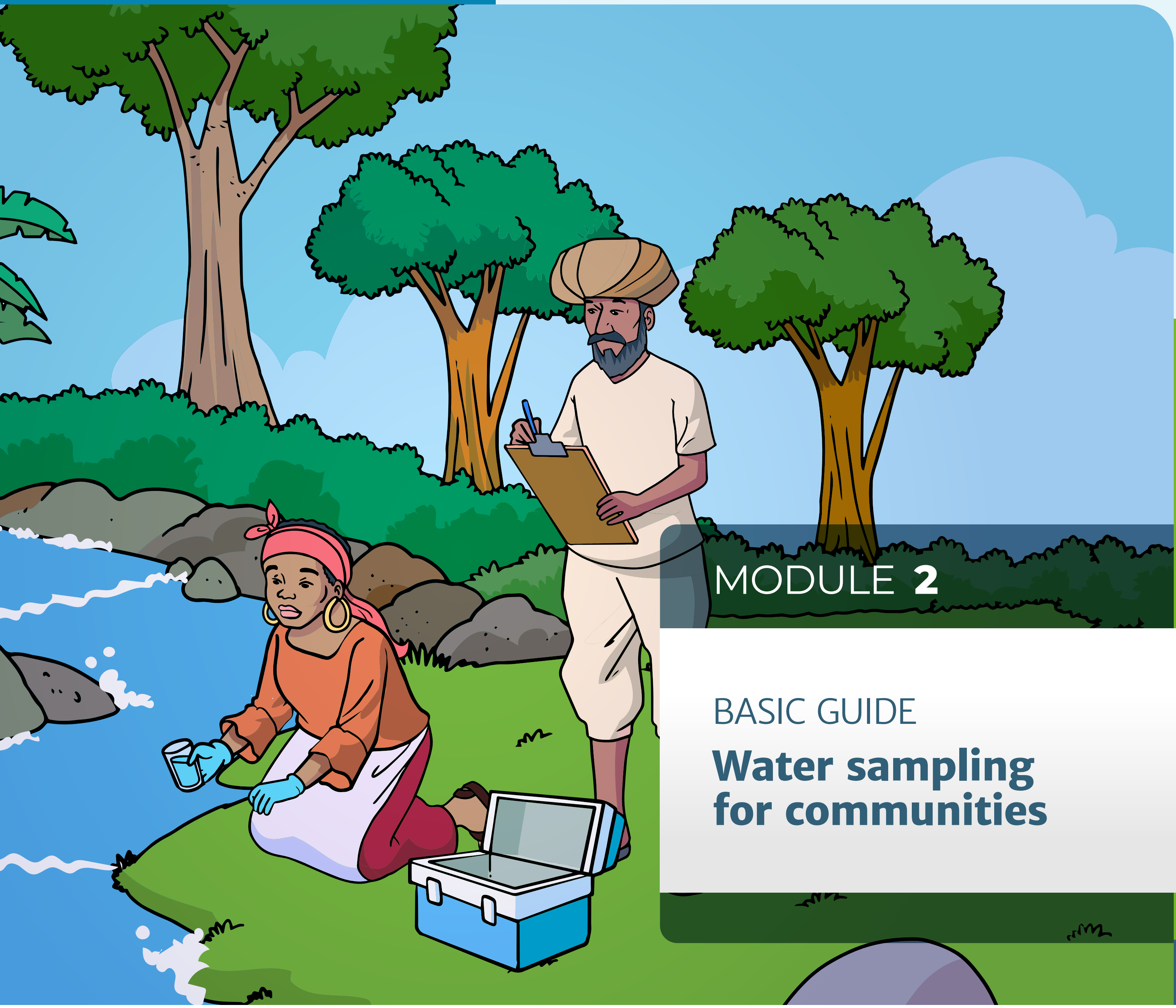
GUIDE

ENVIRONMENTAL
SAMPLING
GUIDE

MODULE 2



MODULE 2

BASIC GUIDE

Water sampling for communities

ELAW
Environmental Law Alliance Worldwide

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Acknowledgements

This guide is part of the Basic ***Guide to Environmental Sampling for Communities (ELAW),*** which is composed of four modules:

- **Module 1**. General Considerations for Community Environmental Sampling
- **Module 2.** Water Sampling – A Basic Guide for Communities
- **Module 3.** Air Sampling – A Basic Guide for Communities
- **Module 4.** Soil Sampling – A Basic Guide for Communities

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This guide has been made possible thanks to the support of the **Philip Stoddard and Adele Smith Brown Foundation** and has the objective to help citizens and grassroots organizations interested in community-based environmental monitoring initiatives to defend the right to a healthy environment. This guide contains basic information and does not include analytical aspects of sample processing in a laboratory.

Environmental Law Alliance Worldwide (ELAW) supports environmental and public interest advocates in their efforts to defend the right to a healthy environment. ELAW supports environmental advocates and the communities they represent with legal and scientific information to protect the air, water, soil, and ecosystems in their countries.

Additional information on ELAW and the three modules of the **Basic Guide to Environmental Sampling for Communities** are available free of charge on the ELAW website: www.elaw.org.

Environmental Law Alliance Worldwide

GUIDE TO TAKING ENVIRONMENTAL SAMPLES

MODULE 2

BASIC GUIDE

Water Sampling for Communities

Content

MODULE 2:

BASIC WATER SAMPLING GUIDE FOR COMMUNITIES

OBJECTIVES OF THIS GUIDE

Provide basic guidelines and advice for being able to organize and conduct water sampling for environmental NGOs and communities. Users of the guide should be able to:

- Understand the basics of water quality.
- Organize and design a water sampling.
- Know the basic principles for taking and handling water samples.
- Select the most important parameters for common cases and the transportation of the samples to a laboratory.
- Find sources of information to help interpret the results of a laboratory analysis.

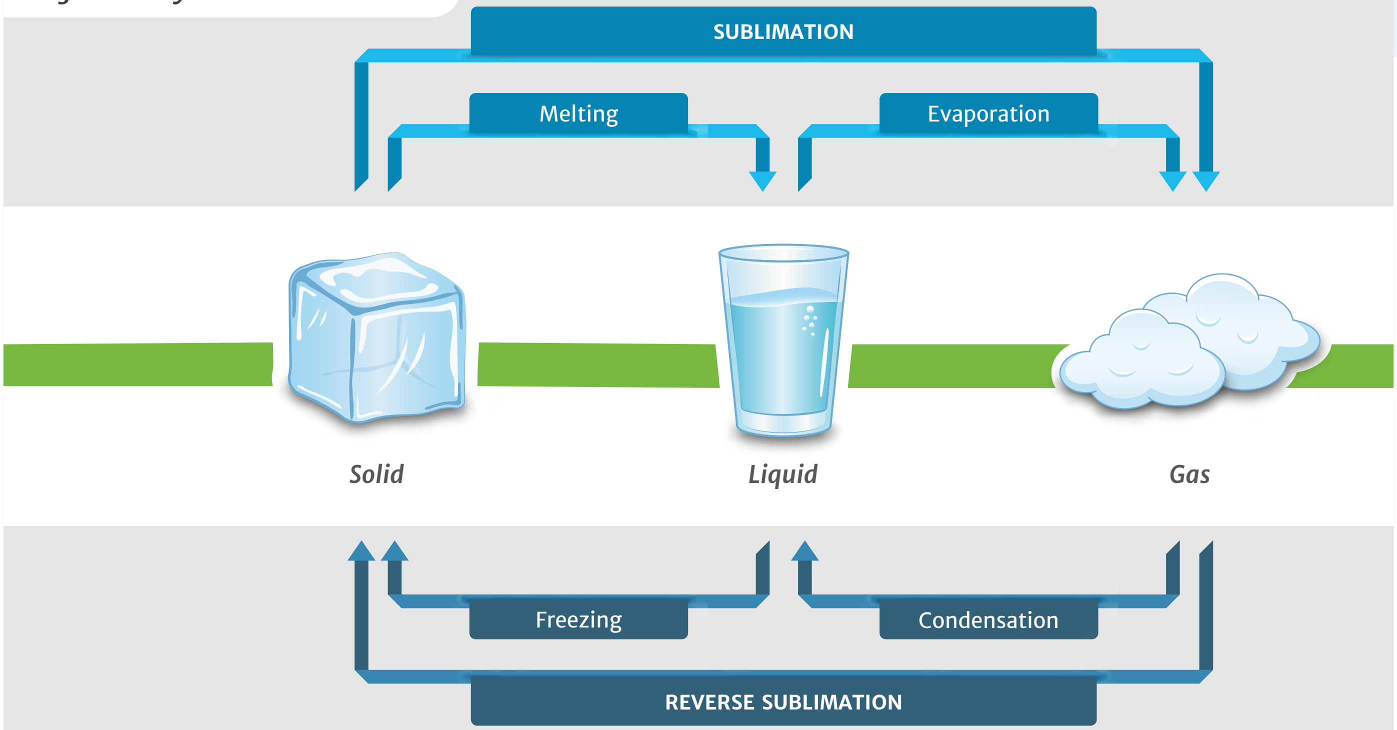
Basic concepts:

1. Water, water cycle, watershed, importance (health/environment).

1.1. WATER

Water is fundamental to life and covers about three-quarters of our planet's surface. In addition to the liquid form, it is also found in solid (ice, snow) and gaseous forms (water vapor). It is composed of hydrogen and oxygen (H2O) and in nature can be found on the surface of the earth (surface water) and below the earth (groundwater, in the air, as well as ice and snow).

Figure 1. Physical states of water



Water in its pure state has no smell, color, or taste, but sometimes we can perceive flavors, colors or smells depending on the presence of differ,ent dissolved or suspended substances, as we will see later. Water from rivers, lakes, and other natural water sources (surface or ground) is called freshwater, and "salt water" comes from seas, oceans, and sometimes lakes. Substances that may be present in water are minerals and organic matter, which can be found naturally in the environment.

All these forms of water are found in nature ina balance, continual state of physical change (solid, liquid, gas). River water and seawater evaporate, transform into water vapor and, in the form rain or snow, is returned to the earth. It is distributed on the Earth's surface, forming glaciers, rivers, and seas, thus moving through a cycle of constant change.

Natural water sources have been used for centuries as a source of energy, a sustenance of agriculture, and for different uses in our homes, general productive activities, cultural and traditional or cultural rites, recreational uses, etc.

Did you know that?

The human body is composed of 60% water.

Only 2.5% of the planet's water is fresh water, the rest (97.5%) is salt water.

