Food and Agriculture Organization of the United Nations

21-23 November 2023

GLOSOLAN Standard Operating Procedures (SOPs)

Filippo Benedetti, FAO

7th Meeting of the **Global Soil Laboratory Network** (GLOSOLAN)

GLOSOLAN
GLOBAL SOIL LABORATORY NETWORK

GLOBAL SOIL PARTNERSHIP

Globally harmonized standard operating procedures (SOPs)

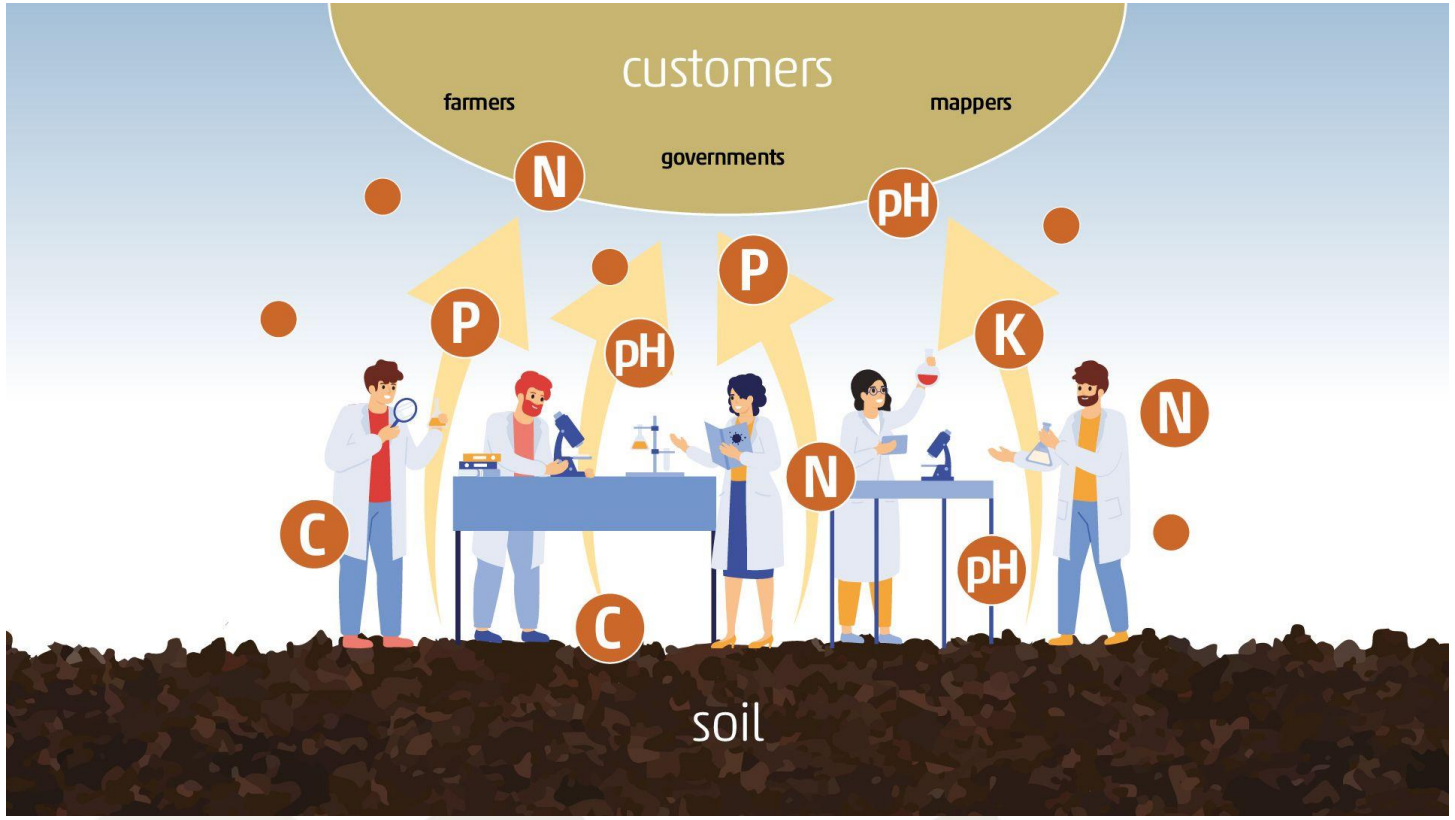
Harmonized soil data - critical for addressing a wide range of environmental, agricultural, and societal challenges

Soil data:

- Accuracy and precision
- Reliability
- Comparability
- Interpretability

Main issues for laboratories:

- Cost of the protocols
- Language barrier
- More confident with local/national/regional procedures



SOP = Standard Operating Procedure

- **Globally harmonized - bottom-up, inclusive approach**

e.g. GLOSOLAN SOP for OC by Walkley and Black involved 67 laboratories from 52 countries located on the different continents.

