

Standard operating procedure for saturated soil paste extract

Prof. Marija Romić, PhD, Global leader

University of Zagreb Faculty of Agriculture

Zagreb, Croatia

Dr. Riham Zahalan & Dr. Manhal AL-Zoubi

Syrian General Commission for Scientific Agricultural Research –
GCSAR, Syria



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Standard operating procedure for saturated soil paste extract

The GLOSOLAN training

Prof. Marija Romić, PhD, Global leader
University of Zagreb Faculty of Agriculture
Analytical laboratory MELILAB, Head
Zagreb, Croatia, mromic@agr.hr

Dr. Riham Zahalan & Dr. Manhal AL-Zoubi
Syrian General Commission for Scientific Agricultural Research – GCSAR, Syria

Video: Filip Kranjčec, B.Sc.
Benjamin Atlija, B.Sc.
MELILAB University of Zagreb Faculty of Agriculture
Zagreb, Croatia

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University of Zagreb Faculty of Agriculture Analytical laboratory of the Department of Soil Amelioration, Zagreb, Croatia **MELILAB**

Soil physical analysis

- soil particle size analysis, soil porosity, soil air capacity, bulk density, aggregate stability

Soil chemical analysis

- determination of soil pH, soil electrical conductivity, dry matter and water content on a mass basis, soil carbonate, the ionic composition of saturated soil water extract, organic and total carbon, total nitrogen, available phosphorus and potassium, extraction and determination of aqua regia soluble elements (Al, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, V, Zn)

Water analysis

- determination of pH, electrical conductivity
- determination of the ionic composition: Ca^{2+} , Mg^{2+} , HCO_3^- , Cl^- , K^+ , Na^+ , NH_4^+ , NO_3^- , SO_4^{2-} , PO_4^{3-}

Plant material analysis

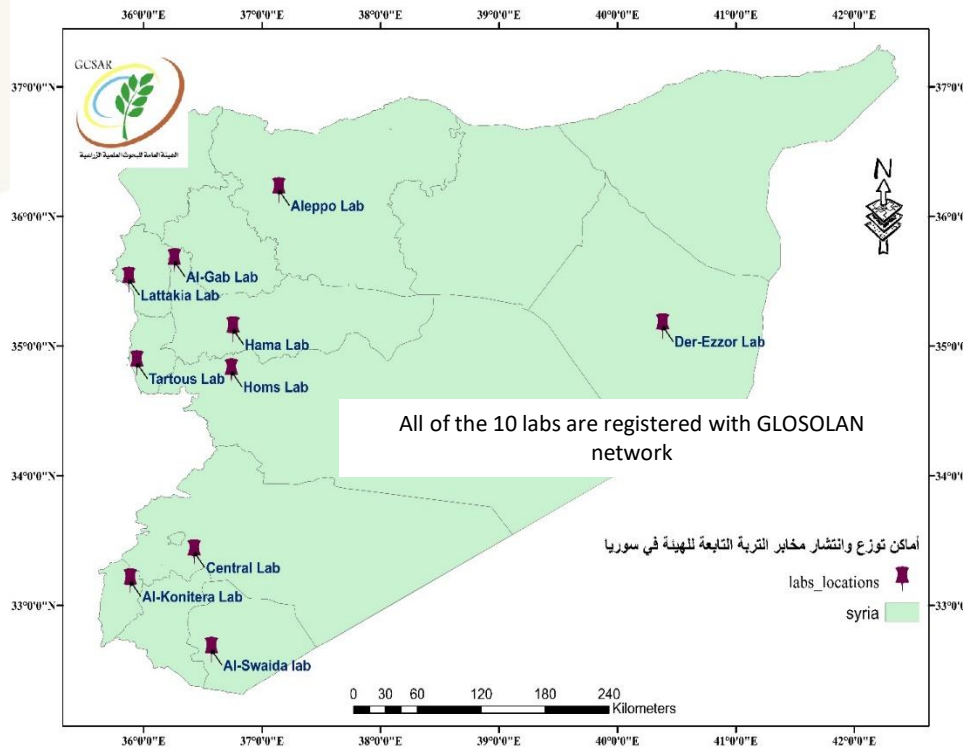
- determination of dry matter and water content on a mass basis
- determination of mineral element composition: P, K, Cl, Ca, Mg, Cu, Zn, Mn, Fe, Na, S, Mo, Cd, Hg



