the stream usually heats up.

Finally, streams with small flows will heat faster than streams with lots of water, so removing water from a stream can cause an increase in temperature.

Suggested sources of water samples, with expected results and explanation:

Water Source	Expected Result	Explanation
A stream or river in the late summer / Early fall	warmer	Warmer air temperatures, plus no source of cold water (e.g., snowmelt) cause streams to be warmer in the later summer / early fall
A stream or river in the spring or winter	cooler	Cold air temperatures plus snowmelt in the spring lower the temperature of the water.
A stream near its headwaters	cool	The water source is snowmelt or groundwater. These streams are also usually shaded by trees and bushes.
A stream after it has traveled through a large valley or through a city	warmer (compared to the headwater stream)	The water warms as it travels away from the headwaters due to solar radiation and heat transfer from the streambed and banks. Areas with little riparian vegetation (no shading) will heat faster. Streams with concrete banks (e.g., urban areas) will absorb heat from these artificial banks.
A stream near a hot spring	warmer	Hot spring water will mix with the stream water, raising the temperature.

Dissolved Oxygen

What is Dissolved Oxygen?

Dissolved oxygen (DO) is a measurement of the concentration of O₂ molecules actually dissolved in water. This is the form of oxygen that fish and aquatic insects need.

Oxygen is not very soluble in water. Usually, about 12 parts of oxygen can dissolve into a million parts of water. In very cold water however, concentrations can be as much as 14 parts per million (ppm) or mg/l. The maximum amount of oxygen that can dissolve in water is called its saturation concentration. The saturation concentration decreases as water temperature or elevation increase.

DO must be measured in the field. The DO will change if the water is collected and stored, and will not reflect the true value at the site.

Oxygen is dissolved into water by contact with the atmosphere, or from aquatic plants that produce oxygen during photosynthesis. Therefore, oxygen will be higher in turbulent stream water (lots of mixing with the atmosphere) or in water with lots of plants (but only during the day, when photosynthesis can occur).

The respiration of animals and plants uses oxygen. Bacterial decomposition of dead organic materials can be a major factor, and may cause the dissolved oxygen to be completely consumed in deep pools or lakes. Some chemical reactions (oxidation reactions) also require and consume oxygen.

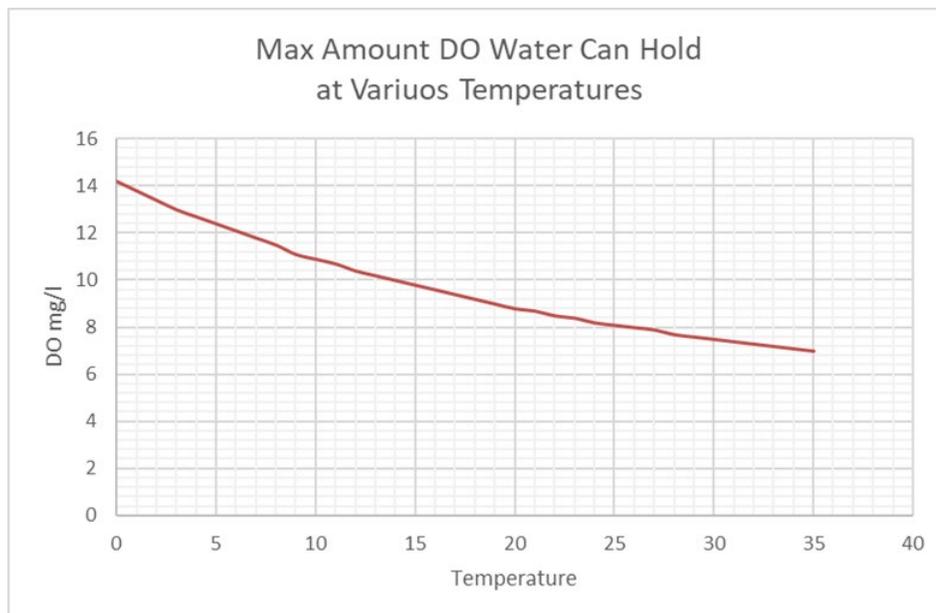
The decomposition of organic materials such as these may use all the available oxygen in the water. Secondary treatment by municipal treatment plants removes the organic material from the water for just this purpose. Before municipal wastewater was treated properly, many rivers and streams had fish kills and dead zones caused by low oxygen as this waste was decomposed.