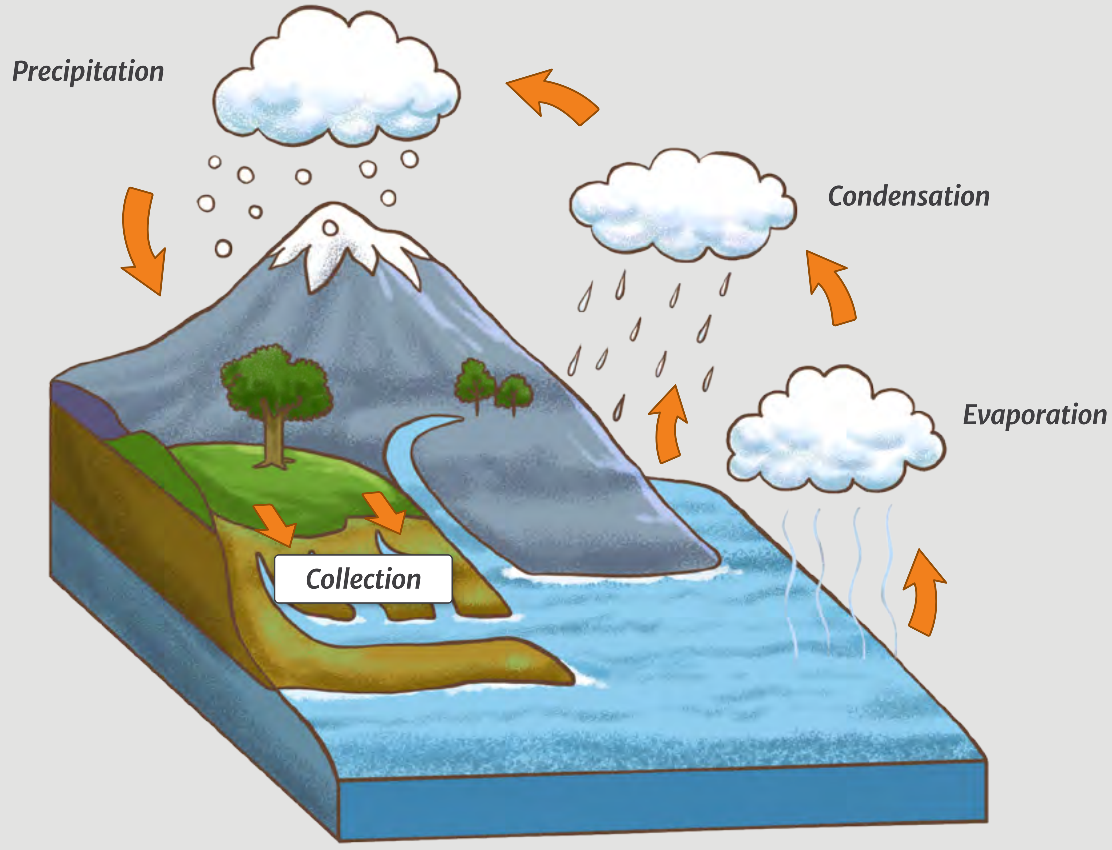
Water is a scarce resource and must be taken care of.

1.2. WATER IN NATURE. WHAT IS THE WATER CYCLE?

The water cycle (hydrological cycle) is the process of transformation and circulation of water on our planet. It consists of the constant changes of the physical state of water and its transfer from one place to another. Water changes from the liquid state (in rivers, seas, lakes) to the gaseous state (clouds) and solid state (snow and ice) successively, depending on temperature, altitude, and other environmental conditions.

The sun's energy heats the water in oceans, lakes, and rivers. This water evaporates, transforming into water vapor, and the wind and air currents carry the vapor to the upper layers where the clouds are formed. Then through changing temperature and natural conditions (wind, temperature, humidity, solar radiation), rain or snow occurs and may remain for a long time as glaciers in the northern and southern latitudes, including the North and South Poles of the planet. The rain and snow melt run over and through the earth, creating rivers, lakes, and aquifers, many of which eventually empty into the sea, starting the cycle again.

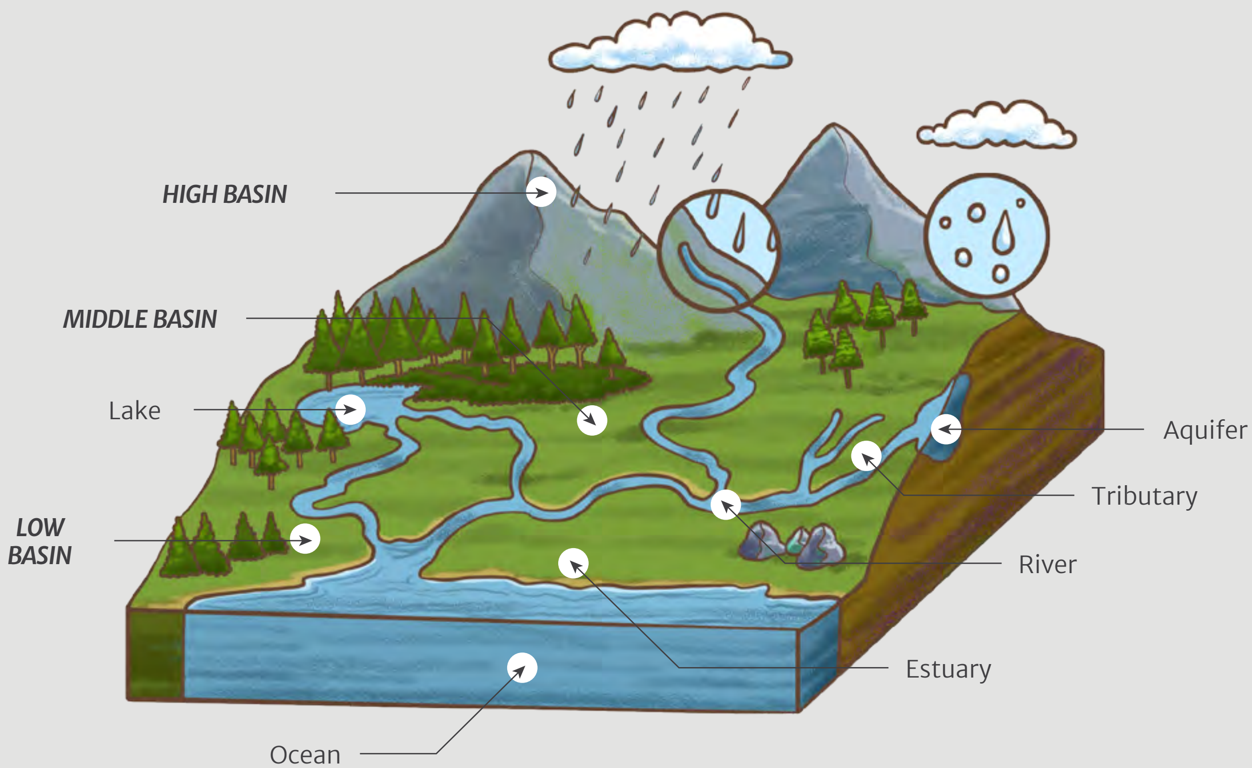
Figure 2. The Water Cycle



1.3. WHAT IS A WATERSHED?

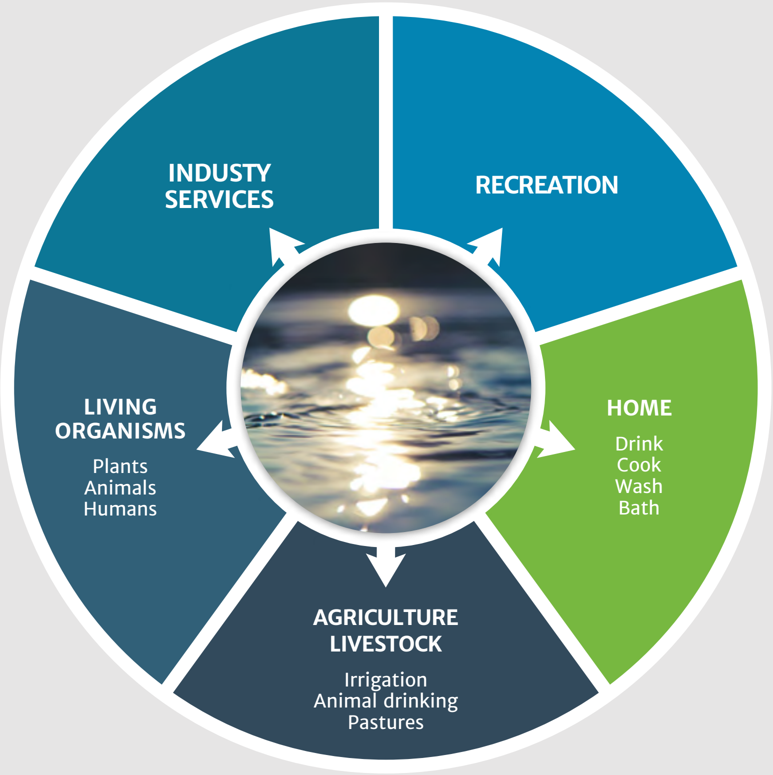
A watershed is an area of land that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean (NOAA[1]). It is also known as a catchment area or area of land where rainfall flows into a river, stream, lake, lagoon, wetland, estuary, spring, or swamp. As seen in Figure 2, water is constantly evaporating, infiltrating the subsurface and flowing across the surface into the sea and other bodies of water. As it flows, water can evaporate and return to the atmosphere, restarting the cycle. In this process, forests and plants play an important role because the vegetation layer helps evaporate water and filter water in the soil. Forests help reduce erosion, sedimentation, and runoff while maintaining the quality and quantity of water in nature.

Figure 3. Watershed



1. NOAA. 2021 What is a watershed. National Ocean Service Website https://oceanservice.noaa.gov/facts/watershed.html

1.4. IMPORTANCE OF WATER FOR HEALTH AND THE ENVIRONMENT



Importance

- Water is a human right (UN and WHO, 2010).
- Many countries have constitutions that acknowledge the right to a healthy environment and have water quality laws and standards that define water quality guidelines for human consumption. According to these constitutions, all, without exception, (companies, states, and citizens) must comply with the rules to protect water.
- WHO has developed guidelines for water quality and methods to monitor and analyze water quality, thus facilitating the protection of the right to clean and safe water for human consumption and for the health of the environment.
- Water is fundamental to life on the planet and the health of all people.
- Health is a state of complete physical, mental, and social well-being and not just the absence of infection or disease (WHO).

2. What do we mean by water quality?

Water can dissolve substances in the environment, contain suspended elements, and carry solids as it flows in a natural environment. The concentrations of these substances, either from natural or human sources, may change the water quality to varying degrees and may adversely affect normal physical and biological environmental processes. Water can be contaminated by microorganisms or chemical elements that affect the quality of water, putting the health and well-being of people and the environment.

3. Types of Water Contaminants

Disease-causing microorganisms

Bacteria, viruses, and protozoa that cause diseases such as cholera, typhoid, diarrhea, hepatitis, etc.

Chemical substances

- Inorganic: metals, toxic salts, acids.
- Organic: hydrocarbons, plastics, some pesticides.

Radioactive substances

Some activities such as the exploitation of hydrocarbons, mining, and discharge of some types of waste, among others, may contain soluble radioactive materials. These can accumulate in the tissues of fish and other organisms over long periods of time. Other species or people who consume these organisms can also be exposed.

