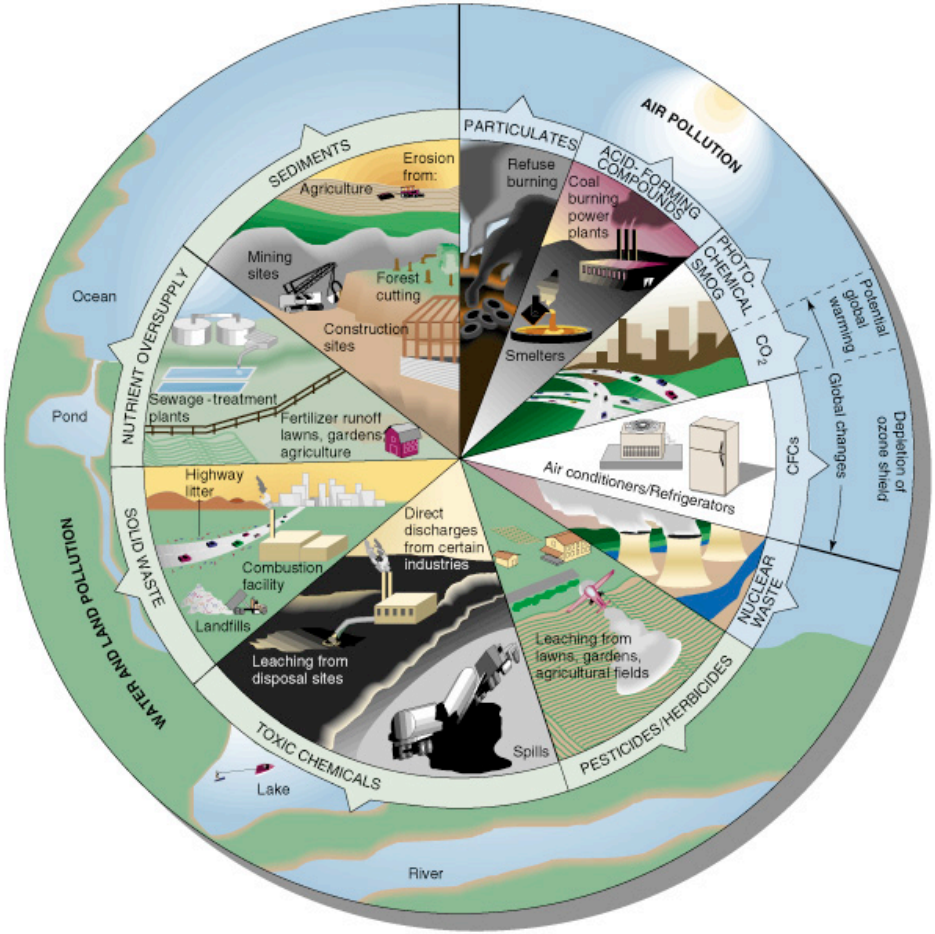
Water Pollution and its Prevention
IB Chemistry

Pollution

- Pollution: “the presence of a substance in the environment that because of its chemical composition or quantity prevents the functioning of natural processes and produces undesirable environmental and health effects.”
- Water pollution is the presence of such substances in bodies of water (lakes, rivers, aquifers, etc.)