Effect of Temperature on Dissolved Oxygen Concentrations

The data below show the maximum amount of dissolved oxygen the water can hold at different temperatures. This is called the “saturation concentration” of oxygen.

Temp (°C)	Dissolved Oxygen (mg/l)	Temp (°C)	Dissolved Oxygen (mg/l)	Temp (°C)	Dissolved Oxygen (mg/l)
0	14.2	12	10.4	24	8.2
1	13.8	13	10.2	25	8.1
2	13.4	14	10.0	26	8.0
3	13.0	15	9.8	27	7.9
4	12.7	16	9.6	28	7.7
5	12.4	17	9.4	29	7.6
6	12.1	18	9.2	30	7.5
7	11.8	19	9.0	31	7.4
8	11.5	20	8.8	32	7.3
9	11.1	21	8.7	33	7.2
10	10.9	22	8.5	34	7.1
11	10.7	23	8.4	35	7.0

Create a graph showing the “saturation concentrations” of water as temperature changes.



Changes in Temperature and Dissolved Oxygen Throughout a Year

The table below contains temperature and dissolved oxygen concentrations measured at the same site in a stream throughout an entire year.

The site has slow moving water, and aquatic plants grow in the soft sediments of the stream from spring through fall.

The first column of DO measurements were taken at 4:00 p.m. and the second column of DO measurements were taken at 4:00 a.m.

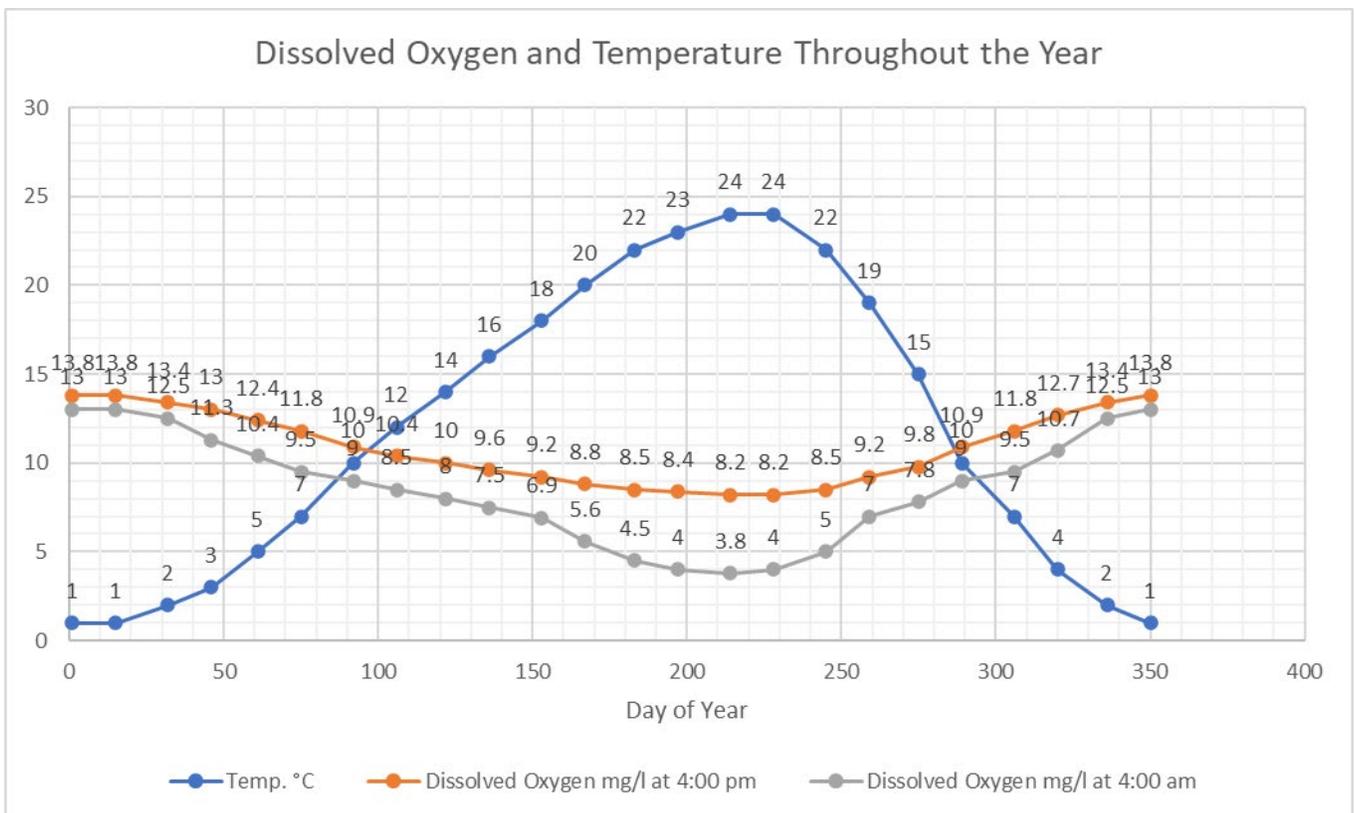
Have your students graph temperature and dissolved oxygen versus time.