Thermal pollution

Often thermal power plants, factories or industrial centers, oil wells, etc., discharge water at high temperatures that could affect the environment, especially aquatic organisms.

Organic waste and nutrients

Biodegradable materials create favorable conditions for bacteria that consume oxygen in the water, generating unhealthy conditions for organisms and favoring the growth of other bacteria that do not depend on oxygen, algae, and aquatic plants. This causes a serious deterioration of water quality and the death of fish and other aquatic organisms. Some fertilizers such as nitrates and phosphates can also promote the growth of algae and other organisms that contribute to a decrease of oxygen content, affecting the diversity of organisms in rivers, streams, lakes, etc. This phenomenon is called **eutrophication** (see below).

3.1. HOW CAN WE DETERMINE WATER QUALITY?

Water quality can be determined using qualitative and quantitative laboratory tests or biological analyses. Water **quality indicators** express changes in water quality such as the ability to sustain fish, amphibians, small organisms that live in water, etc. There are also **parameters** that serve to assess this with values of physical, chemical, and microbiological aspects.

Sometimes our senses can help with noting organoleptic characteristics (smell, color, taste), but they cannot detect the presence of microorganisms and other contaminants.

Water quality standards usually rely on quantitative indicators of contaminants as sometimes it could be difficult to use qualitative indicators, for example, seeing water contamination. Many contaminants are not seen, smelled, or perceived by our senses. These standards typically have tables with parameters according to the type or **category of water use** (human consumption, recreational use, surface waters, coasts, protection of the aquatic environment, etc.).

Example of categories of water use	Water for human consumption
	Surface water that would be treated for drinking water use
	Surface water for recreational use (swimming pools)
	Coastal and marine environment
	Water for agricultural use
	Water for the preservation of aquatic species

Many countries and international organizations, such as the World Health Organization (WHO), have issued criteria, guidelines, or standards for water quality parameters for different water use categories. These guidelines or **water quality standards** are assigned according to each objective; for example, WHO has water quality values that prioritize human health. The values for the parameters included in the standards vary in each country.

SOME BASIC PARAMETERS OF WATER QUALITY (This is not a comprehensive list)	
Physical-Chemical Parameters	▪ Temperature ▪ Turbidity ▪ Conductivity ▪ Color ▪ Smell, taste ▪ pH ▪ Metals/inorganic elements, salts ▪ Dissolved oxygen ▪ Biochemical Oxygen Demand (BOD) ▪ Chemical Oxygen Demand (COD) ▪ Total solids (TS) ▪ Total Dissolved Solids (TDS) ▪ Hardness ▪ Nutrients: nitrogen, phosphorus ▪ Elements: lead, mercury, cadmium, arsenic, etc. ▪ Pesticides

Biological Parameters	▪ Bacteria ▪ Parasites ▪ Virus ▪ Protozoa
Biological Indicators	Indicate the quality of a natural body of water (river, lakes, oceans). They can offer various measures of the diversity of fish and other aquatic organisms.

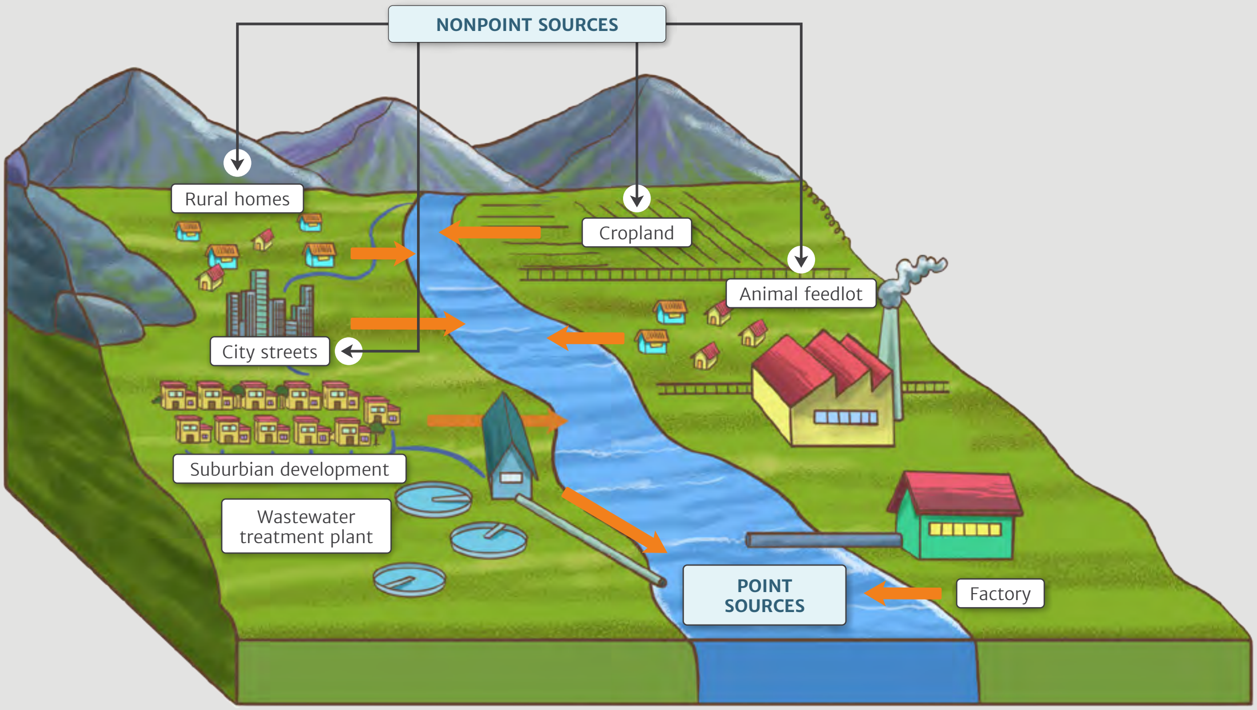
Biological indicators are used to determine the health of flora and fauna in a watercourse. Observations could include the number and diversity of fish, algae, and small organisms that live at the lowest level of a body of water (benthic zone). Water quality guidelines or standards usually are centered on quantitative parameters of physical, chemical, and microbiological indicators and have values for each of the use categories. This guide focuses on some basic physicochemical and microbiological parameters that are most frequently used.

3.2. WHAT ARE THE WATER POLLUTION SOURCES?

Water is easily contaminated because it can dissolve and carry many kinds of substances and some sources of pollution are ubiquitous.

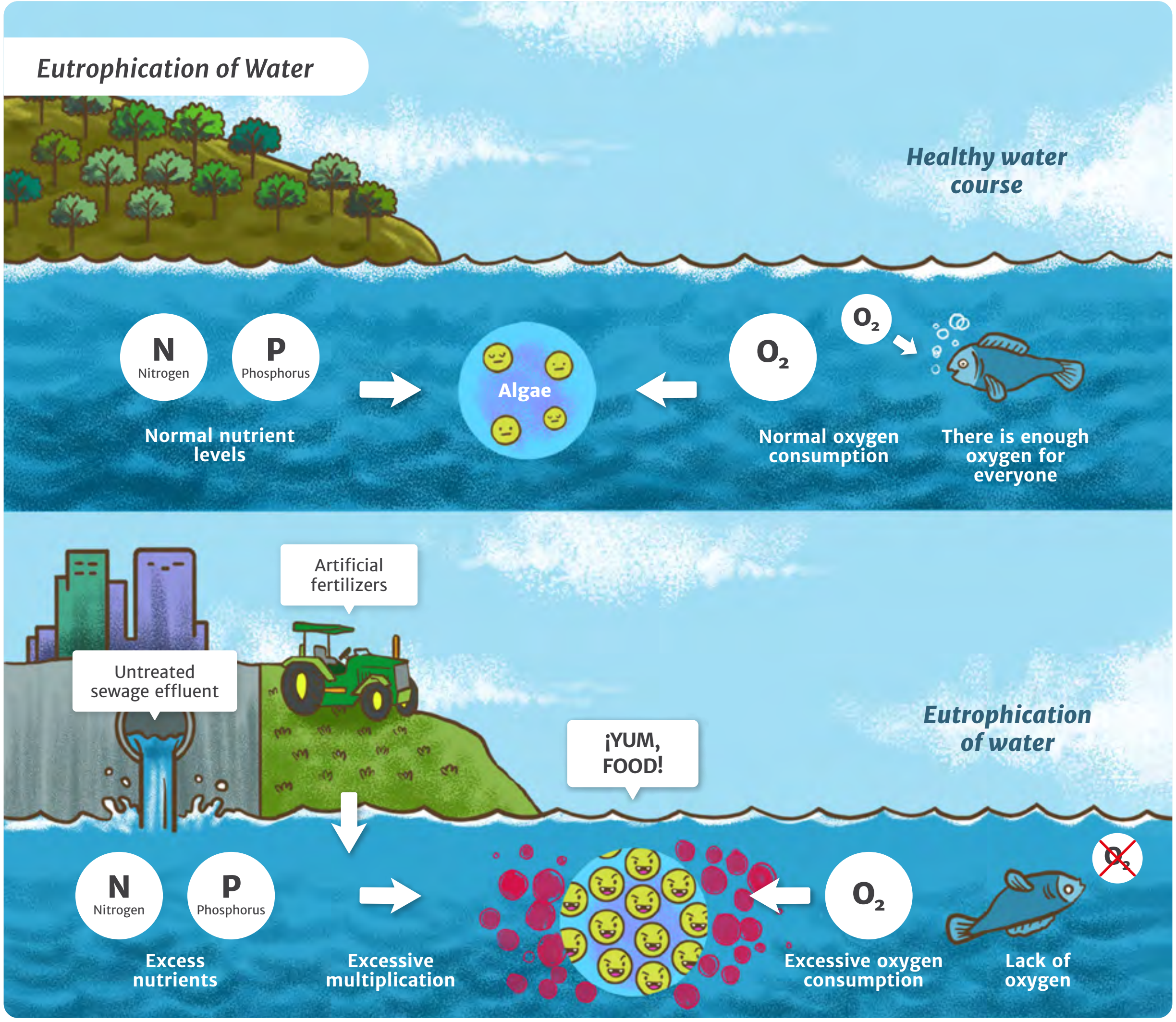
Frequently, water pollution sources are classified as **point sources, and non-point sources.** Point sources are those that have a precise, identifiable point of origin, for example, an oil spill, a wastewater treatment plant, an industry, refinery, mine dump, etc. **Non-point sources** are those in which the origin of the contamination is diffused. These can be agricultural fields, urban runoff or substances blown by the wind.

