PART 3 – ANALYSIS – FRESHWATER

Along with biological analysis, water chemistry analysis plays an important role in determining water quality. Lack of key nutrients or excess of others can result in the degradation of the aquatic environment and harm aquatic life. The areas to be considered in Part 3 are the following:

Data Interpretation and Procedural analysis – some of the key chemical analysis areas

- temperature
- pH
- turbidity
- dissolved oxygen
- BOD biochemical oxygen demand
- phosphates
- nitrates
- total solids
- fecal coliform
- salinity ó only actual testing with a self-made salinometer

Build and calibrate a salinometer (Hydrometer) prior to the competition and use in competition

- Test salt water
- 1-10%

Understand the types of pollution, their effects on the aquatic ecosystem, and remediation strategies.

Chemical Analysis Tests

Temperature – measures changes in the ambient water temperature

- Measured with a thermometer or temperature probe
- Affects the amount of gases such as oxygen that can be dissolved in the water ó cold water holds more oxygen than warm water
- Increases the metabolic rates of aquatic organisms
- Affects the rate of photosynthesis by aquatic plants and algae
- Increases the sensitivity of organisms to disease, parasites and pollution
- Small chronic temperature changes can adversely affect the reproductive systems of aquatic organisms
- Raising water temperature increases decomposition rate of organic matter in the water depleting dissolve oxygen supplies
- Types of temperature changes include natural seasonal changes, manøs activities, industrial thermal pollution as discharge of cooling water, stormwater runoff from heated surfaces as streets, roofs, parking lots, soil erosion increasing water turbidity which warms the water, removal of shade trees from along the shores



pH – measures the hydrogen ion concentration of substances in a scale of 0 to 14

- Measured with a pH meter, pH probe or pH paper
- Water contains both hydrogen and hydroxyl ions
- pH of 0 to 7 is acidic with 0 being the most acidic
- pH of 7 is neutral ó water containing equal numbers of hydrogen and hydroxyl ions
- pH of 7 to 14 is basic with 14 being the most basic
- The pH scale is logarithmic ó pH change of one points indicated a 10 fold change
- Water with a pH of four is ten times more acidic than water having a pH of five
- Normal pH of rivers in the US is between 6.5 and 8.5
- pH range of 6.0 to 9.0 appears to provide protection for the life of freshwater fish and bottom dwelling invertebrates
- Small changes in pH result in large changes in water chemistry
- Extremely high or low pH levels (above 11.0 and below 4.5) become lethal for most organisms
- In basic/alkaline water, ammonia compounds convert to a toxic form
- Very acidic waters can cause heavy metals to be released and be accumulated in the food chain
- Acid rain has a pH of less than 5 and will lowers the pH of bodies of water
- The geology of the area affects water pH change ó limestone neutralizes the effects of acid rain
- Natural sources of acids include volcanoes, natural geysers, and hot springs

pH Ranges that Support Aquatic Life

Bacteria	1.0 to 13
Carp, catfish, some insects	6 to 9
Snails, Clams	7 to 9
Largest variety of animals plus mayfly, dragonfly nymph	6.5 to 7.5
Plants (algae, rooted, etc.)	6.5 to 12
Sunfish	6.5 to 8.5

As water pH approaches	Effects		
6.0	• crustaceans, insects, and some plankton species begin to disappear.		
5.0	 major changes in the makeup of the plankton community occur. less desirable species of mosses and plankton may begin to invade. the progressive loss of some fish populations is likely, with the more highly valued species being generally the least tolerant of acidity. the water is largely devoid of fish. the bottom is covered with undecayed material. the nearshore areas may be dominated by mosses. 		
Less than 5.0	• terrestrial animals, dependent on aquatic ecosystems, are affected. Waterfowl, for example, depend on aquatic organisms for nourishment and nutrients. As these food sources are reduced or eliminated, the quality of habitat declines and the reproductive success of birds is affected.		