Categories of pollution

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Sources of water pollution

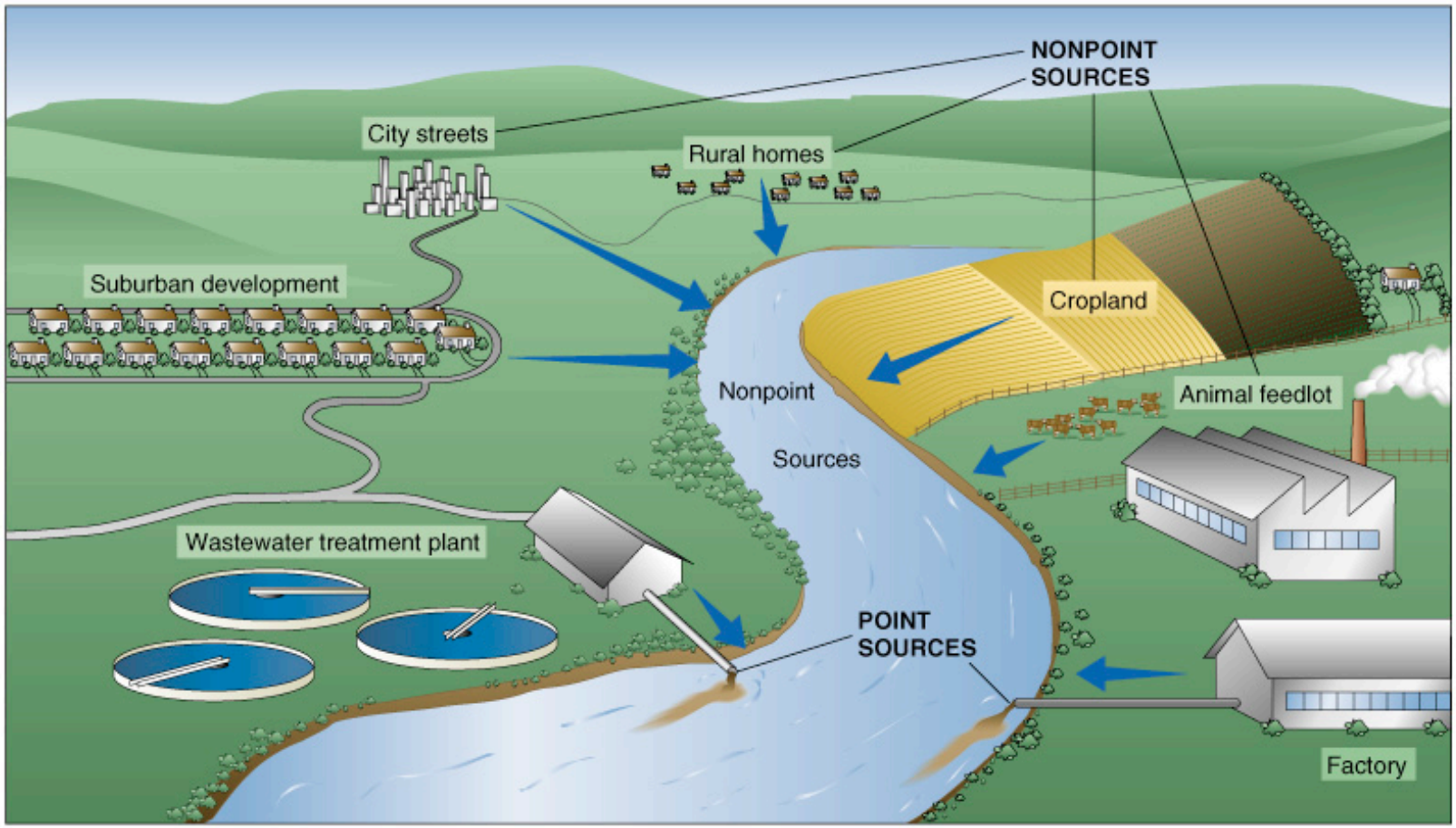
- Point sources [pollution originating from concentrated, easily identified sources]
- Examples: factories, sewage systems, oil wells

- Non-point [pollution originating from diffuse, poorly defined sources]
- Examples: storm water runoff from parking lots and streets; agricultural runoff from fields

Point source


CAUTION
PESTICIDE APPLICATION
6-16
APPLICATION DATE
11:40
APPLICATION TIME
REMOVE SIGN
11:40
AM
6-18
DATE
KEEP OFF UNTIL DRY
DO NOT REMOVE
FOR 48 HOURS