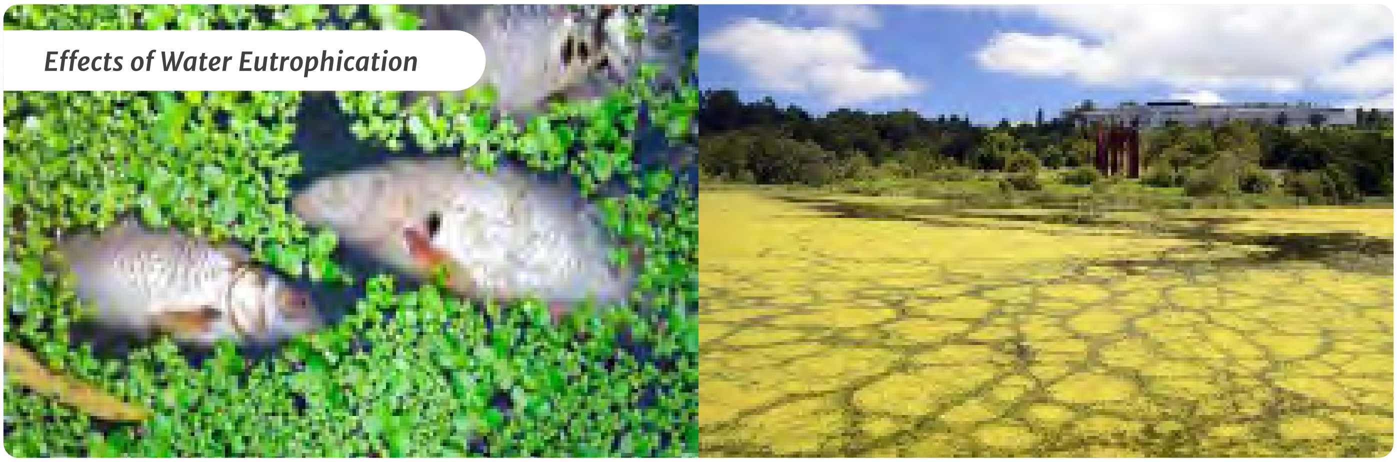
Point and Non-Point Sources of Water Pollution



3.3. WHAT IS EUTROPHICATION?

The word **eutrophication** derives from the Greek eu "very good" and trophies "food" and it refers to the excessive amount of nutrients such as nitrogen (N) and phosphorus (P) and their compounds in a body of water. Eutrophication is usually (not exclusively) caused by human activities such as the discharge of untreated sewage, untreated effluents from food industries, or fertilizer runoff (from gardens, agricultural fields, detergents, etc.). Excess nutrients increase the reproduction of algae to the extent that they deplete the oxygen levels in a water body to the extent that it affects aquatic organisms. Eutrophication in the marine environment can cause red tides and, in many cases, poisoning of wildlife species and humans.





https://unautes.com/index.php/2020/11/01/humanos-contra-el-planeta-eutrofizacion/?lang=es
https://es.dreamstime.com/photos-images/eutroficacion.html

4. Is the Water Contaminated?

4.1. PLANNING AND SAMPLING DESIGN

Define a **purpose and a scope.** What do you specifically want to know and how would you use the information? When trying to understand the state of water quality, it is better to define the purpose and scope of the analysis according to your priorities (see more about this in Module 1 inthe guide "Define Priorities").

A common mistake is to want to analyze all possible parameters everywhere. We may believe that by analyzing everything everywhere possible we will have more information. However, such an approach can be too costly, unnecessary, and overwhelmingly complicated. We could be overwhelmed with redundant or superfluous information. Although each case is different, it is always necessary to start with the basic questions: what you want to know? and how you are going to use the information? Set priorities!.

Initial Questions

- ***What is the purpose of the analysis?***
- ***What is the most important thing we want to know?***
- ***How will we use the information?***

The answers to the initial questions will help us to:

(a) Define **the scope of sampling** i.e., the priority area(s) where we are going to take water samples and, specifically, **where the samples will be taken and when.**

(b) Select the most appropriate **parameters or indicators.**

We can organize ourselves to do a sampling by following six steps described below.

4.2. THE SIX STEPS OF WATER SAMPLING

What do we want to know and why:

Define the problem and set priorities

- Make a list of your concerns and observations.
- Set priorities and a scope.

Define the parameters to analyze.

Assess your capacity

- Select the parameters relevant according to step 1 (priorities)
- Draft a budget
- Assess your capacity (funds, time, logistics).

Design a sampling plan

Adjust you plans based on the analysis of Steps 1 and 2. Select sampling points based on your specific objectives and scope. Assess the number of samples, the best time to collect the samples (i.e., avoid rainy season).

Collect the samples, then follow guidelines to handle and store the samples (chain of custody). Deliver the samples to a laboratory asap, Record observations.

- Follow the sample collection guidelines (see below).
- Define a system to keep your records, notes, and observations.

Interpret the results

- Compare the results with international water quality guidelines and/or national water quality standards.
- Ask support from experts or colleagues. Map the results if possible.
- Share the information and analyze it with peers and support groups.

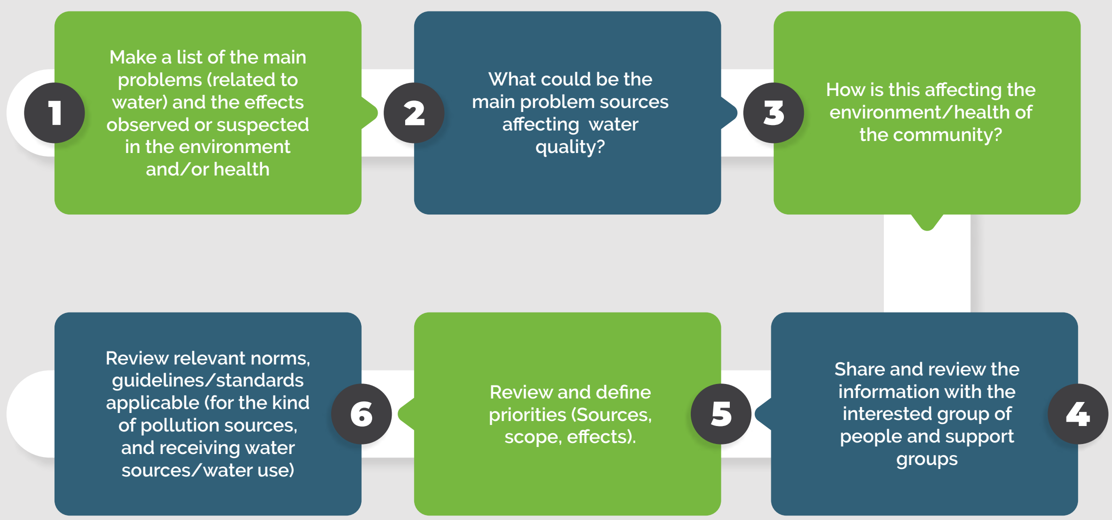
Analyze and communicate the results

- Discuss the results with the interested parties.
- Identify lessons learned, conclusions, or information gaps.

STEP 1. Define the problem and priorities: What do you want to know and why?

Define the specific problem that currently concerns you in order to explore its possible causes, thus designing a water sampling according to your needs and capacity. Once the problem has been identified and analyzed, it is possible to determine **the scope or purpose of the sampling.**

How to define the problem and priorities



Once the priorities have defined and the applicable standards revised, the parameters can be defined and analyzed with the resources we have.

STEP 2. Select the parameters and analyze our capabilities

The selection of parameters or indicators must correspond to the objectives of the sampling and the use of the information. These aspects are discussed in Step 1.

Once we have analyzed the problem, defined the scope of our sampling and the use of the information resulting from the sampling, we can proceed to:

(a) Select the most appropriate indicators or parameters and reflect on logistical aspects (access to sampling points, means of transport, necessary materials, etc.).

(b) Analyze our capabilities and the cost of sampling and analysis.

A. *How do we select which parameters to analyze?*

We must first review the list of issues and concerns that affect our community most. By doing this, we will avoid analyzing and collecting data that may not be necessary. Later, complementary analyses may be carried out if the case warrants it.

The selection of parameters depends on the following factors:

THE TYPE OF WATER SOURCE(S) TO BE ANALYZED	River, stream, public water supply, lake, lagoon, creek, estuary, mangrove, etc.
THE USAGE OF THE WATER TO BE ANALYZED	Whether it is water for human consumption, crop irrigation, animal consumption, recreational uses (bathing, swimming or other recreational activities), water treatment systems, or water sources that sustain the life of a fragile ecosystem, etc. ***Sources and types of water use:*** Are the water sources coastal and marine? Surface water? Groundwater? Other water uses defined by law may include drinking water (water that has already been treated), surface water intended for treatment to produce drinking water, agricultural use, livestock or animal husbandry, recreational use (swimming, bathing), conservation of aquatic or terrestrial wildlife, and industrial uses.
ANALYZE THE KIND SOURCE(S) THAT MAY BE DISCHARGING EFFLUENTS OR COULD BE AFFECTING THE PRIORITY BODY(IES) OF WATER	Manufacturing, agriculture, mining, oil/gas, municipal sewers, or other sources may have specific national or local effluent discharge guidelines. These norms are helpful to guide the selection of parameters to analyze in a water sample. These could be specific standards, in case of an industrial spill or to assess the effects of a particular effluent discharge source. **What source is it?** Knowing the kind of source water will allow us to select the most appropriate parameters or water quality indicators for the purpose of our sampling.

THE LEGAL FRAMEWORK

Check the country's water quality guidelines, criteria, or standards according to use (see b above) and international guidelines that apply.

Water quality guidelines, criteria or recommendations from international organizations, such as the WHO, EPA, etc., can be used as a reference. They can also help us to select the parameters of analysis, the rules that regulate the effluents for the different types of activity and be a source of information regarding what we are interested in investigating.

This table has some of the most common contaminants from some sources as an example. More detailed lists are in Annex 1.

