



Environmental Analysis Program

Pomona College
Biogeochemistry Laboratory

SOP-L300

pH and Conductivity – Bench-Top Measurements

Standard Operating Procedure

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1. Purpose

This procedure describes bench-top measurement of pH and specific conductance (conductivity) in water samples, soil extracts, and other aqueous solutions using a laboratory pH/conductivity meter. Accurate pH and conductivity measurements are fundamental to water quality assessment and are referenced by multiple analytical SOPs throughout the EA Program (APHA et al., 2012; Eaton et al., 2005).

2. Scope

- **Applies to:** Bench-top pH and specific conductance measurements on surface water, ground-water, wastewater, soil-water extracts (e.g., 1:1 or 1:5 soil slurries), KCl extracts (see [SOP-L403](#)), and reagent solutions
- **Does not apply to:** Field measurements using portable multiprobes (see [SOP-F200 Eureka Manta2](#)); continuous monitoring or in-situ deployments
- **Location:** EA Program laboratory, SGM 133

3. Responsibilities

Role	Responsibility
Lab PI	Approve SOP, ensure training compliance
Lab Manager	Maintain meter and electrodes, stock buffer solutions
Trained Personnel	Calibrate meter before each session, measure and record results
New Students	Complete training before independent use

4. Definitions

- **Buffer solution:** A solution that resists changes in pH upon addition of small amounts of acid or base; used to calibrate pH electrodes; standard buffers are pH 4.00, 7.00, and 10.01 at 25 °C.
- **Calibration slope:** The millivolt change per pH unit measured during two-point calibration; theoretical value is -59.16 mV/pH at 25 °C (Nernst equation); acceptable range is 90–102% of theoretical.
- **Conductivity:** A measure of a solution's ability to conduct electrical current, expressed in $\mu\text{S}/\text{cm}$ or mS/cm ; proportional to the concentration of dissolved ions; temperature-dependent.
- **Junction potential:** A small voltage that develops at the reference electrode junction where two solutions of different composition meet; a source of measurement error that is minimized by proper electrode storage and frequent replacement of the reference filling solution.
- **pH:** The negative base-10 logarithm of the hydrogen ion activity: $\text{pH} = -\log_{10}[H^+]$; measured potentiometrically using a glass electrode and a reference electrode.
- **Specific conductance:** Conductivity corrected to a reference temperature of 25 °C; allows comparison of measurements made at different temperatures.

- **Temperature compensation:** Automatic adjustment of conductivity readings to 25 °C using a built-in thermistor; essential for accurate comparisons because conductivity changes approximately 2% per °C.

5. Safety and Hazards

Hazards

- **Chemical:** pH buffer solutions (pH 4, 7, 10) are mild irritants. Conductivity standards contain dissolved salts. KCl electrode fill solution is a mild irritant. Acidic or alkaline samples may cause skin or eye irritation.
- **Electrical:** Keep the meter and power supply away from water spills on the bench.

5.1. Required PPE

- ☐ Nitrile gloves
- ☐ Safety glasses
- ☐ Lab coat

5.2. Emergency Procedures

For buffer or sample splashes to eyes, flush with water at the eyewash station for at least 15 minutes. For skin contact, wash with soap and water. Refer to [SOP-L002 Laboratory Safety](#).

6. Equipment and Materials

6.1. Equipment

Item	Location	Notes
pH/conductivity meter	Lab bench, SGM 133	<i>TBD – confirm model (e.g., Accumet AB150, Orion Star, or equivalent)</i>
pH electrode (combination glass)	Stored in pH 4 or KCl storage solution	Replace annually or when response time degrades
Conductivity cell (2- or 4-electrode)	Stored dry or in DI water	Cell constant typically 1.0 cm ⁻¹
Magnetic stir plate and stir bars	Lab bench	Optional, for large-volume samples
Temperature probe (ATC)	Built into meter or separate	For automatic temperature compensation

6.2. Standards and Consumables

Item	Notes
pH buffer 4.01 (red)	NIST-traceable; store at room temperature
pH buffer 7.00 (yellow)	NIST-traceable; store at room temperature
pH buffer 10.01 (blue)	NIST-traceable; store at room temperature
Conductivity standard (1413 uS/cm)	KCl-based; store at room temperature
Conductivity standard (84 uS/cm or 12,880 uS/cm)	For low- or high-range verification
KCl electrode fill solution (3 M or saturated)	For refilling the reference junction
DI water (Type I or II)	For rinsing electrodes between samples
Lint-free wipes (Kimwipes)	For blotting electrodes
Small beakers or sample cups (50–100 mL)	Clean, for holding aliquots

