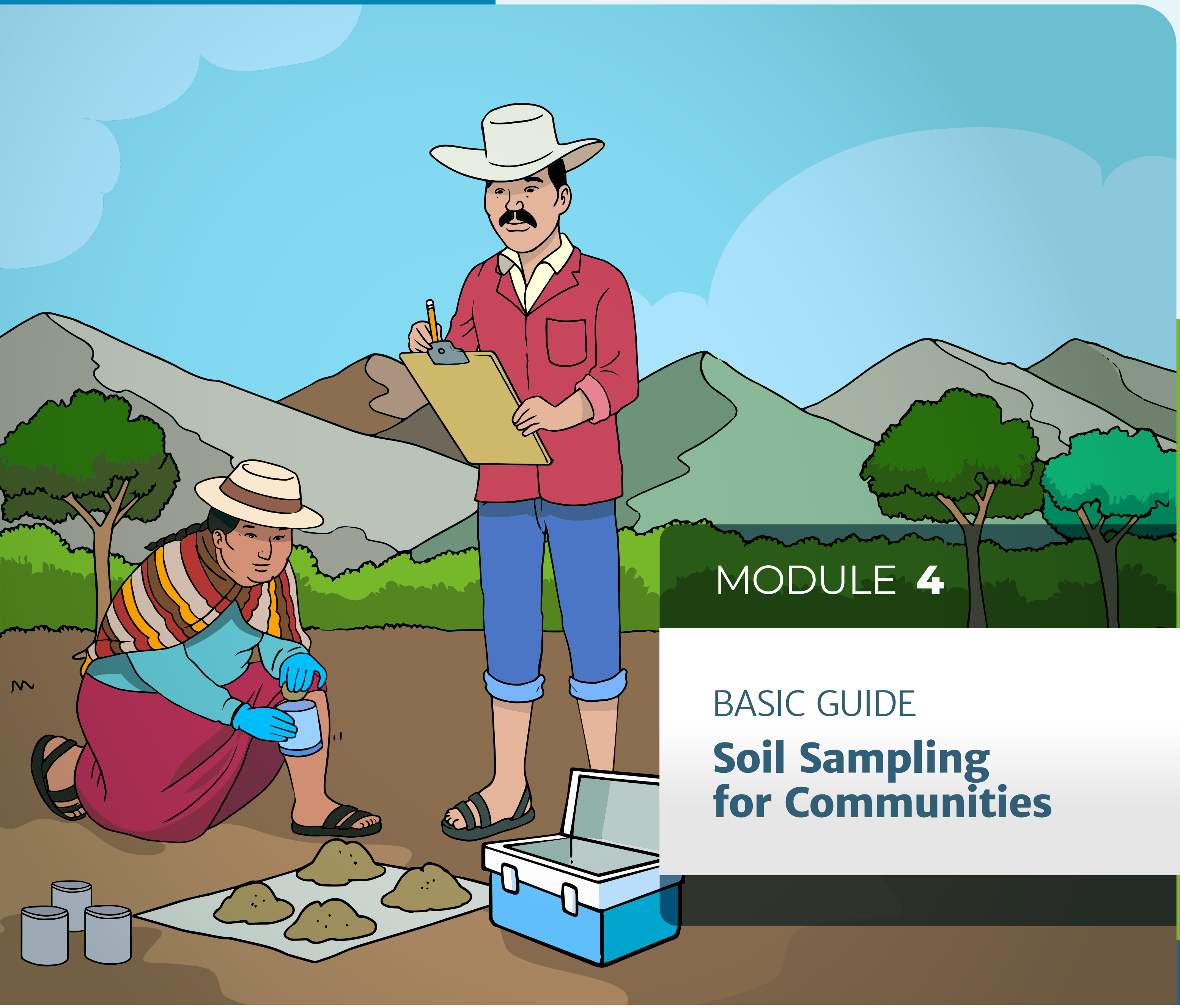
GUIDE

ENVIRONMENTAL
SAMPLING
GUIDE

MODULE 4



MODULE 4

BASIC GUIDE

Soil Sampling for Communities

ELAW
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Acknowledgments

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

- **Module 1**. Basic Concepts of Environmental Quality and Community Environmental Monitoring
- **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 is aimed at interested citizens and grassroots organizations interested in conducting water quality sampling for community environmental monitoring initiatives, and defense of 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 to defend the right to a healthy environment. ELAW supports lawyers and the communities they represent with legal and scientific information to protect the air, water, soil, and ecosystems in their countries. It contributes to strengthening the bonds of collaboration and exchange of experiences across borders.

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.