Temperature is highest in summer, while DO is lowest in summer. This is because saturation concentration of dissolved oxygen decreases as the water temperature increases.

Dissolved oxygen will be higher at 4:00 a.m. than at 4:00 p.m.

The plants in the water consume oxygen at night (due to metabolic respiration), but cannot produce oxygen from photosynthesis at night when there is not light.

Therefore, DO can be substantially lower in water at one time of day than another.



Dissolve Oxygen Concentrations Measured at the Same site in a Stream Throughout an Entire Year

Day of year	Date	Temp. °C	Dissolved Oxygen	
			mg/l at 4:00 pm	mg/l at 4:00 am
1	1-Jan	1	13.8	13.0
15	15-Jan	1	13.8	13.0
32	1-Feb	2	13.4	12.5
46	15-Feb	3	13.0	11.3
61	1-Mar	5	12.4	10.4
75	15-Mar	7	11.8	9.5
92	1-Apr	10	10.9	9.0
106	15-Apr	12	10.4	8.5
122	1-May	14	10.0	8.0
136	15-May	16	9.6	7.5
153	1-Jun	18	9.2	6.9
167	15-Jun	20	8.8	5.6
183	1-Jul	22	8.5	4.5
197	15-Jul	23	8.4	4.0
214	1-Aug	24	8.2	3.8
228	15-Aug	24	8.2	4.0
245	1-Sep	22	8.5	5.0
259	15-Sep	19	9.2	7.0
275	1-Oct	15	9.8	7.8
289	15-Oct	10	10.9	9.0
306	1-Nov	7	11.8	9.5
320	15-Nov	4	12.7	10.7
336	1-Dec	2	13.4	12.5
350	15-Dec	1	13.8	13.0

Handouts

Effect of Temperature on Dissolved Oxygen Concentrations

Temp (°C)	Dissolved Oxygen (mg/l)	Temp (°C)	Dissolved Oxygen (mg/l)	Temp (°C)	Dissolved Oxygen (mg/l)
0	14.2	12	10.4	24	8.2
1	13.8	13	10.2	25	8.1
2	13.4	14	10.0	26	8.0
3	13.0	15	9.8	27	7.9
4	12.7	16	9.6	28	7.7
5	12.4	17	9.4	29	7.6
6	12.1	18	9.2	30	7.5
7	11.8	19	9.0	31	7.4
8	11.5	20	8.8	32	7.3
9	11.1	21	8.7	33	7.2
10	10.9	22	8.5	34	7.1
11	10.7	23	8.4	35	7.0