7. Procedure

7.1. Electrode Preparation

1. Remove the pH electrode from its storage solution. Inspect the glass bulb for cracks, chips, or deposits. If the bulb is damaged, replace the electrode.
2. If the electrode has a refillable reference junction, check the KCl fill level. Refill to the indicated line with 3 M KCl or saturated KCl solution if low. Open the fill hole during measurements to allow proper electrolyte flow (Rundle, 2011).
3. Rinse the pH electrode thoroughly with DI water and blot gently with a Kimwipe. Do not rub the glass bulb.
4. Rinse the conductivity cell with DI water and blot dry.

7.2. pH Calibration (Three-Point)

Calibrate before each measurement session and whenever the meter has been turned off (APHA et al., 2012).

1. Pour approximately 30–50 mL of each buffer solution into clean, labeled beakers. Do not pour used buffer back into the stock bottle.
2. Rinse the pH electrode with DI water and blot gently.
3. Place the electrode into pH 7.00 buffer first. Allow the reading to stabilize (stability indicator on the meter display).
4. Accept or set the first calibration point to 7.00.
5. Rinse with DI water, blot, and place into pH 4.01 buffer. Allow to stabilize and accept.
6. Rinse with DI water, blot, and place into pH 10.01 buffer. Allow to stabilize and accept.
7. The meter should display the slope (ideally 95–102% of theoretical Nernstian slope, i.e., approximately 56–60 mV/pH unit at 25 °C). If the slope falls below 90%, the electrode may need cleaning or replacement (Illingworth, 1981).
8. Record the calibration date, buffer lot numbers, slope, and any offset in the meter calibration log.

 Tip

Always calibrate starting with pH 7.00, then move to pH 4.01, and finish with pH 10.01. The 7.00 buffer sets the zero point (offset), while the acidic and basic buffers define the slope. If you only have two buffers, bracket the expected sample range (e.g., pH 4 and 7 for acidic samples, pH 7 and 10 for alkaline samples).

7.3. Conductivity Calibration (One-Point)

1. Rinse the conductivity cell with DI water and blot dry
2. Pour approximately 30–50 mL of the 1413 uS/cm standard into a clean beaker
3. Immerse the conductivity cell fully in the standard. Tap gently to release air bubbles from the cell opening.
4. Allow the reading to stabilize with temperature compensation active
5. Calibrate (adjust the cell constant) so that the display reads 1413 uS/cm (at 25 C)
6. Record the calibration date and standard lot number in the log
7. *TBD – if your lab uses a different primary conductivity standard (e.g., 84 uS/cm for low-conductivity water or 12,880 uS/cm for brackish water), adjust accordingly*

 Important

Never measure conductivity on a water sample that has already been used for pH measurement. The KCl from the pH electrode reference junction leaks into the sample and alters conductivity. Always measure conductivity first, or use a separate aliquot (APHA et al., 2012).

7.4. Measuring pH

1. Rinse the pH electrode with DI water and blot gently
2. Pour approximately 30–50 mL of the sample into a clean beaker. Use a separate aliquot from the one used for conductivity.
3. Immerse the electrode so that the glass bulb and reference junction are fully submerged
4. Allow the reading to stabilize (typically 30–60 seconds for well-buffered samples; may take 2–3 minutes for low-ionic-strength water)
5. Record the pH value, sample temperature, and sample ID in the lab notebook
6. Rinse the electrode with DI water between samples

7.5. Measuring Conductivity

1. Rinse the conductivity cell with DI water and blot dry
2. Pour approximately 30–50 mL of the sample into a clean beaker
3. Immerse the cell fully. Tap gently to dislodge air bubbles.
4. Allow the reading to stabilize
5. Record the specific conductance (uS/cm at 25 C), sample temperature, and sample ID in the lab notebook

6. Rinse the cell with DI water between samples

7.6. Measuring Soil pH and Conductivity (Soil Slurry Method)

For soil pH and electrical conductivity, prepare a soil-water slurry (Rhoades, 1996; Thomas, 1996):

1. Weigh 10 g of air-dried, sieved (2 mm) soil into a clean beaker
2. Add 10 mL of DI water for a 1:1 soil-water ratio (or 50 mL for a 1:5 ratio, depending on the protocol). Record the ratio used.
3. Stir the slurry vigorously for 30 seconds, then allow to stand for 10 minutes
4. Stir again briefly, then insert the pH electrode into the slurry while it is still suspended. Allow to stabilize and record.
5. For conductivity, use a separate slurry aliquot or prepare a fresh slurry. Insert the conductivity cell into the supernatant after the soil has settled. Record.
6. See also *SOP-L57 Soil pH and Salinity* for additional detail.

