How to set up a new soil laboratory

Setting up a new soil laboratory is not an easy task as it is rather an overwhelming challenge.

As a laboratory manager, when you decide to set up a new soil laboratory, you need to consider not only the laboratory management but also the technical management plan.

Below are reported some preliminary steps that you should take into consideration when setting up a new soil laboratory.
STEP 1
Know what you want and really need!

The first step is to ensure you fully understand the organization’s mission and goals. Therefore, it is necessary to evaluate:

**THE OBJECTIVE**
**WHAT SERVICES SHOULD THE LABORATORY PROVIDE?**

Is the analysis aiming to support decision making on soil fertility/salinity/pollution/other management, soil classification, evaluation of the soil for its use, research purposes, other? Knowing the objective will help you to have an idea of which parameters you need to test and the required analytical methods and equipment. There are specific procedures for each of the desired objectives.

**THE ANALYTICAL DEMAND**
**TYPE AND AMOUNT OF ANALYSIS**

What soil analysis do you want to conduct? And how many samples per year do you estimate to analyse? Please note that investing in expensive equipment for analysing only a few samples per year is not worth it.

Other aspects to consider before starting to setup of a new laboratory are:

**FINANCIAL ASPECTS**
**INITIAL/MAINTENANCE COSTS AND BUDGET**

The resources to install a soil analysis laboratory include the cost of infrastructure, hiring personnel (technicians and those responsible for quality control including training), acquisition of materials and reagents (including proficiency sample tests), and acquisition of equipment (including calibration and verification of equipment, also service contracts for the equipment). Resources should also be considered to follow up on personal training, calibration and verification of equipment and their maintenance, and proficiency sample test, aspects that are costly and must be permanently developed. Costs associated with the general maintenance of the infrastructure such as cleaning, janitorial, technical and IT services must also be considered.

**INFRASTRUCTURE AND FACILITIES AVAILABLE**
**NEED FOR CONSTRUCTION OR ADAPTATION**

In general, all countries have national regulations for the establishment of laboratories. Electricity installations, pipes and wastewater recovery systems, aeration systems, emergency exits and all systems needed for the safe and efficient function of the laboratory should be considered during the identification or construction of the laboratory spaces. Cleaning and sanitary material like sinks and automatic dishwashers should also be considered during the laboratory’s design phase.

**AVAILABLE HUMAN RESOURCES OR NEED FOR TRAINING**

The minimum staff is one person in charge, preferably with two laboratory technicians and another person in charge of the quality control program. Staff working in soil chemistry laboratories especially, should be trained in analytical chemistry and preferably have experience in soil analysis.

**EQUIPMENT AVAILABLE OR NEED TO PURCHASE**

**QUALITY ASSURANCE**

When setting up a new laboratory, it is important to have a clear idea of objectives from the start and record information on the management of the laboratory beginning with planning process. This can be done in the form of a Laboratory Quality Manual (LQM) or other documents. In this regard, documents have to be generated according to the type, size and characteristics of the laboratory. The selected document must include at least the following points:

- **the Organization and Organizational Policies** (legal name and address of the laboratory, ownership and management structure of the laboratory, organization chart of the laboratory, clearly showing relevant internal organizational components);
- **the Laboratory Technical Staff** (position description(s) for each technical operational position shown)

on the organizational chart, a description of the method(s) used to ensure all personnel are trained to perform tests conducted by this laboratory in accordance with standard procedures, description of the method(s) used to evaluate the competency of each staff member to perform tests conducted by this laboratory, to ensure all testing is performed in accordance with standard procedures); and
- **the Laboratory Equipment**, (inventory, including description of the procedures used for calibration and verification of equipment); and
- **the Test Records and Reports** (methods used to produce test records and reports, proficiency sample test results, typical data sheets (test report forms)). On the internet, there are several examples that can be consulted for this purpose.

If the decision to generate a LQM is made, please be careful to keep it updated in order to reduce the risk of relying on multiple, inconsistent documents. Indeed, as soon as the laboratory is set up and running, the LQM is usually replaced by other more specific and detailed documents.

### HEALTH AND SAFETY CONDITIONS

In general, all countries have regulations on health and safety conditions, including emergency plans that must be specified in the LQM.