Sources of water pollution



Types of Water Pollutants

- Pathogens
- Oxygen demanding wastes
- Toxins
- Sediments

Pathogens

- Pathogens are disease-causing agents
- Sources: human and animal wastes
- Most commonly untreated human sewage

table 17-1 Pathogens Carried by Sewage

Disease	Infectious Agent
Typhoid fever	*Salmonella typhi* (bacterium)
Cholera	*Vibrio cholerae* (bacterium)
Salmonellosis	*Salmonella* species (bacteria)
Diarrhea	*Escherichia coli*, *Campylobacter* species (bacteria) *Cryptosporidium parvum* (protozoan)
Infectious hepatitis	Hepatitis A virus
Poliomyelitis	Poliovirus
Dysentery	*Shigella* species (bacteria) *Entamoeba histolytica* (protozoan)
Giardiasis	*Giardia intestinalis* (protozoan)
Numerous parasitic diseases	(Roundworms, flatworms)

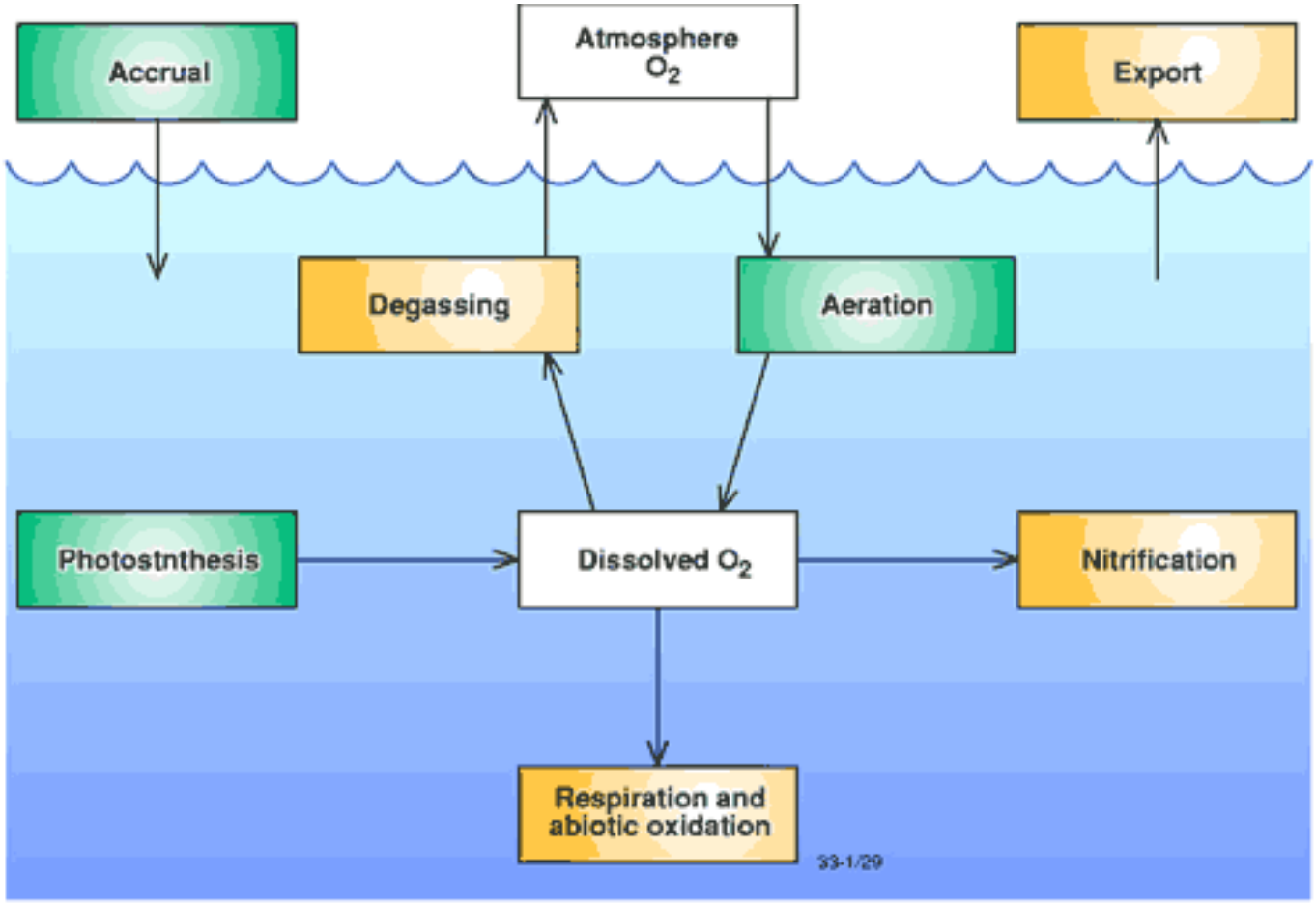
Oxygen demanding wastes

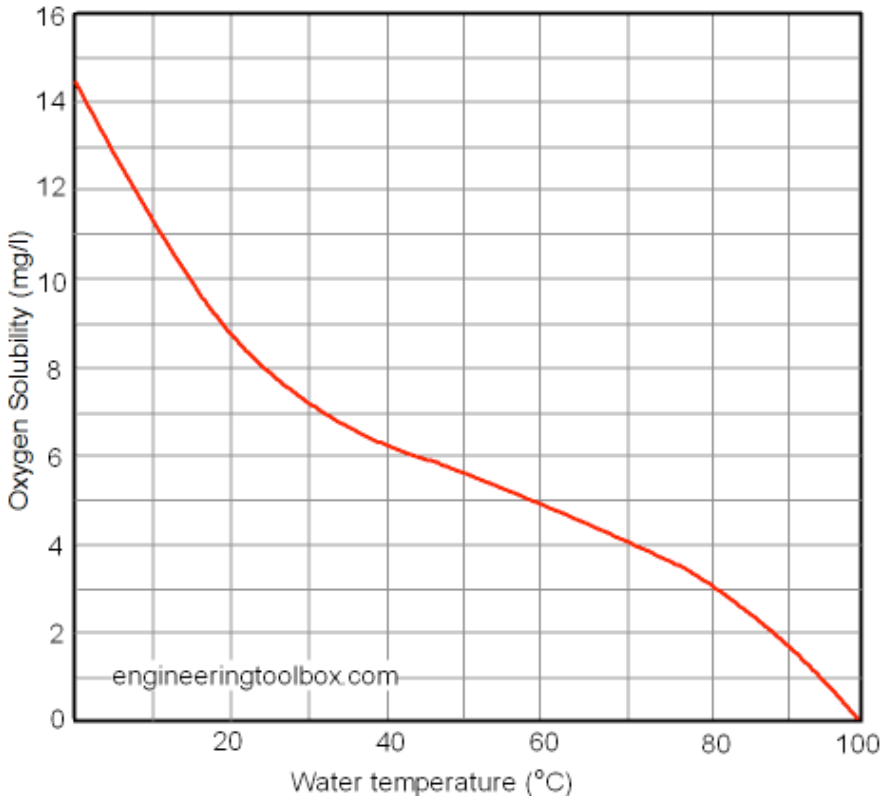
- Pollutants that result in increased bacterial growth that deplete dissolved oxygen in water

- Dissolved oxygen (DO) in the water is depleted during decomposition of organic wastes. [cold water can hold up to 10ppm (parts per million) compared to 200,000ppm for air]

