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EFFECT OF FINE MATERIAL FRACTIONS ON THE RESULTS FOR SOIL TEXTURAL PARAMETERS

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Seloste

HIENON AINEKSEN VAIKUTUS MAAN RAKEISUUSTUNNUKSIIN

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The role played by the medium and fine silt and clay contents in determining the quartiles and the degree of stratification from a cumulative particle-size curve was studied in order to determine what time savings could be made in the sedimentation phase of soil mechanical analysis. The clay content of the samples was, in general, found to be so small that it did not affect the parameters studied. In contrast to this, the medium and fine silt content affected the lower quartile of the distribution for many soils classified as finer than medium sand. Consequently, only the omission of the determination of the clay fraction can be recommended as a time-saving measure in mechanical analysis.

1. INTRODUCTION

Of the procedures used in determining different soil properties in the laboratory, the determination of soil texture is one of the most time-consuming. The analysis includes removal of organic matter and other impurities by oxidation with hydrogen peroxide and treatment with hydrochloric acid, dispersion of the soil aggregates by means of sodium pyrophosphate, sedimentation analysis of the fine particles, and sieving of the coarser material. A detailed account of the subject has been given by Elonen (1971).

In the laboratory of the Department of Soil Science, the Finnish Forest Research Institute, the textural analysis takes eight days to complete. Although the samples are treated in series of six at a time, only about 30 samples can be handled by one person a month. Since this is by far the slowest of the routine soil analyses carried out by the department, ways of simplifying the procedure were studied.

The most effective way to speed up the analysis would be to omit the removal of impurities. This would, however, lead to gross errors in the percentages of the silt and clay fractions, especially if the organic matter content is high (Elonen 1971). The use of a hydrometer instead of a pipette would also save time, but this was shown by Elonen (1971) to have some disadvantages which may lead to inaccurate results. Consequently, if we stick to the original method of purifying the sample and determining the finer fractions by pipetting, the next possibility is to reduce the number of fractions to be determined. Since the sedimentation of the fine particles takes up most of the time during the pipetting stage, the time saved by omitting the determination of the clay and fine silt fractions would be the greatest.

The omission of the determination of the fine fractions is justified only if no essential information about the soil texture is subsequently lost. As the particle-size distribution in its complete form can seldom be used as an indicator of soil texture, the information is anyway condensed into a few parameters which describe the whole distribution. Wilde (1958, p. 177) suggests that the texture can be indicated simply by giving the content of silt and clay in the soil. Sepponen (1982) found that this indicator correlates well with both the field capacity and the cation exchange capacity. Another possibility is to use quartiles of the cumulative particle-size curve as textural parameters (Virkkala 1969). If only the proportion of silt and clay is to be determined, the separate determination of the clay content is not needed (cf. Wilde et al. 1964). In the case of quartiles, whether or not the fine material content affects the parameters is dependent on the shape and the level of the curve. In this study, the quartiles and the quartile-based degree of stratification were taken as the textural parameters to be studied.

The aim of the study was to find out what is the effect of the clay (< 0,002 mm) and medium and fine silt (< 0,02 mm) fractions on the final results for soil textural parameters of Finnish forest soils. This was done in order to determine whether the textural analysis could be simplified by omitting one or both of the two fractions from the analysis.

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2. MATERIAL AND METHODS

21. Material

The material consisted of 70 soil samples collected from the control plots of fertilizer experiments set up by the Department of Soil Science in southern and central Finland. Most of the samples (41) were from non-stratified tills, the rest being from stratified soils of fluvioglacial deposits.

Each sample was first passed through a 2 mm sieve, and the gravel content (20–2 mm) determined by weighing. Then the < 2 mm material was subjected to a complete mechanical analysis as outlined in the introduction. The following fractions were determined:

Gravel	20–2	mm
Coarse sand	2–0,5	"
Medium sand	0,5–0,2	"
Fine sand	0,2–0,05	"
Coarse silt	0,05–0,02	"
Medium and fine silt	0,02–0,002	"
Clay	Below 0,002	"

The percentages of the different fractions were then summed up sequentially in order to obtain the cumulative curve of the particle size distribution on semilogarithmic graph paper (Fig. 1). The textural class of the sample can be obtained from the graph by taking the median of the curve (Q_2). The class of the median particle size is taken as the textural class of the sample (Virkkala 1969). The samples were divided into the following classes:

Coarse silt	1 sample
Fine sand	45 samples
Medium sand	14 "
Coarse sand	10 "

The distribution of the samples reflects the general occurrence of the different textural classes in Finnish forest soils (Aaltonen 1941).