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GUIDE TO TAKING ENVIRONMENTAL SAMPLES

MODULE 4

Basic Guide to Soil Sampling for Communities

Content

MODULE 4

BASIC GUIDE TO SOIL SAMPLING FOR COMMUNITIES

OBJECTIVES OF THIS GUIDE

Provide basic guidelines and advice to organize and carry out a basic soil sampling for Non-Governmental Organizations (NGOs) and communities. Users of the guide should be able to:

- Organize and design a basic soil sampling.
- Know the fundamental principles for taking and managing soil samples.
- Select the most important parameters for the most common cases and transport the samples to a laboratory.
- Find sources of information to help interpret the results.

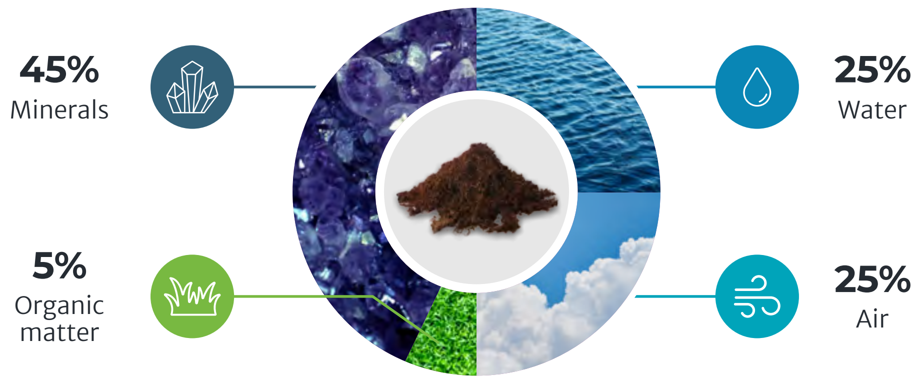
Soil sampling can serve different purposes, ranging from a simple one-time identification of elements to more detailed long-term assessments of soil remediation. This is a guide to basic soil sampling for simple element or substance identification purposes by groups of citizens interested in learning how to collect a soil sample for laboratory analysis.

1. Basic Concepts

1.1. WHAT IS SOIL?

Soil is the natural body formed by unconsolidated organic and/or mineral material, with varying amounts of liquid and gases found in the most superficial layer of the Earth. It has different and distinguishable horizons or layers of depth from the most superficial horizon in contact with air and terrestrial plants to deeper ones that are in contact with solid rocks with little biological activity (USDA[1]).

Soil has a vital role in an ecosystem to sustain the life of plants, animals, and people. It contains living organisms such as bacteria, fungi, and other microbes that coexist interdependently. Soil provides nutrients for plant growth, absorbs and stores water, nutrients and other substances fundamental to life on the planet.



Source: FAO (2018) Good Practice Guide for Sustainable Land Use and Management in Rural Areas

1. USDA What is soil? https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054280

1.2. IMPORTANCE OF SOIL

A healthy soil is critical to maintaining crops and forests, which in turn gives us clean air and water, grazing areas, and maintains wildlife and landscapes.

Soil fulfills these functions by:

- *Regulating water resources:* Soil helps control where rain, snowmelt, and irrigation water go. Water and dissolved solutes flow over the earth and through the soil.
- *Serving as a substrate for plant and animal life* – The diversity and productivity of living things depend on the soil. Agriculture, livestock, forests, and life in general on the planet depend on soil.
- *Filtrating and buffering pollutants:* Minerals and microbes in the soil are responsible for filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal byproducts and atmospheric deposits.
- *Providing nutrients to vital functions of an ecosystem:* Carbon, nitrogen, phosphorus, and many other nutrients are stored, transformed, and recycled in the soil.
- *Providing physical stability and support:* Soil structure provides a medium for plant roots. The soil substrate also provides support for people's homes and infrastructure, as well as important archaeological and cultural assets.

Did you know?

- ***Healthy soil can contain vertebrate animals, earthworms, insects, fungi, bacteria, and other microorganisms.***
- ***More than 1000 species of invertebrates can be found in 1 square meter (about 10 square feet) of forest soils.***
- ***Soil is one of nature's most complex ecosystems.***