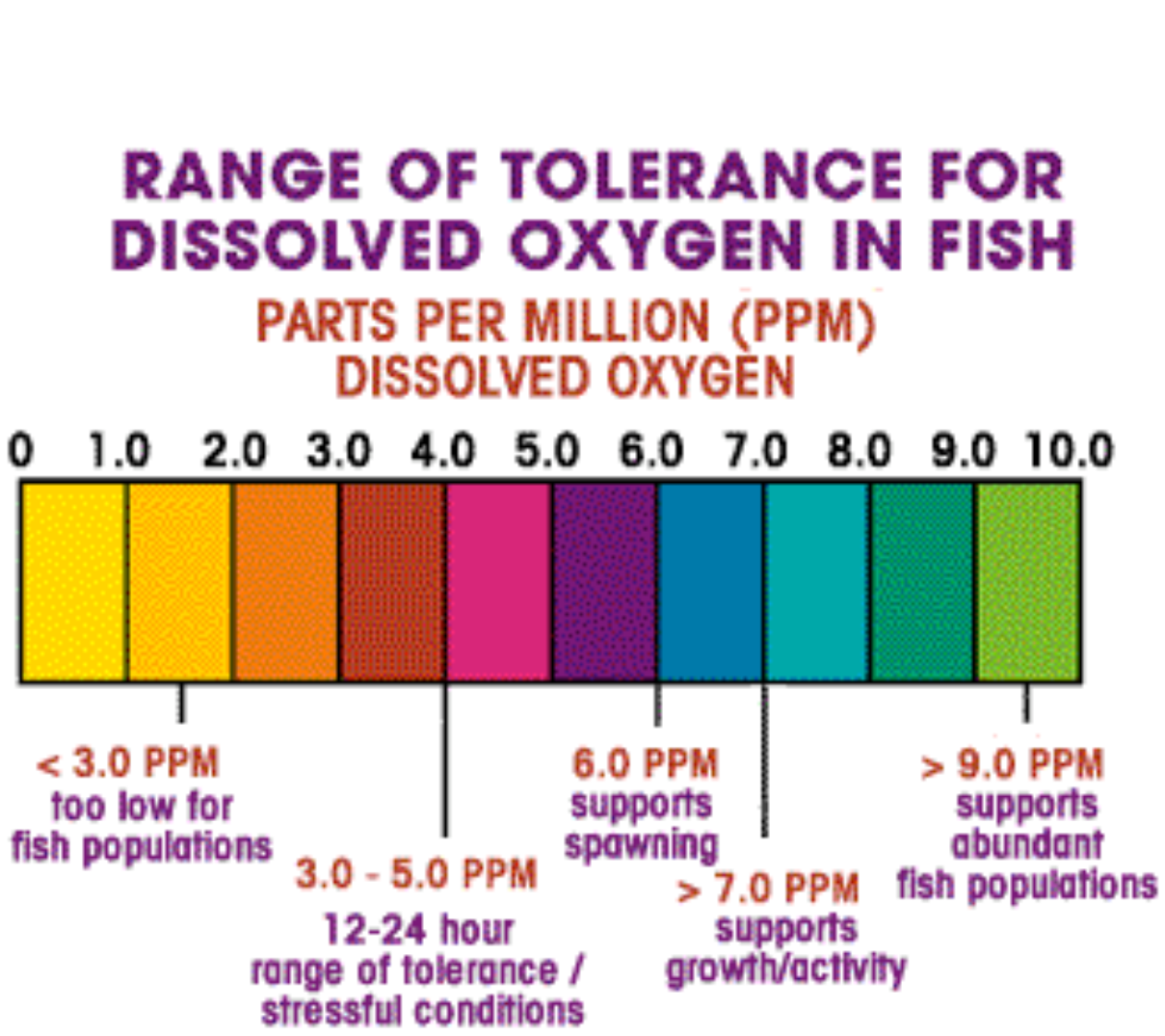
Dissolved oxygen factors

- Temperature
- Salinity
- Oxygen consuming metals
- Water movement: mixing with air
- Air pressure
- Respiration of animals and micro-organisms
- Plant photosynthesis
  - Light, amount of plants


Accrual
Atmosphere
O_2
Export
Degassing
Aeration
Photostnthesis
Dissolved O_2
Nitrification
Respiration and
abiotic oxidation
33-1/29


16
14
12
10
8
6
4
2
0
Oxygen Solubility (mg/l)
engineeringtoolbox.com
20
40
60
80
100
Water temperature (°C)