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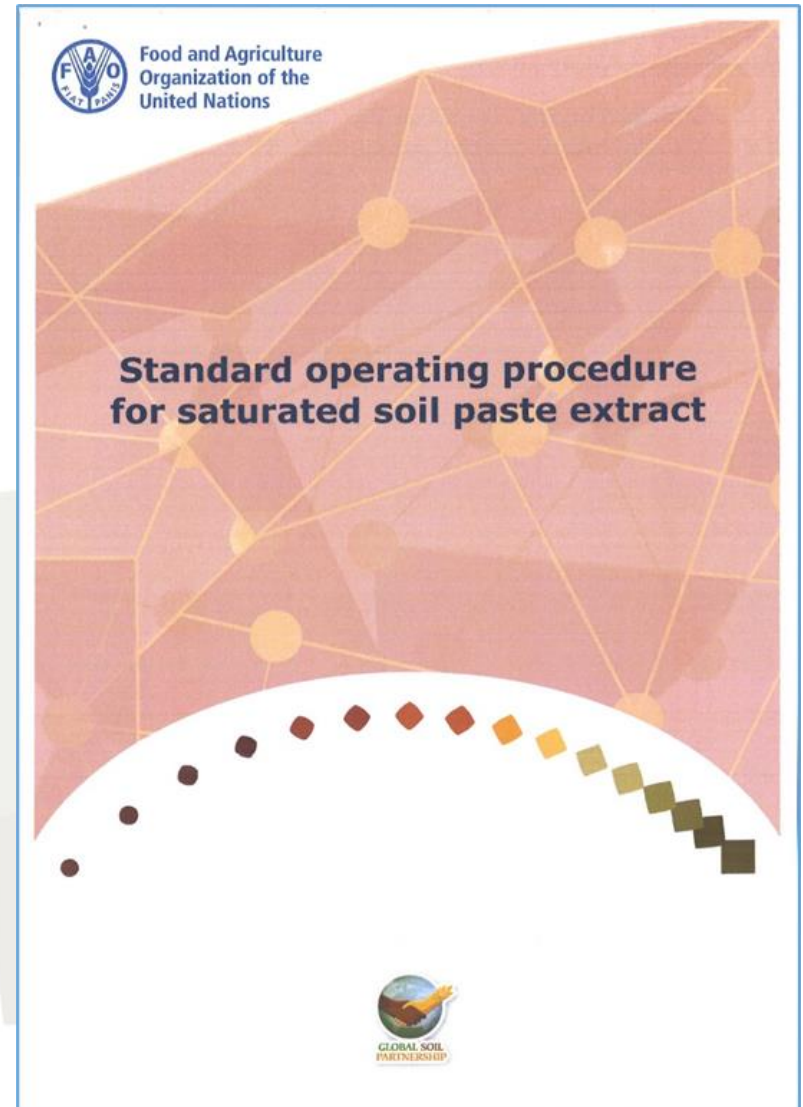


- Soil physical analysis
- Soil chemical analysis
- Water analysis
- Plant analysis
- Fertilizer analysis



Training outline

- Introduction
- Scope and field of application
- Principles of the method
- Sample preparation and procedure description
- Equipment/apparatus/material
- Calculation
- Quality assurance/Quality control
- Health and safety issues
- **Video**
- Conclusions and further analysis



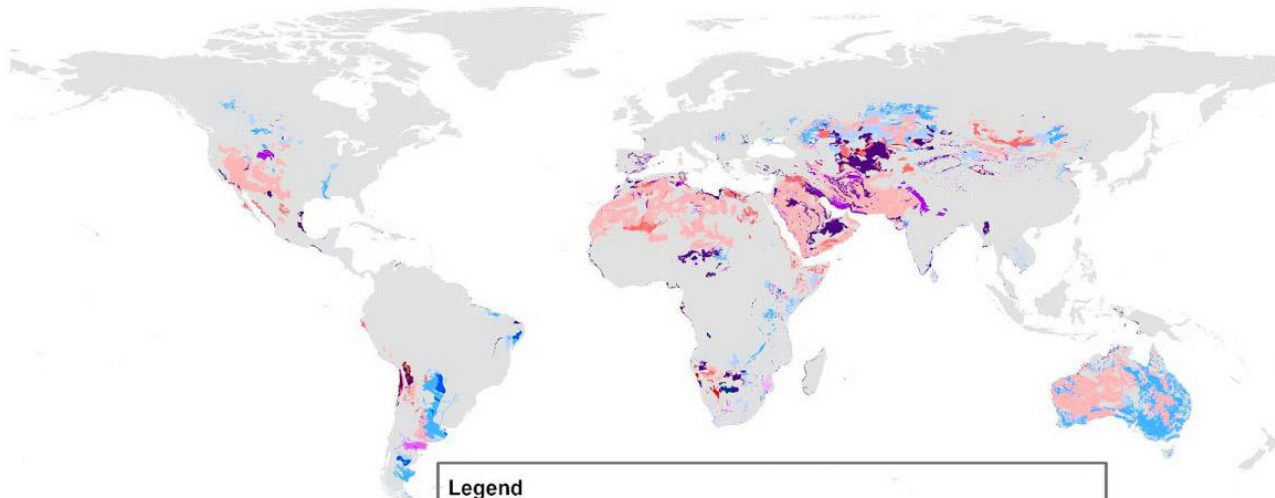
<http://www.fao.org/3/cb3355en/cb3355en.pdf>