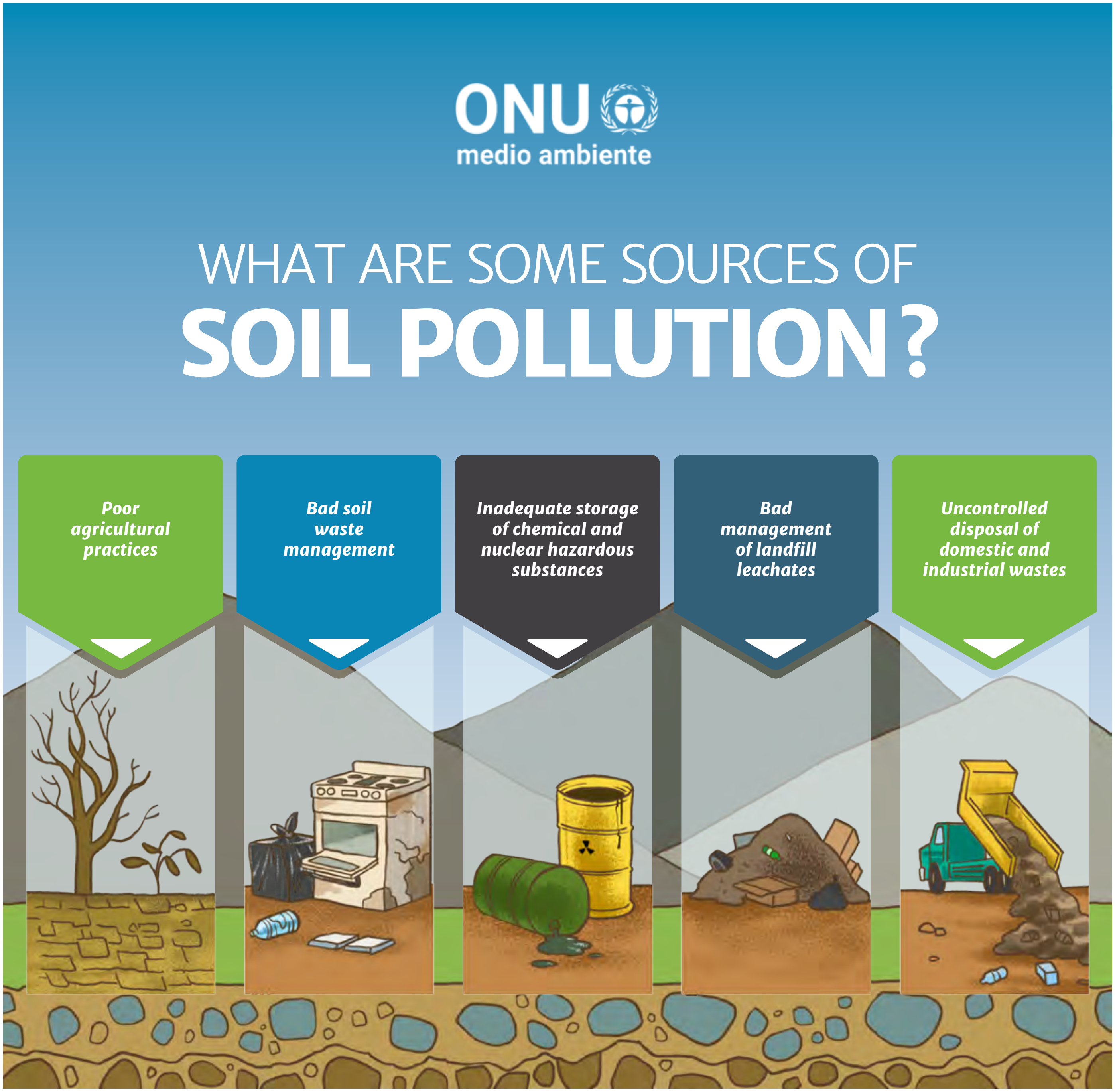
Source: FAO (2015) Soils and Biodiversity

1.3. SOIL POLLUTANTS

Soil can become contaminated when some substances such as persistent chemical substances, salts, radioactive material, disease agents, and others are present in amounts high enough to affect the natural soil's functions and composition.

Soil can be contaminated in different ways, such as:

- The dumping of municipal and industrial solid and liquid waste.
- The percolation or filtration of waste dumps.
- Spills from pipelines or means of transport of hydrocarbons, minerals, solvents, or industrial effluents.
- Rupture of storage tanks containing different types of substances.
- Excessive application of fertilizers and pesticides.



Source: https://www.unep.org/es/noticias-y-reportajes/reportajes/es-el-suelo-tan-importante

These contaminants may affect surface layers of the soil, as well as deeper layers. Contaminants can accumulate in different horizons or layers of the soil. Depending on the type of substance, they can also persist in the soils for long periods of time, as is the case with organochlorine pesticides and other substances that resist degradation in the natural environment and that can be transported by wind and water to other places.

Soil can be contaminated with chemical elements such as mercury, cadmium, arsenic, lead, pesticides, and residues from mining and other productive activities. Some of these elements occur naturally in soils, although very often these pollutants are related to human activities.