RANGE OF TOLERANCE FOR DISSOLVED OXYGEN IN FISH



Oxygen demanding wastes

- Fertilizers primarily nitrogen and phosphorous, which are limiting factors in most bodies of water
  - Runoff from agriculture, yards, golf courses
  - Detergents may be rich in phosphates
- Animal and human wastes
  - Sewage lacking tertiary treatment
  - Waste runoff from farms (cattle, sheep, chickens, etc)

BOD – Biological oxygen demand

- BOD – biological oxygen demand is a measure of the amount of oxygen required, chemically or biologically, to break down a nutrient.
- The higher the BOD in a body of water, the more likely it will be that dissolved oxygen will be depleted during break down.

BOD Calculations

Collect two sets of samples from the same source

Measure the DO in one set

Put the other set in the dark for 3 – 5 days

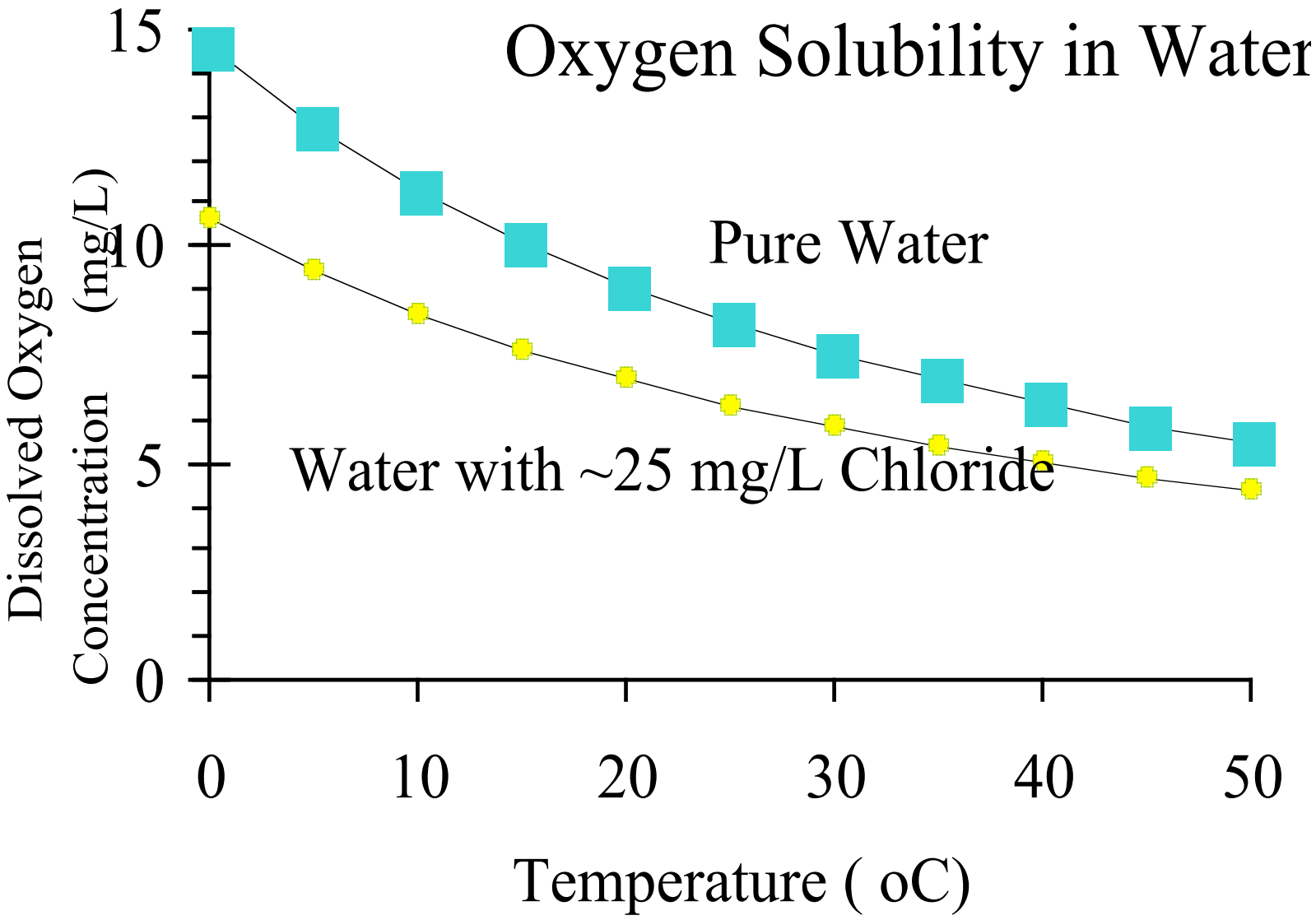
Measure the DO in the dark sample

The difference in DO over the time period is the BOD

Typical BOD Calculations

Unseeded BOD:

$$BOD_5 = \frac{7.8 - 1.7}{0.033} = \sim 185 \text{ mg/l} \qquad P = \frac{10 \text{ ml}}{300 \text{ ml}} = 0.033$$


Oxygen Solubility in Water
Pure Water
Water with ~25 mg/L Chloride