Table No.1 Sources and their most frequent associated contaminants

SOURCE	MOST FREQUENT CONTAMINANTS
Agricultural	Turbidity, phosphates, nitrates, temperature, total suspended solids. Pesticides
Livestock	Total coliforms, fecal coliforms, turbidity, phosphorus, nitrates, ammonia, temperature
Forest harvesting	Turbidity, temperature, total suspended solids
Manufacturing	Temperature, conductivity, total suspended solids, toxic substances (see Annex 1), pH
Metal mining	pH, total dissolved solids, conductivity, metals (cadmium, lead, mercury, arsenic) (See Annex 1)
Hydrocarbons (oil and gas)	Oils and fats, benzene, toluene, xylene, aromatic polycyclic hydrocarbons, barium, chlorides, lead
Septic systems	Fecal coliforms (E. coli, enterococci), nitrates, phosphorus, dissolved oxygen, biochemical oxygen demand, temperature
Wastewater treatment plants	Dissolved oxygen, biochemical oxygen demand, turbidity, conductivity, phosphorus, nitrates, fecal bacteria, temperature, total suspended solids, pH
Construction	Turbidity, temperature, dissolved oxygen, biochemical oxygen demand, total solids, and toxic substances
Urban runoff	Turbidity, phosphorus, nitrates, temperature, conductivity, dissolved oxygen, and biochemical oxygen demand

Fuente: https://archive.epa.gov/water/archive/web/html/vms50.html

B. *How can we analyze our capabilities and costs?*

Capacity: Some key questions are:

ACCESSIBILITY	■ Is the analysis area accessible? Is it safe to reach this area? ■ Do you have the necessary means of transport (considering time and temperature restraints for the sample)? ■ Are the weather conditions right?
SAMPLE ANALYSIS AND OBSERVATION PROCESSING	■ How much would a laboratory charge for the water sampling analysis? ■ If you do the analysis, are you using portable kits? How much will it cost? ■ Who will collect the samples? (See sample collection section below) If you will base your assessment on observations only: ■ How will the observations be made, who will make them it, and how will the data be recorded? ■ Do you have a team of volunteers or committed community members?
BUDGET	Drafting a budget is key in any environmental quality analysis. The budget can be adjusted throughout the process according to the design of the sampling or environmental monitoring project. It depends on the analysis of our logistical capabilities, personnel, the type of parameters that need to be analyzed, and the cost of laboratory services.
BUDGET MODEL (List of some expenses to consider)	■ Transportation ■ Local expenses (accommodation, food, etc.) ■ Materials: gloves (you may also need boots, rope, etc.) ■ Flasks (coordinate with the laboratory) ■ Coolers and/or other containers to store the samples during transportation to the laboratory ■ Tags, bookmarks, notebooks ■ Laboratory Analysis Costs / Portable Kits ■ GPS or mobile phone with the ability to take coordinates

The costs, capabilities and logistics analysis, and sampling design all rely on each other, and will improve with the support of allies and stakeholders, especially the local population.

STEP 3. Sampling design

A sampling design consists of defining where and when the samples will be collected and how the samples will be handled, stored, and transported to a laboratory. Other key issues are determining who will be responsible for every step of the process and planning to take a representative sample (see below).

A. *Design: Where? When? How?*

WHERE

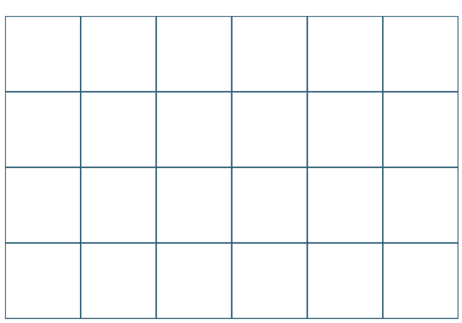
Review the priorities and objectives described in Step 1. The design will depend on the type of water source (river, lake, well, stream, etc.), the accessibility of the site(s), and our capabilities (Steps 1 and 2). All these conditions may vary greatly so we may need to make some adjustments. An option is to conduct a preliminary sampling prior to embarking on a complex and more comprehensive sample collection plan. During the sample collection planning, we may consider collecting samples in selected sites as a **selective sampling,** if we have information in advance about the places that specifically interest us. Alternatively, samples could be collected **randomly.**

WHAT IS A REPRESENTATIVE SAMPLE?

A representative sample for water quality analysis means that the sample(s) collected can consistently reflect the characteristics of the water source we are interested in analyzing.

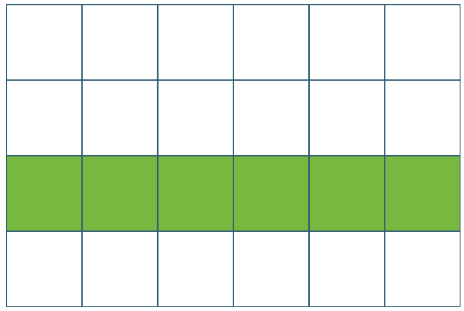
Ramdom sampling

Let's imagine that we would like to collect a sample from a lake. If we imagine that the grid below is a lake, and you wanted to collect three samples, where would you collect them?

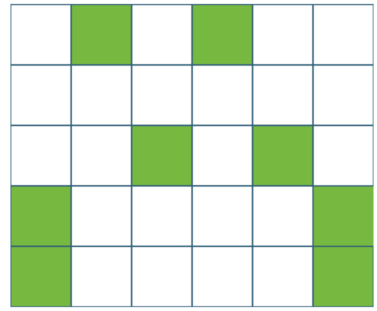


Of the following grids, which one is considered heterogeneous? Homogeneous? Which sampling do you think is more representative?

A.



B.



Alternatively, samples can be taken at selected sites. Maps of the places where the samples will be collected are very helpful. Talking with local people can help identify the areas of interest, any obstacles, and opportunities to access the sampling sites.

WHEN?

Assess the local weather conditions, especially if there is a chance of rain or the intimes of a drought. Floods or heavy rain could prevent us from reaching the areas of interest. Seasonal precipitation differences will also affect the results of the analyses.

HOW?

Two key issues to think about are:

a. The sample collection equipment and necessary materials to preserve the samples and transport them (see below).

b. Consider the logistical aspects such as transportation and the time it will take to get to the sampling points and the laboratory for analysis.

With regards to the first issue, we recommend asking the laboratory if it can provide flasks (sterile bottles are needed to analyze microorganisms in the water) and the volume of sample that is needed. Both the type of bottle and the volume of sample may vary depending on the parameters to be analyzed.

Testing some water parameters require sample preservation solutions to keep the samples in good condition for analysis. Ask the laboratory about this.

Keep the samples at a low temperature (5°C). These aspects are detailed below.

Other important details to keep in mind are:

Review the instructions and practice how to collect a water sample. Rehearsing in an area close by could be helpful to sort out any unforeseen problems. Having meetings with the people in charge of the sample is a good idea. Go through all the steps and discuss possible problems.

Safety first. Take all the necessary measures to protect the people in charge of collecting the water samples. Collecting and handling samples can be risky; for example, potentially dangerous pathogens and toxic substances (carcinogenic, corrosive, volatile, reactive, etc.) -among other substances are harmful to human health. Take all the necessary safety and protection measures; use gloves and other safety gear.

STEP 4. Sample Collection

The more prepared we are the better. Here are four key elements to consider:

a. The flasks or bottles where the samples will be collected.
b. The sample collection procedures.
c. The preservation of the samples during transportation.
d. The chain of custody.

These aspects are detailed in this guide (see below).

A. *The Necessary Equipment*

As mentioned, coordinate in advance with the laboratory to determine if they can provide containers such as bottles and coolers, and ask about the necessary sample preservatives.

Water samples for **chemical and/or physical analysis** should be collected and stored in clean, colorless jars with equally clean airtight lids. Generally, bottles for chemical and physical analysis do not need to be sterile, but they must be clean. Wash and rinse them ten times in distilled water to remove residues and odors.

In the case of **microbiological analysis,** sterile bottles and lids are necessary. Precise guidelines must also be followed for the sample collection, handling, and transport. Samples must be analyzed within 24 hours (see below), creating ideal conditions for physical, chemical, and ecotoxicological analyses. Store the samples in boxes or containers at an appropriate temperature (4-8°C) to preserve the integrity of the samples for microbiological, physical, and chemical analyses.

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WHAT ARE PRESERVATIVES AND WHY THEY ARE NEEDED

Ideally, water samples for analysis of physical, chemical or microbiological parameters should arrive at the laboratory within 24 hours. If this is not possible, depending on the parameters tested, preservatives may be used to maintain the water samples in good conditions for analysis (see below for information on sample storage and transport).

Preservatives and Maximum Time for Some Analysis Parameters Water Samples		
Parameter	Preservation Method	Maximum Time
Ammonia	Temperature 4°C, solution of sulfuric acid (H_2SO_4) up to pH<2	28 days
Chlorides	Not needed	28 days
Metals – Hexavalent chromium [Cr (VI)]	Temperature 4°C	24 hours
Metals – Mercury (Hg)	Nitric acid (HNO_3) up to pH<2	28 days
Metals – all others	Nitric acid (HNO_3) up to pH<2	6 months
Phosphates	Temperature 4°C	48 hours
Nitrates	Temperature 4°C	48 hours
pH	Not needed because it is analyzed on site	Scan immediately

EQUIPMENT LIST

- Gloves
- Clean bottles with an airtight lid (with preservatives, if necessary). If microorganisms are to be analyzed, bottles with sterile lids are needed
- Tags
- Markers
- Thermal containers to store the bottles
- GPS or a phone application to record sampling coordinates
- Notebook
- Chain of Custody form (see below)

B. *Sampling Procedures*

The collection of a sample is always a critical point in any water analysis. In the previous sections, the design of the sampling, including where the sampling should be conducted and how many samples to take, has already been addressed.

Taking samples for microbiological, chemical, and physical analysis of water all basically follow the same process. The only difference is that for microbiological analysis, sterile bottles are needed (they are usually supplied by the analysis laboratories).

Rinse the bottle at least three times with the water to be tested. Fill the bottle completely and immediately close the lid tightly.

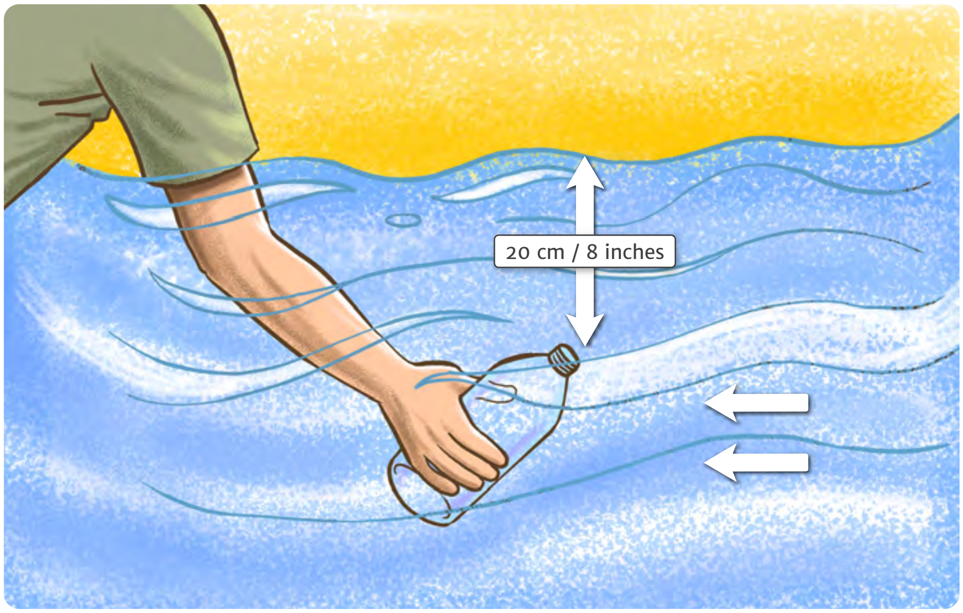
Source: WHO/PAHO Guidelines for Drinking Water Quality: Recommendations, Washington DC 1985.

Next, **label the bottle** as described below. Analyses should be performed as soon as possible and should not be delayed more than 24 hours for microbiological and parasitological analyses, and no more than 72 hours for physical and chemical analyses. Samples should be stored between 4-8 °C during storage and transport as best as possible (see below).