Soil erosion occurs gradually when surface soil particles are removed by water, movement of land masses, fires, or wind. The removal of fertile soil cover causes degradation of land and the quality of the environment in general.

1.4. CONSEQUENCES OF SOIL POLLUTION

AGRICULTURE	***INDUSTRIAL***	***URBAN***	***NATURAL ECOSYSTEMS***
▪ Loss of soil fertility due to lower concentrations of nutrients ▪ Lower nitrogen fixation ▪ Increased erosion ▪ Lower productivity ▪ Sediment runoff from water sources ▪ Negative effects on the diversity of local species of flora and fauna	▪ Migration of toxic substances underground ▪ Negative impacts on the ecoesystem's health ▪ Increased salinity ▪ Changes in acidity or alkalinity levels that affect soil productivity ▪ Presence of toxic substances that pose a health risk	▪ Floods and landslides ▪ Less availability of food ▪ Effects on water quality and quantity ▪ Higher exposure to diseases.	▪ Forest cover loss ▪ Negative effects on terrestrial and aquatic species ▪ Increased soil erosion ▪ Impacts on water quality ▪ Effects on biodiversity and overall negative effects in an ecosystem


TYPES OF SOIL POLLUTANTS AND THEIR SOURCES
Inorganic elements – Various sources
Heavy metals and other elements (arsenic, cadmium,copper, mercury, lead, etc.)
Pesticides and fertilizers Agriculture
Runoff
Intensive use of agrichemicals
Organic wastes Various Sources
Domestic and industrial wastes.
Effluents and discharges from livestock and poultry farms, etc.
Sewage sludge, etc.
Deposition of Airborne Pollutants Industries, urban areas, power plants, motor vehicles
Emissions from power plants, transportation motor vehicles, industries, urban areas.

2. Steps to Design a Soil Sampling

2.1. HOW TO DESIGN A SOIL SAMPLING

A soil sampling allows us to take specimens for analysis and is a crucial step for an environmental assessment. Key elements for success are *clearly defined objectives and thoughtful planning.*

Some helpful initial questions are:

- What do we want to know with soil analysis? Do we want to assess the soil fertility or basic conditions of the soil? Identify a source of contamination? Assess the effects of a known source of pollution?
- When assessing the effects of a pollution source, what is the scope or extension of the area that we would like to cover with the analysis? Is there more than one priority area?
- Is the area(s) of interest accessible for sample collection?
- What previous analyses or studies have been done in the area? If so, how can they inform our plans?
- What special safety measures are needed to take the samples?
- Do we have the financial resources and adequate personnel to collect the samples and analyze them?
- What is the overall budget?
- When is the best time/season(s) to collect the sample(s)?
- How many samples should I collect?
- What equipment and materials are needed to collect the samples?

The answers to the initial questions will help us to:

(a) Define the scope of sampling or the priority area(s) where we are going to collect the soil samples, specifically where the samples will be taken and when.

(b) Select the most appropriate parameters or indicators. It is possible that your country has soil quality standards that can help us select parameters for analysis. If there are no national standards, the standards of other countries could be taken as a reference (see Resources section at the end of this guide).

A common mistake is analyzing all possible parameters. Sometimes we believe that by analyzing everything we will have more complete information. While analyzing everything may seem like the best step, it can be costly, the sample volume required may be very large, and we can be overloaded with information that is not necessary to identify the sources of pollution that interest us.


https://www.photosforclass.com/search/soil

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?*

2.2. STEPS OF SOIL SAMPLING

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

Define what the specific problem is that concerns us currently to explore possible causes. Answering this question will guide the sampling design 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.

STEP 2. Define the Scope or Priority Area(s) of Interest

Learning about what studies have been done previously can save time and resources. Ask local people what they observe. Discuss your plans and the information available with the community or stakeholder groups. It is important to find out:

- Are there previous records of contamination at the site? That is, it is necessary to investigate environmental assessments have been made before. We can often find studies, reports, or academic research that can give us important information.
- What are the main activities in the area to be investigated? Are there industrial, agricultural, urban, commercial, industrial, etc. activities in the area?
- Are there any special rules governing land use? It is possible that there are municipal ordinances and regional decrees that establish uses and / or restrictions for the use of the areas that we are interested in analyzing. Groups or communities can consult with experts or local authorities who may be aware of the rules of land use in the area (industrial use, agricultural, protected natural area, archaeological zone, urban area or residential areas, recreational use, etc.). This will also give us guidelines about the soil quality standards to use when we interpret the laboratory results.

A. *How can we define the parameters to analyze?*

Once we have analyzed the problem and 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.).