Dissolved Oxygen Concentration (mg/L)
15
10
5
0
0
10
20
30
40
50
Temperature (oC)

Eutrophication

- Process where a nutrient poor body of water (oligotrophic) becomes enriched with nutrients (eutrophic), primarily phosphorus and nitrogen.
- These added nutrients stimulate the growth of phytoplankton (algae and other organisms) which live suspended in the water.

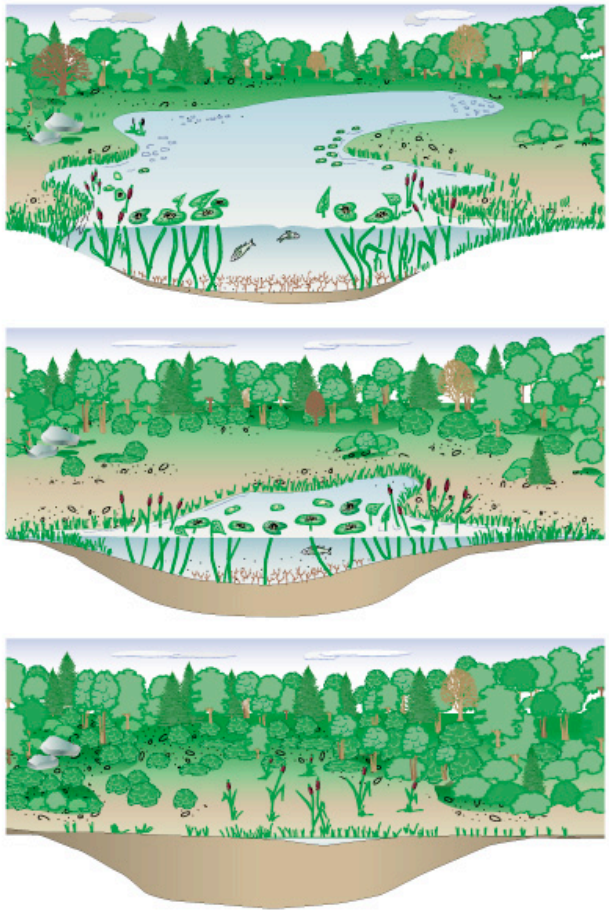
Eutrophication

- As nutrients are added from pollution, an oligotrophic condition rapidly becomes eutrophic.

Natural vs. Cultural Eutrophication

- Natural eutrophication
  - aquatic succession
  - occurs over several hundreds of years
- Cultural eutrophication
  - driven by human activities
  - occurs rapidly

Natural eutrophication: aquatic succession



Cultural eutrophication

- Increase in nutrient levels as the result of human activities (eg. sewage discharge

Consequences of eutrophication

- Phytoplankton populations explode reducing sunlight to plants rooted in the bottoms of bays, lakes, and streams (benthic [bottom] aquatic plants). As a result, benthic plants are shaded out, which in turn affects the rest of the food web which depends on them.

