Ethiopian TVET-System

Irrigation & Drainage Construction

Level II

Based on, March 2017G.C. Occupational Standard

Module Title: Sampling &Testing Water Quality

TTLM Code: EIS IDC2 TTLM 0920v2

This module includes the following Learning Guides

LG50: Conduct water quality sampling

LG Code EIS IDC2 M12 LO1-LG-50

LG51: Prepare for and conduct water quality Test

LG Code: EIS IDC2 M12 LO2-LG-51

LG52: Conduct basic waste-water tests

LG Code: EIS IDC2 M12 LO3-LG-52

LG53: Finalize Work

LG Code: EIS IDC2 M12 LO4-LG-53)

Instruction Sheet	Learning Guide- 50: Conduct water quality sampling

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Sampling plan documenting required and samples, sampling locations and sampling schedules are developed to meet assignment requirements.
- Appropriate sampling equipment is selected and checked for the task prior to use.
- Samples are collected according to sampling plan and ensure safety procedures are followed to limit hazards and contamination to self, work area and environment.
- Integrity of samples is maintained during sampling and sample containers labeled according to organizational requirements.
- Sample information is checked and recorded.
- Results of repeat sampling are recorded to identify trends

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Determining requirements and purpose of drawing
- Identification and collection all data necessary to produce the drawing
- Confirming drawing requirements with relevant personnel and timeframes
- Identifying product/system/component/item to be manufactured/ modified
- Preparing a simple map or plan, including selecting tools and equipment and a workable scale
- Taking and recording real world measurements and features on a drawing
- Using field notes and measures to draw a local area map.
- Locating legend on project drawings, and Interpreting symbols and abbreviations correctly

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information “Sheet 1-6” in page 4, 10, 15, 18, 21 and 23 respectively.
4. Accomplish the “Self-check 1-6” in page 9, 14, 17, 20, 22 and 24 respectively
5. If you accomplish the self-checks, do operation sheet in page 25, 27 and 29
6. LAP Test in page 30

Information Sheet-1	Developing sampling plan documenting required and samples, sampling locations and sampling schedules

1. 1 Introduction

To protect the water users and to detect any possible contamination of water at the earliest possible time, operators of public and semi-public water systems should follow the sampling and testing methods. These sampling and testing methods will help you meet the requirements of the Drinking Water and Wastewater Facility Operating Regulations.

It is vital that operators collect samples for testing in the volumes required by the laboratory using the bottles provided by the concerned laboratory. Failure to follow procedures may lead to tests that are delayed, or possibly refused, and may compromise your ability to show that you are delivering the quality of drinking water required by law.

1. 2 Water sampling plan

Before sampling begins, a sampling plan should be designed to address the objectives of a water-quality project or program. A sampling plan should include specifics about sampling locations or sites, methods and techniques, number of samples, kinds of samples including: volume of water, filtered or whole, preservatives and holding times, number and kinds of quality assurance/quality control samples, and desired data quality objectives. Water-quality sampling can be expensive and time-consuming. Sampling plans help assure that sampling results are error free and meet the objectives of the water-quality project or program.

1. 3 Types of water sample

1.3.1 Grab samples

A grab sample is a discrete sample which is collected at a specific location at a certain point in time. If the environmental medium varies spatially or temporally, then a single grab sample is not representative and more samples can be collected. Grab sampling is used to provide information about the water at one point in time. Grab sample shows the characteristics of the water at the time of sampling only and should not exceed a sampling time of 15 minutes. Grab sampling is done for such

procedures as batch discharge, constant waste stream characteristics and when the Parameter tested deteriorates rapidly such as cyanides, volatile organic compounds and phenols.

Figure 1**:** Grab Sample (Source WSSI TTLM)

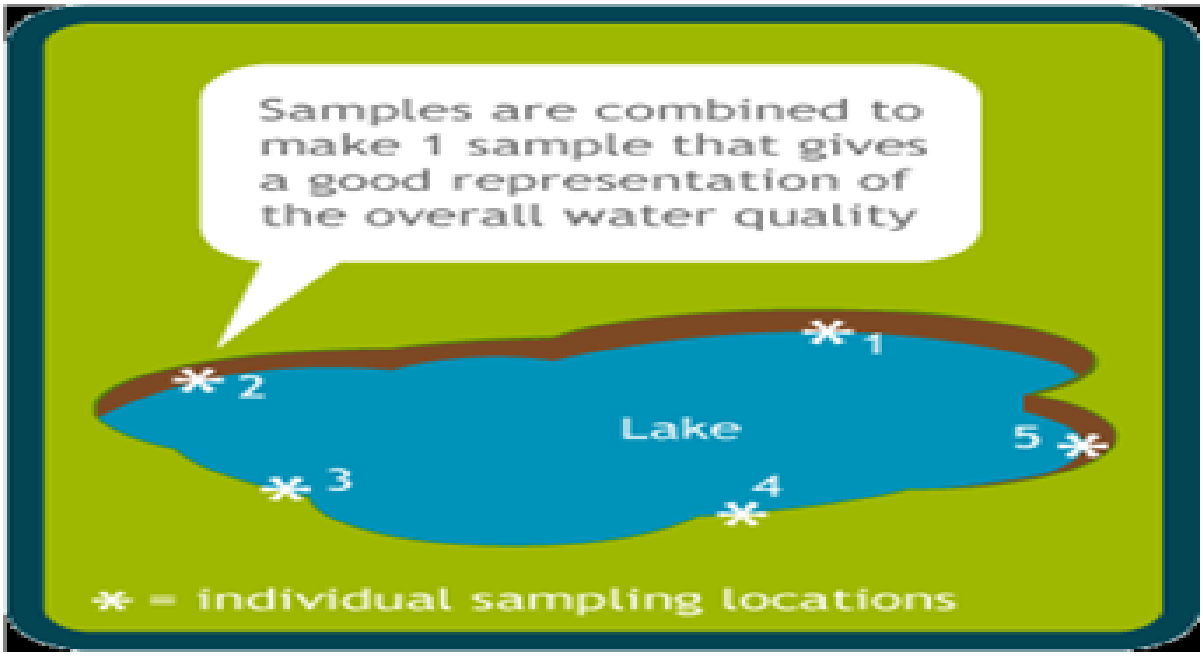


Figure 2**:** Composite sample (Source WSSI TTLM)

1.3.2 Composite Samples

A composite sample is made by thoroughly mixing several grab samples. The whole composite may be measured or random samples from the composites may be

withdrawn and measured. These are individual samples taken and deposited in the same collection bottle. There are two methods that are most common to collecting composite samples.

Time paced is when samples are collected at set increments of time. Flow paced samples: which are taken when a measured volume of water flows over the sensor of a flow meter, which is more preferred; since it gives the most representative sample. Metals, Base/Neutral/Acid Organics, BOD and TSS samples may be collected by this meth