The selection of parameters or indicators must correspond to the objectives of the sampling, and provide potentially useful information.

(b) Analyze our capabilities and the cost of sampling and analysis by requesting a quote from a certified or trusted laboratory.

SOME BASIC QUALITY PARAMETERS
(This is not a complete list)

- **Arsenic:** Occurs naturally but may indicate industrial pollution, mining, wood preservatives, or pesticides
- **Barium:** Exploitation of hydrocarbons, industrial pollution, burning of coal or oil
- **Benzene:** Industrial pollution, hydrocarbons
- **Boron:** General parameter of agricultural interest. Contaminants from glass manufacturing, leather tanning, cosmetics, photography materials, cleaning agents, high-energy fuels, and pesticides
- **Cadmium:** It can occur naturally. Possible contaminants in metal mining, hydrocarbons, industrial processes, batteries, pigments, metal, and plastic coating
- **Calcium:** General parameter of agricultural interest
- **Chromium (total):** Industrial pollution, steelmaking, chrome plating, mining, dyes, leather tanning, wood preservation
- **Chromium VI:** Industrial pollution, leather tanneries, mining
- **Copper:** It can occur naturally. Possible contaminant in metal mining and various industrial processes
- **Free cyanide:** Some algae, bacteria and fungi can produce it. Can be a contaminant of metallurgical processes, leaching in metal mining, electroplating, plastics manufacturing
- **Lead:** Industrial pollution, mining
- **Magnesium:** General parameter of agricultural interest
- **Manganese:** Industrial pollution, steel production, fertilizers, paints, cosmetics, gasoline additive, mining
- **Mercury:** Industrial pollution, use of fossil fuels, mining (especially alluvial gold mining), thermoelectric plants, manufacture of thermometers, electrical switches, incineration of solid waste. Methyl mercury in reservoir sediments, areas affected by deforestation, fungicides
- **Nitrogen:** General parameter of agricultural interest
- **Petroleum hydrocarbons:** Oil pollution
- **pH:** General physicochemical parameter, especially in measuring mining, industrial, and urban pollution
- **Phosphorus:** General parameter of agricultural interest
- **Polychlorinated biphenyls (PCBs):** Industrial contamination, lubricants in transformers, and/or other electrical equipment, old fluorescent tubes, hydraulic fluids
- **Potassium:** General parameter of agricultural interest
- **Sulfur:** General parameter of agricultural interest, may indicate industrial pollution, volcanic eruptions, fossil fuel power generation plants, metal smelters
- **Toluene:** Industrial pollution, oil and gas exploitation
- **Xylene:** Industrial pollution, oil and gas exploitation
- **Zinc:** Industrial pollution, mining

B. *Things to Consider During Sampling*

ACCESSIBILITY AND WEATHER CONDITIONS	▪ Is the analysis area accessible? Is it safe to reach this area? ▪ Does the group/community organization have the necessary means of transport? ▪ Are weather conditions favorable? Depending on the circumstances, it is preferable to avoid the presence of water in the area to be sampled (rain, snow, floods, etc.).
COST	▪ How much would a laboratory charge for the analysis? ▪ Is it necessary to hire staff to perform sampling? ▪ How much would transportation and other local expenses cost?
COORDINATION WITH THE LABORATORY ON SAMPLE VOLUME	▪ Coordinate with the laboratory on the amount of sample needed, the depth for sample taking, and verify the sampling technique (simple, composite sample), prior to the sample collection. ▪ Coordinate the delivery to the laboratory, taking into account times and hours of operation.
SAFETY	▪ Take all necessary safety measures for personnel involved in all phases of sampling. Make sure they have safety glasses, gloves, appropriate shoes, and appropriate clothing. ▪ Avoid direct contact with samples because they may contain toxic or health-threatening substances.
IDENTIFY A LOCATION FOR COLLECTING A CONTROL SAMPLE	▪ When information or data on the background levels of contaminants or the composition of the soil is unavailable, it is advisable to take a control sample in an area not exposed to the contaminants that you are interested in analyzing. This can determine the concentration of the elements that are going to be analyzed in areas not exposed to the source(s) of pollution.
SITE RECOGNITION	▪ An initial visit to the sampling site can give provide invaluable information to plan and carry out a sampling. You can establish sampling sites, possible limitations or ease of access to sampling sites of interest, identify risks, map the sampling area, and obtain information about wind direction and other important climatic factors, etc.