Aerial photo showing a boat crossing the algae-dominated waters at Lake Apopka in 1995.

Consequences of eutrophication

- When phytoplankton die, they fall to the bottom, in massive amounts, where they are broken down by decomposers.
- Decomposition requires oxygen. As a result, the decomposition of phytoplankton increases BOD, making the water oxygen poor and therefore unfit habitat for plants and animal (dead zone).


Geographic Features
Orlando
UPPER CHAIN OF LAKES
Lake Kissimmee
Kissimmee River
Atlantic Ocean
Fort Pierce
St. Lucie River
Lake Okeechobee
Gulf of Mexico
Caloosahatchee River
West Palm Beach
Fort Myers
Corkscrew Swamp & Sanctuary
EAA
CREW
Naples
Fakahatchee Strand
BIG CYPRESS PRESERVE
WCAs
Ft. Lauderdale
Miami
10,000 ISLANDS
Homestead
EVERGLADES NATIONAL PARK
Florida Bay
FLORIDA KEYS
Key West


Photo: South Florida Water Management District

historically

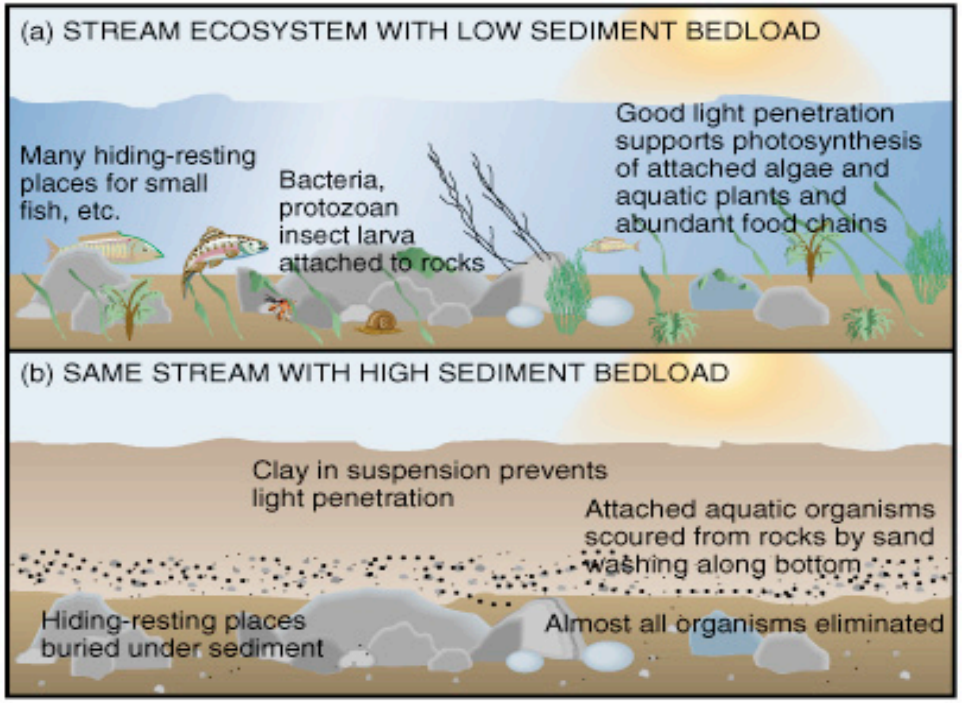
Heat and thermal pollution

- Elevated temperatures, whether natural or not, lower the solubility of oxygen in water
- Thermal pollution is warm water, usually from cooling towers of power plants
- Heat increases the rate of bacterial and blue-green algal growth

Sedimentation

- Definition: the filling in of water bodies with soil particles, mainly sand and silt.
- Effects of sedimentation:
- Loss of hiding-resting places for small fish.
- Attached aquatic organisms scoured from the rocks and sand.
- Poor light penetration

Impact of sedimentation



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