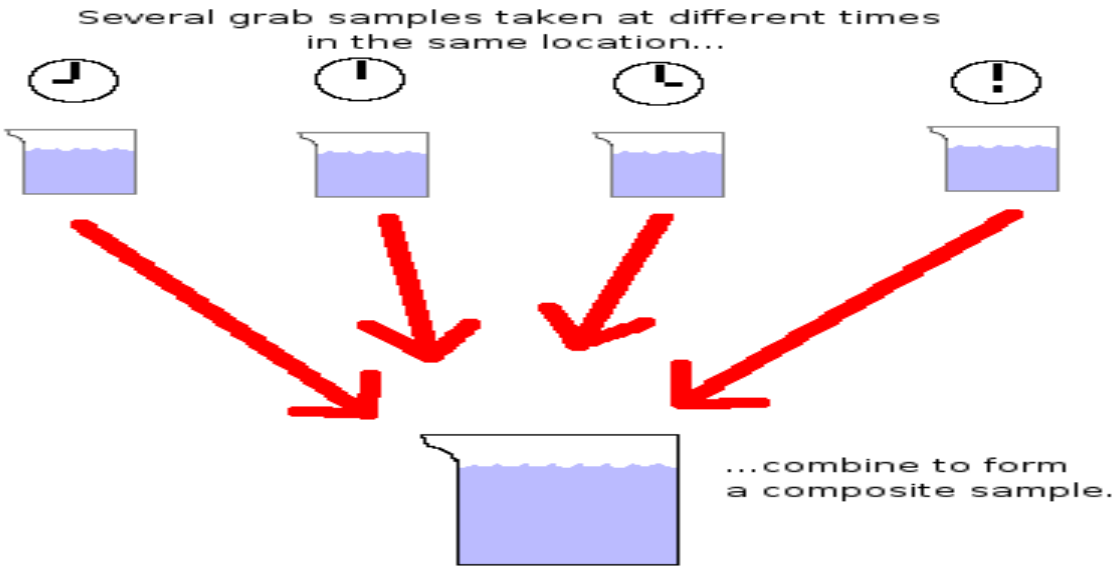


Figure 3: several grab samples

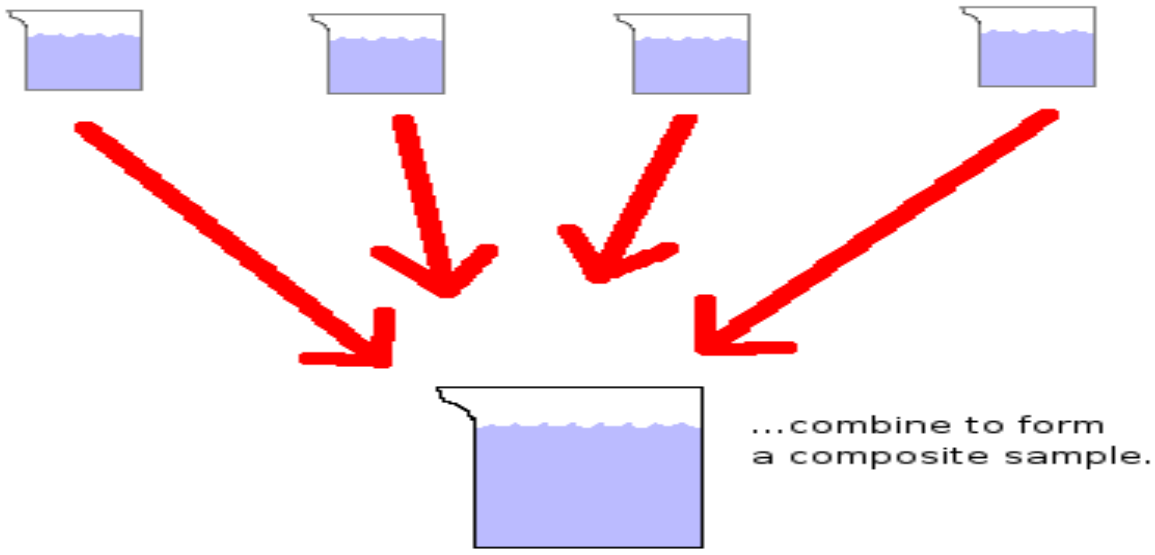


Figure 4: Integrated samples

1.3.3 Integrated samples

Those are combination of grab samples collected at the same time but at different locations. Integrated samples are required when the knowledge of the volume, movement, and composition of the various parts of the water being sampled usually is required. Collecting integrated samples is a complicated and specialized process that must be described adequately in a sampling plan for each test.

1. 4 Sampling Locations

Samples must be taken from locations that are representative of the water source, treatment plant, storage facilities, distribution network, points at which water is delivered to the consumer, and points of use.

Sampling Locations may include the followings;

- Surface water
- Groundwater
- Treatment systems,
- Distribution systems and
- Household level/tap

Surface water is what is seen on the Earth's surface. It can be either flowing water, like oceans, rivers and streams, or stored in natural depressions, like lakes and water holes. Surface water can be:

- Permanent: flowing or held in natural depressions throughout the year
- Semi–permanent: flowing or held for only part of the year
- Constructed: held in structures ranging from dams to a water tank that catches rain.

Groundwater is water stored in–between the particles of soil underground. The soil acts like a sponge eventually forming a groundwater reservoir, called an aquifer. There are two main forms of groundwater.

- Superficial: usually between 3 to 20 meters down. It is the most accessible because it is near the surface.
- Confined: deep down below the surface of the Earth. Special equipment is needed to access this water.

Water distribution systems: are ways of controlling the flow and direction of both surface water and groundwater. They are the link between the water supply source and the consumer. They include:

- Irrigation systems – used in agriculture
- bore lines – used to deliver bore water
- Scheme water systems – used to deliver water to households.
  - ✓ Some of these systems have been in use for decades, so sampling and testing is used to determine the health of the pipes and water.

Water treatment system: Water is used for many purposes. Water treatment systems function to make untreated water suitable for a particular purpose. For example, as drinking water or for industrial processes

1. 5 Purpose of water sample collection and testing

- For long-term monitoring of water quality.
- To determine whether the water quality is generally good or bad for the intended use
- To identify specific areas of concern such as points of suspected contamination
- To determine if a particular problem has been corrected.

Self-Check 1	Written Test

Name: _____ Date: _____

Directions: Answer all the questions listed below. (15 points)

1. What are the three types of water samples? (3points)
2. Write down the type of water sources for taking water samples? (4 points)
3. What are the purposes of water sampling? (4 points)
4. Mention at least four points that can be included in water sampling plan. (4pts.)

Note: **Satisfactory if score 15 points** **Unsatisfactory if below 15 points**

Score = _____

Rating: _____

Answer Sheet for self check-1.

1. ----------
2. ----------
3. ----------
4. ----------

Information Sheet-2	Selecting and Checking appropriate sampling equipment for the task prior to use

2.1 Introduction

To take proper sampling for determining the quality of water, different materials and equipments should be prepared and selected according to their purpose and size.

2.2 Types of Sampling Equipments

Equipments which are required for collecting raw water sample from the surface, ground or other sources are listed below.

- Buckets or wide-mouthed containers
- Depth samplers
- Sample dippers
- Sterile sample containers:
- Plastic
- Glass
- Test-specific (such as acid washed)
- Weighted sample bottles
- Dip tubes
- Composite and discrete automatic samplers
- Equipment for preservation of samples, including:
- Refrigeration
- Cool storage devices
- Screw top containers
- Containers for storing and carrying samples safely

2.3 Selecting Sampling Equipments

When taking water samples, it's important to:

- Use the correct sampling equipment
- Use the correct personal protective equipment (PPE)
- Record the necessary information correctly
- Check all equipment before carrying out sampling.

There are many different types of equipment used for sampling water. Groundwater sampling is conducted using groundwater bores and low flow pumps. Using this kind of equipment requires advanced knowledge. You may have an opportunity to observe this sort of water sampling.

Equipment typically used when sampling surface water includes:

- New plastic bottles
- Glass sampling bottles
- Sterile disposable gloves
- A cooler for storing and transporting filled sample bottles.
- Ice box

Any equipment needed for taking on-site tests (for example: thermometer, conductivity meter, pH meter)

Communication equipment (for example: mobile phone, walkie-talkie)

Any maps needed

Figure 5: Types of plastic samples

Figure 6: Gloves

2.4 Cleaning of Sample Containers

Cleaning is an important requirement to make the container free from contaminants. During collection of water sample, the sample containers must be washed and rinsed using hot water, optional detergents, tap water, distilled water and acids depending on the requirement of the type of water sample to be taken. In water sample collection we may use containers made of plastic or glass having different sizes and volumes. Selection of the appropriate type of container depending of the sample type to be collected is important.

2.5 Sample Preservation

The preserving methods for the analytical parameters of water quality of springs, ponds, ground water and reservoir water are closely tied to laboratory analysis methods. In fact, the desired sensitivity and quantification limits can be used to determine the volume and type of sample to be collected. The type of container and sample preservation technique are also determined on the basis of the analysis method.

- Sample preservation should be performed immediately upon sample collection. For composite samples each aliquot (portion) should be preserved at the time of collection.

- Samples should be analyzed as soon as possible after collection
- From the moment samples are collected to the time they are received by a laboratory; all samples must be preserved at a temperature of approximately 4°C (use ice boxes or refrigerants) or chilled in an environment where an ambient temperature of approximately 4 °C is maintained;
- If ice boxes are used, they must remain clean.
- Preservation and transportation are the responsibility of the sample collector or reservoir manager.

Self-Check 2	Written Test

Name: _____ Date: _____

Directions: Answer all the questions listed below. (11 Points)

1. List down at least three types of equipments required for taking samples (3pts.)
2. Mention at least four equipments typically used for surface water sampling. (4pts.)
3. How can we clean glass sample containers before taking of samples? (3pts.)
4. Who is the responsible body for preserving and transporting collected samples to the laboratory? (1pt.)

Satisfactory rating: If score 11 points Unsatisfactory rating if: below 11 points

Score = _____

Rating: _____

Answer Sheet

1. ----------
2. ----------
3. ----------
4. ----------

Information Sheet-3	Collecting samples according to sampling plan and ensure safety procedures

3.1 Introduction

The main purpose of collecting water sample either from the surface water or the ground water is to obtain a representative water sample and transfer it with minimal change to the laboratory for analysis. It provides a general overview of the surface and ground water sampling event.