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Introduction

- One of the most serious and persistent problem over the history of agriculture, in so many of the drier regions of the world where human civilizations have arisen, has been salinity.
- Worldwide, soil salinization and alkalization have been identified as major threats to the quality and availability of the land resources.
- According to FAO sources more than 800 million ha of land are salt affected (6 % of the world's total land area), covering a range of soils defined as saline, saline-sodic and sodic. Furthermore, nearly 20 % of 230 million hectares of irrigated land are salinized in a certain degree.



Legend		
Type and severity levels of salt-affected soils		
saline slight	sodic slight	saline-sodic slight
saline moderate	sodic moderate	saline-sodic moderate
saline high	sodic high	saline-sodic high
saline extreme	sodic extreme	saline-sodic extreme

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Introduction

Why it is important to measure EC and monitor its value?

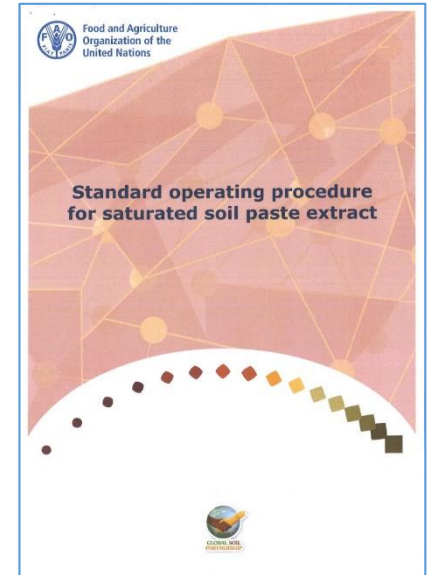
- Salinization severely limits crop growth, reduces yield and causes plant stress. Therefore, soil salinity interpretation is essential to develop and apply sustainable agricultural management and suitable irrigation techniques in semiarid and arid environments.
- Salinity is a soil condition characterized by a high concentration of soluble salts, generally defined as one in which the electrical conductivity (EC) of saturate soil paste extract (EC_e) in the root zone exceeds 4 dS m^{-1} at $25 \text{ }^\circ\text{C}$



Introduction

What's the main purpose of applying this method?

- Soil saturated paste extract (SPE) electrical conductivity (EC_e) is widely used measure of soluble salts to evaluate the salinity hazard to crop growth and the sodicity hazard to soil permeability.
- This is a simple and accurate manual method but requires a trained technician to ensure the proper amount of water is added.
- The method requires a larger amount of soil sample compared to the other chemical soil analysis, and the procedure takes over 24 hours.
- Soil texture is a parameter that greatly influences the performance of this soil testing method, and consequently the result.
- Over a wide soil textural range, the saturation percentage (SP) is approximately twice the Field Capacity (FC) or -33 kPa soil water potential and is four times the Permanent Wilting Point (PWP) or -1500 kPa soil water potential for soils of loam, to clay loam texture.



<http://www.fao.org/3/cb3355en/cb3355en.pdf>

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Starting points

- This soil:water ratio is used because it is the lowest reproducible ratio for which enough extract for analysis can be readily removed from the soil with common laboratory equipment (pressure or vacuum)
- This ratio is often related in a predictable manner to the field soil:water content.
- Soil solutions obtained at lower soil moisture conditions are more labor intensive and require special equipment.
- This extract is used in a series of chemical analyses, e.g., EC and concentration of major solutes.