STEP 3. Sample collection

A. *Equipment List*

- Gloves
- Labels
- Markers
- A clean scoop or trowel. Depending on the depth, a hand shovel, probe, or corer could also be used (see table below)
- Containers (with an airtight lid or bags with an airtight closure)
- GPS or an application on a mobile phone to record the coordinates of the sampling points
- Notebook
- Rubber gloves
- Chain of Custody form (see below)

MATERIALS/EQUIPMENT	*SAMPLE TYPE*	*NOTES*
Scoop or trowel	Surface soil 0-30 cm / 0-1 foot	Avoid using painted shovels
Trowel or small shovel	0-60 cm/ 0-2 feet	For areas affected by chronic oil/gas spills, long-term contaminated sites
Manual corer	15 cm – 5 m/ 1.2 feet – 10 feet	More than one person may be required to collect the samples

B. *Type and Amount of Sample Collection*

Groups and community organizations should try to take as representative a sample as possible. This means samples should reflect the concentration and distribution of the contaminants of interest as accurately as possible for the analysis.

There are several soil sampling methods. This guide focuses on basic procedures that can be performed manually without the use of expensive tools or equipment and that can be used for simple sampling or contaminant identification.

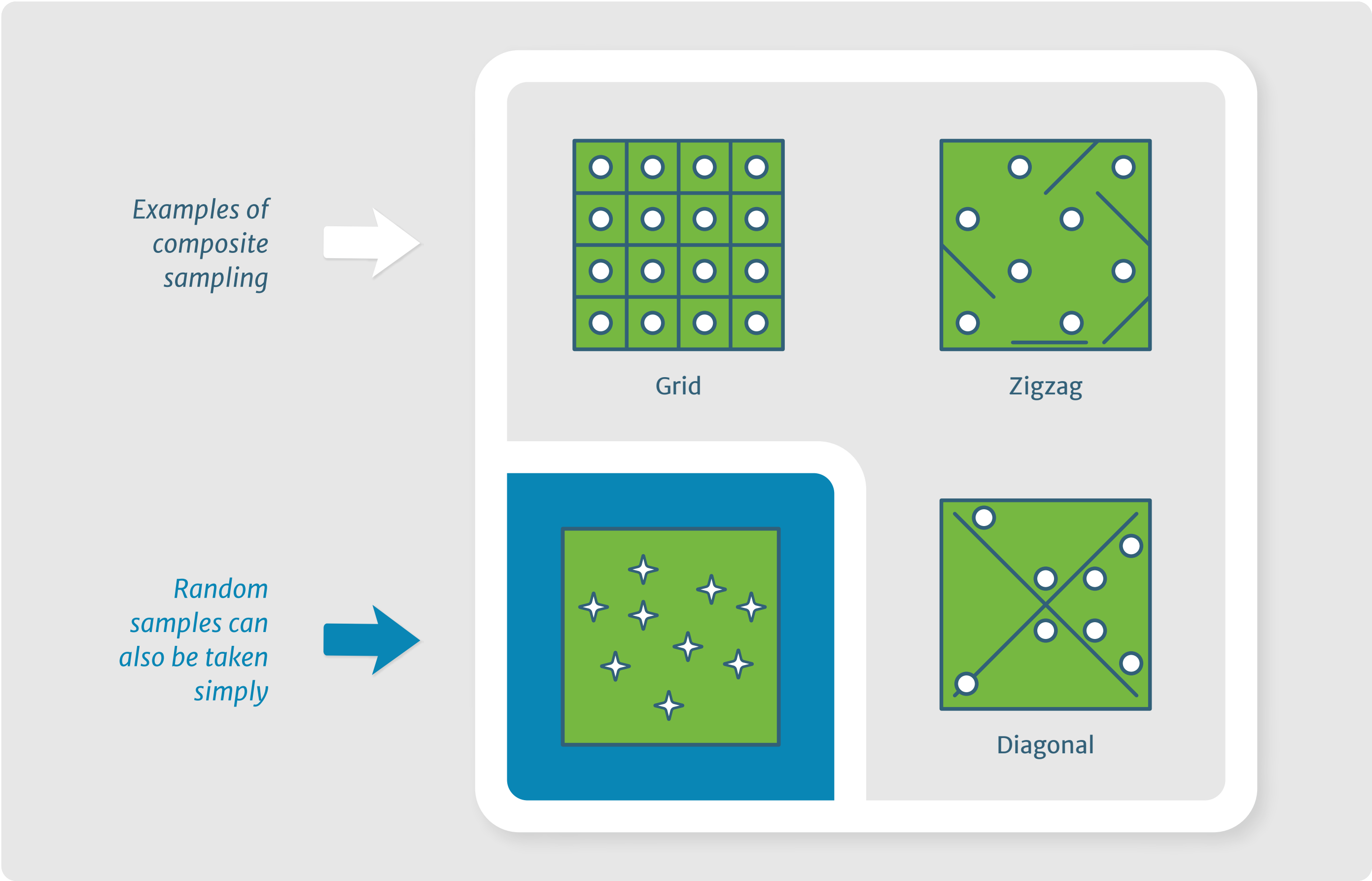
Simple Random Sampling

A simple random sample can be used in a preliminary assessment by collecting a sample from, for example, the top layer of the soil. They are used when the area is generally homogeneous and in a relatively small plot or area (situations can vary). We recommend coordinating with the laboratory in advance about the required sample volume. Depending on the situation, for example, four samples of 1 kg (2 pounds) can be taken on one hectare, each in a resealable bag or a container with an airtight lid.

Composite Sample

A composite soil sample combines discrete samples collected from a defined area, which are then mixed into a single homogenized sample for the purpose of analysis. The benefit of a composite sample is to represent the average concentration of elements in a sampled body of material.

The simple samples conforming the composite should be collected at the same depth and should be approximately the same amount as often of possible (try to be consistent and uniform during the sample collecting process). For instance, 1 kg (2 lb) soil sample could comprise five 200g (0.44 lb) simple soil samples that are mixed and stored in a closed container or airtight bags.



SAMPLING DEPTH

Soil sampling dephts

LAND USES	*RECOMMENDED DEPTH*
Agricultural land	0-30 cm / 0 - 1 foot 30-60 cm /1 - 2 feet
Residential land	0-10 cm / 0 - 0.3 feet
Commercial land	0-10 cm / 0 – 0.3 feet

Source: Ministry of the Environment, Peru (2014) Guide to soil sampling.

C. *How to Collect a Simple Random Soil Sample*

- Identify the area to be sampled according to the criteria set out in the sampling plan (see above).
- Depending on the situation, take simple or compound samples.
- Wear gloves and be sure to thoroughly clean the scoop, trowel or small shovel, or instrument with which you will take the sample.
- Put the sample in an airtight container or bag. See the sample volume in the previous sections.
- Be sure to label the sample well. See labelling instructions below.