3.2 Techniques for water sampling

Water sampling techniques includes the rules of sampling, sampling bottle labelling, sample collection procedure, sample transportation and submitting of samples. Here under the rules of sampling are mentioned. The rest sampling techniques are discussed in different topics of this learning material.

3.3 Rules of Sampling

Do Not:

- Contaminate the bottle by touching the inside of the bottle.
- Contaminate the bottle lid by touching the inside rim.
- Put the bottle lid on the ground while sampling
- . Rinse the bottle.
- Transport aquatic facility water samples with other water samples,
- e.g. effluent or drinking water.

Always:

- Collect microbiological samples before collecting other samples.
- Label the bottle before sampling.
- Discard damaged or contaminated bottles. If in doubt throw it out and take sample in a new bottle.
- Wash your hands thoroughly before and collecting samples
- Before taking samples rinse the sampling vessel with water on site 3~4 times.
- When you take sample from surface sources, submerge the sampling vessel gently, fill it with the water sample and close it tightly.

- If the collected water sample may be frozen, leave some space for expansion equivalent to about 10% of the sampling vessel.

3.4 Correct Water Sample

To conduct simple water quality test, several samples may be collected based on the number of samples required and the purpose of testing. During testing the collect samples should be identified and be sure that the tested and not tested samples are not mixed. Generally, identifying the correct water sample should maintain sample integrity.

Self-Check -3	Written Test

Name: _____ Date: _____

Directions: Answer all the questions listed below. (12 points)

1. What is the main purpose of water sample collection? (1 point)
2. Why do you rinse the sampling vessel before taking of sample? (1 point)
3. Write down the steps applied in collecting water sample from a tap. (9 points)
4. Why a space has left in sample bottle during sampling collection? (1 point)

Note: **Satisfactory if score 12 points** **Unsatisfactory if below 12 points**

Score = _____

Rating: _____

Answer Sheet for self-check-3

1. _____
2. _____
3. _____
4. _____

Information Sheet-4	Maintaining Integrity of samples during sampling and sample containers labeled

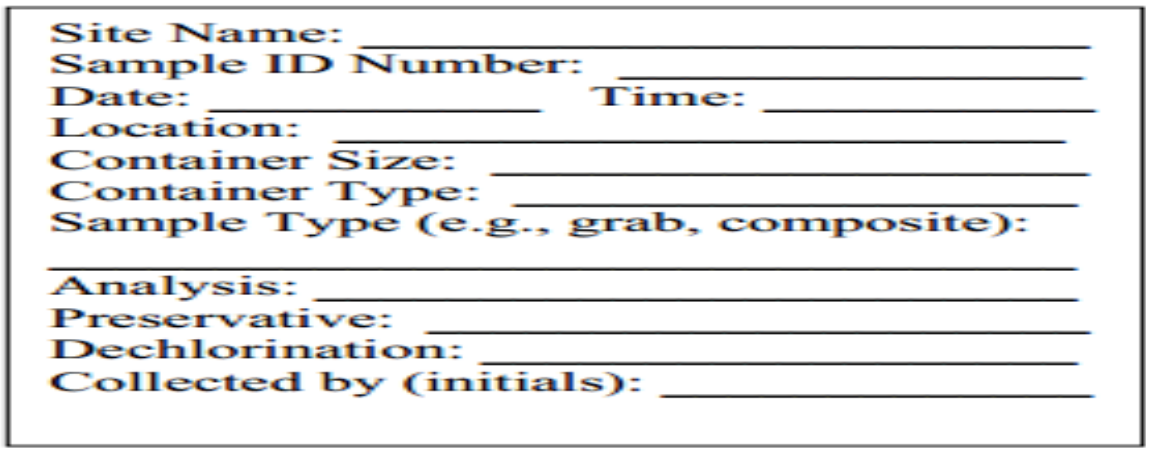
4.1 Sample Labeling

Correct labeling of samples is essential. They need to be easily identified at all times. Without proper labeling, all samples can look alike and mistakes can happen. Water sample labels must include:

- A unique identification codes
- Date of sampling
- Time of sampling
- Location of sample
- Sampling site name
- The name of the sampler
- The type of sample
- Any observations that might affect test results.

You must always keep a record of your activity when sampling water. This is done using field sheets. Field sheets are forms used to record data relating to each sample.

Table1. Labelling format



4.2 Maintaining Sample Integrity

Sample integrity is an important component of good and proper water quality analysis. All samples should be collected with enough time for analysis within the

holding time of desired analysis. Guidelines need to be followed in order to minimize sample contamination and degradation. In order to ensure good representative data is collected from field samples, field preparation planning must be completed prior to any field activities. In order to maintain sample integrity, the sample should be available with adequate volume, correct handling procedure, free contaminations and good labeling.

Abnormal characteristics of water samples

- Samples which are not taken correctly may have the following characteristics.
- Insufficient volume: at least one liter of sample should be taken.
- Odor: water with bad odor may be characterized as an abnormal sample.
- Visible contaminants such as scum, debris, etc.

4.3 Handling of samples

For bacteriological testing, samples should be transported in ice box. If they can't be tested immediately; preferably held at <10 °C during transit.

- The samples should be tested within six hours.
- Shake the sample well before processing for test.

Self-Check 4	Written Test

Directions: Answer all the questions listed below. (7points)

Part I. Short answer questions

1. Why correct labeling of sample is essential? (1 point)
2. List down at least five sample labeling information. (5points)
3. Why is water sample shaking required before test? (1 point)

Part II. Multiple choice items (5 points)

1. For biological testing water samples should be transported to testing laboratories through: -

   A. Bags B. Box C. Ice-box D. Post office

2. Which of the following terms shows abnormal characteristics of water sampling?

   A. visible contaminants B. Odor C. Debris D. All

3. Which one of the following is not used in the cleaning up of Sample collection containers?

   A. Hot water B. Acid

   C. Alcohol D. Tap water

Note: **Satisfactory if score 12 points** **Unsatisfactory if below 12 points**

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet for self-check-4 for part I

1. ----------
2. ----------
3. ----------

Answer sheet for self-check-4 for part II

1. --------- 2. ---------- 3. ----------

Information Sheet-5	Checking and Recording Sample Information

5.1 Checking & recording sample information.

The operator should check and record all relevant information that can be labelled in sampling bottles such as:

- Site name
- Sample code,
- sample type
- Sample point
- Pre-treatment
- Volume of sample
- Preservation
- Atypical results
- Test results
- Time sample was taken
- Details of person collecting sample
- Data gathered at time of collection
- Instructions to transporters
- Time and logging of sample receipt and testing
- Visual observations
- Equipment identification

Self-Check -5	Written Test

Name: _____ Date: _____

Directions: Answer all the questions listed below. (11-points)

1. Write down relevant information required to be recorded and checked during water sampling and testing. (10 points)
2. Why samples are disposed in proper way? (1 point)

Note: **Satisfactory if score 11 points** **Unsatisfactory if below 11 points**

Score = _____

Rating: _____

Answer sheet for self-check-4 for part I

1. ----------
2. ----------

Information Sheet-6	Recording results of repeated sampling

6.1 Recording of Sample Results

After analysing the testing values of repeated sample water results, the obtained data should be recorded on log books, recording formats or other data recording forms. Sample results can be stored or filled in a computer or printed paper forms to produce reports and logs.

Advantages of recording sample water results:

- To provide accurate records of the agency's contact with the client and aid in continuity of case management between co-workers
- To protect the worker and the agency, particularly from later claims of negligence.
- To serve as an evidence for further decisions on the quality improvisation program of the water source.
- It may add credibility to a claim by a client.
- Records can help resolve customer complaints.
- Records can help facilitate communication with customers, regulators, and decision makers.