Samples that are collected in the same place and at the same time must be tested for bacteriological analysis first to avoid any dangers of contamination. In both types of sampling (for physicochemical and microbiological analyses), the main considerations are the same: obtain representative samples of water without contaminating them, close the lid of the containers or bottles tightly, and take them promptly to the laboratory where the analysis will be conducted.

SAMPLING A CURRENT OR RESERVOIR

It is better to collect the sample from the center (at points far from the banks) of the riverbed, stream, or reservoir with the mouth of the jar facing the water current – in the case of rivers and streams. If the sample is taken from a boat or small vessel, collect the water sample placing the jar or flask against the water current.



Source: WHO/PAHO Guidelines for Drinking Water Quality: Recommendations, Washington DC 1985.

How to collect the water sample

1. Remove the lid of the bottle, being careful not to touch the inside or neck of the bottle.
2. Hold the bottle from the bottom. With the mouth of the jar against the current, dip the jar with the neck down into the stream or river.
3. Tilt the bottle until the bottle's neck points slightly upwards with the bottle's mouth pointing against the current. Allow the jar to fill completely. Do not allow water to splash around inside the jar.
4. Cover the bottle carefully.
5. Label the bottle immediately.

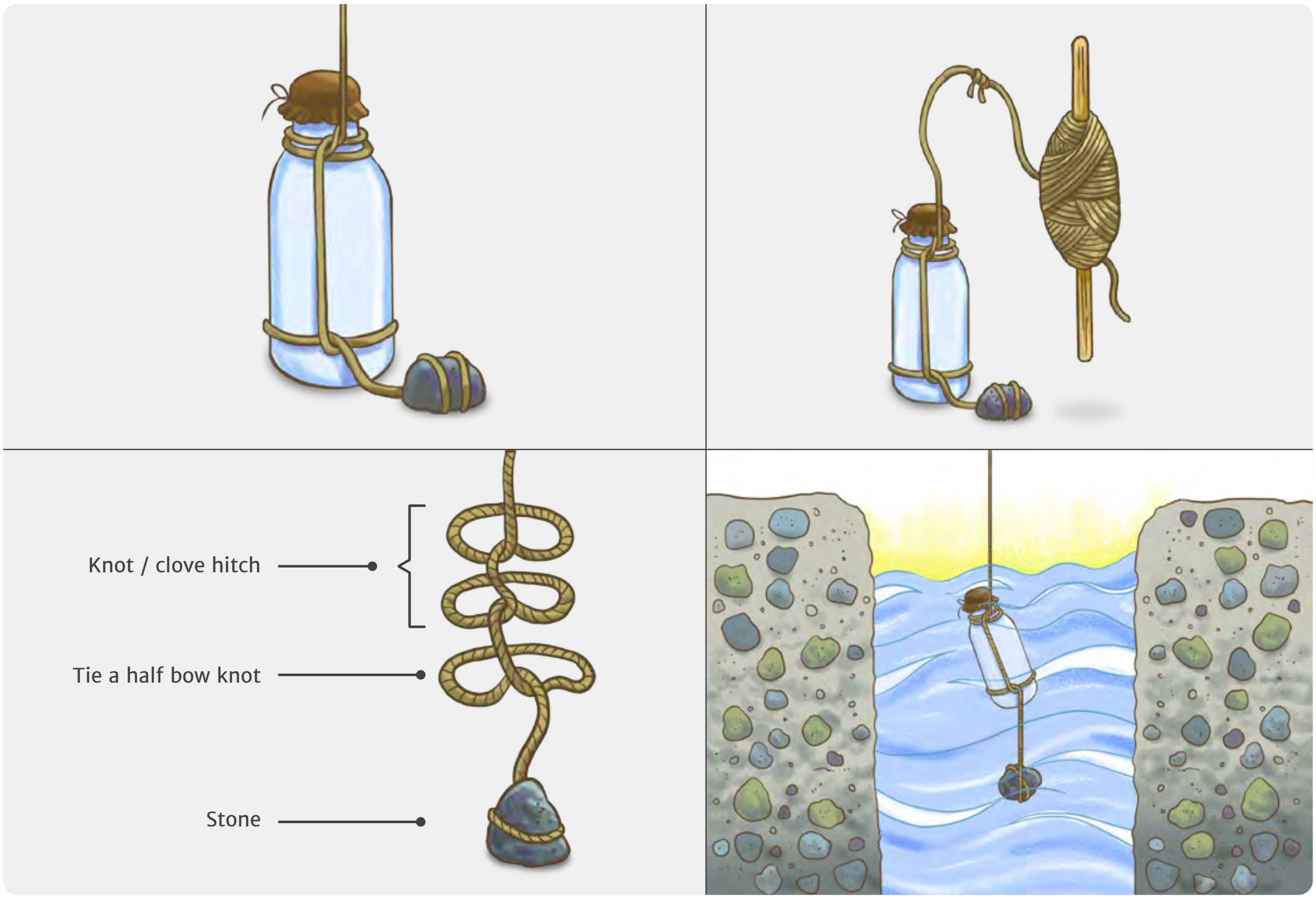
SAMPLING A LAKE, POND, OR RESERVOIR

How to collect the sample

1. Remove the lid of the bottle, being careful not to touch the inside or neck of the bottle.
2. Hold the bottom portion of the bottle. Immerse it in the water with the neck down.
3. Tilt the bottle so that the bottle's neck points slightly upwards. Move the bottle forward horizontally away from the hand, body, or boat so that water that has had contact with the hand, body or boat does not enter the bottle. Allow the jar to fill completely. Do not allow water to splash around inside the jar.
4. Cover the bottle carefully.
5. Label the bottle immediately.

SAMPLING OF A WELL OR GROUNDWATER SOURCE

The next figure shows the procedure to take a sample of water from a well, groundwater, or deep water.



Source: WHO/PAHO Guidelines for Drinking Water Quality: Recommendations, Washington DC 1985.

How to collect the sample

1. With the lid in place, tie a long, sturdy rope to the jar.
2. Tie a stone or piece of metal to the lower end of the rope that serves as a weight so that the jar can be submerged.
3. Remove the lid of the jar and carefully lower the jar into the well until it is immersed in water.
4. As soon as air bubbles stop coming to the surface, raise the jar from the well and carefully cover the jar with aluminum foil.
5. Label the bottle immediately.

SAMPLING TAP WATER OR THE OUTLET OF A WATER PUMP

If what you want is information on the quality of water for human consumption, proceed as follows:

How to collect the sample

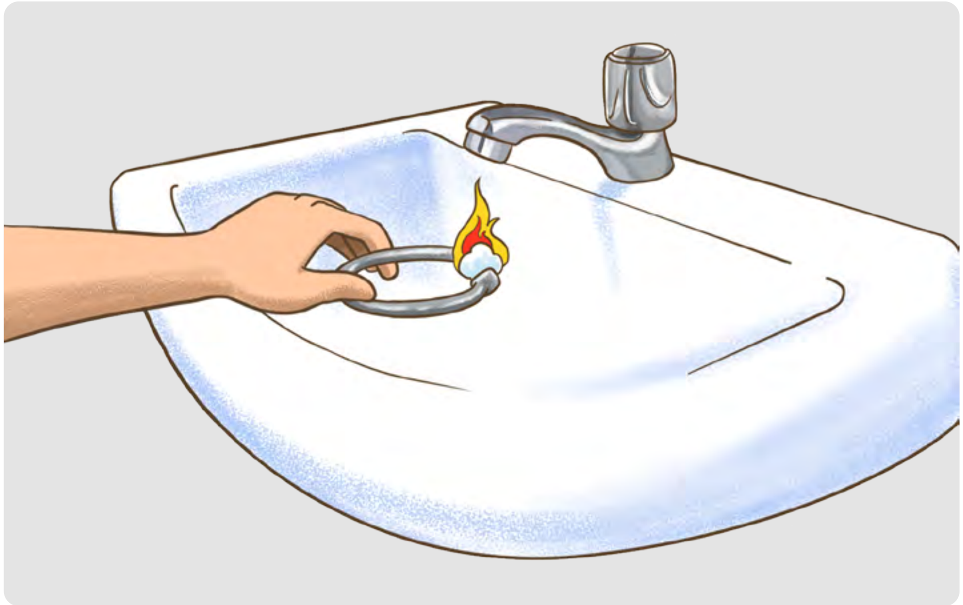
1. Clean the faucet. Remove any adhesions from the faucet that may cause the water to splash. Use a clean cloth and dry the outlet hole to remove any dirt.
2. Open the faucet to the maximum and let the water flow for 1-2 minutes.
3. Collect the sample.

If what you want is information on water quality excluding contamination from the tap, proceed as follows:

Source: WHO/PAHO Guidelines for Drinking Water Quality: Recommendations, Washington DC 1985.

For microbiological analysis

1. Sterilize the faucet for one minute with the flame of a lighter or the flame of a swab soaked in alcohol.
2. Open the faucet before taking the sample and let the water flow for 1-2 minutes at half force. Do not readjust the flow once fixed.



Source: WHO/PAHO Guidelines for Drinking Water Quality: Recommendations, Washington DC 1985.

3. Remove the lid of the bottle, being careful not to touch the inside or neck of the bottle.
4. Hold the bottle – do not touch the neck or the inside of it. Fill it immediately under the water flow. Do not forget to leave some air space so that it is easier to shake the sample before the analysis.
5. Cover the bottle carefully.
6. Label the bottle immediately.

It is important to prevent contamination during the sample collection, either by other sources or by the person taking the sample. Keep the bottle closed until the moment when the sample is taken. Do not touch inside the bottle or the inner part of the bottle's neck or the lid during handling. Labels should be prepared in advance so that they can be placed immediately after sampling.

C. Labelling

All samples must have an identifying label, which must be placed on the container immediately after the sample is collected. The figure below shows the type of label that is needed. The information on the label should include:

Basic Label Facts

Sample number
Precise location of the sampling point
Date and time
Type of water source
Name of the person who took the sample
Temperature
pH

1. Sample number (this is a correlative number).
2. State where the sample was collected. It is ideal to include the coordinates or landmarks to help identify the exact location.
3. Date and time.
4. Type of water source (lake, stream, pump, reservoir, etc.).
5. Name of the person who collected the sample.

Additionally, the following information can be included

Temperature of the water at the time of sampling. Some devices can measure the temperature and pH simultaneously. It is ideal if dissolved oxygen could be measured onsite, too.

D. The Chain of Custody

In addition, it is important to write down on a sheet, complementary to the label, some data such as:

- Sample number (which must be the same as the one on the label).
- Name of the person who took the sample and the person or entity responsible for requesting the analyses.
- Observations and comments for each case such as:

If the sample comes from a well, specify data including: the depth of the well, whether it is covered and, if so, what type of cover it has, age, and possible sources of contamination (e.g., pits, latrines).