- **Ensures the replicability of a measurement and the credibility and traceability of data**

- **Step-by-step instructions**

- **Includes sections on health and safety, quality assurance and quality control (QA/QC) – and in some cases sampling guidelines**

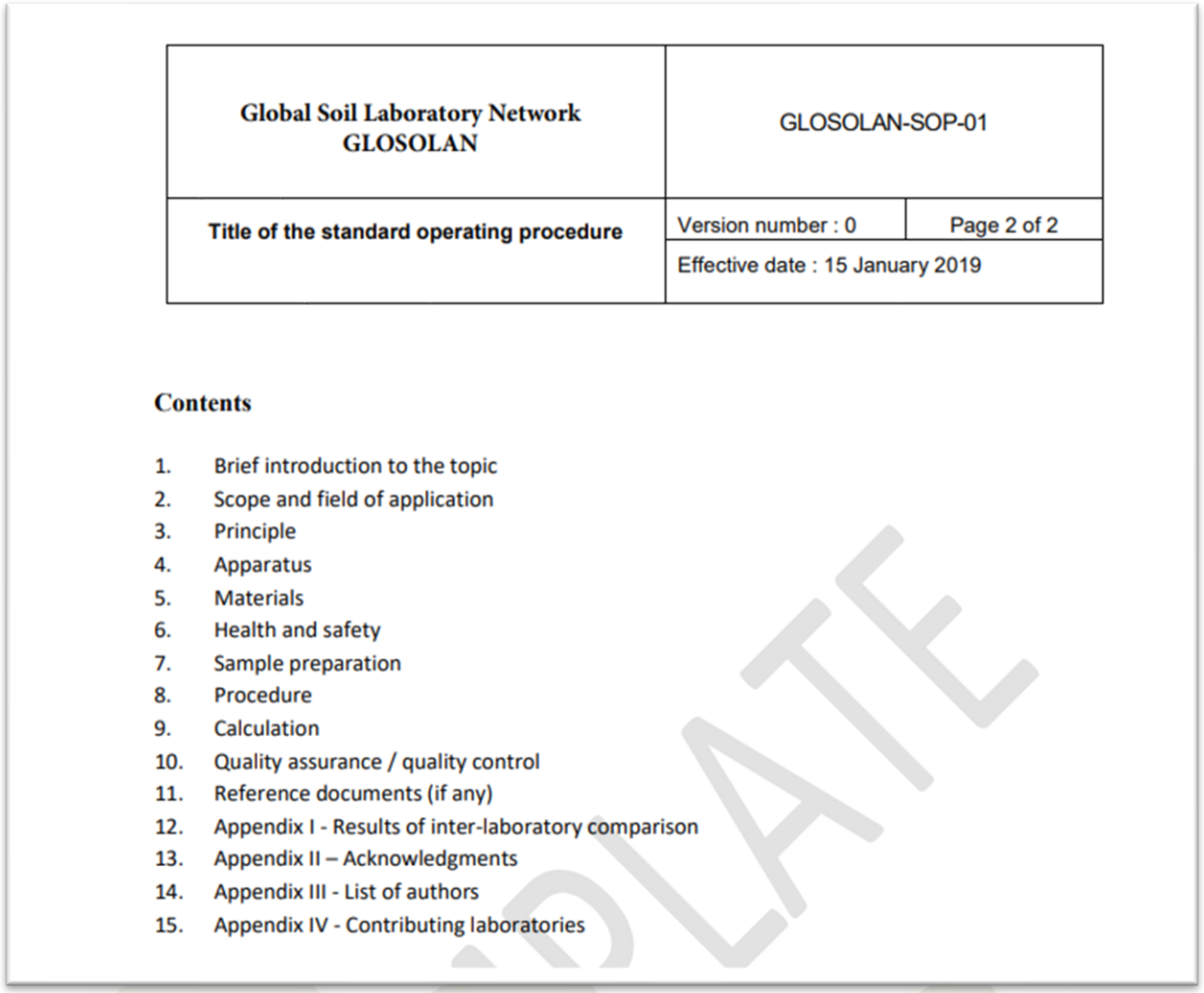
- **Available online, <u>for free</u> and in multiple languages**

