Lesson 16

Title of the Experiment: Determination of water quality parameters such as temperature, colour, turbidity and total solids by physical methods

(Activity number of the GCE Advanced Level practical Guide – 28)

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(A) Temperature

Introduction

Temperature is an easy measurement to make. It is, however, very important since temperature is a factor in certain algal blooms, in the degree of dissolved-oxygen saturation, and in carbon dioxide concentration. Temperature influences the amount and diversity of aquatic life. Lakes that are cold and have little plant life in winter, bloom in spring and summer when water temperatures rise and the nutrient-rich bottom waters mix with the upper waters. Because of this mixing and the warmer water temperatures, the spring overturn is followed by a period of rapid growth of microscopic aquatic plants and animals. Many fish and other aquatic animals also spawn at this time of year when the temperatures rise and food is abundant. Shallow lakes are an exception to this cycle, as they mix throughout the year. Water temperature is also important because warm water can be fatal for sensitive species, such as trout or salmon, which require cold, oxygen-rich conditions. Warm water tends to have lower levels of dissolved oxygen.

Because water temperature is an easy measurement to take, students sometimes become careless about following the protocol. Sources of error include not leaving the instrument in the water long enough to stabilize, removing the thermometer from the water so that the measurement changes before it can be read, and not reading the thermometer at eye level. Water temperature is taken before the other water measurements. Take the water temperature measurement as soon as possible after the water sample is taken because temperature tends to change very rapidly after a sample is collected. Read the temperature value on the thermometer while the bulb is in the water. The temperature reading can change quickly once the thermometer is out of the water, especially if the air temperature is very different from the water temperature.

The materials needed to correctly take temperature readings may vary, depending on your thermometer. A mercury-filled Celsius thermometer with a range of 0°C-100°C can be used for most purposes. At a minimum, the scale should be subdivided into 0.1°C. Thermometers are calibrated for total or partial immersion. Total-immersion thermometers must be completely immersed in water to yield the correct temperature. Partial-immersion thermometers must be immersed only to the depth of the etched circle that appears around the stem just below the scale level. For best results, the accuracy of the thermometer in routine use should be checked against the precision of a certified thermometer. An all-metal dial thermometer may also be used but must be calibrated. An electronic thermometer with a thermistor and digital readout must also be calibrated. Follow the manufacturer's instructions for use and calibration.

Learning outcomes:

After completing this practical, students will be able to

- develop skills in water sampling
- measure temperature of water samples

Materials/equipment:

thermometer

water sample/s

water sampling bottles

Procedure

(1) Immerse the thermometer in the sample to the proper depth for a correct reading. Record the temperature to the nearest fraction of a degree Celsius before removing.

(2) Record the temperature of water sample at different depth at different time intervals.

Results

Type of water sample						
Time						
Surface						
………… cm						
……….. cm						
………… cm						
……….. cm						

Plot the graph of temperature vs time for each sample.

Note: Water temperature is sometimes called a master variable because almost all properties of water, as well as chemical reactions taking place in it, are affected by it. Dissolved oxygen is strongly correlated with temperature. A graph of the water temperature and dissolved oxygen shows that the oxygen solubility increases for colder temperatures. Sudden increases or decreases of water temperature are unusual. Water has a higher heat capacity (specific heat) than air, thus it heats and cools more slowly. Unusual swings in water temperature of the expected seasonal patterns should be investigated. Identify the watershed for your site. Possible sources of sudden temperature changes might be due to release of water from upstream dams, factories, or snowmelt.

(B) Colour

Introduction

Colour in water is the result of dissolved extracts from metals in rocks and soil, from organic matter in soil and plants, and occasionally from industrial by-products. When colour is caused by metals, it is usually due to iron, copper, or manganese ions in the water. Leaves and peat may add tannin, glucosides, and their derivatives to the water, resulting in a yellow or brown hue. Industries can add a variety of chemicals with various colours.

In water and wastewater treatment, we make a distinction between true colour and apparent colour. **True colour** is the result of dissolved organics, minerals, or chemicals in water, as noted above. When testing the colour of a water sample, the goal is to measure the true colour of the water. However, suspended materials in the water (turbidity) can change the **apparent colour** of the water (the colour of the water before filtration.) As a result, the first step of measuring true colour is to remove the water's turbidity by filtration or centrifugation.

You should also be aware that changes in pH can change the true colour of water. As a result, pH is always measured along with colour during colour testing.

