
**Soil quality — Determination of
effective cation exchange capacity
(CEC) and exchangeable cations using
a hexamminecobalt(III)chloride
solution**

*Qualité du sol — Détermination de la capacité d'échange cationique
(CEC) effective et des cations échangeables à l'aide d'une solution de
trichlorure de cobaltihexammine*

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Contents

Page

| | |
|--|-----------|
| Foreword..... | iv |
| Introduction..... | v |
| 1 Scope | 1 |
| 2 Normative references | 1 |
| 3 Terms and definitions | 1 |
| 4 Principle | 1 |
| 5 Reagents | 2 |
| 6 Apparatus | 3 |
| 7 Procedure | 4 |
| 7.1 Test portion..... | 4 |
| 7.2 Exchange reaction..... | 4 |
| 7.3 Determination of CEC..... | 4 |
| 7.3.1 General..... | 4 |
| 7.3.2 Determination of ammonia nitrogen by distillation..... | 4 |
| 7.3.3 Spectrophotometric determination..... | 5 |
| 7.3.4 Spectrometric determination of cobalt..... | 7 |
| 7.4 Determination of cobalt and exchangeable cations..... | 7 |
| 7.4.1 General..... | 7 |
| 7.4.2 Standard solutions for exchangeable cations..... | 8 |
| 7.4.3 Standard solutions for cobalt..... | 8 |
| 7.4.4 Spectrometric determination of exchangeable cations..... | 9 |
| 7.4.5 Spectrometric determination of cobalt..... | 9 |
| 7.4.6 Calculation of exchangeable cations..... | 9 |
| 8 Test report | 10 |
| 9 Validation | 10 |
| Annex A (informative) Comparison of different methods for the determination of effective CEC | 11 |
| Annex B (informative) Results of the interlaboratory comparison for extraction with hexamminecobalt(II)chloride | 15 |
| Annex C (informative) Results of the interlaboratory comparison for extraction with calcite saturated hexamminecobalt(III)chloride solution | 17 |
| Annex D (informative) Carbonate and sulfate field model | 18 |
| Annex E (informative) Effect of minimization of Ca errors by calcite saturation of hexamminecobalt | 20 |
| Bibliography | 22 |

Foreword

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This document was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 3, *Chemical and physical characterization*.

This second edition cancels and replaces the first edition (ISO 23470:2007), which has been technically revised.

The main changes compared to the previous edition are as follows:

- the scope has been broadened for soils with a pH > 6,5;
- a new [Annex C](#) has been added;
- a new [Annex D](#) has been added;
- a new [Annex E](#) has been added;
- the document has been editorially revised.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The cation exchange capacity (CEC) of soils and clays as well as the exchangeable cation population are essential features of soil fertility. Various attempts have been made in the literature to measure these parameters accurately and efficiently. The completeness of cation exchange on the other hand is not absolute but should be comparable between different methods. Traditional methods used ammonium or barium as exchangeable cations which require repeated treatments to ensure complete cation exchange. The oldest one-step CEC method is based on hexamminecobalt(III)chloride solution which has a much stronger affinity to soil clay minerals than the typical cations of the soil solution (usually Ca, Mg, Na and K). The principle of this method was published by Morel (1958)[11] and has been modified by Ciesielski and Sterckeman (1997)[2]. This method, as described in this document, is very efficient and comparable to the established CEC methods. It determines the effective CEC when used for soils with pH value of <6,5.

All CEC methods including hexamminecobalt(III)chloride have typical limitations such as inflation of exchangeable cations caused by dissolution of carbonates, sulfates or other soluble minerals (compare also ISO 13536). Carbonate dissolution is one of the most frequently occurring source of error (e.g. in the procedure described in ISO 13536), hence, many studies focused on minimization of their dissolution or correction of the dissolved fraction. Reference [13] summarized the discussion and presented solutions for this analytical problem. For calcareous soils or clays, the authors used exchange solutions that were previously equilibrated with calcite. In the course of the extraction, dissolution of carbonates present in the samples was minimized largely and resulting exchangeable Ca values were nearly free of errors. It was a great success compared to methods used in the past (Annex E). This method using calcite-saturated hexamminecobalt(III)chloride exchange solutions was published as VDLUFA-method[6]. The resulting exchangeable cation values agreed well with the total CEC when tested in a round robin (Annex C) which is a good measure for the plausibility of the results. Using different solution/solid ratios, identical exchangeable cation values were measured indicating absence of systematic errors caused by mineral dissolution (compare the model described in Reference [12], for detection of inflated exchangeable Ca values as described in Annex D). This calcite-saturated hexamminecobalt(III)chloride exchange solution should be used for calcareous soils and clays only, practically for soils with pH values of $\geq 6,5$ in which only Ca, Mg, Na and K are present as “exchangeable bases”. Thus, the results are comparable to the determination of potential CEC (for example according to ISO 13563). This method was introduced to avoid erroneous (inflated) Ca values.

Hexamminecobalt(III)chloride is recommended as extractant for non-calcareous soils with a pH value of $\leq 6,5$. As the pH value of a soil suspension in the hexamminecobalt(III)chloride solution is close to the pH value of the suspension in water, this method is considered to give the effective CEC, i.e. the CEC at the soil pH value (e.g. according to ISO 11260).