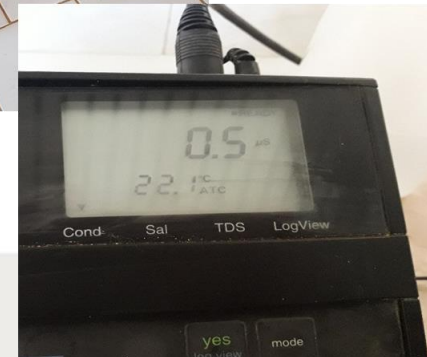
Scope and field of application

- **Saturated Paste Extract** is the standard method for determining the amount of salt in soil.
- The saturated paste is a particular mixture of soil and water, and when preparing a saturated paste, an aqueous extract is obtained.
- This extract is used in a series of chemical analyses, e.g. EC_e and concentration of major solutes, i.e., Na^+ , Ca^{2+} , Mg^{2+} , K^+ , Cl^- , SO_4^{2-} , HCO_3^- , CO_3^{2-} , NO_3^- , etc.
- Furthermore, **Saturated Paste Extract** is used to estimate other important parameters, such as Sodium Adsorption Ratio (SAR) which also predicts the Exchangeable Sodium Percentage (ESP).

Therefore, the main aim of this SOP is preparing saturated soil paste for measuring electrical conductivity (EC_e) and soluble salts of a soil from a saturated paste extract.

Principles

- A saturated paste is prepared and allowed to stand for a period of time, not exceeding 24 hours.
- The extract is obtained using a vacuum pump/mechanical vacuum extractor.
- The electrical conductivity of the saturated paste extract (EC_e) is determined using a conductivity meter and is expressed in $dS\ m^{-1}$.



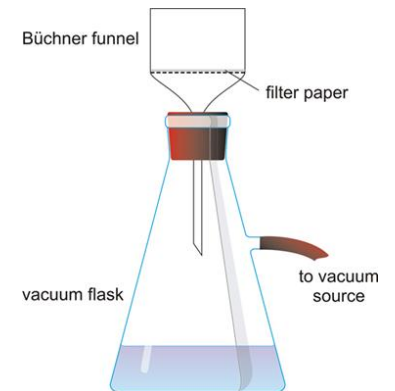
Preparation of Saturated Soil Paste

Equipment/apparatus

- Balance, readable and accurate to 0.1 g
- Beakers, ceramic dishes
- Spatula or mixing spoons
- Vacuum pump/mechanical vacuum extractor
- Buchner funnel/ cups for the extractor
- Filter papers, Whatman no. 42, 44
- Receiving tube, syringes or small bottle to collect the filtrate
- Measuring cylinder/burette



For preparing the saturated paste



For getting the soil extract from the saturated paste



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Equipment



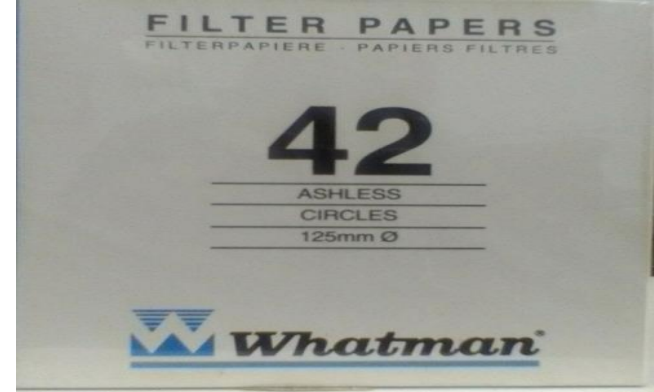
Glass stir stick



Spatula



Measuring cylinder



Filter papers, Whatman no.