7.7. Electrode Storage and Maintenance

1. After use, rinse the pH electrode with DI water and return it to its storage solution (pH 4 buffer or KCl storage solution as recommended by the manufacturer). Never store the pH electrode dry or in DI water, as this damages the glass membrane (Illingworth, 1981).
2. Store the conductivity cell dry or in DI water (per manufacturer recommendation).
3. If the pH electrode response becomes sluggish (stabilization takes more than 3 minutes) or the calibration slope drops below 90%, soak the electrode in electrode cleaning solution or dilute HCl (0.1 M) for 15–30 minutes, rinse with DI water, and recalibrate.
4. Replace the pH electrode if the slope remains below 90% after cleaning or if the glass bulb is cracked.

8. Quality Control and Acceptance Criteria

- Calibrate the pH meter before each measurement session using a three-point calibration
- Calibrate the conductivity meter before each session using a traceable standard
- Acceptable pH calibration slope: 90–102% of theoretical Nernstian slope (approximately 54–60 mV/pH at 25 C)
- Check calibration by re-reading pH 7.00 buffer after every 10 samples. If the reading has drifted by more than ± 0.05 pH units, recalibrate.
- Check conductivity by re-reading the 1413 $\mu\text{S}/\text{cm}$ standard after every 10 samples. If the reading has drifted by more than $\pm 5\%$, recalibrate.
- Run duplicate measurements on at least 10% of samples. Acceptable precision: ± 0.1 pH units and $\pm 5\%$ for conductivity.
- Record all calibration data, standard lot numbers, electrode condition, and QC check results in the meter log.

9. Waste Disposal

Waste Type	Disposal Method
Used pH buffer solutions	Collect in waste container; do not pour down the drain
Used conductivity standard	Drain with copious water (KCl solutions are non-hazardous)
Soil slurry waste	Standard trash (if non-hazardous soil)
Spent KCl fill solution	Drain with copious water
DI water rinses	Drain

10. References

- APHA, AWWA, & WEF. (2012). *Standard methods for the examination of water and wastewater* (22nd ed., p. 1360). American Public Health Association.
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- Illingworth, J. A. (1981). A critical review of glass electrode theory and practice. *Biochemical Journal*, 195(2), 259–262. <https://doi.org/10.1042/bj1950259>
- Rhoades, J. D. (1996). Salinity: Electrical conductivity and total dissolved solids. In D. L. Sparks, A. L. Page, P. A. Helmke, & R. H. Loeppert (Eds.), *Methods of soil analysis, part 3: Chemical methods* (pp. 417–435). Soil Science Society of America.
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- Thomas, G. W. (1996). Soil pH and soil acidity. In D. L. Sparks, A. L. Page, P. A. Helmke, & R. H. Loeppert (Eds.), *Methods of soil analysis, part 3: Chemical methods* (pp. 475–490). Soil Science Society of America.

11. Training Record

Before measuring pH and conductivity independently, personnel must:

1. Read this SOP and [SOP-L002 Laboratory Safety](#) in full
2. Demonstrate a three-point pH calibration with acceptable slope
3. Demonstrate a one-point conductivity calibration
4. Perform measurements on at least 5 practice samples under supervision with acceptable duplicate precision
5. Demonstrate proper electrode storage
6. Be signed off by the PI or lab manager

12. Appendix A: Troubleshooting

Symptom	Probable Cause	Corrective Action
pH reading drifts and does not stabilize	Fouled or aging electrode; depleted KCl fill	Clean electrode; refill KCl; replace if slope is below 90%
Calibration slope below 90%	Electrode aging or contamination	Soak in cleaning solution; replace if unresponsive
pH buffer reads correctly but samples do not stabilize	Low ionic strength sample	Allow extra stabilization time (up to 5 min); consider adding ionic strength adjuster
Conductivity reads zero	Air bubble in cell; broken cell	Tap cell to dislodge bubbles; inspect for cracks
Conductivity reading too high on all samples	Contaminated cell or residual standard	Rinse cell thoroughly with DI water; recalibrate
Conductivity standard reads correctly but samples seem wrong	Temperature compensation off or incorrect cell constant	Verify ATC is enabled; recalibrate cell constant