#### STEP 2

**Study the national legislation on soil laboratories and soil analysis**

It is necessary to check if there is existing national or regional legislation on soil laboratories and soil analysis. This is important and can guide you on:

- The selection of the **methods of analysis**. In some countries, the methods of analysis are defined by specific regulations.
- The setup of the **drainage system** of the laboratory. Ideally, the drainage system of the laboratory should be isolated from the public one.
- The **management of laboratory waste**. The specific legislation on the final disposal of hazardous and pathogenic waste in each country must be respected.
- **Local regulations**, e.g. for inspection of pressurized equipment, licensed reagents.

#### EXAMPLE OF LEGISLATION: AZERBAIJAN

**Presidential Decree No. 155 on the approval of the statute and committee structure of the Azerbaijani State Committee on Standardization, Metrology and Patents.**

This Presidential Decree sets forth the duties and authorities, rights and organization of the Azerbaijani State Committee on Standardization, Metrology and Patents. The Committee on Standardization, Metrology and Patent is the executive central body which carries out state policy on technical regulation, standardization, metrology, conformity assessment, accreditation, quality management and the protection of industrial property rights. The core activities of the Committee shall be in accordance with the Constitution of Azerbaijan Republic, international treaties, laws, decrees and orders of the President of the Republic of Azerbaijan, decrees and orders of the Cabinet of Ministers and the statutes. The Committee shall carry out its duties and rights, in cooperation with executive authorities, local self-government bodies, non-governmental organizations and other relevant agencies. The Committee shall take measures within its authority to prevent production, import, sales of harmful products and also to prevent direct and significant threat to the environment, human life and health that do not meet international and regional standards recognized by the Republic of Azerbaijan.

Source: FAOLEX Database
www.fao.org/faolex

Read **full document**
STEP 3
Study the environment - Infrastructure

HOW MUCH SPACE DO YOU HAVE AVAILABLE?

The facilities and environmental conditions must not affect the validity of the results, for this reason you will need to have different sectors in the laboratory, which will be defined based on the tests to be carried out, the available infrastructure and equipment. The facilities must avoid cross-contamination, interference or adverse influence on the results. This can be achieved through an effective separation between the different areas of the laboratory where incompatible activities are carried out. Having separate sectors of the laboratory will help reduce chemical inhalation, keep unauthorized personnel from entering areas where hazardous operations are performed, dust cross-contamination, etc.

Consider a designated space to place all equipment you want to purchase. Always remember that technicians should have enough space to move, operate the equipment and conduct the analysis in security. The laboratory shall be provided with adequate natural or artificial illumination to ensure sufficient visibility for operational safety.

Please also consider that a lot of equipment has ideal working conditions and high technology equipment has high maintenance costs and requires properly trained staff to be operated. Please learn about special requirements of the equipment before placing your order. Also remember that decisions on where to place each piece of equipment should take into consideration:

- Room size
- Room temperature and humidity
- Number of technicians allowed in the room
- Electricity and aeration conditions, need for specific atmosphere conditions

IDEAL WORKING CONDITIONS

Regardless of the objective of the laboratory (chemical, physical, biological analysis) and depending on its size and complexity, the organization of different sectors should be defined according to the tests to be carried out, the infrastructure, equipment and available resources.

If different types of analyses (for example, chemical and microbiological) or analyses of different matrices (for example, soil and plant material) are to be carried out in the same laboratory, it will be essential to consider an effective separation of sectors and materials that will be used for that purpose (for example, not sharing the sample preparation room, or not sharing materials such as sieves).

<table>
<thead>
<tr>
<th>SECTORS</th>
<th>IT MUST BE ENSURED</th>
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</thead>
<tbody>
<tr>
<td>ATTENTION OF CLIENTS AND RECEPTION OF SAMPLES</td>
<td>Effective separation of the Laboratory sector</td>
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<tr>
<td>LABORATORY</td>
<td>Temperature, humidity, ventilation or air renewal and lighting conditions appropriate for the tasks to be carried out</td>
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<td></td>
<td>Samples need to be stored in stable environmental conditions that are free from pest infestation</td>
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<td>Take into account the conditions required by the tests and by the equipment that will be located in each sector</td>
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<td>Effective separation of the sectors dedicated to handling and storage of samples, reagents and/or waste</td>
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<td>Control and record these environmental conditions to ensure the validity of the activities that are carried out or the operation of the installed equipment, when the procedures demand it</td>
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<tr>
<td>SECTORS</td>
<td>IT MUST BE ENSURED</td>
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| REAGENT STORAGE ROOM                  | • Safe storage of reagents  
• Effective separation of incompatible reagents (strong acids from strong bases, flammables, oxidizers from reducers)  
• Separation and control of reagents or substances controlled by legal requirement (for example, narcotic precursors)  
• Keep a small supply of reagents in the laboratory warehouse and build a main warehouse in a room outside the building (consider that long-term storage of reagents should be avoided, a stock should be kept for as short time as possible, depending on of laboratory management dynamics) |
| WASTE STORAGE ROOM                    | • Safe storage of waste until its removal and final disposal  
• Hazardous waste must be handled and disposed of in specific ways. Separate the general waste water system and the laboratory hazardous waste, then perform a treatment before draining to public water system |
| PRESSURIZED GAS SUPPLY SECTOR         | • Distribution from an external storage, with optimal ventilation  
• Avoid locating pipes with gas inside the laboratory (if this is not possible, they must be tied down and under strict periodic control of pressure and maximum load) |
| OFFICE                                | • Strict control of all documentation related to laboratory management (consider confidentiality, etc.)                                                                                                            |
| ACCESSORY AREAS                       | • Effective separation of the sectors dedicated to meetings, change and storage of protective clothing, and resting                                                                                                                                 |

