

Ammonium in Soil Samples

Reflectometric determination by using the indophenol blue method

Introduction

Ammonium (NH_4^+) is a major form of inorganic nitrogen in soil and an important nitrogen source for plant growth.¹ Studies on nitrogen uptake in plants have shown that ammonium is the naturally preferred nitrogen form over nitrate under a range of growth conditions.² However, when present as the sole nitrogen source at elevated concentrations, ammonium can result in toxicity symptoms in many plant species, making its accurate quantification in soil an agronomically critical measurement.¹

Soil ammonium levels are particularly relevant when organic amendments such as compost or manure are applied, as nitrogen availability from these materials depends on the extent and stage of organic matter decomposition. Monitoring ammonium concentration in soil therefore supports informed fertilizer management and helps avoid both nutrient deficiency and excess.^{1,4}

For analysis, ammonium is first extracted from soil using a calcium chloride (CaCl_2) solution, which provides stable ionic conditions and ensures the recovery of readily soluble, plant-available nitrogen forms. The resulting extract can then be quantified using a range of analytical techniques, including colorimetric, reflectometric, or photometric methods, depending on the available instrumentation and required throughput.

Experimental

The procedure detailed in this application note details sample preparation and analysis using the Reflectoquant® Ammonium Test strips in conjunction with the portable RQflex® 20 reflectometer. This method offers a rapid, cost-effective, and reliable approach for assessing ammonium concentrations while also allowing comparisons with photometric and official LUFA method to ensure the accuracy and validity of results.

Method

Ammonium ions react with a chlorinating agent to form monochloramine. This in turn reacts with a phenol compound to form a blue indophenol derivative that is determined reflectometrically.

Measuring Range

Reflectoquant® Ammonium Test (1.16892)	Test kit: 0.2–7.0 mg/L NH_4^+
	Method: 0.8–28 mg/kg NH_4^+
Reflectoquant® Ammonium Test (1.16899)	Test kit: 5.0–20.0 mg/L NH_4^+
	Method: 20–80 mg/kg NH_4^+

Applicable Sample

Soil samples

Influence of Foreign Substances

Foreign substances in the sample solution can

- increase the measurement value because of an amplification of the reaction
- lower the measurement value because of a prevention of the reaction

A quantification of these effects is stated in tabular form in the respective package insert for the most important foreign ions and substances. The tolerance limits have been determined for the individual ions and substances; they may not be evaluated cumulatively.

In the case of samples with a complex, in many cases inexactly known composition (matrix) it is particularly difficult to estimate the potential influence of the foreign substances on the analysis (matrix effect). The following instructions describe a method by means of which the user can test whether a matrix effect is present or not.

Interference check by dilution

Interference check by spiking

Reagents, Instruments and Materials

Test/Reagent Kit(s)

- Reflectoquant® Ammonium Test, 0.2–7.0 mg/L NH_4^+ (1.16892)

- Reflectoquant® Ammonium Test, 5.0–20.0 mg/L NH_4^+ (**1.16899**)

Instrument(s) & Devices

- Reflectometer RQflex® 20, Reflectoquant® (**1.17246**)

Other Reagents and Accessories

- Calcium chloride dihydrate for analysis EMSURE® ACS, Reag. Ph Eur (**1.02382**)
- Distilled water (e.g., from a suitable Milli-Q® system) or water for analysis (**1.16754**)
- Balance
- Volumetric flask
- Beaker
- Filter paper

Products for AQA

- RQcheck set for RQflex® 20 Reflectometer (**1.17247**)
- Recalibration Set for RQflex® 20 Reflectometer (**1.16954**)
- Ammonium standard solution CRM Certipur®, 1000 mg/L NH_4^+ , (**1.04622**)

Analytical Procedure

Sample Preparation

Preparation of the extraction solution (CaCl_2 solution 0.0125 mol/L):

Dissolve 1.838 g calcium chloride dihydrate (**1.02382**) in distilled water and make up to 1,000 mL with distilled water in a volumetric flask.

Preparation of the sample solution:

- Homogenize ca. 150 g (exactly weighed) of soil sample with 600 mL of 0.0125 mol/L CaCl_2 solution by shaking for 60 minutes.
- Filter through a filter paper immediately.

Measurement

- Rinse the test vessel several times with the sample solution and fill to the 5-mL mark.
- Add 10 drops of reagent NH_4 -1 and swirl.
- Add 1 level blue microspoon of reagent NH_4 -2, close the test vessel, and shake vigorously until the reagent is completely dissolved.
- Press the START button of the reflectometer and - this is imperative - at the same time immerse both reaction zones of the test strip in the pretreated sample (20–30 °C) for 8 (**1.16892**) or 4 minutes (**1.16899**), respectively.
- Approx. 10 seconds before the end of the reaction time, remove the strip from the measurement sample

and carefully allow excess liquid to run off via the long edge of the strip onto an absorbent paper towel.