If the sample comes from a stream or spring, specify whether the sample has been taken directly from the spring or from a collecting source such as a bucket (if the latter is the case, specify the material from which the collecting source or bucket is made).

If the sample has been taken from a river or stream, specify data such as the depth at which the sample has been taken. If the sample has been taken from a vessel, indicate the type of vessel and any possible sources of contamination.

E. *Sample Chain of Custody Form*

SAMPLING PROJECT			NAME AND SIGNATURE OF RESPONSIBLE PERSON(S) FOR COLLECTING THE SAMPLES		
Samples collection sites	Date	Time	Sample type (random selective)	Bottle number	Parameters/ preservatives used. Temperature
Details of when and where the chain of custody form was filled	Name and signature		Name of the person who received the samples in the laboratory		Date and time
Name of the person who delivered the samples to the laboratory:	Date and time		Name of the person who received the samples at the laboratory		Date and time

F. *Handling, Storage, and Transport of Samples*

Sample stability is a critical factor for the success of an analysis. This depends on how the samples are handled, stored, and transported to the laboratory. Some things to consider avoiding are:

a. External contamination during sampling
b. Contamination caused by the bottle
c. Chemical, physical, or biological processes that could affect the integrity of the sample if it is not kept at an adequate storage temperature and/or with the necessary preservatives.

Source: WHO /PAHO. Drinking water guidelines and recommendations, Washington DC 1985.

Failure to take proper precautions can lead to serious errors. Therefore, the recommended methods should be considered to avoid sample contamination and damage to the sample's integrity during storage and transport.

G. *How to Handle Samples*

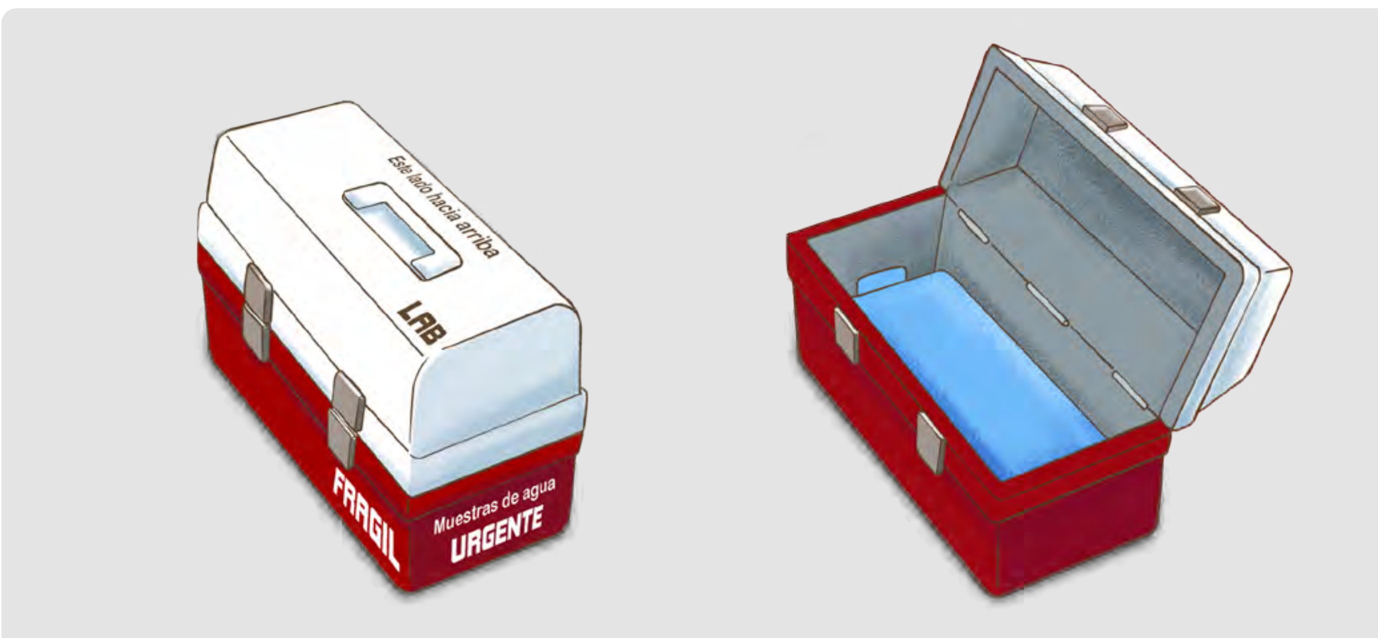
Key points:

1. Check that the bottles are correctly closed and labelled.
2. Keep the bottles with the water samples inside a cooler or thermal box. The box must have enough space for ice to keep the temperature between 4-8°C (39-46°F) – see details below.

3. Keep the box in the shade if possible and take it to the laboratory for analysis as soon as possible.
4. Accompany the box with the chain of custody form to keep record of the storage and handling conditions from the moment of sampling until the samples are delivered to the laboratory.
5. If necessary, label the box with "FRAGILE".

H. *Sample Storage*

A water sample can change its microbiological, physical, and chemical content properties, depending on the storage conditions. To avoid this, water samples for microbiological analyses must be analyzed within 24 hours of collection. When portable equipment ("kit") is used in the field, it is possible to perform the analysis of the samples within one hour of taking the sample. If the samples must be transported elsewhere, it is often impossible to analyze them quickly. Therefore, these must be carefully stored and transported in such a way that, at the time of analysis, they are still representative of the water source subject to the analysis. The storage temperature should preferably be between 4° and 8 °C (39°-46°F) to prevent its alteration. Storage times and temperatures should be recorded.



Source: WHO/PAHO Guidelines for Drinking Water Quality: Recommendations, Washington DC 1985.

STEP 5. Interpret the Results

Laboratories must deliver the results within a deadline previously agreed upon with the interested parties. The report may look like the one in the figure below and must have a list of the parameters analyzed and the values found. Pay attention to the units in the laboratory report. These could be in milligrams per liter (mg/L) for metals and some ions such as nitrates. One milligram per liter equals one part per million (ppm). Units may vary depending on the parameters. For example, bacteria levels are usually reported in units such as Colony Forming Units (CFUs) or Most Likely Number (MPN) by volume of water (100 milliliters-[ml]).

To interpret the results, it is recommended to compare the values of the laboratory report to water quality standards, national guidelines, or with the international organization guidelines such as the Drinking Water Quality Guidelines of the World Health Organization (see recommended sources of information).

SAMPLE LABORATORY REPORT

Order number: 09876
Name: James Doe
Address: 123 Main Street
City, Zip: Jacksonville, 12345

Source/Location: lake,
42.9446°N. 122. 1090°W
Data Collected: May 8, 2021

Physico chemical

Parameter	Guideline value	Units	Result
Turbidity [pH, etc.]			

Microorganism

Parameter	Guideline value	Units	Result
Total Coliforms			

Inorganic Parameters

Parameter	Guideline value	Units	Result (mg/LI)
Lead			
Arsenicc			
Anllomony			
Mercury			
Nickel			
Copper			

Organic Parameters

Parameter	Guideline value	Units	Result
Styrene			
Benzene (BTEX)			
Ethylbenzene			
Polychlorinated biphenil (total)			
Vinil chloride			
Toluene			
m,p-Xylene (BTEX)			
Tetrachloroethylene (PCE)			

Herblcldes and Pestlcldes

Parameter	Guideline value	Units	Result
Atrazine			
Simazine			
Glyphosate			
2,4-Dichlorophenoxyacetlc acid			

Fertilizers

Parameter	Guideline value	Units	Result
Atrazine			

A. *Guideline Values of Some Physicochemical Parameters and Chemical Elements - Drinking Water*

PARAMETER AND UNITS	WHO	USA	EUROPEAN UNION	CANADA	AUSTRALIA
pH	6.5-8.5	6.5-8.5	6.5-9.5	6.5-8.5	6.5-8.5
Turbidity UNT	5	n/a	Acceptable to consumers and no abnormal change	0.3	5
Chlorides (Cl-) mg/L	250	250	250	≤250	250
Nitrates (NO3) mg/L	11	10	11	10	11
Sulphates (SO4) mg/L	--	250	250	250	500
Fecal coliforms NMP/100 ml	0	0	0	0	0
Total coliforms NMP/100 ml	0	0	0	0	0
Cyanobacteria / toxins de mg/L	--	--	--	0.0015	0.0013
Aluminum (Al) mg/L	0.2	0.05 – 0.2	0.2	0.1-0.2	0.2
Antimony (Sb) mg/L	0.02	0.006	0.005	0.006	0.006
Arsenic (As) mg/L	0.01	0.01	0.01	0.01	0.007
Barium (Ba) mg/L	0.7	2	--	1	0.7
Boron (B) mg/L	0.5	--	1	5	4
Cadmium (Cd) mg/L	0.003	0.005	0.005	0.005	0.002
Copper (Cu) mg/L	2	1.3	2	1	2
Chromium (Cr) total mg/L	0.05	0.1	0.05	0.05	0.05
Cyanide -free (CN-) mg/L	0.07	0.2	0.05	0.2	0.08
Iron (Fe) mg/L	0.3	0.3	0.2	≤0.3	0.3

PARAMETER AND UNITS	WHO	USA	EUROPEAN UNION	CANADA	AUSTRALIA
Lead (Pb) mg/L	0.1	[0.015 action level]	0.01	0.01	0.01
Manganese (Mn) mg/L	0.4	0.05	0.05	≤0.05	0.5
Mercury (Hg) mg/L	0.001	0.002	0.001	0.001	0.001
Molybdenum (Mo) mg/L	0.07				
Nickel (Ni) mg/L	0.02	--	0.02	--	0.02
Selenium (Se) mg/L	0.01	0.05	0.01	0.01	0.01
Sodium (Na) mg/L	--	--	200	≤200	180
Thallium (Ta) mg/L	--	0.0005			
Zinc (Zn) mg/L	3	5			

B. *Guide Values of Some Organic Compounds and Pesticides - Drinking Water*

PARAMETER (MG/L)	WHO	USA	EUROPEAN UNION	CANADA	AUSTRALIA
1,1 dichloroethylene	0.03	0.007	---	0.014	0.03
1,2 dichlorobenzene	1	0.6	0.0001	0.2	1.5
1,2 dichloroethane	0.03	0.005	0.003	0.005	0.005
Aldicarb	0.01	0.003	0.0001	0.009	0.001
Aldrin/dieldrin	0.00003	--	0.00003	0.0007	0.00001
Atrazine	0.002	0.003	0.0001	0.005	0.0001
Benzopyrene	0.01	0.005	0.001	0.005	0.001

