



Environmental Analysis Program

Pomona College
Biogeochemistry Laboratory

SOP-L406

Soil Organic Matter – Loss on Ignition

Standard Operating Procedure

SOP Number	SOP-L406
Revision	1.1
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Date	2026-06-26
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1. Purpose

This SOP describes the estimation of soil organic matter (SOM) content using the loss-on-ignition (LOI) method. SOM is quantified by measuring the mass lost when oven-dried soil is combusted at 550 °C in a muffle furnace (Heiri et al., 2001; Nelson & Sommers, 1996).

2. Scope

- **Applies to:** Air-dried, sieved soil samples collected per [SOP-F400 Soil Sampling and Processing](#).
- **Does not apply to:** Soils with high calcium carbonate content (CaCO_3 decomposes above $\sim 450^\circ\text{C}$ and may inflate LOI values; consider an alternative method such as elemental analysis for calcareous soils (Heiri et al., 2001)).
- **Location:** EA Program laboratory, SGM 133.

3. Definitions

- **Ash-free dry mass (AFDM):** The mass remaining after removing water (drying at 105°C) and organic matter (igniting at 550°C); equivalent to the inorganic mineral mass of the sample.
- **Crucible:** A heat-resistant porcelain or ceramic container used to hold soil samples during furnace ignition; must be pre-ignited and weighed to constant mass before use.
- **Inorganic carbon (IC):** Carbon associated with carbonates (CaCO_3 , MgCO_3); released as CO_2 during ignition above $\sim 550^\circ\text{C}$; can inflate LOI values in calcareous soils if ignition temperature is not controlled or if acid pre-treatment is omitted (Heiri et al., 2001).
- **Loss on ignition (LOI):** The percentage mass loss when an oven-dried soil is ignited at 550°C for 4 hours: $\text{LOI} = (M_{105} - M_{550})/M_{105} \times 100$; used as a proxy for SOM content (Heiri et al., 2001).
- **Soil organic matter (SOM):** The organic fraction of soil, including plant and animal residues at various stages of decomposition, microbial biomass, and stabilized humus; estimated by LOI as approximately $\text{SOM} \approx 1.72 \times \text{LOI}$ (the Van Bemmelen factor) when organic carbon is the target (Nelson & Sommers, 1996).
- **Tare mass:** The pre-weighed mass of the empty, pre-ignited crucible; subtracted from all subsequent measurements to obtain sample mass.
- **Van Bemmelen factor:** The empirical conversion factor (1.724) relating organic carbon content to SOM by assuming that SOM contains 58% carbon by mass; use with caution for soils with unusual organic matter composition (Nelson & Sommers, 1996).

4. Responsibilities

Role	Responsibility
Lab PI	Approve protocol, ensure training compliance
Trained Personnel	Perform analysis, record and report results
New Students	Complete training before independent use

5. Safety and Hazards

Hazards

- **Thermal:** Muffle furnace operates at 550 °C; severe burn risk. Drying oven operates at 105 °C. Ceramic crucibles remain extremely hot for many minutes after removal from the furnace.
- **Physical:** Crucible tongs can slip; always use two hands when moving hot crucibles.

5.1. Required PPE

- ☐ Safety glasses
- ☐ Laboratory coat
- ☐ Heat-resistant gloves (mandatory when handling furnace-hot crucibles)

5.2. Emergency Procedures

Refer to [SOP-L002 Laboratory Safety](#) and [SOP-L111 Muffle Furnace](#). For burns, cool with running water for at least 10 minutes and seek medical attention.

6. Equipment and Materials

6.1. Equipment

Item	Notes
Muffle furnace	Capable of 550 ±10 °C; programmable ramp preferred
Drying oven	Regulated at 105 ±2 °C
Analytical balance	Resolution 0.0001 g (0.1 mg)
Desiccator	With active color-indicating silica gel
Crucible tongs	Heat-resistant; long-handled

6.2. Consumables

Item	Notes
Porcelain or ceramic crucibles	Pre-ignited to constant mass
Weighing paper or spatulas	For soil transfer

7. Procedure

7.1. Crucible Preparation

1. Pre-ignite crucibles in the muffle furnace at 550 °C for at least 1 hour to remove any residual organic matter.
2. Transfer to a desiccator and cool to room temperature.
3. Weigh each crucible to the nearest 0.0001 g and record as the tare mass (W_{crucible}).