Summary on collecting water sampling &performing simple water quality test

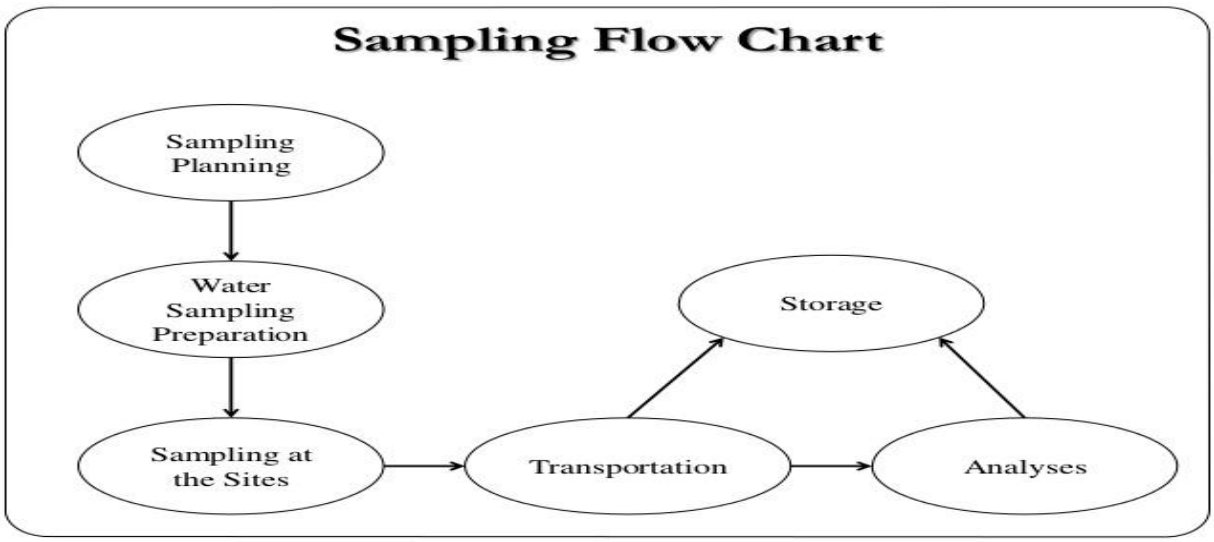


Figure 6: Samplig flow chart

(https://www.slideshare.net/praveenvatsh/water-sampling-methods-and-tools)

Self-Check 6	Written Test

Part I. DIRECTION: Give short answers for the following questions (6 points)

1. What are the advantages of recording water sample results?

Note: **Satisfactory if score 6 points** **Unsatisfactory if below 6 points**

Score = _____

Rating: _____

Answer sheet for self-check-6

1. ----------

Operation Sheet 1	Procedures for cleaning of sample containers

Procedures for cleaning sample containers

1. Prepare equipments required for sample collection**.**
2. Apply PPE as required.
3. Wash containers before taking samples for:

   3.1. Plastic (polyethylene):

   - Wash with hot water (detergent optional).
   - Rinse with acid (nitric for metals).
   - Rinse with tap water, then three times with Distilled water.

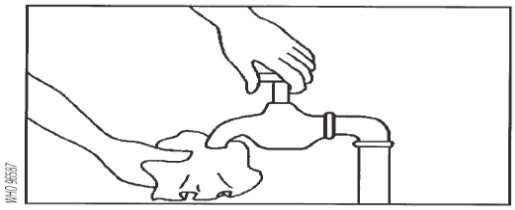
   3.2. Glass:

   - Wash with hot water (detergent optional).
   - Rinse with acid (nitric for metals).
   - Rinse with tap water, then three times with Distilled water.
   - Dry in contamination-free area.

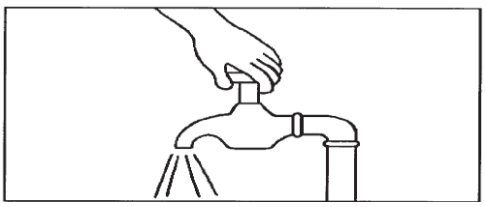
Operation Sheet 2	Collecting Tap water Sample

Procedures: For collecting tap water sample

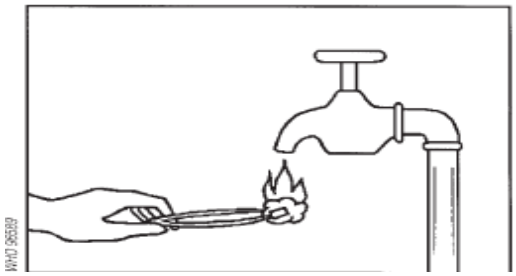
1. Collect required equipments and materials
2. Apply appropriate safety requirements
3. Clean the tap- removes from the tap any attachments that may cause splashing and, using a clean cloth, wipe the outlet to remove any dirt.



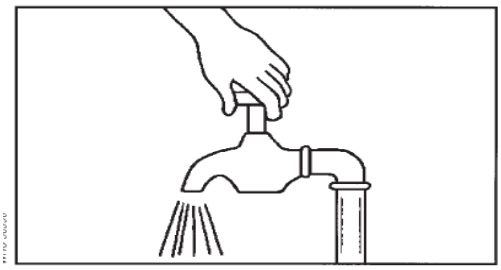
4. Open the tap- turn on the tap at maximum flow rate and let the water flow for 1-2 minutes.



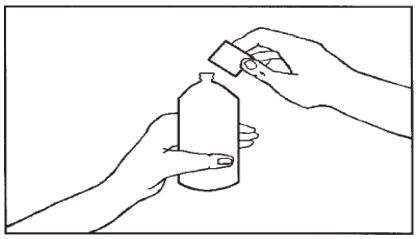
5. Sterilize the tap for a minute with the flame from an ignited cotton wool swab soaked in an alcohol; alternatively, a gas burner or cigarette lighter may be used.

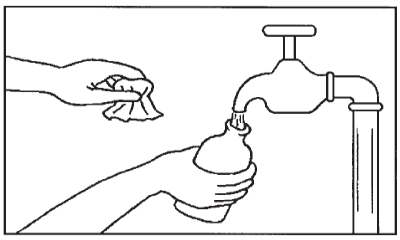


6. Open the tap prior to sampling- carefully turns on the tap and allow the water to flow for 1-2 minutes at a medium flow rate.

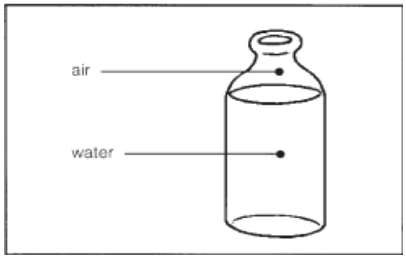


7. Rinse the sampling bottle with a distilled water by the water from which sample is to be taken.
8. Fill the bottle- while holding the cap and protective cover face downwards (so as to prevent entry of dust that might carry microorganisms), immediately hold the bottle under the water jet and fill.





9. A small air space should be left to facilitate shaking at the time of inoculation prior to analysis.



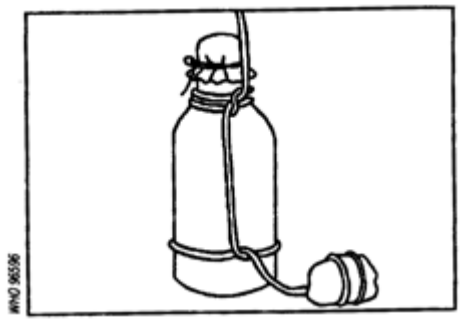
10. Finally close the bottle tightly and cover with clean cloth. Use new cork of Plastic cap, avoid rubber plugs.

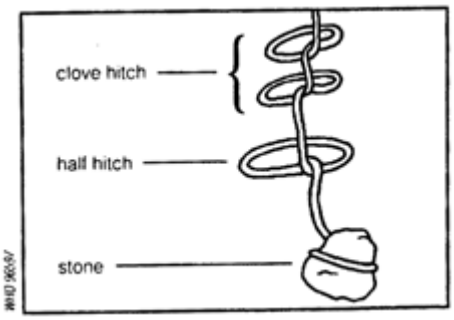
11. Label the bottle properly and handle it to your trainer.

Operation Sheet 3	Collect sample from a well

Procedures for collecting water sample from a well.

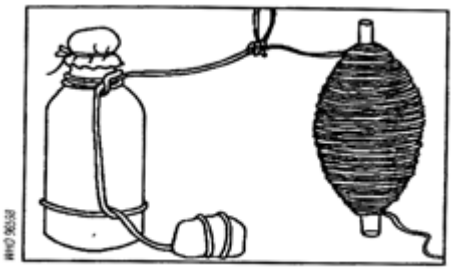
1. Prepare the bottle: With a piece of string, attach a clean weight to the sampling bottle





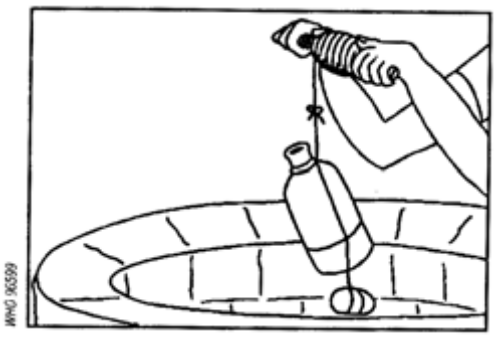
2. Attach the bottle to the string

Take a 20-m length of clean string rolled around a stick and tie it to the bottle string. Open the bottle.