42, 44
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Equipment

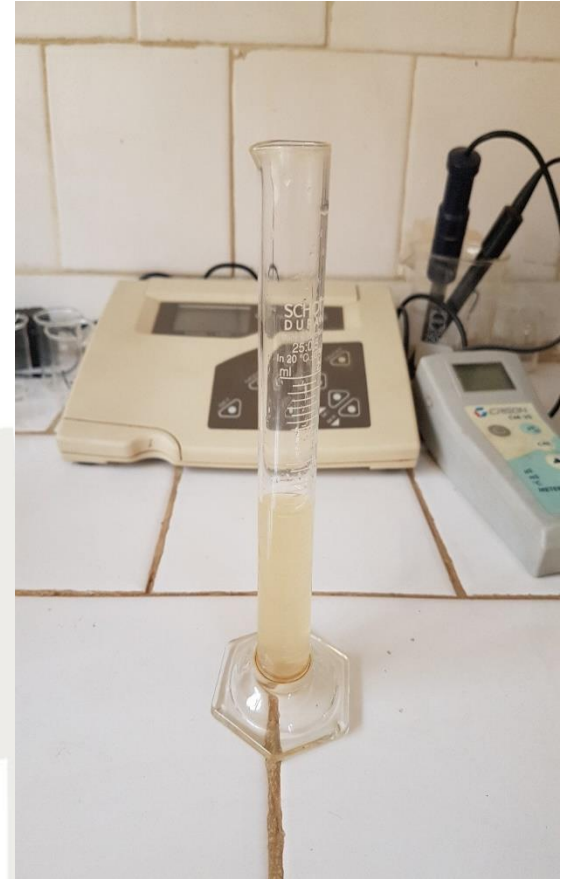
Vacuum pump



Buchner funnel



Cups for the extractor



Receiving tube

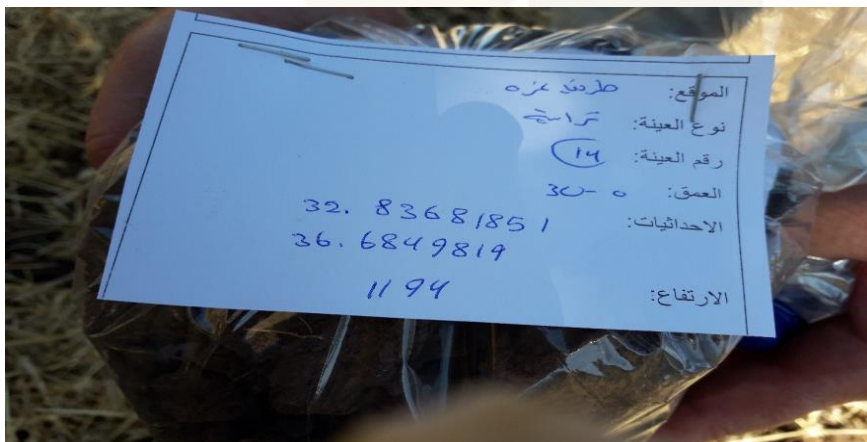
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Materials

- Soil samples are air-dried, ground and homogenized to pass through a 2 mm sieve. Sieved samples are stored in glass bottles.

1-Collecting sample



2-Drying the sample



3- Grinding and Sieving



4-Saving the sample

Materials

- Deionized water/distilled water, it should have an EC < 0.001 dS m^{-1} (ASTM D1193-91 and ISO 3696:1987).
- Sieved samples are stored in glass bottles, paper boxes or plastic bottles.



Sample label



Data/information

Preparation of Saturated Soil Paste

Soil samples

Basic soil properties

Sample ID	Soil profile	Depth cm	Particle size analysis (mm)					Macroaggregate stability	Ca	K	Mg	Na	CEC
			2 - 0.2	0.2 - 0.05	0.05- 0.02	0.02 - 0.002	<0.002						
121141	P - 1	0-25	2	10	15	40	33	highly unstable	34.8	0.77	2.92	0.44	30.6
121142		25-50	2	8	5	47	38		41.7	0.50	2.17	0.44	32.77
121143		50-75	1	2	9	38	50		76.6	0.53	3.74	0.43	42.2
121144		75-100	3	40	30	20	7		9.58	0.11	0.40	0.35	7.90
121149	P - 3	0-25	3	16	23	43	15	highly unstable	25.5	0.51	1.04	0.08	8.24
121150		25-50	5	27	34	25	9		15.5	0.36	1.54	0.30	4.12
121151		50-75	5	34	27	24	10		13.8	0.44	1.83	0.44	3.77
121152		75-100	2	46	29	17	6		9.74	0.46	2.42	0.44	6.78

- The weight of the soil sample may vary depending on the soil texture.
- To obtain a sufficient extract for analysis, more sample should be used (400 g) when the soil has a high content of clay.
- **The more clay that a soil has, the more water it takes to come to saturation.**



Saturated paste appearance vary with the variation of soil type and organic content