Figure 1: Forel-Ule scale

Two types of procedures can be used to measure the colour in water - the visual method or the instrumental method. The visual method is the simplest since it consists of a water sample being compared to a series of coloured slides or tubes. This method can be used in most cases, but it is not appropriate for use on water which has been contaminated by industrial wastes. Various instrumental methods can be used to create a more accurate portrayal of the water's colour if the colour cannot be matched using the visual method.

Observations of the water colour date back all the way to the late 19th century, when the Forel-Ule colour comparator scale was created. This scale is composed of 21 colours, going from indigo blue to 'cola' brown, through blue-green, green, and yellow colours. This system works well because the human eye can accurately match colours when viewed simultaneously.

The colour measurement with a Forel-Ule scale should be done with a secchi disc at the moment, but methods are being developed within the Citclops project to assess the water colour without the use of a disc. The determination of the water colour using a Forel-Ule scale can be accomplished using either a FU scale made of plastic or free Citclops app for smart phones.

Learning out comes:

After completing this practical, students will be able to

- use Secchi disk
- measure colour of water using Forel-Ule scale

Materials / equipment:

Secchi disk

Forel-Ule scale

Scale to measure length

Procedure

With the plastic Forel-Ule scale:

(1) Slowly lower the disc into the water until it disappears from sight and note the depth. If possible this has to be done in the shaded area.

(2) Slowly raise the disc until half the Secchi depth.

(3) Determine the colour of the water with the Forel Ule scale (in the shade).

(4) Compare the colour observed on top of the Secchi disc, with the colours of the scale (over the white bars (see red square) in the back.

(5) Record the FU number.

Note: Some natural phenomena can change water colour but it does not necessarily mean that the water is of bad quality. The different colour numbers correspond mainly to these types of water bodies:

- **Indigo blue to greenish blue with high light penetration** (1-5 FU scale). These waters have often low nutrient levels and low production of biomass. The colour is dominated by microscopic algae (phytoplankton).

- **Greenish blue to bluish green** (6-9 FU scale). The colour is still dominated by algae, but also increased dissolved matter and some sediment may be present. Typical for areas towards the open sea.
- **Greenish** (10-13 FU scale). Often coastal waters which usually display increased nutrient and phytoplankton levels, but also contain minerals and dissolved organic material.
- **Greenish brown to brownish green** (14-17 FU scale). Usually with high nutrient and phytoplankton concentrations, but also increased sediment and dissolved organic matter. Typical for near-shore areas and tidal flats.
- **Brownish green to cola brown** (18-21 FU scale). Waters with an extremely high concentration of humic acids, which are typical for rivers and estuaries.

Results

Source of Sample	FU scale	Comments

(C) Turbidity

Introduction

Turbidity of water is caused by suspended particles, primarily of clay, silt, organic matter, and microorganisms. In natural waters, turbidity can range from a few Nephelometric Turbidity Unit (NTU) to about 1,500 NTU.

While turbidity is not harmful by itself, excess turbidity hinders the efficiency of disinfection which can result in unsafe drinking water. The test for turbidity is a physical test rather than a chemical test. An instrument called a nephelometer is used to measure the amount of light which is scattered by hitting turbidity particles in the water. In the treatment plant, operators usually test the turbidity of the finished water at intervals throughout the day. This gives the operator an indication of how well the water is being treated. If the effluent water has an unexpectedly high turbidity, then the chemical feed rates may need to be adjusted or the filters may need to be backwashed.

Turbidity can be measured using several methods. The easiest and least expensive method is through the employment of a Secchi disk. A Secchi disk is an 8-inch diameter disk with alternating black and white quadrants that is lowered into the water column until it can no longer be seen from the surface. The point at which the disk disappears is a function of the lake turbidity. A turbidity tube, or T-tube, can be used as an alternative to lowering a Secchi disk through the water column. The T-tube is a plastic tube with a small-scale Secchi disk pattern at its base. Water samples can be poured into the tube and the clarity of the bottom disk can be used to reveal turbidity.

Turbidity can also be measured using higher tech instruments that measure the scattering effect suspended particles have on light. Chlorophyll concentrations can also be quantified using a fluorometer to determine turbidity contributions from photosynthetic organisms.

Learning out comes:

After completing this practical, students will be able to

- use Secchi disk
- measure the turbidity using Secchi disk

Materials / equipment:

Secchi disk

Scale to measure length

Procedure

1. Slowly lower the Secchi disk into the water until it is no longer visible. Record this depth.
2. Slowly raise the disk until it just becomes visible once again. Record this depth.
3. Average the depths from steps 1 and 2 to get the Secchi depth.
4. This may be repeated for a measurement of precision.