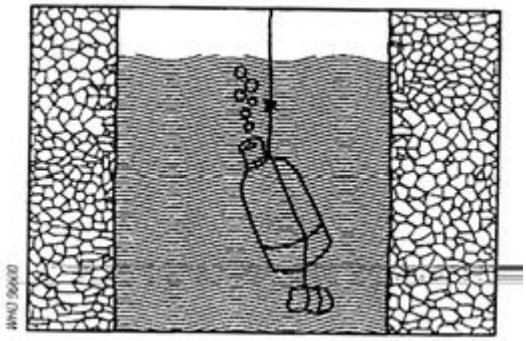
3. Lower the bottle

Lower the bottle, weighed down by the weight, into the well, unwinding the string slowly. Do not allow the bottle to touch the sides of the well.



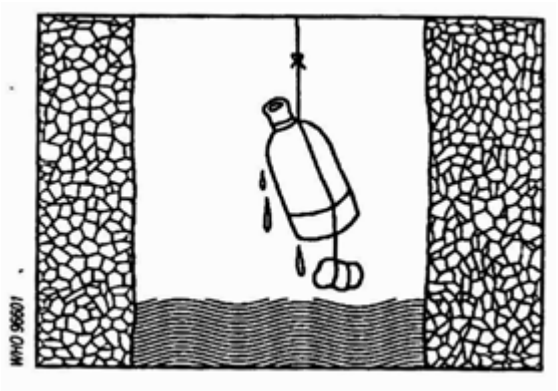
4. Fill the bottle

Immerse the bottle completely in the water and lower it well below the surface without hitting the bottom or disturbing any sediment.



5. Raise the bottle

Once the bottle is judged to be filled, rewind the string on the stick to bring up the bottle. If the bottle is completely full, discard some water to provide an air space. Stopper or cap the bottle as described previously.



6. Label the sample bottle properly.
7. Transport the Water Samples to a Water Testing Laboratory

Operation Sheet 4	Labeling Sample Bottles

PROCEDURE: for labeling water sample bottle

1. Clean the outside part of the sampling bottle.
2. Use a water-proof permanent marker to label the sampling bottle.
3. If you are using preprinted label, securely attached the label on the sampling bottle using water-proof adhesive.
4. Write legibly and include as a minimum the following information:
    i. place of location
    ii. Type of Sample
    iii. Date of sample collection
    iv. Time of sample collection
    v. Sample designation code

LAP Test	Practical Demonstration

Project Title: **Water Sample collection and Labeling**

Name: _____ **Date**: _____

Time started: _____ **Time finished**: 6hrs

Instructions: Go to the nearby spring/Tap/well/Reservoir water and do the following activities. (Use at least two sources)

Task 1: Cleaning sample containers

Task 2: Collect water sample.

Task 2: Label the sample properly.

Instruction Sheet	Learning Guide-51: Prepare for and conduct water quality Test

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics –

- Confirming instructions for conducting basic water quality testing.
- Selecting Basic Water Quality Testing Equipments
- Selecting personal protective equipment.
- Conducting simple water quality tests.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Confirm Instructions for conducting and recording basic water quality tests and plan testing work according to standard practice.
- Select, check and use required testing and personal protective clothing and equipment
- Identify correct samples and record for testing
- Conduct simple water quality tests according to standard procedures, ensuring that sample integrity is maintained during the testing process.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4” in page 32, 37, 40 and 42 respectively.
4. Accomplish the “Self-check 1, Self-check 2, Self-check 3 and Self- check 4” - ” in page 36, 39, 41 and 46 respectively
5. If you accomplish the self-checks, do operation sheet in page 47
6. LAP Test in page 50

Information Sheet-1	Instructions for conducting basic water quality tests

1.1 Introduction

In order to conduct simple water quality tests proper instructions and procedures of each test type should be clearly identified. Also, the plan testing work for water quality should be confirmed according to standard practices**.**

1.2 Planning testing work

To address a range of requirements for planning water quality test the following points should be included in the testing work plan. These include:

- The time line from planning to test of samples.
- Communication with other team members and individuals.
- Interpretation of organizational and statutory requirements
- Locations where the sample tested
- Range testing procedures and techniques
- Variety of sample to be tested
- Testing equipments and
- Reporting system

From the above listed water quality plan test work, identification of the location where sample can be tested is important. The locations in which water quality testing to be carried out are mainly includes field water testing and laboratory water testing and mobile laboratory testing.

1.3 Field water testing

In rural and remote communities, it is more convenient to carry out water testing on site. However, in practice, it is difficult to transport samples in a way that does not affect their bacteriological quality. Field testing has its own advantages and limitations. Some advantages are:

- Easy to use and handle Portable and self-contained.
- Rapid results.
- Do not require high level of training or knowledge for use.
- End users are able to participate in the testing process.

- Less expensive than laboratory testing.

Some limitations are:

- Reduced precision and accuracy
- Reduced level of quality assurance
- More difficult to process a large number of samples.

1.4 Laboratory testing

Water quality testing can be carried out in a laboratory. This method requires facilities, trained technician, equipment and other supporting materials. Laboratory testing can be useful if you are only taking a small number of samples and your project is located close to an urban area where a laboratory is present.

1.5 Mobile laboratory testing

It is possible to set up a laboratory in a suitable motor vehicle, e.g. truck or van. In effect, this is a variant of field testing, but may provide better facilities than test kits. In practice, it is only feasible where projects are scattered in different locations and they have common water quality monitoring. Government agencies and research centers responsible for monitoring and water quality testing sometimes use mobile laboratories for periodic water quality testing.

1.6 Standard practices

Standard practices in water quality testing may include the followings.

- Standard procedures for testing
- Equipments manufacturers' operation manuals.
- Methods recommended by Ethiopian public associations (EPHA) reference document.
- Risk and hazard assessment
- Safe handling of samples and chemicals
- Use of Personal Protective Equipments and clothes.
- Relative Organizational polices, regulations, legislatives and guidelines.

1.7 Water quality guideline

It is a principle or general rule that shows a recommended limit of dissolved, suspended or colloidal substances in water. It specifies the maximum amount of chemicals that can be found in drinking water so that its health impact is minimized.

Countries can take the WHO Guidelines into consideration along with the local environmental, social, economic and cultural conditions. This may lead to countries developing their own national standards that are quite different the WHO Guidelines. The implementation of the WHO Guidelines for Drinking Water Quality varies among countries. There is no single approach that is used worldwide. The Guidelines are recommendations to work towards and they are not mandatory limits. WHO guideline includes:

- It is an international guideline for drinking water.
- Although there are several contaminants in water that may be harmful to humans, the first priority is to ensure that drinking water is free of pathogens that cause disease.
- For example, the guideline values for major anions are: F^-= 1.5mg/L, NO_3^-= 50mg/L.
- The implementation of the WHO Guidelines for Drinking Water Quality varies among countries. There is no single approach that is used worldwide. The Guidelines are recommendations to work towards and they are not mandatory limits.

1.8 WHO Guidelines for Physical Parameters

The appearance, taste and odour of drinking water should be acceptable to the consumer. The table below shows WHO and Ethiopian guidelines values for basic drinking water parameters.

Table 2. WHO and Ethiopian guide line values of drinking water.

Parameter	WHO standard	Ethiopian standard
pH	6.5-8.5	6.5-8.5
Turbidity (NTU)	<5 at disinfection point	<5
Free chlorine residual(mg/L)	0.2-0.5 at distribution point	0.2-0.5
Fluoride (mg/l)	1.5	3
Fecal coliform (CFU/100m)	0	0
Total coliform (CFU/100mL)	0	0
Colour	Aesthetic Value Of < 15 True Colour Units (Tcu)	
Odour	Aesthetic Only, No Health Based Value Is Proposed	
Temperature	Aesthetic Only, No Health Based Value Is Proposed	
Turbidity (NTU)	<5 NTU	

Self-Check 1	Written Test

Part I. Direction: Give short answers for the following questions (15 points)

1. Write down the three location in which water sample can be tested? (3 points)
2. Write the advantages and limitations of field laboratory testing? (4 points)
3. A type of laboratory testing that can be set up on the basis of moveable trucks, motor bicycles and vans is called----------. (1 point)
4. The WHO recommended value of Turbidity and Colour of water is-----&------. (2 pts)

Note: **Satisfactory if score 6 points** **Unsatisfactory if below 6 points**

Score = _____

Rating: _____

Answer sheet for self-check-1

1. ----------
2. ----------
3. ----------
4. ----------

Information Sheet-2	Basic water quality testing equipments

2.1 Introduction

To determine values of the chemical, physical and biological characteristics of water sample, different basic water quality testing equipments and instruments are used.