**ALSO CONSIDER:**  
- the need for associated services (water, electricity, natural gas, vacuum, compressed air, special gases required by high-tech equipment such as atomic absorption, plasma, chromatograph) and support services (communications, telephone, IT networks, transportation, provision of reagents and supplies, waste management, among others).  
- the need to install distilled water generators and associated distribution and storage systems.  
- whether you will be constructing a new building or partitioning of available infrastructure? The construction of a new laboratory could be expensive. Where possible, partitioning of available infrastructure will reduce costs. The renovations must be specific to the required standard for accommodating laboratory equipment and spacious enough for the job to be carried out smoothly. The expected number of samples to be handled and storage capacity and duration would also help in determining the space required.  
- what is the average humidity/temperature/exposition to the sunlight of each room? Where will you store soil samples and dispose of laboratory waste and expired reagents?  
- that the hazardous waste must be handled and disposed of in specific ways. Separate the general waste water system and the laboratory hazardous waste, then perform a treatment before draining to public water system

The establishment must focus on the need for a specific purpose (e.g. agriculture, research or industrial) which will then determine the basic tests to start with, equipment required to begin and type of laboratory (chemical, physical or biological) to establish.  
- what is the average humidity/temperature/exposition to the sunlight of each room? Where will you store soil samples and dispose of laboratory waste and expired reagents?  
- that the hazardous waste must be handled and disposed of in specific ways. Separate the general waste water system and the laboratory hazardous waste, then perform a treatment before draining to public water system

Use this information to plan what analysis to perform in each room and where to place any equipment you wish to purchase. Please note that many items of equipment have ideal working conditions and that some analysis needs to be performed in a controlled environment.
STEP 4
Create a safe working environment - Health and safety (H&S) equipment to purchase

Make sure that the laboratory is equipped with all necessary equipment and materials to ensure appropriate health and safety conditions for your technicians. It is important to be aware of safety requirements such as eye-wash stations and showers, ventilation, containing compressed gas cylinders, fume hoods, etc.

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>SOIL CHEMISTRY LABORATORIES</th>
<th>SOIL PHYSICAL LABORATORIES</th>
<th>SOIL BIOLOGICAL LABORATORIES</th>
<th>CONSIDER</th>
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</thead>
<tbody>
<tr>
<td>SIGNALS</td>
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<td>Post emergency signals in a visible place, in the official language, with an appropriate font size (visible to the naked eye)</td>
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<tr>
<td>FIRE CONTROL</td>
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<td>Appropriate to the existing risks in each sector.</td>
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<td>FIRST AID</td>
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<tr>
<td>COLLECTIVE PROTECTION</td>
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<td>REAGENTS STORAGE</td>
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<td>PERSONAL PROTECTION</td>
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<tr>
<td>EQUIPMENT (PPE)</td>
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<td></td>
<td>• Respiratory protection – dust and chemical</td>
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<td>• Gloves, including thermal protection gloves. It may be necessary to handle elements at high temperatures (many are handled with tweezers, but if they are large, it may be necessary to handle them with the hands and, for this, specific gloves are required)</td>
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<tr>
<td>WASTE MANAGEMENT</td>
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<td></td>
<td></td>
<td>• Waste containers</td>
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<td>• ECO funnel</td>
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<td>• Incinerator</td>
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<td></td>
<td>• Hazardous substance spill containment kits</td>
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<td>• Glass bin for safe disposal of broken lab-ware</td>
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<tr>
<td>PLANS</td>
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<td>• Emergency evacuation (include roles and drills)</td>
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<td>• Load control and hydraulic test of fire extinguishers</td>
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<td>• Verification that collective protection elements like safety/emergency showers, eyewashes stations and fume extraction hoods work properly. The former should be checked for correct operation at least monthly. Although there may be personnel dedicated especially to this, generally, this task is carried out by the laboratory personnel</td>
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<td>• Note: the hoods are usually checked for operation annually to verify that it is extracting with a flow that is safe for the analyst who uses it (if the extraction flow is not adequate, it may require some adjustment or it may only be necessary to modify the conditions of use, for example, reconfiguring the opening of the window to regulate the flow). This task can be carried out by personnel from outside the laboratory, but the analyst (user) is the one who must respect the established conditions of use and report any malfunction detected (vapors that are not extracted, odors, etc.) and check that the deadlines and the defined controls are met</td>
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<td>• Instructions and protocols for the safe handling and use of samples (materials), reagents and equipment</td>
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<tr>
<td>GENERAL</td>
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<td>• Protection of electrical connections</td>
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<td>• Protection of moving parts in equipment</td>
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<td>• Ergonomic aspects (chairs, table heights, etc.)</td>
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</table>