7.2. Oven Drying at 105 °C

1. Using a spatula, transfer 5–10 g of air-dried, sieved soil into a pre-weighed crucible.
2. Record the mass of crucible plus moist or air-dry soil.
3. Place uncovered crucibles in the drying oven at 105 °C for at least 24 hours.
4. Transfer crucibles to a desiccator and cool to room temperature (approximately 20–30 minutes).
5. Weigh to the nearest 0.0001 g and record as W_{105} (mass of oven-dried soil only, i.e., crucible + dry soil mass minus crucible tare).

7.3. Combustion at 550 °C

1. Transfer the crucibles containing oven-dried soil directly into the muffle furnace (Heiri et al., 2001).
2. Ramp the furnace to 550 °C (if programmable, use a ramp rate of approximately 10 °C per minute to prevent crucible cracking and reduce convective loss of fine particles).
3. Hold at 550 °C for 4 hours (Heiri et al., 2001).
4. Turn off the furnace and allow crucibles to cool inside the furnace until they can be safely transferred (below approximately 200 °C).
5. Transfer crucibles to a desiccator and cool to room temperature.
6. Weigh to the nearest 0.0001 g and record as W_{550} (mass of combusted soil, excluding crucible).

7.4. Calculation

Soil organic matter content is calculated as (Heiri et al., 2001):

$$\text{SOM (\%)} = \left(\frac{W_{105} - W_{550}}{W_{105}} \right) \times 100$$

where:

- W_{105} = mass of oven-dried soil (g)
- W_{550} = mass of soil after combustion at 550 °C (g)

To convert LOI (%) to approximate organic carbon (%OC), divide by 1.724 (the Van Bemmelen factor); note that this conversion assumes constant elemental composition and is less accurate for samples with unusual organic matter (Nelson & Sommers, 1996).

8. Quality Control

- Run analytical duplicates for at least 10% of samples; coefficient of variation between duplicates should be less than 5% (Heiri et al., 2001).
- Include an empty crucible blank in each furnace run to verify no mass gain from ambient contamination.
- Include a laboratory reference soil with known SOM content in each batch.
- Verify oven (105 °C) and furnace (550 °C) temperatures using a calibrated thermocouple at regular intervals.

9. Waste Disposal

Waste Type	Disposal Method
Combusted soil residue	Standard trash (inert mineral ash)
Crucibles	Clean and reuse

10. References

- Heiri et al. (2001)
- Nelson & Sommers (1996)
- [SOP-L002 Laboratory Safety](#)
- [SOP-L111 Muffle Furnace](#)

Heiri, O., Lotter, A. F., & Lemcke, G. (2001). Loss on ignition as a method for estimating organic and carbonate content in sediments: Reproducibility and comparability of results. *Journal of Paleolimnology*, 25(1), 101–110. <https://doi.org/10.1023/A:1008119611481>

Nelson, D. W., & Sommers, L. E. (1996). Total carbon, organic carbon, and organic matter. In D. L. Sparks (Ed.), *Methods of soil analysis, part 3: Chemical methods* (pp. 961–1010). Soil Science Society of America. <https://doi.org/10.2136/sssabookser5.3.c34>

11. Related SOPs

SOP	Title	Relationship
L002	Laboratory Safety	General safety framework
L111	Muffle Furnace	Instrument operation
L400	Soil Moisture	Companion moisture determination
L407	Total Carbon	Direct combustion alternative

12. Training Record

Before performing this procedure independently, personnel must:

1. Read this SOP in full
2. Complete [SOP-L111 Muffle Furnace](#) training
3. Demonstrate safe operation of the muffle furnace and drying oven
4. Demonstrate proper use of the analytical balance and desiccator
5. Perform the procedure under supervision with acceptable duplicate precision
6. Be signed off by the PI or lab manager