22. Computation of the textural parameters

The quartiles of the particle-size distribution (Q_1, Q_2, and Q_3) were determined for each sample by means of a cumulative curve (Fig. 1), and the degree of stratification (S) was calculated as follows (cf. Seppälä 1971):

$$S = \sqrt{Q_3/Q_1}$$

The four parameters (Q_1, Q_2, Q_3 and S) were taken as independent variables, and the effect of the content of clay (< 0,002 mm) and that of medium and fine silt plus clay (< 0,02 mm) on these variables was studied.

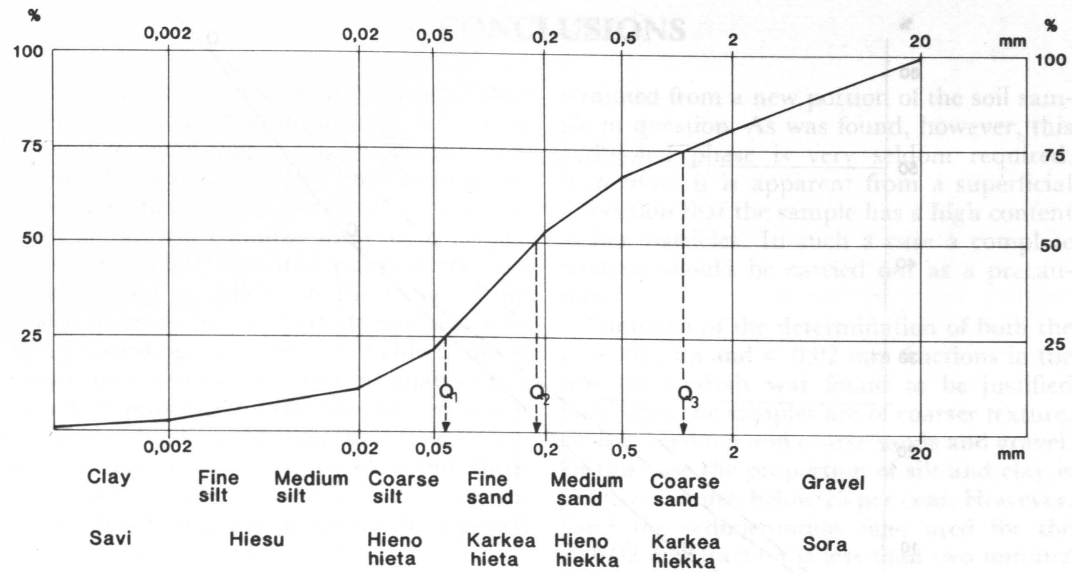

Figure 1. The cumulative particle-size curve and its quartiles: The average distribution of the whole material.
Kuva 1. Kumulatiivinen rakeisuuskäyrä ja sen kvartiilit: Koko aineiston keskimääräinen raekokojakaantuma.

Since the graphical method for determining the quartiles turned out to be laborious and inaccurate as a result of the semilogarithmic scale used, a computer programme was prepared for calculating the parameters mathematically. The programme simulates the process of graphical determination, and uses linear interpolation.

In order to determine the effect of the fine fractions on the calculated parameters, the programme was further developed so that the parameters could also be calculated without knowing either the < 0,002 mm or the < 0,02 mm fractions.

3. RESULTS

The value of the upper quartile (Q_3) did not change in any of the cases where either the < 0,002 or the < 0,02 mm fraction was ignored. This is not surprising since the sum of the finer materials was always far below the 75 % level (Fig. 1).

The median of the distribution (Q_2) was affected only in one case out of the total of 70 samples. The situation is illustrated in Figure 2 as the change of Q_2 to Q_2'', caused by ignoring the < 0,02 mm part of the curve. In this case the sum reached the 50 % level when the coarse silt was added to the sum (see line CD in the fiqure). In such a case straightening the curve (from ABCD to AD) is bound to change both Q_1 and Q_2 unless B and C are on the line AD in the first place.

The omission of the clay fraction changed the value of the lower quartile (Q_1) only in one case out of 70. In this case the 25 % level was passed before the 0,02 mm point on the abscissa had been reached (Fig. 2). Straightening the line ABC into the line AC caused the change, Q_1 to Q_1'.

The clay fraction in the majority of the cases (69 out of 70) was so small that it did not have any effect on the values of the quartiles. In contrast, the value of the lower quartile (Q_1) was in rather many cases changed when both the clay and the fine plus medium