Considerations:

Several considerations are involved with Secchi disk measurements:

- The quality of Secchi depth data is user-dependent; that is, it varies from person to person as a function of vision.
- The depth of visibility for the Secchi disk is dependent on external factors such as sun light intensity and waves. Hence, measurements should be taken at the same general time between 10am and 4pm, in the shade, and in calm waters.
- Repeated measurements can aid in resolving precision. In addition, repeated measurements by multiple observers can aid in determining the relative accuracy of the measurement.

Results

Sample location	**Depth**	**Comments**

(D) Total Suspended Solids

Introduction

Total Solids (TS) are the total of all solids in a water sample. They include the total suspended solids and total dissolved solids. Total Suspended Solids (TSS) are the amount of filterable solids in a water sample. Samples are filtered through a glass fiber filter. The filters are dried and weighed to determine the amount of total suspended solids in mg/l of sample. Total Dissolved Solids (TDS) are those solids that pass through a filter with a pore size of 2.0 micron or smaller. They are said to be non-filterable. After filtration the filtrate (liquid) is dried and the remaining residue is weighed and calculated as mg/l of Total Dissolved Solids. Most of the impurities in potable waters are in the dissolved state, principally as inorganic salts. Thus, the parameters, "total solids" and especially "total dissolved solids" are of primary importance here. Waters containing high concentrations of inorganic salts are not suitable as sources of drinking water, because such materials are often difficult to remove during treatment. Finished drinking waters containing more than 1000 mg/L TDS are generally considered unacceptable.

There are a variety of terms referring to solids in water, each of which is defined below:

Total solids - all solids in water. Total solids are measured by evaporating all of the water out of a sample and weighing the solids which remain.

Dissolved solids - solids which are dissolved in the water and would pass through a filter. Dissolved solids are measured by passing the sample water through a filter, then drying the water which passes through. The solids remaining after the filtered water is dried are the dissolved solids.

Suspended solids - solids which are suspended in the water and would be caught by a filter. Suspended solids are measured by passing sample water through a filter. The solids caught by the filter, once dried, are the suspended solids.

Settleable solids - suspended solids which would settle out of the water if given enough time. Settleable solids are measured by allowing the sample water to settle for fifteen minutes, then by recording the volume of solids which have settled to the bottom of the sample.

Nonsettleable solids - suspended solids which are too small and light to settle out of the water, also known as **colloidal solids**. Nonsettleable solids are measured by subtracting the amount of settleable solids from the amount of suspended solids.

The measurement of solids is by means of the gravimetric procedure. The various forms of solids are determined by weighing after the appropriate handling procedures. The total solids concentration of a sample can be found directly by weighing the sample before and after drying at 103 ^{o}C. However, the remaining forms, TDS and TSS require filtration of the sample. For liquid samples, all these solids levels are reported in mg/L.

Learning out comes:

After completing this practical, students will be able to

- measure water volumes using measuring cylinder
- take measurement using electrical balance
- calculate total dissolve solids

Materials / equipment:

Secchi disk

Scale to measure length

Beakers

Measuring Cylinder

Filter paper

Electrical Balance

Drying Oven

Desiccator

Funnel

Filter papers

Dropper

Wash bottle with DI water

Glass rod

Procedure

Total Solids

(1) Take a clear dry glass beaker (which was kept at 103 ^{0}C in an oven for 1 hour) of 150 mL capacity and put appropriate identification mark on it. Weight the beaker and note the weight.

(2) Pour 100ml. of the thoroughly mixed sample, measured by the measuring cylinder, in the beaker.

(3) Place the beaker in an oven maintained at 103 ^{0}C for 24hours. After 24 hours, cool the beaker and weigh. Find out the weight of solids in the beaker by subtracting the weight of the clean beaker determined in step(1)

(4) Calculate the total solids (TS) as follows:

Total solids, TS (mg/L) = mg of solids in the beaker x 1000 /(volume of sample)

Dissolved Solids

(1) Same as above (step 1 of total solids).

(2) Take a 100 mL of sample and filter it through a double layered filter paper and collect the filtrate in a beaker.

(3) Repeat the same procedure as in steps (3) and (4) of the total solids determination and determine the dissolved solids contents as follows:

Total Dissolved Solids, TDS (mg/L) = mg of solids in the beaker x1000 (volume of sample)

Suspended Solids

Total Suspended Solids, TSS (mg/L) = TS (mg/L) – TDS (mg/L)

Can use 1 mg/L = 1 ppm if density of water sample is 1 g/mL

References:

American Public Health Association, American Water Works Association, and Water Environment Federation, 1998, Standard *Methods for the Examination of Water and Wastewater*, American Public Health Association, Washington, D.C.