2.2 Basic water quality testing equipments

The basic water quality testing equipments for conducting simple physical, chemical and biological water quality tests are given below.

2.2.1 Physical testing equipments

- Thermometer is an instrument used to measures temperature.
- Turbidity meter is used to measure the cloudiness or the clarity of water.
- This instrument is also called Nephelometric Turbidity meter.
- Colur, odour and taste of water are identified using our sense organs.

2.2.2 Chemical testing equipments

- To measure the pH of water we use pH meter. It indicates the acidity or basicity of water.
- TDS meter is an instrument used to measure the total dissolved Solids in water.
- EC (Electrical Conductivity) is measured by using Conductivity meter. It indicates the power of conducting electrical current in water.
- Dissolved Oxygen meter an instrument used to measure the amount of dissolved Oxygen in water.

2.2.3 Biological testing equipment

- Incubator is used for bacteriological test by using of readymade growth media.

2.3 Handling and Storing Chemicals

- Chemicals should be handled with precaution.
- Avoid contact of chemicals with your body.

- Chemicals should be stored in a plastic and glass bottles and kept safely on shelf.
- You need to put back all chemicals that you have used to their original place properly.

Self-Check 2	Written Test

Part I. DIRECTION: Give short answers for the following questions (6 points)

1. What instruments do you use to perform simple water quality tests? (3 points)
   A. Turbidity
   B. Electrical conductivity
   C. pH
2. What is the use of thermometer? (1 point)
3. How can you identify the color, odor and taste of water sample? (1 point)
4. For what purpose do you use Incubator? (1 point)

Note: **Satisfactory if score 6 points** **Unsatisfactory if below 6 points**

Score = _____

Rating: _____

Answer sheet for self-check-2

1. A.---------- B. ---------- & C.----------
2. ----------
3. ----------
4. ----------

Information Sheet-3	Apply Personal Protective cloths &Equipments

3.1 Introduction

While you are conducting simple water quality test, handle, use and store chemicals, reagents and equipments, great care should be taken to a void personal healthy injury and accidents by using appropriate personal protective equipments in accordance to specified routine water tests.

3.2 Types of PPE for conducting simple water quality test.

Use safety equipments properly to avoid damage or harm that may occur during laboratory work. Some of the personal protective clothing and equipments are gloves, over oats, face mask and necessary materials.

When performing tests, we have to: -

- Use safety wears,
- Use gloves,
- overcoats,
- face mask.
- Gloves are used to protect your hands from toxic and corrosive chemicals and reagents.
- Safety wears are personal protective clothing that protects your legs from an injury.
- Over coats are PPE that protect your body from chemical contamination and being unclean.
- Face mask: Is personal protective clothing which protect your face from un wanted chemical contact.

Figure 7: PPE for conducting simple water quality test

Self-Check 3	Written Test

Name: _____ Date: _____

Directions: Answer all the questions listed below. (8 points)

1. List down at least four personals protective equipments used in water quality testing. (4 points)
2. -------- is a PPE used to cover your hands from injury while you are conducting water quality testing. (2 point)
3. List PPE for (2 pts for each)
   A. Foot protection
   B. Body protection
   C. Eye protection

Note: **Satisfactory if score 4 points** **Unsatisfactory if below 4 points**

Score = _____

Rating: _____

Answer sheet

1. _____
2. _____
3. _____
4. A. _____
   B. _____
   C. _____

Information Sheet-4	Conduct simple water quality test

4.1 Introduction to water quality tests

Water quality test is the assessment of the quality of water. It refers to the physical, chemical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of human need or other purposes. Water quality can be tested onsite, field based and in the laboratory. Simple water quality tests include: pH, temperature, electrical conductivity, turbidity, colour, odor and dissolved oxygen.

4.2 Types of simple water quality tests

Simple water quality tests can be divided into two main classes:

- Physical tests
- Chemical tests

4.2.1 Physical tests

Physical test includes:

- **Temperature**- temperature of drinking water is best in the range 7-11^{O}C.
  - ✓ Temperature does not carry any significance in terms of contamination. However, we generally prefer cool water over warm water.
  - ✓ High water temperature (20-30°C) can also enhance the growth of microorganisms and may lead to taste, odor, color and corrosion problems.
  - ✓ The most desirable temperature for drinking water is between 4^{o}C to 10^{o}C (39-50^{o}F) and temperatures above 25^{o}C (77^{o}F) are usually objectionable

- **Turbidity**- Turbidity is an important water quality parameter in drinking water provision and treatment.
  - ✓ Turbidity is the 'cloudiness' of water caused by small particles (suspended solids) that are generally invisible to the naked eye.
  - ✓ It usually increases after heavy rain as the water picks up the dirt particles before emptying into the water sources.
  - ✓ It is given by the unit called Nephelometric Turbidity Units (NTU).

- ✓ According to WHO guideline turbidity of drinking water should not be more than
- ✓ 5NTU.

Figure 8: Turbidity meter

- **Color**- indicates the presence of organic matter from natural and manmade sources.
- **Taste**- drinking water should not have bad taste. Pleasant taste of water is due to dissolved oxygen.
- **Odor**- drinking water should be odorless.

Although taste and odor are not parameters of health concern, they are perhaps the most important characteristics of drinking water from the point of view of the user. It is next to impossible to convince people that water is safe to drink if it either tastes or smells bad. Bad taste and odor may cause people to reject the water in favor of another.

4.2.2 Chemical Tests

Chemical test includes:

- **Total dissolved solids (TDS**) are made up of inorganic salts (mainly sodium chloride, calcium, magnesium, and potassium) and small amounts of organic matter that are dissolved in water. TDS in drinking water comes from natural sources, sewage, urban runoff and industrial wastewater. Drinking water with

high concentrations of total dissolved solids will not make people sick. TDS of water can be determined by an instrument called TDS meter. Its value can be described by a unit of parts per million(ppm) or mg/lt.

- **Electrical conductivity (EC**) of a substance is defined as its ability to conduct or transmit electricity. The presence of chemicals (such as calcium and magnesium ions) gives water the ability to conduct electricity. Testing for EC does not give specific information about the chemicals present in water, but it gives an estimation of TDS. Thus, the EC of water is an indirect measure of dissolved chemicals. Electrical Conductivity is expressed in the unit of micro Siemens per centimeter.
- **pH**- is the measure of acidity and alkalinity of water. It is the measure of how acidic or alkaline a water sample is, on a scale from 0 to 14. Neutral is 7; values less than 7 are acidic and values greater than 7 are alkaline. The pH of drinking water in the range of 6.5 to 8.5 according to Ethiopian and WHO guidelines.

Figure 9. Different model pH meters

- **Dissolved oxygen:** It is the amount of dissolved oxygen in water. It is one of the important water quality tests to measure water's ability to support plants and animals
- **Hardness**- is due to dissolved calcium and magnesium ions. There are two types of hardness. These are: temporary hardness and permanent hardness. Hardness in water causes scale formation in pipes and house utensils.

4.3 Equipment Calibration

Calibration is a process of making an instrument correlate its reading with those of a standard. If there is a variation adjustment of the instrument will be carried out using a known standard. Before conducting water quality tests, it is important to calibrate equipments according to the manufacturer's specifications to get good results. Most electronic equipment will require some sort of calibration. Commonly used equipments that require proper calibration include: -

- pH meters,
- Turbid meters, and photometers.
- The pH meter must be calibrated (i.e., checked against known standards, usually 4.00 and 7.00 buffers) before use. The supplier of the equipment will provide information and instructions on calibration. Always use reagents that have not past their use by date, and rinse the probe in de-ionized water.

4.4 Precautions in the laboratory

There are some precautions that should be taken in the laboratory:

- Never eat, drink or smoke when carrying out tests.
- Wear gloves if you have any open wounds
- Wash hands before starting work
- Regularly clean your working area with disinfectant
- Put testing equipment in a clean place.
- Never touch the inside of equipment (e.g. sample containers, Petri dishes, test tubes)
- If testing from more than one source at the same time, test the least contaminated samples first (e.g. test filtered water first, then storage water, and test source water last)

4.5 Operational Health and Safety (OHS)

It is important to work safely and avoid injuries while carrying out water quality testing. It is the responsibility of the instructor or laboratory technician to provide safety equipment, but it is the responsibility of each individual to use the equipment properly and to request equipment if it is not available. It is also the responsibility the trainer to provide safety training to anyone involved in water sampling and testing.