Turbidity – measures the clarity or haziness of the water in a given body of water

- Clear water has low turbidity and cloudy or murky water has high turbidity
- Cloudiness occurs from suspended sediment, algal blooms, or dead organic matter in the water
- Turbidity id measured in nephelometric turbidity units (NTUøs) ó a comparison of the amount of light scattered by the suspended particles in the water
- The turbidity affects the amount of light penetrating to the plants for photosynthesis
- High particulate concentrations can affect the ability of fish gills to absorb oxygen
- Contaminants as viruses and bacteria can become attached to particulate matter
- The Secchi disk is used to measure turbidity in a lake
- Black and white disk is lowered into the water until it can no longer be seen
- Secchi disk depth is usually reported in feet to the nearest tenth of a foot, or meters to the nearest tenth of a meter.
- The rule of thumb is that light can penetrate to a depth of about 2 3 times the Secchi disk depth.
- Natural color of water may affect the reading
- Seasonal variations may change the turbidity as with lake turnover in the fall due to nutrients being released from the bottom
- Algal blooms with affect turbidity
- Pollution tends to reduce water clarity
- Human activity as construction, agriculture, and land disturbances can lead to high sediment in storm water runoff
- Industries as mining can generate high levels of colloid rock particles





Secchi disk measurement.

Dissolved Oxygen (DO) ó measures the amount of gaseous oxygen dissolved in an aqueous solution

- Oxygen gets into the water by diffusion from the surrounding air, as a waste product of photosynthesis or by rapid movement of the water or aeration
- Kits are available for testing DO levels
- DO levels must be tested done carefully and quickly because so many factors affect DO
- Air is about 21% oxygen which is 210,000 ppm (parts per million)
- Most surface waters contain between 5 and 15 ppm of dissolved oxygen
- An appropriately high level of dissolved oxygen is essential for aquatic life
- Below 5 ppm puts aquatic life under stress, below 1-2 ppm for a few hours can kill large fish



- Absence of dissolved oxygen is a key sign of severe pollution **DO Testing materials**
- Total dissolved oxygen levels should not exceed 110% above this level can be harmful to aquatic life
- Many natural factors affect the levels of dissolved oxygen such as
 - Seasonal temperature changes ó lower temperature equals more dissolved oxygen
 - Dissolved or suspended solids can reduce effectiveness dissolving of oxygen in water
 - Dry periods can lower stream discharge and raise water temperatures resulting in lower DO levels
 - The amount of plant life affects photosynthesis rates ó more photosynthesis equals more oxygen being released by plants
 - The rate of respiration by all plants and animals aerobically
 - The rate of decomposition of organic matter uses oxygen so it greatly affects DO levels
 - Daily changes ó night to day or /diel oxygen fluctuation cause DO to fluctuate because plants need light for photosynthesis but respiration uses oxygen all through the 24 hr period
 - Algal blooms can cause large fluctuations in DO through the night especially in areas where there is not much current for aeration
 - Very low DO levels can cause aquatic animals to die
- Humans can also cause changes in DO by dumping organic waste into water increasing rates of decomposition in the water and can increase aquatic plant growth
- Urban runoff can bring pollutants, sediment, heat and other materials which raise water temperatures and lowering DO levels
- The release of water from a dam (top or bottom) release can affect the amount of DO in the water
- Removing shade vegetation as trees can increase water temperature and increase erosion to reduce DO levels





Biochemical Oxygen Demand (BOD) - measures how fast organisms use up the oxygen in the water

- Aerobic microbes use oxygen to oxidize the organic matter in the water
- BOD is tested using the maters for testing dissolved oxygen but the test is done over a period of time to determine the rate of oxygen being used
- Natural sources of organic matter may include plant decay or leaf fall
- Human waste as leaves, lawn clippings, paper waste, pet waste entering into the water can accelerate plant growth and decay because nutrients and sunlight are overly abundant
- These human wastes can increase oxygen demand
- Oxygen used for decomposition processes rob other organisms of oxygen needed to live
- Organisms with low tolerance may die off and be replaced by organisms with more tolerance for low oxygen levels



Phosphates – measures the amount of phosphates in the water (the compound for phosphorus in the

- water)
- The phosphorus cycle recycles phosphorus in the form of phosphates for most life forms
- Phosphorus is necessary for plant and animal growth
- Test kits are available to test total phosphates
- The *total phosphorus* test measures all the forms of phosphorus in the sample (orthophosphate, condensed phosphate, and organic phosphate).
- Phosphates enter waterway in a variety of natural ways such as phosphate containing rock and normal animal and plant waste in the water
- Phosphates will enter waterways from runoff
- Phosphates enter waterway in a variety of human sources such as fertilizers, pesticides, industrial and cleaning compounds, human and animal waste, power plant boilers (used to prevent corrosion), septic tanks and wastewater from sewage treatment plants
- Phosphates stimulate the growth of water plants and plankton
- Limited increases in plant growth can provide more food for aquatic macroinvertebrates and fish
- Too much phosphate can cause excess algae and aquatic weeds using up large amounts of oxygen and causing aquatic organisms and fish to die