All these controls are very important and must be included in the planning of tasks related to health and safety.

Please do not forget to:
- Prepare and provide Induction manual and orientation guidelines for visitors and new employees
- Encourage the use of prior Risk Assessment and Material Safety Data Sheets which include guidance on safe handling and disposal of chemicals.
STEP 5
Equipment and materials

Knowing the type and amount of analysis to conduct in the laboratory will guide you through the purchasing of the required equipment and critical materials. Any procurement decision should be anticipated by an inspection of the laboratory facilities to understand how much space you have available and to plan where to place each piece of equipment, accessory and material. This will ensure their perfect fit in the proposed space.

BASIC EQUIPMENT COMMON TO SOIL CHEMISTRY, SOIL PHYSICAL AND SOIL BIOLOGICAL LABORATORIES

- **Analytical and precision balances, with a set of weights suitable for its control.** If the budget is limited, please consider only purchasing analytical balances that serve a larger pool of analysis
- Beakers and test tubes
- **Burettes and pipettes (eventually also digital or automatic burettes and pipettes)**
- **Centrifuge suitable for the type of analysis**
- Chemical funnels
- Deionized/distiller water plant or Reverse Osmosis Machine water treatment
- Desiccator
- Different type of flasks, including dark glass for some reagents (measuring cylinders and Erlenmeyer flasks)
- **Dispensers (eventually also digital or automatic dispensers)**
- Drying oven
- Drying racks, for washed glass-ware
- Electrical hot block
- Filters/membranes
- Fume Hood
- Glass rods
- Heat proof mats, if handling hot items
- Inert packaging material for the storage and transport of the samples
- Laboratory trolleys to transport samples, equipment, chemicals and glassware
- Refrigerators and freezers
- Sample containers and storage trays
- Sample or chemical weighing boats
- Shaker
- Sieve shaker
- Sieves
- Spatulas, scoops and others
- Stirrer and magnetic bars
- Tables and tables for analytical balances / Special coated tables
- Test tube racks
- **Thermometer or temperature probe**
- Timer
- Trays (for carrying flasks)
- Tweezers and tongs
- Ultrasonic batch for material cleaning
- Vacuum pump/line
- Volumetric flasks of various capacities
- Water bath and/or sand bath
- Wooden and porcelain mortar and pestle

NOTE: the equipment or materials that are written in blue are considered critical, so they must be under control. This means that they must be kept properly calibrated and verified, depending on their intended use.

EQUIPMENT FOR SOIL CHEMISTRY LABORATORIES

- **Atomic Absorption/Emission Flame Spectrophotometer**
- Calcimeter
- Combustion furnace
- Conductivity meter
- Digestion unit or Kjeldahl Digestor
- Distillation unit or Kjeldahl distiller
- **Flame photometer**
- ICP-OES (Optical emission spectroscopy based on inductively coupled plasma)
- MP-AES (Microwave plasma- atomic emission spectrometer).

Choice of spectrometer will depend upon local availability and maintenance infrastructure. For example, MP-AES utilises nitrogen plasma and does not rely on an external source of gas such as acetylene or argon.