In addition, the technician should understand any special hazards and risks associated with specific chemicals and follow the prescribed safety precautions.

Samples and any waste generated during the testing process may contain pathogens or chemicals that may be harmful to health and must be properly and safely disposed.

Self-Check 4	Written Test

Part I. Direction: Give short answers for the following questions (12 points)

1. What instrument is used to measure water turbidity? (2 point)
2. List down the physical characteristics of water? (4 points)
3. Write down some advantages of field water testing (4 points)
4. List down some safety equipments in performing water quality testing. (2 points)

Note: **Satisfactory if score 6 points** **Unsatisfactory if below 6 points**

Score = _____

Rating: _____

Answer Sheet

1. ----------
2. ----------
3. ----------
4. ----------

Operation Sheet 1	Procedures for conducting basic water quality testing

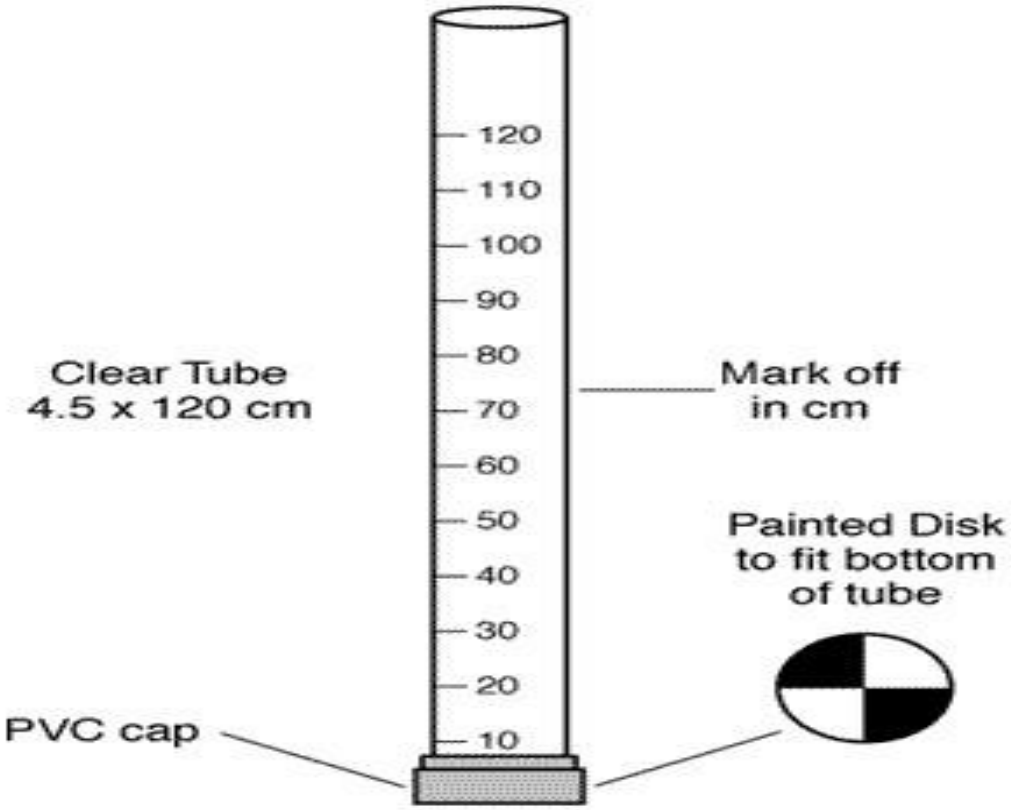
1.1 Procedures for measuring the pH of water

1. Apply appropriate personal protective equipment.
2. Prepare all required equipment and materials for testing
3. Take 50ml of water sample in a clean container and
4. Stir the water sample vigorously using a clean glass stirring rod.
5. Let the sample stand for few minutes to allow the temperature to stabilize, stirring it occasionally while waiting.
6. Standardize the pH meter by means of the standard solutions provided.
7. Gently immerse the electrode(s) of the pH meter into the water sample and allow the meter to stabilize.
8. Read and record the pH value.

9. Rinse the electrode(s) well with distilled water, then dab lightly with tissues to remove any film formed on the electrode.

1.2 Procedures for measuring turbidity of water

1. Go outside or in a room with good lighting.
2. Rinse the turbidity tube with sample water 2 to 3 times.
3. Place a sheet of white paper on the floor
4. Hold the tube vertically and pour water sample into the tube slowly in stages of few centimeters of water column at a time.
5. Holding the tube at hip level, over the white sheet of paper, try to see the cross or circle at the bottom of the tube after each addition of water column from the top of the tube. Keep on doing this until the black cross or circle at the bottom of the tube just disappears or blurs completely.
6. Hold the tube vertically and read turbidity in NTU using the graduation on the side of the tube. The result is the value of the line nearest the water level.



1.3 Procedures: For measuring electrical conductivity of water

1. Prepare the required equipments and materials.
2. Put the EC meter in a labeled surface/working table.
3. Enter EC measurement range by pressing the RANGE key.
4. Immerse the probe in to the sample water to be tested and submerge the sleeve holes will be completely.
5. Tap the probe repeatedly to remove any air bubble that may be trapped inside the sleeve.
6. Then allow the reading to stabilize;
7. The value reading will be displayed in the LCD.
8. Take the reading and record it.
9. Report any inconveniences to your Trainer/Lab assistant/

LAP Test	Practical Demonstration

Project Title: **Water Sample collection and Labeling**

Name: _____ **Date**: _____

Time started: _____ **Time finished**: 8hrs

Instructions: Go to the nearby spring/Tap/well/Reservoir water and do the following activities. (Use at least two sources)

Task 1: Conduct basic water quality testing

Task 1.1: Measuring the pH of water

Task 1.2: Measuring turbidity of water

Task 1.3: Measuring electrical conductivity of water

Instruction Sheet	Learning Guide-53: Finalize work

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics –

- Recording water quality test results.
- Recording measurements that are outside guidelines.
- Disposing samples & cleaning test equipment.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Record assignment requirements.
- Report Observations or measurements results that are outside established organizational guide lines for further action.
- Dispose Samples and clean and store test equipment according to organizational procedures.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information “Sheet 1, Sheet 2, and Sheet 3” in page 53, 57 and 59 respectively.
4. Accomplish the “Self-check 1, Self-check 2 and Self- check 3” -” in page 56, 58 and 62 respectively
5. If you accomplish the self-checks, do operation sheet in page 63
6. LAP Test in page 64

Information Sheet-1	Recording of water quality test results

1.1 Introduction

In taking water samples from different water sources and conducting various water quality tests the information that are obtained should be recorded precisely on recording formats such as field detail sheets, log books or chain of custody forms.

Records are made according to Standard procedures, WHO and Ethiopian Water Quality Standards, Environment Protection Authority sampling guidelines, Organizational Legislative requirements and Safety procedures. Some of the information that may be included in data recording is:

- Time sample of taken
- Sample points
- Volume of sample
- Data gathered at time of collection
- Time and logging of sample receipt and testing
- Visual observations
- Equipment identification
- Atypical test results

1.2 Recording, interpreting & reporting data

The following ways used to record, interpret and report data:

- Analyzing quality of water is to take corrective measures based on the results.
- Therefore, it is important to record the results properly. For example, if the amount of P^H in your sample you analyzed is 6.8, you have to report as P^H as 6.8.
- The result you got for each and every water quality parameter need to be compared with WHO and Ethiopian water quality Guideline.
- If the value is greater than the guideline value, then the water is not safe for drinking.
- If the result for PH of above 8.5, that is more than the guideline value for PH. Then that water sample is reported as" unsafe water" that may require additional pH correction.

- If the water is turbid or cloudy, contaminated surface run-off may be entering the aquifer through cracks in the casing or the cement pump pad or through surrounding soil which is very permeable.
- While turbidity is not dangerous, it reduces the effectiveness of disinfection and indicates the presence of other conditions that need to be further investigated.
- Odors should not be present in the drinking water. If present, potentially harmful substances may be entering the water from households (washing activities), agricultural sources (animal fecal matter), or natural sources (sulphates from springs or aquifers).
- If total dissolved solids (TDS) exceed 500 mg/l, objectionable taste may drive people to use unsanitary water supplies.
- Increasing TDS concentrations over time indicates that the well is drawing groundwater from deeper in the earth or that contaminants (such as salt water if the well is near the ocean) are leaching into the aquifer.
- Serious TDS changes over time will require reducing pumping volumes and/or drilling a new well (likely at a higher elevation).