Silt %	Clay%	Sand %	OM %	Silt %	Clay%	Sand %	OM %
28	36	36	4	30	42	28	1.4

Preparation of Saturated Soil Paste

Procedure

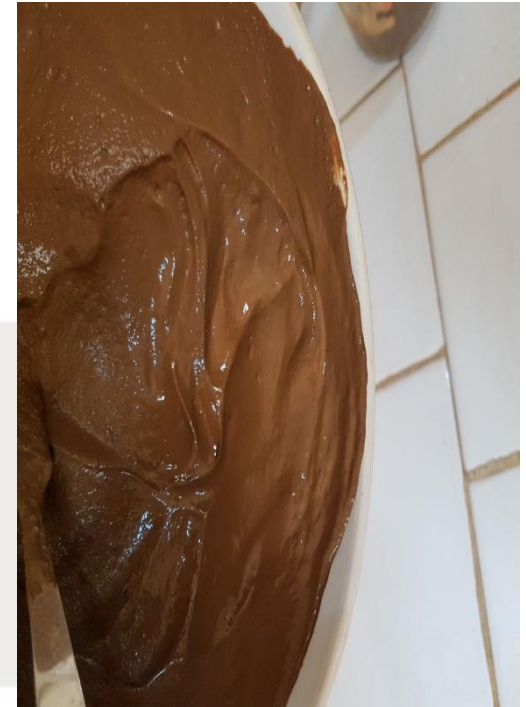
- Weigh 200 g of soil into 500 ml beakers/ceramic dishes.
- Weigh the container plus its content.



Preparation of Saturated Soil Paste

Procedure

- Slowly add distilled water while stirring and mixing with spatula until saturated paste is achieved. The soil paste glistens as it reflects light, flows slightly when container is tipped, and slides freely and cleanly from spatula unless the soil has a high clay content.



Preparation of Saturated Soil Paste Procedure

- The soil paste glistens as it reflects light, flows slightly when the container is tipped, and slides freely and cleanly from the spatula unless the soil has a high clay content.
- Consolidate easily by tapping or jarring the container after forming a trench in the paste with the slide of the spatula.

Preparation of Saturated Soil Paste Procedure

- Allow paste to stand for 1 to 2 hrs and then recheck criteria for saturation. If necessary, add more water or soil.
- Allow paste to stand for 24 hrs.



- Place extraction cups into the mechanical extractor and connect the syringes with connection tubes.

- Put filter paper in cups and moisten with distilled/ deionised water

1- choosing the size of Buchner funnel



2- Adding the filter paper



3- Moisturizing the edges



4- Connecting with the system



- Transfer saturated soil paste into cups. Carefully smooth paste over filter paper with spatula. Paste should cover bottom of cup completely to depth of at least 1.3 cm.

1- Ideal saturated paste



3- spreading the soil paste on the filtering paper



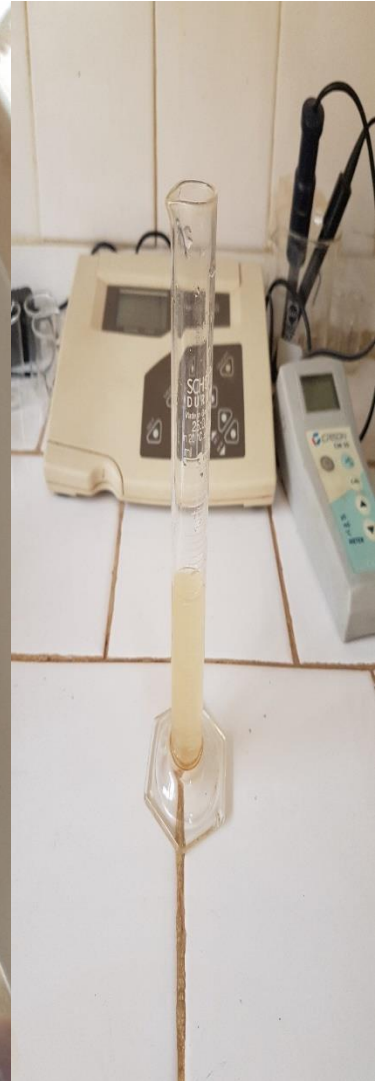
2- Moving the soil past to the funnel



4- connecting with extractor



- Set extractor to 1-hour extraction time and start extractor.



Disconnect apparatus and transfer contents in the syringes into test tube.

- Sample is ready for further analysis.



