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Standard operating procedure for saturated soil paste extract



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SATURATED SOIL PASTE EXTRACT

VERSION HISTORY

N°	Date	Description of the modification	Type of modification
01	16 December 2020	All comments by RESOLANs and reviewers to the draft SOP were addressed	Finalization of the SOP
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1. Brief introduction

Worldwide, soil salinization and alkalization have been identified as major threats to the quality and availability of land resources. According to FAO sources (<http://www.fao.org/soils-portal>), more than 800 million ha of land are affected by salt (6 percent of the world's total land area), covering a range of soils defined as saline, saline-sodic and sodic. Furthermore, almost 20 percent of the 230 million hectares of irrigated land are salinized to a certain degree. Agricultural land in arid and semi-arid regions of the world is particularly affected due to erratic rainfall, high evapotranspiration rates as well as growing competition for fresh water between agriculture, urban needs, and industrial use. Most salt-affected land arises from natural phenomena, such as weathering of parental rocks that release soluble salts, salt deposition by wind and rain, capillary rise from groundwater, seawater intrusion or limited provision for field drainage. Secondary salinization is the result of improper agricultural practices, mostly irrigation-related, when salts added by (saline) irrigation water accumulate because of insufficient leaching or limited provision for field drainage.

Salt-affected soils severely limit crop growth, reduce yield, and cause plant stress and soil structure degradation. Therefore, soil salinity/alkalinity interpretation is essential to develop and apply sustainable agricultural practice 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 °C (Richards, 1954). Sodic soils are those with a percentage of exchangeable sodium (ESP) greater than 15. Because of the considerable experimental errors involved in ESP determination, emphasis has been placed on using the sodium adsorption ratio (SAR) of the equilibrium soil solution instead of the ESP for classification purposes. The electrical conductivity of saturation soil extracts may vary, but usually remains below 4 dS m⁻¹ at 25 °C.

The pH of saturated soil paste in sodic soils is 8.2 or higher, and in extreme cases may exceed 10.5. However, many crops exhibit a yield reduction at a lower EC_e because soil salinity/alkalinity affects a number of morphological, physiological and biochemical processes and water and nutrient or toxic elements uptake (FAO, 2018; Filipovic et al, 2018).

The main aim of this SOP is to prepare a saturated soil paste to measure electrical conductivity (EC_e) and soluble salts of a soil from a saturated paste extract.

2. Scope and field of application

The saturated paste is a particular mixture of soil and water. The soil paste glistens as it reflects light, flows slightly when the container is tipped, and slides freely and cleanly from a spatula, unless the soil has a high clay content. 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) and because this ratio is often predictably related to the soil:water content of the field. Soil solutions obtained at lower soil moisture conditions are more labor intensive and require special equipment. When preparing a saturated paste, an aqueous extract is obtained. This extract is used in a series of chemical analyses, e.g. EC and concentration of major solutes.

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This SOP applies to the preparation of saturated soil paste and the extraction of the liquid phase for the subsequent determination of the electrical conductivity (ECe) and concentrations of dissolved salts in the soil. Further laboratory chemical analyses can be carried out on soil extract samples to determine the electrical conductivity of the extract (ECe), the concentrations of the individual solutes, i.e., Na⁺, Ca²⁺, Mg²⁺, K⁺, Cl⁻, SO₄²⁻, HCO₃⁻, CO₃²⁻, NO₃⁻, etc., and to calculate the SAR of the soil.

3. 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 (ECe) is determined using a conductivity meter and is expressed in dS m⁻¹.

4. Apparatus

- Balance, readable and accurate to 0.1 g
- Vacuum pump/mechanical vacuum extractor
- Beakers
- Buchner funnel/ cups for the extractor
- Receiving tube/ syringes
- Filter papers, Whatman no. 42 , 44
- Spatula
- Measuring cylinder/burette

5. Materials

Deionized water/distilled water, it should have an EC < 0.001 dS m⁻¹ (ASTM D1193-91 and ISO 3696:1987).

6. Health and safety

No significant hazard is associated with this procedure, but the personal protection elements required for analytical determinations are employed.

7. Sample preparation

Soil samples are air-dried, ground and homogenized to pass through a 2 mm sieve. Sieved samples are stored in glass bottles. Samples can also be stored in paper boxes or plastic bottles.

8. Procedure

8.1. Weigh 200 g of soil into 500 ml beakers. The weight of the soil may vary depending on the soil texture. When the soil has a high content of clay, it could be necessary to use more sample (400 g) to obtain a sufficient extract for analysis. Weigh the container plus its content.

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8.2. Slowly add distilled water while stirring and mixing with a spatula until a saturated paste is achieved. 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.

Mix or beat with a spatula to form a homogeneous paste; add more water and beat until the paste has a metallic luster on the surface (it reflects light and slides slowly down the sides of the bottle when tilted).

8.3. Allow the paste to stand for 1 to 2 hours and then check the saturation criteria again. If necessary, add more water or soil. Free water should not accumulate on the soil surface, nor should the paste stiffen markedly or lose its glisten. If the paste is too wet, add dry soil in a known amount (weight) to the paste mixture.

8.4. Allow paste to stand for 24 hours. Once saturation is attained, weigh the container plus its contents. Record the increase in weight to find out the amount of water added.

8.5. Place the extraction cups in the mechanical extractor and connect the syringes with the connection tubes.

8.6. Put filter paper in the cups and moisten with distilled/deionized water.

8.7. Transfer the saturated soil paste into the cups. Carefully smooth the paste over filter paper (with spatula). The paste should completely cover the bottom of the cup to a depth of at least 1.3 cm.