Nitrates – measures the different forms of nitrogen in aquatic environments

- Nitrogen is required for building proteins by all living plants and animals
- Forms of inorganic nitrogen include ammonia (NH3), nitrates (NO3), and nitrites (NO2)
- Usable forms of nitrogen for aquatic plant growth are ammonia (NH3) and nitrates (NO3)
- Test kits and probes are for testing the forms on nitrogen
- Nitrates stimulate the growth of plants and algae in the water allowing for more animal food
- Excess amounts of nitrates can cause algae to bloom wildly reducing oxygen levels for fish and sometimes causing their death (accelerated eutrophication)
- Accelerated eutrophication from excess nitrogen and phosphorus can also affect water temperature, dissolved oxygen and other key water quality indicators
- As plants and animals die, bacteria break down the organic matter
- Ammonia is oxidized to form nitrates and using up dissolved oxygen in the water
- Nitrates get into waterways from farm fertilizer, poorly functioning septic tanks, inadequately treated wastewater from sewage treatment plants, manure from farm livestock, animal wastes including fish and birds, storm drains, runoff from crop fields, parks, lawns, feedlots and car exhausts

Total Solids - measures the suspended and dissolved solids in water

- **Suspended solids** can be retained on a water filter and will settle to the bottom of a water column and include silt, clay, plankton, organic wastes, and inorganic precipitates
- **Dissolved solids** pass through a water filter and include calcium, bicarbonate, nitrogen, phosphorus, iron, and sulfur and other ions in the water
- Concentration of dissolved solids in stream water is important because it determines the flow of water in and out of the cells of aquatic organisms
- Many of the dissolved solids as nitrogen, phosphorus, and sulfur are essential nutrients for life
- Low concentrations of total solids can limit growth of aquatic organisms
- Elevated levels can lead to accelerated eutrophication of the water system and increase the turbidity both of which decrease water quality
- Sources of elevated levels of total solids may result as a result of runoff from agricultural activities, dredging, mining, salt from streets in winter, fertilizers from lawns, water treatment plants, plant materials, soil particles and soil erosion, and decaying organic matter
- High concentrations of suspended solids can reduce water clarity, affect turbidity, reduce light reaching plants and effecting photosynthesis, increase water temperature due to increased absorption of light at the water surface and bind with toxic chemicals and/or heavy metals



Fecal Coliform - measures the amount of Fecal Coliform bacteria in the water

- Fecal Coliform bacteria live in the intestines of warm-blooded animals
- Fecal Coliform bacteria are also found in the feces excreted from humans and other warmblooded animals
- Fecal Coliform bacteria are living organism entering the waterway
- High numbers of Fecal Coliform in water means that the water has received fecal matter from some source
- Although Fecal Coliform bacteria are not necessarily agents of disease but they may indicate the presence of disease causing microbes which live in the same environment
- Fecal Coliform concentrations are reported in number of bacterial colonies per 100 mL of sample water
- When Fecal Coliform counts are over 200 colonies/100 mL of water sample, there is a greater chance of pathogenic organisms being present
- Diseases as dysentery, typhoid fever, gastroenteritis, hepatitis, and ear infections are associated with waters having high Coliform counts
- Primary sources of Fecal Coliform bacteria are failing septic systems, animal waste, and water treatment plant discharges
- Urbanization can cause problems with storm and sanitary sewers, sewer pipes, domestic plant wastes seeping into storm water runoff
- Higher temperatures and high levels of nutrients increase the growth rate of bacteria

Salinity – measures the amount of salt in the water

- High levels of salt can adversely affect plant growth and water quality
- Sources of salt include seawater intrusion, human and animal wastes, industrial wastes, fertilizers, and winter highway deicing (salt spread on streets in winter can soak into adjacent soils and continue to leach into nearby waterways throughout the year)
- Vertical salt seepage into shallow costal aquifers is causing many problems
- Measuring the salt in a water sample by using a hydrometer/salinometer (water with more salt is more dense and will float the hydrometer/salinometer at higher levels in the cylinder depending upon the concentration of salt)







freshwater

saltwater

calibrating the salinometer



correct when you have 20-80 evenly dispersed colonies

Making A Simple Salinometer







Materials

Water

Saltwater Solution

Several types of salinometers can be made. The simplest is a hydrometer calibrated to read in % of salt concentration instead of specific gravity. Follow the instructions below to make and calibrate a simple salinometer. You will need to research how to make a known saltwater solution to use as a calibration standard.