Table 3: Sample recording and reporting formats

LOCATION: _____ **SAMPLE TAKEN BY:** _____

DATE OF SAMPLING: _____ **SAMPLE TESTED BY:** _____

SAMPLE DESCRIPTION	SAMPLE ID #	COLOR	TEMPERATURE	TURBIDITY (NTU)	PH	TDS	EC	CHLORINE (MG/L)	IRON (MG/L)	*FECAL COLFORM* (CFU/100 ML)	TOTAL COLIFORM

Self-Check 1	Written Test

Part I. Direction: Give short answers for the following questions (17 points)

1. List down types of format used for recording data. (3 points)
2. Mention at least five information which can be written in recording formats. (5 points)
3. List down at least seven points that can be included in Sample recording and reporting formats. (7 points)
4. Why water is turbid or cloudy in color. (2 points)

Note: **Satisfactory if score 17 points** **Unsatisfactory if below 17 points**

Score = _____

Rating: _____

Answer sheet for self-check-1

Part I. Short answer

1._____, _____&_____

2._____, _____, _____, _____&_____

3._____,_____,_____,_____,_____,_____,_____ &_____.

4._____, _____

Information Sheet-2	Recording measurements that are outside guidelines.

2.1 Introduction

All water quality test results must be recorded and stored in a way that allows them to be easily located again. It is recommended that records are kept on formatted sheets, either paper or computer-based. On these sheets it is important to include the recommended WHO or National water quality standards values so that all readings can be compared to them. These values may help you identify the need to take corrective action as appropriate. Data collected should be assessed daily and over time to determine both immediate actions required and any trends that are emerging.

2.2 Recording values outside guidelines

- Once the laboratory testing of your sample water has completed, you have to record each value in record book or other recording formats.
- Depending on the requirement of your organization you may prepare and compile a report.
- The report from the analysis result may include various parameters of water such as pH value, dissolved oxygen, Turbidity, Electrical conductivity and the taste, odor and color of the sample water.
- In addition to the test results, making recordings of the analyzed Report those parameters that exceeded the WHO and Ethiopian Water Quality Standards may be valuable.
- Report water test results of your sample which are outside the standards set by your organization may not satisfy the organizational requirements.
- Reporting test results, observations or measurements that are outside established organizational guidelines for further action is advisable.

Self-Check 2	Written Test

Directions: **Answer all the questions listed below. (4 points**)

1. Why is needed to record of water quality test results? (2 point)
2. What materials do you use to record your water sample results? (2 point)
3. List down two water quality standards that you may use to compare water Quality results at your area. (2 points)

Note: **Satisfactory if score 3 points** **Unsatisfactory if below 3 points**

Score = _____

Rating: _____

Answer sheet

1._____

2. _____

3._____ & _____.

Information Sheet-3	Disposing samples & cleaning test equipment

3.1 Introduction

Collecting Water sample and performing simple water quality test is important to determine the quality of water either within the limit range of Ethiopian drinking water quality guideline or not. After performing the basic water quality test and recording their results, the wastes and excess water sample should be disposed appropriately and the equipment and container also cleaned properly and returned to their right location for storage.

3.2 Waste Disposal

Waste disposal is the removal of waste materials such as excess samples, used chemicals, plastics and other scraps to waste disposing sites using proper technique. In addition to the waste materials, tools and equipments can also be broken or consider as wastage after giving a long-time service. These also should be stored and disposed according to the manufacturer's specifications, organizational procedures and regulations.

Generally, after completing all the water sampling and performing simple water quality test activities, all containers, leftover fluids, waste and other unwanted materials should be disposed safely and appropriately.

Waste materials which may be toxic to human beings or pollutes environmental conditions should be disposed properly in the way that can eliminate/minimize hazards.

3.2.1 Types of wastes

Wastes can be classified in to two, such as:

- Solid wastes; such as plastic bottle, scratch paper, broken glasses, packing plastics, excess chemicals and other non-reusable containers.
- Liquid wastes; like tested water samples, Excess water sample and chemical residues.

3.2.2 Importance of waste disposal

Waste disposal has the following importance:

- Minimizes and reduces the risk of accidental injury to staff, clients, visitors, and totally to the community.
- Helps to have an aesthetically pleasing working environment.
- Reduces odors from chemicals, tested water
- Reduces the contamination nearby rivers, plants and soil with chemicals wastes.

3.3 Cleaning and Storing used tools and equipments

After completing the simple water quality test, the used tools and equipment must be cleaned properly using the right cleaning material and restore to their original shelf.

3.3.1 Cleaning

It is the removal of dirt and organic substances from surfaces of tools and equipment. The first step in equipment cleaning is:

- to physically remove scrap, i.e. coarse solid particles, with a dry brush or broom. This is usually referred to as “dry Cleaning”.
- And the next can be cleaned using distilled water and chemicals.

Care should be taken when using water to remove dirty materials not wastage the water and eventually cause drains to clog and waste water treatment facilities to become over loaded.

Manual cleaning using brushes or scrapers is widely applied in small-scale operations although labor and time-intensive. Advantages of cleaning materials, tools and equipment are:

- To prevent from rust
- To be durable and long-life span to use
- To prevent our health and the environmental pollution.

3.3.2 Storing

After completion of using of materials, utensils and equipments in different activities, they should be cleaned appropriately based on organizational requirements and returned to their original stores safely. Cleaning and storing of materials and equipments have some benefits. These include:

- Better control & layout.
- Technical skill is high & supervision is better.
- Less storage space is needed because stocks should be kept as low as possible.
- Replenishment should be quicker.

Self-Check 3	Written Test

Answer the following short answer questions

1. What is waste disposal in relation to performing simple water quality test? (2points)
2. List down the types of wastes? (2points)
3. Why proper waste disposal is important? (4points)
4. Write down the benefits of proper cleaning, storing tools and equipment? (4points)
5. Define cleaning and its importance? (4points?

Note: Satisfactory rating - 8 points Unsatisfactory –if the score is less than 8

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Short Answer Questions

1. ----------
2. ----------
3. ----------
4. ----------
5. ----------

Operation Sheet 1	Procedures for recording measurements that are outside guidelines

Procedure: Identifying test results out of Guide Lines

1. Take a sample water from tap and reservoir/Surface water/
2. Perform water quality test of the PH, turbidity, temperature, EC of your samples
3. Compare your result with WHO and Ethiopian drinking water standard.
4. Identify those results out of the range of the guide lines.
5. Report your result to your instructor.

Operation Sheet -2	**Steps for disposing samples & cleaning test equipment**

Procedures for the disposal of hazardous waste

1. Segregate all waste materials; do not mix chemicals together in one container.
2. Put the wastes in separate container and Label it by itemized the content list.
3. Dump liquid wastes in Liquid dumping containers.
4. Dump solid wastes in solid dumping containers
5. Pack segregated wastes appropriately
6. Dispose the wastes

LAP Test	Practical Demonstration

Name: _____ **Date**: _____

Time started: _____ **Time finished**: 8hrs

Instructions: Go to the nearby spring/Tap/well/Reservoir water and do the following activities. (Use at least two sources)

Task 1: Record measurements that are outside guidelines

Task 2: Dispose samples & cleaning test equipment

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You tube Video sources for collecting water sample and perform simple quality test.

8. Collection and preparation of water sample. (https://www.youtube.com/watch?v=t13XnjQhPlc)
9. How to collect a drinking water sample for lab testing. (https://www.youtube.com/watch?v=YkzFvXlWcPw)
10. Water sampling. (https://www.youtube.com/watch?v=qoSvbbId18o)
11. Collecting a water sample. (https://www.youtube.com/watch?v=SncaXyOITog)
12. Water Testing Sample Collection.mov. (https://www.youtube.com/watch?v=b0rCLv16BWI)
13. How to Collect a Grab Sample. (https://www.youtube.com/watch?v=dbCE4R3AD90)
14. Webinar -- Water Quality Sampling and Analysis (https://www.youtube.com/watch?v=LU6Mwmi49eo)
15. HOW TO TEST DRINKING WATER QUALITY. (https://www.youtube.com/watch?v=HEhXsaL0Vh0)

16. Water pH Test - 19 waters tested.
(https://www.youtube.com/watch?v=G8MtaD-Ski4)
17. Turbidity water quality test.
(https://www.youtube.com/watch?v=uxhi1S5eBZM)
18. A beginner's guide: electrical conductivity (EC).
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