PARAMETER (MG/L)	WHO	USA	EUROPEAN UNION	CANADA	AUSTRALIA
Benzopyrene	0.0007	0.0002	0.00001	0.00001	0.00001
Carbaryl	--	--	0.0001	0.09	0.005
Carbofuran	0.007	0.04	0.0001	0.09	0.005
Carbon – tetrachloride	0.004	0.005	0.0001	0.005	0.003
Chloramines (total)	--	4	--	3	3
Diazinon	--	--	0.0001	0.02	0.08
Dicamba	--	--	0.0001	0.12	0.1
Dichloromethane	0.02	0.005	--	0.05	0.004
Dimethoate	0.006	--	0.0001	0.02	0.05
Ethylbenzene	0.3	0.7	--	--	0.3
Glyphosate	--	0.7	0.0001	0.28	0.01
Malathion	--	--	0.0001	0.19	--
Paraquat	--	0.0001	0.001	--	0.01
Parathion	--	--	0.0001	0.05	0.01
Pentachlorophenol	0.009	0.001	0.0001	0.06	--
Terbufos	--	--	0.0001	0.001	0.0005
Tetrachloroethylene	0.07	0.005	0.01	0.005	--
Toluene	0.7	1	--	--	0.8
Vinyl chloride	0.0003	0.002	0.0005	0.002	0.0003
Xylenes (total)	-.5	10	--	--	0.6

Warner et al. (2016), de la Cruz et al. (2012)

C. *Examples of Surface Water Quality Standards According to Different Uses*

USA CFR TITLE 40 CHAP. 1 SUB CHAPTER D PART 131

	INORGANIC PARAMETERS			
	Freshwater		Coastal and Marine	
	Max.	Continuous	Max.	Continuous
Arsenic	0.36	0.19	0.069	0.036
Cadmium	0.0037	0.001	0.042	0.0093
Chromium (VI)	0.015	0.01	1.1	0.05
Copper	0.017	0.011	0.0024	0.024
Cyanide	0.022	0.0052	0.001	0.001
Lead	0.065	0.0025	0.21	0.0081
Mercury	0.0021	1.2e-5	0.0018	2.5e-5
Nickel	1.4	0.16	0.074	0.0082
Selenium	0.02	0.005	0.29	0.071
Silver	0.0034	--	0.0019	--
Zinc	0.11	0.1	0.09	0.081

	PESTICIDES			
	Freshwater	Saltwater	Freshwater	Saltwater
	Maximum level	Continuous	Maximum level	Continuous
Dieldrin	0.0025	1.9e-6	0.00071	1.9e-6
DDT	0.0011	1e-6	0.0013	1e-6
Endosulfan	0.00022	5.6e-5	3.4e-5	8.7e-6
Endrin	0.00018	2.3e-6	4.7e-5	2.3e-6
Heptachlor	0.00052	3.8e-6	5.3e-5	3.6e-6
PCB	--	1.4e-5	--	3e-5
Toxaphene	0.00073	2e-7	0.00021	2e-7

https://www.ecfr.gov/current/title-40/chapter-I/subchapter-D/part-131

PERU

WATER QUALITY STANDARS-PERU	CATEGORY 1. FRESHWATER FOR DRINKING WATER SUPPLY				CATEGORY 2	CATEGORY 4. CONSERVATION OF AQUATIC ENVIRONMENT			
Parameter	Unit	A1. Simple disinfection	A2. With conventional treatment	A3. With advanced treatment	Irrigation of edible vegetables of short and long stems	E1. Lakes and lagoons	E2. Rivers: coastal, mountain, rainforest	E2. Rivers: coastal, mountain, rainforest	
								Estuary	Marine
BOD	mg/L	3	5	10	15	5	10	15	10
COD	mg/L	10	20	30	40	**	-	**	**
Arsenic	mg/L	0,01	0,01	0,15	0,1	0,15	0,16	0,036	0,036
Cadmium	mg/L	0,03	0,05	0,01	0,01	0,00025*	0,00025*	0,0088*	0,0088*
Mercury	mg/L	0,001	0,002	0,002	0,001	0,0001	0,0001	0,0001	0,0001
Lead	mg/L	0,01	0,05	0,05	0,05	0,0025	0,0025	0,0081	0,0081
Manganese	mg/L	0,4	0,4	0,5	0,2	-	-	-	-
Iron	mg/L	0,3	1	5	5	-	-	-	-
Thermotolerant coliforms (44.5°C/112°F)	MPN/ 100mL	10000	20	2000	1000	1000	2000	1000	2000

BOD: Biochemical Oxygen Demand / COD: Chemical Oxygen Demand

STEP 6. Share and Discuss Results

Every water sampling experience is unique and provides important new lessons. Reviewing the results can help us identify successes and difficulties to overcome and reflect on our expectations. Designing and implementing sampling involves time, money, and collective effort that can sometimes pose major challenges for an organization and local communities.

Useful tips:

- Document the sampling process and results in a report, and compare laboratory results with national water quality standards and, whenever possible, with international guidelines (see information sources at the end). Reporting the whole process can help us think about the lessons learned, findings, and communicate the impacts of our work.
- Identify the successes and possible difficulties in the process.
- Share the results with those who participated in the sampling and stakeholders.
- Discuss the results with allies or scientific professionals before sharing the results. Only once the reports are thoroughly reviewed by these groups can you share the results with a group of people at community assemblies, radio programs, websites, social media, etc.

Discussions about the process and the results can help us improve experiences in the future. We can identify the capabilities to develop and strengthen our team, to anticipate unforeseen events, to evaluate logistical issues for further efforts, and review the planned budget and compare it with the actual expenses.

Glossary

BIOCHEMICAL OXYGEN DEMAND	The amount of oxygen required for the decomposition of organic matter by single-celled organisms under laboratory conditions. It is measured in milligrams per liter (mg/L) and is used to measure the amount of organic pollution in the water. It is usually reported in laboratory reports as BOD5, the amount of dissolved oxygen in the water that is consumed in five days by bacteria that degrade organic matter.
CHEMICAL OXYGEN DEMAND	The amount of oxygen that is consumed in the oxidation of organic matter and inorganic matter oxidizable under laboratory conditions. It is measured in milligrams per liter (mg/L) and is used to measure the total amount of organic pollution in the water. Usually reported in laboratory reports as COD, it differs from BOD in that COD indicates the levels of all oxidized compounds in the sample, not just those that are consumed by bacteria that degrade organic matter.
COLIFORM BACTERIA	Bacteria that indicate sewage contamination. Coliform bacteria normally inhabit the intestinal tract of warm-blooded humans and animals.
CONDUCTIVITY	The amount of electricity that a water sample can conduct.
DIFFUSE [POLLUTION] SOURCES	Sources of pollutants which do not have a known specific place of origin.
DISSOLVED OXYGEN	Amount of oxygen dissolved in water expressed in milligrams per liter (mg/LL or parts per million (ppm).
ENVIRONMENTAL MONITORING	Systematic process of periodic sampling of water, air, soil, and biota; to observe, analyze and record changes in the quality of the environment.

ESCHERICHIA COLI	Escherichia coli is a coliform bacteria that lives in the intestines of humans and animals. It is used to measure the quality of water to determine if the water body has been contaminated by drains or excreta of animals or humans.
EUTROPHICATION	Excessive enrichment of nutrients in the water that causes the excessive growth of aquatic plants and the activity of anaerobic microorganisms (which live with little to no oxygen). This growth causes the suffocation of aquatic organisms such as fish.
HEAVY METAL	A metal or semimetal (metalloid) that has a high atomic density, weight, or number (5 times or more) compared to water. While the use of the term has become quite widespread to refer to toxic or poisonous inorganic elements at low concentrations, this definition has been discussed, though there is no standard definition.
LEACHATE	Water containing solid substances in its solution after it has been percolated through the soil or a filter.
NUTRIENT	Any substance that promotes the growth of living organisms. As for water quality, it mainly refers to nitrogen and phosphorus in wastewater, effluents, or runoff, although it can also be applied to other elements.
ORGANIC MATTER	Matter based on carbon compounds in nature that comes from a living organism such as plants and animals.
PARAMETER	An element or variable that can be used to measure or evaluate the condition or characteristics of a system like temperature, density, etc.

PARTS PER MILLION	A measure of the concentration of an element or substance. It is equivalent to mg/L.
PATHOGEN	Any organism that can produce a disease, such as an infectious agent, bacteria, viruses, fungi, parasites, or algae.
pH	The acronym indicates "hydrogen potential. It indicates the acidity or alkalinity of a substance based on a scale from 0 to 14 where 7 is a neutral level. Values below 7 indicate that a substance is acidic. Values above 7 indicate that a substance is alkaline or basic.
POINT SOURCE	Stationary place from which pollutants are discharged.
POLLUTANT	Compound, element, or organism that is in a concentration sufficient to cause damage, disease, or death in nature to living beings depending on the type, concentration, time, and route of exposure. Some pollutants may be of natural origin or may be derived from human activities.
SAMPLING	Process by which a portion of material is selected in a sufficient volume to be transported and analyzed.
SEWAGE	Waters with residues of excreta of humans, or animals.
TOTAL DISSOLVED SOLIDS (TDS)	Indicates all organic and inorganic substances that are suspended in a filter medium after filtration or evaporation of a water sample. They are frequently reported as parts per million (ppm).

TOTAL SUSPENDED SOLIDS	Refers to the dry weight of suspended particles that are not dissolved in a water sample.
TURBIDITY	Measure of cloudiness or haziness of a liquid caused by the presence of particles, microscopic plants (phytoplankton), sediments and sludge, or other contaminants. Measurements are usually reported in Nephelometric Turbidity Units (NTU).
WATER [CONTAMINATED]	Presence in water of sufficient harmful or unpleasant elements or materials that can cause damage to water quality.
WATER [DRINKING]	Water that is safe to drink and use for cooking.
WATER [HARD]	Water that has high concentration of calcium and magnesium. It is observed when soap cannot be dissolved well.
WATER [SURFACE]	Natural water on the surface of the earth: rivers, lakes, streams, oceans, wetlands, etc.
WATER CYCLE	Natural water cycle in nature, comprising of evaporation, condensation, retention, and runoff.

Information Resources

U.S. EPA. Summary of the Clean Water Act
https://www.epa.gov/laws-regulations/summary-clean-water-act

U.S. EPA. Online Water Quality Monitoring Resources
https://www.epa.gov/waterqualitysurveillance/online-water-quality-monitoring-resource

World Bank. How to test water quality? Chemical tests for limited budgets
https://blogs.worldbank.org/water/how-test-water-quality-chemical-tests-limited-budgets

World Health Organization (WHO) 2017. Guidelines for drinking water quality 4th Ed. 2017.
https://www.who.int/publications-detail-redirect/9789241549950

World Health Organization (WHO) 2011. Guidelines for the quality of water for human consumption (4th Edition)
https://www.paho.org/es/documentos/guias-para-calidad-agua-consumo-humano-40-ed-2011

Environmental Law Alliance Worldwide – ELAW

www.elaw.org

Environmental Law Alliance Worldwide (ELAW) helps communities speak out for clean air, clean water, and a healthy planet. We are a global alliance of attorneys, scientists and other advocates collaborating across borders to promote grassroots efforts to build a sustainable, just future.