Materials:

- soda straw
- modeling clay
- a fine-tipped permanent marker
- a tall clear container to hold the solution for calibrating your device
- salt for mixing one or more standard solutions
- water (tap water will work-distilled is better)
- 1. Mold a ball of modeling clay around one end of the straw. Make sure that the clay prevents water from leaking into the straw. Try to avoid forming pits or voids in the clay that can trap air.
- 2. Fill the container with water. Carefully insert the straw (clay covered end down) and add/remove clay until the straw floats at the maximum depth you wish.
- 3. Use the permanent marker to mark the depth where the salinometer floats in the water (0% salt solution).
- 4. Mix a saltwater solution of known concentration to use as a calibration standard. (10% is a good choice!)
- 5. Place the salinometer in the calibration standard and mark the level where it floats.
- 6. Interpolate/extrapolate from the two marks you have made to add additional lines on the scale. You can calibrate your device using additional standards at other concentrations to improve its accuracy.

You are not limited to this simple salinometer. Use your library, the internet, or other resources to research how to make a device with better accuracy and sensitivity.

Salinometer.doc

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Types of Water Pollution and their Effects

If water pollution is from a single source it is called **point-source pollution** while pollution coming from many sources is called **nonpoint pollution**.

Type of Water Pollution	Cause of Pollution	Symptoms of Pollution	Effect of Pollution	Source of Pollution
Biodegradable waste	Humans and animals	Decreasing numbers of fish and other aquatic life, increasing number of bacteria	Increased number of bacteria, decreased oxygen levels, death of aquatic life	Run-off, improperly treated effluent,
Nutrients	Nitrates and phosphates	Green, cloudy, slimy, stinky water	Algae blooms, eutrophication of water source	Over use of fertilizers, run-off from fields, improper disposal of containers, wastewater treatment
Heat	Increased water temperature	Warmer water, less oxygen, fewer aquatic organisms	Decrease in oxygen levels, death of fish and plants	Industrial run-off, wastewater treatment
Sedimentation	Suspended particles settling out of water	Cloudy water, increased amount of bottom	Warms up water, decreases depth of water source, deposits toxins	Construction sites, farming and livestock operations, logging, flooding, city run-off, dams
Chemicals	Toxic and hazardous chemicals	Water colour changes, develops an odour, aquatic life die out	Kills aquatic life, can enter human food chain, leads to birth defects, infertility, cancer and other diseases in humans and animals	Human-made, improper disposal, run-off, dams, landfill leachate, industrial discharge, acid rain
Radioactive pollutants	Radioactive isotopes	Increased rates of birth defects and cancer in human and animal populations.	Kills aquatic species and leads to cancer and death in humans and other animals	Waste water discharges from factories, hospitals and uranium mines
Medical	Medicines, antibiotics	Infertility in aquatic organisms, and other unknown symptoms	Unknown	Humans dumping medicines into water systems, wastewater treatment

Source: Safe Water Drinking Foundation

Remediation for Water Pollution

Involvement at many levels to prevent sources of pollution

- individuals
- communities
- industries
- states
- federal governments

Stabilization of the ecosystem

- significant remedy to control water pollution
- the reduction in waste input
- harvesting and removal of biomass
- trapping of nutrients
- fish management
- aeration

Reutilization and recycling of water

- industrial effluents (as paper pulp or other chemicals),
- sewage of municipal and other systems
- thermal pollutants (waste water etc.) may be recycled to beneficial use.

Removal of pollutants

- Various pollutants (radioactive, chemical, biological) present in water body
- Using appropriate methods or remedy like adsorption, electro-dialysis, ion-exchange, reverse osmosis etc.



Construction



Mining



Wastewater Disposal



Home & Garden



Agriculture



Logging