8.8. Apply vacuum and collect the extract in a test tube or bottle. If the initial filtrate is turbid, it should be re-filtered. Finish the filtration when air begins to pass through the filter. Sometimes the extraction process needs to be controlled, if cracks have formed on the soil surface, it should be smoothed with a spatula.

8.9. Sample is ready for further analysis.

9. 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:

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

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10. Quality assurance/Quality control

Reference material is used. Electrical conductivity increases by approximately 1.9 percent per degree centigrade increase in temperature. Therefore, EC meter is standardized, and the results are expressed at a reference temperature for comparison and accurate salinity interpretations. The commonly used reference temperature is 25 °C.

11. References

FAO. 2018. *Handbook for saline soil management*. Editors: R. Vargas, E.I. Pankova, S.A. Balyuk, P.V. Krasilnikov and G.M. Khasankhanova. ISBN 978-92-5-130141-8

Filipovic, L., Romic, M., Romic, D., Filipovic, V., Ondrasek, G. 2018. Organic matter and salinity modify cadmium soil (phyto)availability. *Ecotoxicology and Environmental Safety*, 147: 824-831.

Rhoades, J.D., Chanduvi, F., & Lesch, S. 1999. *Soil salinity assessment: Methods and interpretation of electrical conductivity measurement*. Food and Agriculture Organization of the United Nations, Rome, Italy, pp. 1-150.

Richards, L.A. (ed.). 1954. *Diagnosis and Improvement of Saline and Alkali Soils*. U.S. Department of Agriculture Handbook 60. U.S. Gov. Printing Office, Washington, DC.

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Appendix I – Acknowledgments

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Appendix II - List of authors

Leading author:

- Ms. Marija Romic, University of Zagreb Faculty of Agriculture, Analytical Laboratory of the Department of Soil Amelioration, **Croatia**

Main authors (in alphabetical order):

- Mr. Jorge Alberto Sánchez Espinosa, GIT Laboratorio Nacional de Suelos, **Colombia**
- Ms. Lesego Mooketsi-Selepe, Soil and Plant Analytical Laboratory, **Botswana**
- Mr. Rob de Hayr, Department of Environment and Science, Science Division, Chemistry Centre, **Australia**

Members of the Review Panel (in alphabetical order):

- Mr. Karim Shahbazi, Soil and Water Research Institute laboratory, **Islamic Republic of Iran**
- Ms. Marija Romic, University of Zagreb Faculty of Agriculture, Analytical Laboratory of the Department of Soil Amelioration, **Croatia**
- Mr. Wobbe Schuurmans, Chemisch Biologisch Laboratorium Bodem (Wageningen University), **Netherlands**

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Appendix III - Contributing laboratories

GLOSOLAN thanks the following laboratories for completing the GLOSOLAN form on the method and providing information on their standard operating procedure for saturated soil paste extract, which were used as baseline for doing the global harmonization:

From the Asian region:

- Laboratory Services Division, Bureau of Soils And Water Management, **Philippines**
- Laboratory of Soil Science, Department of Plant and Soil Sciences, Faculty of Agriculture, Chiang Mai University, **Thailand**
- Department of soil science, Faculty of Agriculture, Kasetsart University, Kamphaeng Sean Campus, **Thailand**

From the Pacific region:

- None

From the Near East and North African region:

- Soil and Fertilizer, Directorate of plant Wealth, Ministry of Works, Muncipalities & Urban Planning, **Bahrain**
- KIMIA AB environmental and agricultural consulting laboratory, **Islamic Republic of Iran**
- Soil and Water Research Institute, **Islamic Republic of Iran**
- Ministry of Science and Technology, Directorate of Agricultural Researches, Soil and Water Resources Centre, **Iraq**
- Soil Lab, National Agricultural Research Center, **Jordan**
- Soil Chemistry Laboratory, Kuwait Institute for Scientific Research, **Kuwait**
- General commission for scientific agricultural research (GCSAR), **Syrian Arab Republic**
- Soil Analysis laboratories Unit, **Sudan**
- Natural Ressources/ Land Use, Conservation and production Administration Central Laboratory, **Sudan**

From the African region:

- Soil and Plant Analytical Laboratory, Department of Agricultural Research, **Botswana**
- Centre d'Etude et de Recherche de Djibouti, Laboratoire de Pédologie, **Djibouti**
- Zambia Agriculture Research Institute, **Zambia**
- Fertilizers Seed and Grain, **Zimbabwe**

From the European region:

- MELILAB, Analytical laboratory of the Department of Soil Amelioration, University of Zagreb, Faculty of Agriculture, Department of Soil Amelioration, **Croatia**
- Soil Fertilizer and Water Resources Central Research Institute, **Turkey**

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From the Eurasian region:

- None

From the Latin America region:

- Laboratorio de Suelos, Foliare y Aguas, Agencia de Regulación y Control Fito y Zoonitario. AGROCALIDAD, **Ecuador**
- Colegio de Postgraduados, LABFER-CPM, **Mexico**
- Colegio de Postgraduados, **Mexico**
- Laboratorio de Fertilidad de suelos y Agua (IDIAP), Instituto de Investigación Agropecuaria de Panamá, **Panama**
- Laboratorio de Suelos y Aguas de la DGRN – MGAP, Ministerio de Ganadería Agricultura y Pesca, **Uruguay**

From the North American region:

- Kellogg Soil Survey Laboratory, **United States of America**

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