- Record the coordinates of the sampling point.

A soil sample (up to 1 meter / 3 feet approximately) can be taken manually using a scoop or hand shovel. This sampling technique could be used for simple and composite samples.

Composite soil samples could also be used to assess pollutants of public health interest. The number of subsamples for a composite sample may vary depending upon the situation, but as mentioned, 4-5 or more subsamples can be taken for a composite sample.

To do this, we must proceed as explained above for simple sampling: take several subsamples in a one specific area, in a specific layer of soil, and at the same depth as seen in the following table. The subsamples of a specific location are then mixed well to form a composite sample. This technique is repeated at each sampling site to obtain various composite samples that must be packaged and labelled separately.

D. *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
Name of the person who took the sample

E. *The Chain of Custody*

The chain of custody form serves as a record with the details of the sampling, the type of sample, the date and time of sampling, number of samples taken, location of sampling, name of the persons in charge of taking samples, mode of sample storage and transport, as well as a record of storage and transport conditions until the sample reaches the laboratory. This form is important because it ensures the quality of the sampling, verifies the suitability of the people who took and handled the samples, and determines whether there may have been contamination of the samples and how this could have occurred.

F. *Chain of Custody Format Model - Soils*

SAMPLE IDENTIFICATION				SAMPLER NAME AND SIGNATURE		
Sampling points	Date	Hour	Container No.	Type of Sample	Required analysis	
Chain of custody point	Delivered by: Name(s) and signature(s)			Received by: Name(s) and signature(s)		Date and time
Delivered to the laboratory by: Name(s) and signature(s)	Date and time			Received in the laboratory by: Name(s) and signature(s)		Date and time

G. *Handling, Storage, and Transportation of Samples*

Check that the containers for soil storage are adequate for the parameters to be analyzed. Label the samples properly (location, date, time, sample number), and store them carefully so they can be kept free from contamination and identified later. Chemicals or preservatives should not be added unless done so under laboratory instructions. Samples should be kept in cool, dry places, preferably at 4-6°C (about 40°F).

Storing, Temperature, and Maximum Holding Time Life for Soil Samples

PARAMETER	TYPE OF CONTAINER	STORAGE TEMPERATURE	MAXIMUM STORAGE TIME
Volatile organic compounds	Wide-mouthed glass jar with airtight Teflon lid	4°C (40°F)	14 days
Benzene, toluene, ethylbenzene, xylene (BTEX)			
Hydrocarbons (light, medium and heavy fractions)			
Volatile organic compounds			
Heavy metals and metalloids	Dense polyethylene bags with hermetic closure	No restrictions	No restrictions
Mercury	Wide-mouthed glass jar with airtight Teflon lid	4°C (40°F)	14 days
Polychlorinated biphenyls (PCBs)		4°C (40°F)	14 days
Polycyclic Aromatic Hydrocarbons (PAH)		4°C (40°F)	14 days

Source: Ministry of the Environment, Peru (2014) Guide to soil sampling.