- Immediately insert the strip all the way into the strip adapter of the RQflex® 20 reflectometer with the reaction zones facing the display.
- After the end of the reaction time, read off the result from the display in mg/L NH_4^+ . The result is automatically stored.

Notes on the measurement

For detailed operating procedures, consult the operating instructions for RQflex® instrument and the package insert of the Reflectoquant® Ammonium Tests.

Analytical Quality Assurance

Analytical quality assurance (AQA) is recommended before each measurement series. Check the instrument using the RQcheck. If RQcheck failed, perform a recalibration using the recalibration set and repeat the RQcheck. For more details see RQflex® 20 manual.

To check test strips, test reagents, measurement device, and handling (recommended before each measurement series):

Dilute the ammonium standard solution with distilled water to 2.5 mg/L NH_4^+ (**1.16892**) or 10.0 mg/L NH_4^+ (**1.16899**) and analyze as described in the section measurement.

Calculation

$$\text{Ammonium content [mg/kg]} = \frac{\text{Measured value [mg/L]} \times \text{Vol. CaCl}_2 \text{ sol. [mL]}}{\text{Weight of sample [g]}}$$

Conversion to kg Ammonium-N/hectare (layer of soil)

$$\text{kg NH}_4\text{-N/ha} = A \times \text{BF} \times 3 \times D \times 0.777$$

where:

A = Measured value

BF = Factor for wetness of soil and extraction BF = 1.41 at an extraction ratio of 1 + 1 and 83% dry mass

3 = For a 30 cm thick layer of soil

D = Soil density (1.5 kg/dm³)

0.777 = Conversion factor NH_4^+ into $\text{NH}_4\text{-N}$

Results

Here in this study, twenty different soil samples were used as test samples for measurement and comparison.

The results were verified using photometric and official LUFA method as orthogonal methods to the Reflectoquant® test kits.

Table 1. Comparison of Reflectoquant® Ammonium Test, photometric and official LUFA method

Sample	Reflectoquant®	Photometry	LUFA method
	[kg NH ₄ -N/ha]	[kg NH ₄ -N/ha]	[kg NH ₄ -N/ha]
1	14.19	16.29	15.72
2	12.51	13.02	12.81
3	9.72	8.01	8.37
4	28.20	26.70	27.21
5	25.71	27.45	24.63
6	4.86	5.82	5.40
7	4.05	5.49	5.37
8	2.34	1.47	1.65
9	1.56	1.86	2.07
10	26.97	29.40	26.61
11	26.13	26.04	23.46
12	12.18	12.60	11.73
13	11.37	10.89	10.50
14	1.56	1.95	2.04
15	12.60	11.58	10.86
16	10.92	11.91	11.31
17	58.05	58.89	55.74
18	50.25	56.49	53.58
19	8.07	10.32	9.54
20	1.56	1.98	1.17

Conclusion

The Reflectoquant® Ammonium Test, used in conjunction with the RQflex® 20 reflectometer, offers a rapid, cost-effective, and reliable analytical approach for routine ammonium monitoring. Unlike traditional laboratory methods, reflectometric analysis enables on-site measurements, facilitating real-time quality control decisions.

Furthermore, validation through orthogonal methods, such as photometric analysis and official LUFA method, demonstrates that the results obtained from this rapid testing method are comparable to traditional techniques. This combination of efficiency and accuracy makes the Reflectoquant® method a valuable tool for analyzing ammonium levels in soil as a screening method.

References

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Featured Products

Description	Cat. No.
Reflectoquant® instruments and strips	
Reflectometer RQflex® 20, Reflectoquant®	1.17246
Reflectoquant® Ammonium Test, 0.2–7.0 mg/L NH ₄ ⁺	1.16892
Reflectoquant® Ammonium Test, 5.0–20.0 mg/L NH ₄ ⁺	1.16899
Products for sample preparation	
Calcium chloride dihydrate for analysis EMSURE® ACS, Reag. Ph Eur	1.02382
Distilled water (e.g., from a suitable Milli-Q® system) or water for analysis	1.16754
Products for AQA	
RQcheck set for RQflex® 20 Reflectometer	1.17247
Recalibration Set for RQflex® 20 Reflectometer	1.16954
Ammonium standard solution CRM Certipur®, 1000 mg/L NH ₄ ⁺	1.04622

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