- pH measurement equipment (including temperature sensor, glass electrode sensitive to hydrogen ions, high flux reference electrode and if possible, detection system for millivolts and specific ions)
- Titration unit
- UV/Visible Spectrophotometer

NOTE: Equipment with specific alternatives are written in red, which one laboratories use will be based on the analytical needs and available budget.

EQUIPMENT FOR SOIL PHYSICAL LABORATORIES

- Conductivity meter
- Granular composition test set, wet and dry sieving
- High speed stirrer
- Hot plate
- Hydrometer kit, standard set
- Pressure plate apparatus
- Pycnometer
- Robinson's pipette apparatus
- Set for pF-curve
- Water bath
- Wet sieving apparatus

EQUIPMENT FOR SOIL BIOLOGICAL LABORATORIES

- Autoclave
- Fermenter
- Freezer -80°C
• Gas chromatography
• Hot air oven
• High-performance liquid chromatography (HPLC)
• Incubator
• Laminar flow cabinet
• Petri dishes
• PCR cycler
• pH measurement equipment (including electrode and temperature sensor system)
• UV/Visible Spectrophotometer

Please make sure to have a sufficient and stable power supply. Consider that some equipment requires a stable power supply to work.

If your power supply is not stable, please consider purchasing a generator or an uninterruptible power supply (UPS). Solar panels may be also considered where possible.

Please do not overlook the wellness of the laboratory staff especially in countries experiencing extremely cold or warm months. The installation of a heating and/or air conditioning system should be considered to improve the working conditions in the laboratory – some instruments require such stable environmental conditions.

Also, do not forget to require a technician on-site to do the installation of some advanced instruments (AAS, ICP etc.) while making sure that your staff have the skills for the basic installation of simple equipment (balance, oven etc.).
STEP 6
People make the difference

A laboratory requires leadership and a well-trained staff to conduct high quality laboratory management and analysis. In this regard:

- Make sure to have sufficient and properly trained technicians to conduct the analysis. Technicians should have undergone intensive training or have acquired sufficient experience before starting to analyse soil samples for clients. A quality assurance and quality control (QA/QC) system should be in place with laboratory staff trained in its implementation or a quality manager.

How will you keep track of your work? Do you need a Laboratory Information Management System (LIMS) or you will use a paper system?

Please note that the best affordable system and cheapest system for laboratories with low resources is a paper system or working in a spreadsheet. LIMS can be purchased when the laboratory has the resources to properly maintain it (support and update costs) and when there is an actual need for it (executing of complex operations and analysis of large amounts of soil samples).

If a laboratory deals with simple operations, it is worth thinking about open source or widely available software for databasing information.

Having a good recording and management system is key to the accreditation process of soil laboratories. However, this can be achieved with a LIMS, or with a paper-based system, or using open-source software.

- Set up a regular training program to maintain ongoing competence and for training of subsequent staff.
Do not focus only on the budget you have available to establish your laboratory!

Who will financially support the laboratory in the long term?

Will you receive annual budget allocation?

Does this cover maintenance of the equipment costs, the purchasing of chemical reagents, consumables, etc.?

Does it include training costs and the recruitment of laboratory personnel?

For certain equipment, do vendors assure effective maintenance and repair services?

If using existing building facilities, does the budget include equipment installation costs, or costs for potential alterations to buildings?

Energy and water supply costs

Please do not move forward establishing a soil laboratory if you do not have a positive answer to these questions.
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In the framework of the Global Soil Laboratory Network and thanks to the financial support of PHOSAGRO®
The Global Soil Partnership (GSP) is a globally recognized mechanism established in 2012. Our mission is to position soils in the Global Agenda through collective action. Our key objectives are to promote Sustainable Soil Management (SSM) and improve soil governance to guarantee healthy and productive soils, and support the provision of essential ecosystem services towards food security and improved nutrition, climate change adaptation and mitigation, and sustainable development.

GLOSOLAN
GLOBAL SOIL LABORATORY NETWORK

GLOSOLAN is a Global Soil Laboratory Network which aims to harmonize soil analysis methods and data so that soil information is comparable and interpretable across laboratories, countries and regions. Established in 2017, it facilitates networking and capacity development through cooperation and information sharing between soil laboratories with different levels of experience. Joining GLOSOLAN is a unique opportunity to invest in quality soil laboratory data for a sustainable and food secure world.

Thanks to the financial support of

For more information
www.fao.org/global-soil-partnership/pillars-action/5-harmonization/glosolan

To join or support the GLOSOLAN network please contact GSP-Secretariat@fao.org

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