STEP 4. Interpret the Results

Values Guide of Some Parameters

PARAMETERS IN MG/ KG DRY WEIGHT	LAND USES			COUNTRY
	Agricultural Land	Residential Land	Industrial Land	
ORGANIC				
Volatile aromatic hydrocarbons				
Benzene	0.05	0,5	5	Canada
Toluene	0.1	0.8	0.8	Canada
Ethylbenzene	0.1	1.2	20	Canada
Xylenes	11	11	11	Canada

PARAMETERS IN MG/ KG DRY WEIGHT	LAND USES			COUNTRY
	Agricultural Land	Residential Land	Industrial Land	
Polyaromatic hydrocarbons				
Naphthalene	0.1	1	1	Canada
Benzo(a)pyrene	0.1	0.7	0.7	Canada
Petroleum hydrocarbons				
Hydrocarbon fraction F1 (C6-C10)	200	200	500	Peru
Hydrocarbon fraction F2 >(C10-C28)	1200	1200	5000	Peru
Hydrocarbon fraction F3 >(C28-C40)	3000	3000	6000	Peru
Organochlorine Compounds				
Polychlorinated biphenyls (PCBs)	0.5	1.3	33	Canada
Tetrachloroethylene	0.1	0.2	0.5	Canada
Trichloroethylene	0.1	3	31	Canada
INORGANIC				
Arsenic (As)	12	12	12	Canada
Barium (Ba)	750	500	2000	Canada
Cadmium (Ca)	1.4	10	22	Canada
Chromium (Cr)total	64	64	87	Canada
Chromium VI	0.4	0.4	1.4	Canada
Cyanide (free)	0.9	0.9	8	Canada
Inorganic mercury	6.6	6.6	24	Canada
Lead	70	140	600	Canada

Glossary

CHAIN OF CUSTODY	Procedures and documentation that serve as a record of a sample's integrity from the moment the samples are taken to the handling and storage procedures, until the moment they are delivered to the laboratory for analysis.
COMPOSITE SAMPLE	It is a sample made up of subsamples (simple samples) which are properly mixed and collected from a specific area.
CONTAINER	Container intended to hold soil samples for storage and transport to the laboratory for analysis.
ENVIRONMENTAL MONITORING	Systematic process of periodic sampling of water, air, soil, or biota to observe, analyze, and record changes in the quality of the environment.
HEAVY METAL	A metal 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 for toxic or poisonous inorganic elements at low concentrations, this definition has been discussed and there is no standard definition.
PARAMETER	A variable that can be used to measure or evaluate the condition or characteristics of a system. For example, temperature, density, etc.
POLLUTANT	Compound, element, or organism that is in a concentration sufficient to cause damage, disease, or death in nature and / or living beings, depending on the type, or time and route of exposure. Some pollutants may be of natural origin or may come from human activities.
SAMPLE	Specimen or portion of soil extracted for laboratory analysis.

SAMPLING	Process by which a portion of material is selected in a sufficient volume to be transported and analyzed.
SEDIMENT	Soils made from deposit materials or those accumulated by mechanical dragging of surface water or wind, then deposited at the bottom of natural water sources such as rivers, seas, lakes and in depressions of land.
SIMPLE SAMPLE	Sample collected from a single place.
SOIL	Unconsolidated material composed of inorganic particles, organic matter, water, air, and organisms, ranging from the upper layer of the earth to different levels of depth.
SOIL QUALITY	The capacity of the soil to fulfill its natural functions in the ecosystem and a function of its physical, chemical, and biological characteristics.
SPILL	Any discharge, release, or dumping of a hazardous liquid, industrial effluents, or hydrocarbons into the ground due to an accident or improper practice.

Information Resources

Canada. Soil quality standards
https://elaw.org/content/canada-soil-quality-guidelines

ELAW (2010) Guidebook for Evaluating Mining Project EIAs
https://www.elaw.org/files/mining-eia-guidebook/Full-Guidebook.pdf

EPA. Soil Sampling
https://www.epa.gov/quality/soil-sampling

Pennsylvania State University. USA (2017) Introduction to Soils: Soil Quality.
https://extension.psu.edu/introduction-to-soils-soil-quality

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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.