WATER AND WASTEWATER MONITORING

PHYSICAL AND CHEMICAL ANALYSES

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Chapter Description

- Aims
  - Student explain the method for analysing physical and chemical characteristics of water sample.
  - Student measure the physical and chemical analyses of water sample in the laboratory.
- Expected Outcomes
  - Student should be able to explain method for analysing physical and chemical characteristics of water sample.
  - Student should be able to measure the physical and chemical analyses of water sample in the laboratory.
- Other related Information
  - Environmental Protection Agency
  - Natural Resources Conservation Service
- References

  - Burden, Foerstner, McKelvie, and Guenther (2002) **Environmental Monitoring Handbook**, The McGraw-Hill Companies, Inc.
  - Jamie Bartram and Richard Balance. 1996. **Water Quality Monitoring: A Practical Guide to Design and Implementation of Freshwater Quality Studies and Monitoring Programmes**, CRC Press.

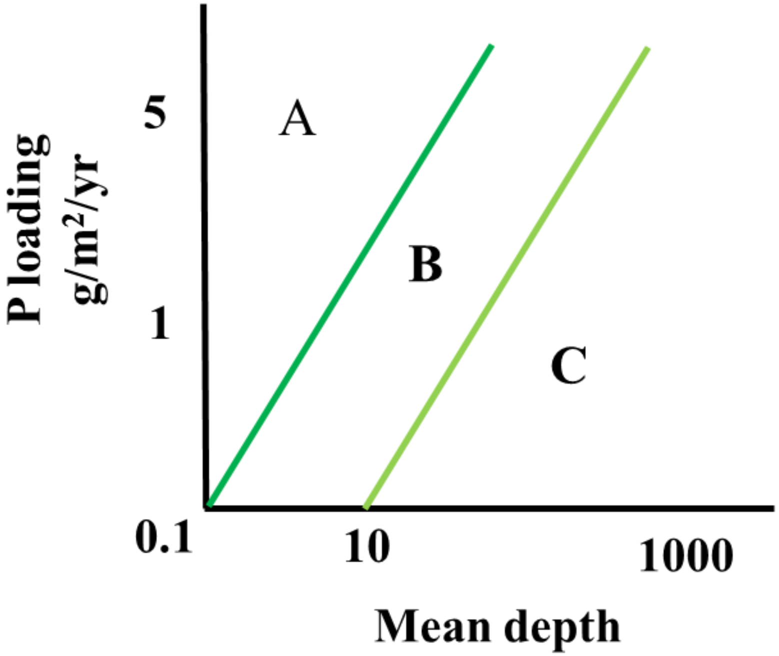
WATER PARAMETER: EX SITU

- Phosphorus
- Nitrogen
- Biochemical oxygen demand
- Chemical oxygen demand
- Total Solids
- Chlorophyll

PHOSPHORUS

- Nutrient for plants
- Usually limiting in freshwater
- Slight increase can cause accelerated eutrophication
  - accelerated plant growth
  - algae blooms
  - low dissolve oxygen (hypoxia)
  - fish kills

PHOSPHORUS



- The productivity of lake is often determined by its P loading and its volume (mean depth)

LAKE CLASSIFICATION

- **Oligotrophic lakes**- deep, nutrient-poor lakes in which the phytoplankton is not very productive.
  - The water is usually clear

- **Eutrophic lakes**-shallow, nutrient-rich lakes with very productive phytoplankton.
  - The waters are usually murky due to large phytoplankton populations
  - the large amounts of matter being decomposed may result in oxygen depletion.

PHOSPHORUS SOURCES

- Soil and rocks
- Wastewater treatment plants
- Runoff from fertilized lawns and cropland
- Failing septic systems
- Runoff from animal manure storage areas
- Commercial cleaning preparations

NITROGEN

- Nitrate (NO_3), ammonia (NH_3), nitrite (NO_2), organic N
- Nitrate is readily available plant nutrient
- If sufficient P, accelerated eutrophication
- Toxic to warm-blooded animals at higher concentrations (10 mg/L) or higher) under certain conditions
- Ammonium toxicity

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BIOLOGICAL OXYGEN DEMAND

- The biological oxygen demand (BOD) is the amount of dissolved oxygen needed by aerobic biological organism in a body of water to breakdown organic material present in a given water sample at certain temperature over a specific time period

  (Nemerow 1974, Tchbanglous and Schroeder, 1985)

- Affected by temperature, pH, the presence of certain kinds of microorganisms, and the type of organic and inorganic material in water

- Many animal species can grown and reproduce normally when DO level is ~ 5.0 mg/L

HIGH BOD AND LOW BOD

Phosfate present in soap and detergent that enhances the growth of algal blooms. As a result depletion of oxygen occur

High BOD and Low BOD:

- In a body of water with large amount of decaying organic material, the DO level may drop by 90%, this would represent **High BOD**
- In a body of water with small amount of decaying material, the DO level may drop by 10%, this would represent **Low BOD**

ANALYSIS OF BOD

- Use glass bottles having 60 mL of greater capacity. Take samples of water
- Turn on the constant temperature chamber to allow the controlled temperature to stabilize at 20°C±1°C
- Record the DO level (ppm) of one immediately
- Place water sample in an incubator in complete darkness at 20°C for 5 days. Exclude all light to prevent possibility of photosynthesis production of DO
- Wrap the water sample bottle in aluminum foil or black electrical tape and store in a dark place at room temperature, if don't have an incubator