Harmonization- bottom-up, inclusive procedure

1. Discussion and decision on the methods to harmonize (done within the Regional Soil Laboratory Network first, and then at a global level)
2. Establishment of the working groups, assignment of roles:
   - Global leader
   - Regional leaders (supporting authors)
   - Review panel
3. Prepare the matrix (=survey) and send it to all GLOSOLAN members who are familiar with the method to collect information on the procedures adopted worldwide
4. Compile the information on a regional basis → regional matrices are harmonized
5. Merge the regional matrices into a global matrix
6. Convert the matrix into a text
7. Review of the procedure's text
8. Publication and translation

Structure of the procedure - standard template

In come cases (e.g. physical or biological parameter tests): sections on **sample collection, storage and disposal**



Global Soil Laboratory Network GLOSOLAN	GLOSOLAN-SOP-01	
Title of the standard operating procedure	Version number : 0	Page 2 of 2
	Effective date : 15 January 2019	

Contents

Not only procedural details

- **Consistency and Quality**
  - QC/QA procedures

- **Recommendations on health and safety**
  - Personal protective equipment, chemical and biological safety, emergency procedures

- **Sustainability of methods**
  - reliable, accurate, and cost-effective, while minimizing the use of resources, energy, and hazardous substances.

Soil Nitrogen methods : Sustainability of methods

Method	Risk for human health related to the use of chemicals and the overall implementation of procedure by staff	Environmental risk (waste disposal)	Level of technology required	Average duration of the analysis	Global median price of the analysis (for the customers)
Kjeldahl	High	High	Medium	> 1 working day	7.5 USD
Dumas	Low	Low	High	Up to half working day	11.6 USD
Distillation method	Medium	Medium	Medium	Up to one working day	8.3 USD

Facilitate the adoption of the SOPs

- Accessibility
  - SOPs are available for free on the GLOSOLAN website
  - Translation in the UN Official languages and other national/local languages as needed (according to the translator availability)

- Capacity building
  - Webinars are regularly organized (in multiple languages) to present the methodologies
  - Training videos are created

Examples from Thailand

Joint products

- GLOSOLAN SOPs are living documents and are revised regularly and/or as needed

- Experts from other GSP Technical Networks support the harmonization process according to the parameter:
  - NETSOB: active members of the working groups for all SOPs dealing with soil biological parameters
  - INSAS: review the SOPs related to soil salinity and sodicity
  - INSOP: review the SOPs related to pollutants and toxic elements

Food and Agriculture Organization of the United Nations

Standard operating procedure for soil bulk density

Cylinder method

GLOSOLAN

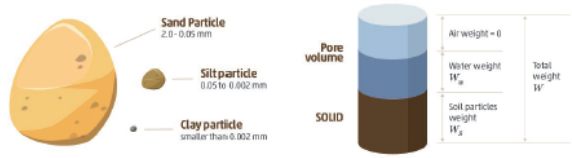
GLOBAL SOIL LABORATORY NETWORK

GLOBAL SOIL PARTNERSHIP

1. A brief introduction to soil bulk density

Soil is the result of rock fractioning and weathering over periods ranging from thousands to millions of years. Fractioning and weathering produce mineral fractions and particles of an extremely large range of sizes, from several metres to less than one micrometre. By definition, soil is made by the packing and assemblage of particles <2 mm, with larger particles being called "coarse material". The way the soil is packed and the particle size determine the size and number of spaces between particles, which are called pores or voids. The fraction that the volume of these voids over the total soil is called the pore volume or porosity (Figure 1). The amount of pore volume depends on the size of the particles, as well as by their shape and packing.

Figure 1. Representation of soil particles (left); major components of soil (right)



Source: Elaborated by FAO

Approximately 10 000 years ago, agricultural practices had started using tools to loosen the topsoil layer, resulting in decreased bulk density (increasing its porosity) and facilitating water infiltration and storage, as well as soil aeration and root penetration. With the eventual development of machinery and extension of soil mechanical tillage, it was then possible to increase the ploughing depth. However, the ever-increasing weight of machinery and tractors has resulted in the intensification of mechanical pressure, thus increasing bulk density (reduced porosity) and consequently lower water infiltration and root growth. Additionally, bulk density can also vary with the differing soil structural conditions of terrain, cultivation, trampling by animals, and weather. Soil compaction is a critical component of soil degradation, and the Protocol for the Assessment of Sustainable Soil Management (FAO-ITPS, 2020) recognized bulk density as a key indicator that is recommended to monitor to assess the impact of sustainable soil management practices.