Further analysis

1- We can use the soil extract from soil saturated paste to measure electrical conductivity (EC), calculate the soil total content of dissolved salts (TDS) and sodium adsorption ratio (SAR).

2- We can use the soil extract from soil saturated paste to measure the soil content of several nutritional elements :

Na^+ , Ca^{2+} , Mg^{2+} , K^+ , Cl^- , SO_4^{2-} , HCO_3^- , CO_3^{2-} , NO_3^- , etc.

Characteristics of identical saturated soil paste



1 - The soil paste glistens as it reflects light



2 - flows slightly when the container is tipped



3 - slides freely and cleanly from a spatula unless the soil has a high clay content

Calculation

- The moisture content of a saturated paste indicates the amount of water needed to saturate 100 gr of soil. The saturation ml/100 g (or gr/100gr) must be indicated.
- Upon reaching saturation, the container and its contents are weighed.
- The difference in weight is used to determine the amount of water added, assuming that 1 g of water is equal to 1 ml.
- The moisture content of saturation is calculated as follows:

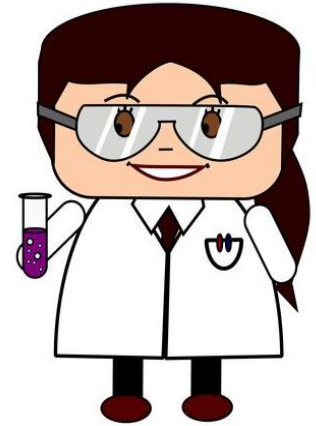
$$SP = (\text{weight of water added (gr)} / \text{weight of soil (gr)}) * 100$$

From/to	dS/m	mS/m	μS/m	mS/cm	μS/cm	TDI mg/L	Meq/L
dS/m	1	100	100,000	1	1,000	667	10
mS/m	0.01	1	1,000	0.01	10	6.7	0.1
μS/m	0.00001	0.001	1	0.00001	0.01	0.0067	0.0001
mS/cm	1	100	100,000	1	1,000	667	10
μS/cm	0.001	0.1	100	0.001	1	0.67	0.01
TDI mg/L	0.0015	0.15	150	0.0015	1.5	1	0.015
Meq/L	0.1	10	10,000	0.1	100	66.7	1

TDI total dissolved ions (note conversion is approx and based on the composition of seawater), *Meq/L* milliequivalent per Liter

Health and safety

- No significant hazards are associated with this procedure but employ the personal protection elements required for the analytical determination. Since no chemicals are involved in the process (soil and distilled water only). But:
- Several new studies have mentioned the possibility of getting infected when dealing with soil (at field /at lab) due to the direct human skin contact. In particular when dealing with soil samples from polluted areas or from fields irrigated or fertilized with gray or sewage water, for example.
- Therefore, gloves and lab coats must be worn when performing this analysis.



Quality assurance/Quality control

- Reference material is used when measuring electrical conductivity.



- Electrical conductivity increases at approximately 1.9 % per degree centigrade increase in temperature
- EC meter is standardized, and results expressed at a reference temperature for purposes of comparison and accurate salinity interpretations.
- The commonly used reference temperature is 25 °C.



Some common mistakes usually done in the lab



1- Adding plenty of water (over saturated)

2- Splattered edges (losing an amount of the soil then the extract)



3- Forget to record the consumed amount of water



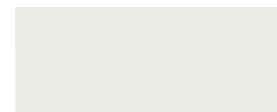
4- very thick structure
(less than saturation
limit)



5- too small amount
of soil



6- small size of filter paper or improperly placed



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Conclusions and further analysis

- The saturation extract, the traditionally used method, reflects the composition of the soil solution, which is the ionic medium in which plant roots develop.
- Although results for pH measurements are similar for the different techniques, results for EC are greatly dependent on which method is used.

The most common techniques are the saturated paste extraction method.

Electrical conductivity (EC)

- The measurement of conductivity is a widely used, rapid and inexpensive way of determining the ionic strength of a solution.
- However, this technique is nonspecific, which means that is unable to distinguish between different types of ions
- It gives instead a reading that is proportional to the combined effect of all the ions present.

Conclusions and further analysis

- Soil salinity may be determined in the laboratory by measuring the
 - electrical conductivity (EC) of soil water extracts,
 - soluble ion concentrations of soil water extracts,
 - mass of total dissolved solids (TDS),
 - total dissolved ions (TDI).



Questions and discussion

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Thank you for your interest in attending this training!



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