DILUTION OF SAMPLE

- Most relatively unpolluted streams have a BOD5 that ranges from 1 to 8 mg/L
- Dilution is necessary when the amount of DO consumed by microorganisms is greater than the amount of DO available in the air-saturated.
- If the BOD5 value of a sample is less than 7 mg/L, sample dilution is not needed.
- The DO concentration after 5 days must be at least 1 mg/L and at least 2 mg/L lower in concentration

(American Public Health Association and Others, 1995)

RECOMMENDED SAMPLE VOLUMES

BOD RANGE	Millilitre of Sample	Millilitre of Water
0-7 mg/L	300	0
6-21 mg/L	100	200
12-42 mg/L	50	250
30-105 mg/L	20	280
60-210 mg/L	10	290

Adapted from Sawyer and McCarty, 1978

DETERMINATION OF BOD VALUE

- The general equation for the determination of BOD values is

$$BOD_5 = \frac{D1-D2}{P}$$

Where:

D1 = initial DO of the sample

D2 = final DO of the sample after 5 days and

P = decimal volumetric fraction of sample used

If 100 mL of sample are diluted to 300 mL then P=0.33. notice that if no dilution was necessary, P=1.0 and the BOD5 is determined by D1-D2

INTERPRETATION OF BOD LEVEL

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BOD LEVEL	STATUS
1-2 mg/L	CLEAN WATER
3-5 mg/L	MODERATELY CLEAN
6-9 mg/L	POLLUTED WATER
> 10 mg/L	VERY POOR QUALITY

CHEMICAL OXYGEN DEMAND

- Chemical oxygen demand (COD) is the total amount of oxygen required to chemically oxidize the bio degradable non biodegradable organic matter
- It is expressed in mg/L or ppm, which indicates the mass of oxygen consumed per liter of solution

ANALYSIS OF COD

- Wash 300 mL round bottom refluxing flask
- In refluxing flask put one spatula of $HgSO_3$ + 10 mL sample + 5 mL $K_2Cr_2O_7$ +15 mL concentrated H_2SO_4.
- Add small amount of silver sulphate
- Shake well and reflux for 2 hr.
- Cool and add little amount of distilled water to the flask throught the condenser
- Titrate the solution in the flask against Ferrous Ammonium Sulfate (FAS) using ferroin indicator
- End point green color to reddish brown

Note: for the blank, add 10 mL distilled water instead of sample. Rest of procedure is the same

DETERMINATION OF COD VALUE

- The COD is determined by the formula:

$$COD = \frac{(A-B) \times N \times 8000}{\text{ml sample taken}}$$

Where

A = mL of FAS required for blank

B = mL of FAS requires for sample

N = normality of FAS

ADVANTAGES OF COD TEST

- COD result are available much sooner than BOD test results
- The COD test requires fewer manipulations of the sample
- The COD test oxidizes a wide range of chemical compounds.
- It can be standardize more easily

DISADVANTAGES OF COD

- The major disadvantage is that the results are not directly applicable to 5-d BOD results without correlation studies over a long period of time
- It is inability to differentiate between biologically oxidizable and biologically inert organic matter.

TOTAL SOLIDS

- Total solids are dissolved solids plus suspended and settleable solids in water

- Dissolved solids = calcium, chlorides, nitrate, phosphorus, iron, sulfur, and other ions and particles that will pass through a 2 micron filter

- Suspended solids = silt, clay, plankton, algae, fine organic debris, and other particulate matter that will not pass through a 2-micron filter

DETERMINATION OF TS VALUE

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- Total solids are measured by weighing the amount of solids present in a known volume of sample
- Total solids (mg/L) = $\frac{(TSA - TSB) \times 1000}{\text{Sample (mL)}}$

Where

TSA = weight of dried residue + dish in mg

TSB = weight of dish in mg

CHLOROPHYLL

- Chlorophyll- is a green pigment found in most plants, algae, and cyanobacteria.
- Its name is derived from ancient Greek

  Chloros = green

  phyllon = leaf

TYPE OF CHLOROPHYLL

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- Chlorophyll-a is the molecule found in plant cells and therefore its concentration is what is reported during chlorophyll analysis
- Chlorophyll d is found only in marine red algae
- Chlorophyll b and c are common in fresh water

THE NEED OF CHLOROPHYLL

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- With over 70% of the surface of the earth covered in water, phytoplankton and photosynthetic bacteria are responsible for almost ½ of the planets primary production
- Chlorophyll measurements are also used to directly monitor phytoplankton populations
- These extraordinarily efficient plants also act as the single largest CO_2 sink on earth

FIELD TECHNIQUE

- Collection of samples

  gather sample of water using either hose sampler or sampling bottle

- Sample Filtration

  Using Glass fiber filter, algae and other suspended will be collected

- Preservation of the samples

  By freeze the sample or immediately submerse the filter in the solvent, seal and darken

LABORATORY ANALYSIS

- Filter paper is then processed, ground and leached to extract the chlorophyll
- Extraction of chlorophyll by solvent such as acetone or methanol
- Chlorophyll pigments are separated in a simple paper chromatography by a spectrophotometer

Conclusion of The Chapter

– The main Physical and chemical analyses of water characteristics contains six parameters, including phosphorus, nitrogen, biochemical oxygen demand, chemical oxygen demand, total solids and chlorophyll.

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Reference

Jamie Bartram and Richard Balance. 1996. **Water Quality Monitoring: A Practical Guide to Design and Implementation of Freshwater Quality Studies and Monitoring Programmes**, CRC Press.