Soil bulk density is an indicator of soil compaction and soil health and is an important factor to consider when assessing the physical behaviour of soils, as it affects infiltration, root depth and restrictions, available water capacity, and soil porosity. Soil porosity controls many soil properties and ecosystem services and is consequently one of the most important soil characteristics. The pore volume can

SOPs harmonized so far

Already published:

- 1 on sample pre-treatment
- 17 on soil chemical parameters (7 more ongoing)
- 2 on soil physical parameter (4 more ongoing)
- 1 on soil biological parameter (6 more ongoing)

	2019	2020	2021	2022
Chemical	**OC Walkley and Black, TC Dumas, Calcium carbonate eq. (titrimetric and volumetric calcimeter methods)**	**Phosphorus (Bray I, Bray II, Olsen, Mehlich I), pH, electrical conductivity (in water and in saturated paste), nitrogen (Dumas, Kjeldah), carbon (Tyurin)**	Particulate organic carbon (physical fractionation), **Quasi-total elements (digestion using aqua regia and EPA), Exchangeable bases and CEC (ammonium acetate), available micronutrients (extraction using DTPA),** Boron (hot water extraction), Mehlich III for macro and micronutrients (including S and B)	Organic matter (loss of ignition), Available phosphorus (KCl), Exchangeable acidity + Exchangeable Al (KCl), Soil buffer capacity (KOH), Fe and Al oxides (ammonium oxalate)
Physical			Particle size-distribution (hydrometer, pipette**), bulk density, moisture content (gravimetric method)**	Water retention (pF) curve, Particle density (pycnometer)
Biological			Microbial biomass C and N by chloroform fumigation-extraction, **soil respiration**	Microbial Enzyme Activities (B-Glucosidase, Arylsulfatase, Dehydrogenase), N Mineralization (incubation method), Nematodes trophic groups (wet extraction), QBSar (mesofauna), ISO-TSBF (megafauna)

Year of proposal	SOP	Status
2021	Particulate organic carbon (physical fractionation)	Under review
2021	Boron (hot water extraction	Under publication
2021	Mehlich III for macro and micronutrients (including S and B)	Some issues with the development of the text
2021	Particle size-distribution (hydrometer, pipette) *[include a focus on salt-affected soils]*	Text ready, to be reviewed
2021	Microbial biomass C and N by chloroform fumigation-extraction	Under review

Year of proposal	SOP	Status
2022	Organic matter (loss of ignition)	Inputs collected. Matrix to be converted into a text
2022	Available phosphorus (KCl)	Finalization of the matrix
2022	Exchangeable acidity + Exchangeable Al (KCl)	Still to develop the matrix
2022	Soil buffer capacity (KOH)	Still to develop the matrix
2022	Fe and Al oxides (ammonium oxalate)	Still to develop the matrix

Year of proposal	SOP	Status
2022	Water retention (pF) curve	Matrix finalized, to be shared
2022	Particle density (pycnometer)	Matrix finalized, to be shared
2022	Microbial Enzyme Activities (B-Glucosidase, Arylsulfatase, Dehydrogenase)	Text ready, under review
2022	N Mineralization (incubation method)	Still to be properly stared
2022	Nematodes trophic groups (wet extraction)	Matrix to be finalized and converted into a text
2022	QBSar (mesofauna)	Matrix received, to be converted into a text
2022	ISO-TSBF (megafauna)	To be started, problems with copyright

Year of proposal	SOP	Status
2023	Exchangeable acidity by BaCl2	To be started
2023	A general multi-element suite of potentially toxic elements (PTEs). Option to review the SOP on Quasi-total elements (digestion using aqua regia and EPA) to include As *To be discussed with INSOP*	To be started
2023	Aggregate stability by Le Bissonais	To be started
2023	Textural determination by laser diffraction	To be started
2023	Greenhouse gases (GHGs) emissions in soil	To be started
2023	DNA extraction	To be started

Proposals from the Regional Network (RESOLANs):

- **Translation** of the GLOSOLAN SOPs in the UN official languages (starting from French, Spanish and Portuguese)
- Focus more on the **review** of GLOSOLAN SOPs (Walkley and Black, EC, etc., with the support of the other GSP Technical Networks)
  →include validation data

- **New** SOPs?
  Proposals from SEALNET:
  - Saturated hydraulic conductivity (constant head method)
  - Alternate methods to those already harmonized

  Proposal from other GSP Technical Networks:
  - Total Soluble Salts
  - Exchangeable Sodium Percentage
  - Sodium Adsorption Ratio

Food and Agriculture Organization of the United Nations

GLOSOLAN

GLOBAL SOIL LABORATORY NETWORK

GLOBAL SOIL PARTNERSHIP