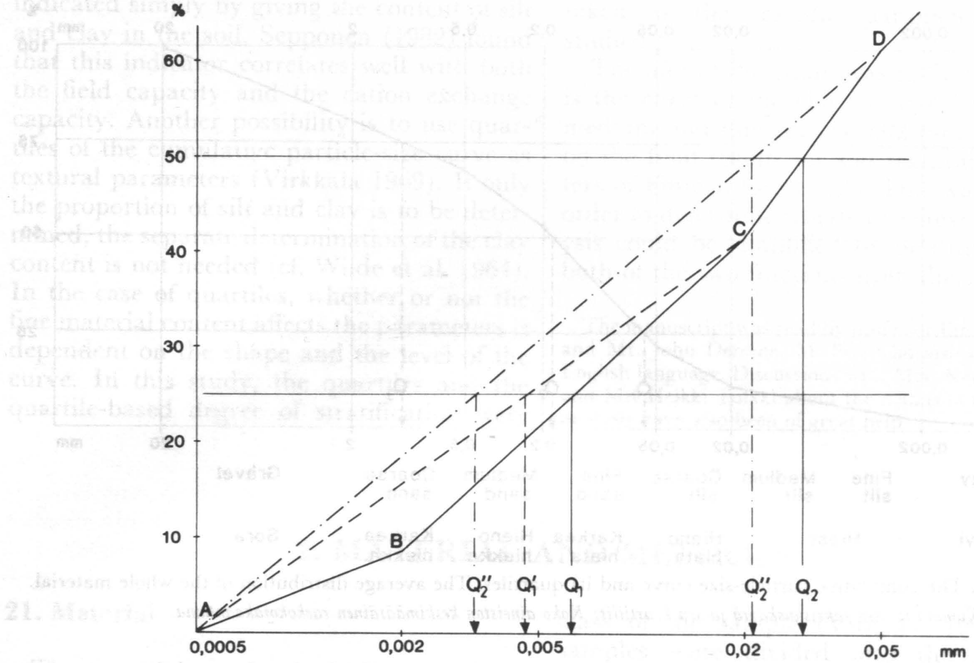

Figure 2. Lower part of the particle-size curve of soil sample no. 50 with an exceptional high content of fine material. The curve is changed from ABCD into ACD by omission of the determination of clay (<0,002 mm), and into AD if also the content of medium and fine silt (<0,02 mm) is ignored. The corresponding changes in the quartiles are Q_1 to Q_1' to Q_1'' and Q_2 to Q_2''.

Kuva 2. Poikkeuksellisen runsaasti hienoa ainesta sisältävän maanäytteen n:o 50 rakeisuuskäyrän alkuosa. Käyrä muuttuu ABCD:stä ACD:ksi, jos savipitoisuus (<0,002 mm) jätetään määrittämättä, ja AD:ksi, jos lisäksi hiesu (<0,02 mm) jää pois. Vastaavat muutokset kvartiileissa ovat Q_1→ Q_1'→ Q_1'' ja Q_2→ Q_2''.

silt fractions (< 0,02 mm fraction) were omitted. This took place in 24 cases out of 70, which indicates that the <0,02 mm fraction should not be left out of the analysis.

All the changes referred to here were restricted to soils with a median particle size corresponding to fine sand or silt. In coarser sands even the omission of the < 0,02 mm material from the analysis did not have any effect on the quartiles. This was due to the low content of silt and clay in this group (Table 1).

The changes in the degree of stratification (S) corresponded to the changes in Q_1. This is logical since Q_3 remained unchanged in all cases.

Table 1. The percentages of fine material in the soil samples (means and standard deviations).

Taulukko 1. Hienon aineksen osuus maanäytteissä (keskiarvot ja keskihajonnat).

Textural class *Maalaji*	<0,05 mm	<0,02 mm	<0,002 mm
Fine sand and silt *Hieta ja hiesu*	26,7± 9,9	13,4±6,1	2,7±1,5
Medium and coarse sand *Hiekka*	10,3± 5,8	6,1±3,1	1,7±0,8
All the samples *Kaikki näytteet*	21,1±11,7	10,9±6,3	2,4±1,4

4. CONCLUSIONS

It can be concluded from the results that the clay content of Finnish forest soils is in general so small that it can be omitted from the mechanical analysis without having any effect on the selected textural parameters. Only if the soil contains more than 25 per cent of the <0,02 mm material does the clay content have an effect on the value of the lower quartile in the particle-size distribution. According to the results (Table 1) this is very rarely the case. In a routine analysis it is therefore possible to omit the determination of the clay fraction. This means a time-saving in the sedimentation stage of about three hours per sample. In addition, the time required for drying and weighing the pipetted clay fraction is saved.

If the clay determination is omitted in routine analysis, and after calculation of the results it is found that the sample contains more than 25 per cent of the < 0,02 mm fraction, then the clay content should be determined from a new portion of the soil sample in question. As was found, however, this additional phase is very seldom required. Sometimes it is apparent from a superficial inspection that the sample has a high content of fine particles. In such a case a complete analysis should be carried out as a precaution.

Omission of the determination of both the < 0,002 mm and < 0,02 mm fractions in the textural analysis was found to be justified only when the samples are of coarser texture, such as medium and coarse sands and gravel. In this case the proportion of silt and clay is in general much below 25 per cent. However, since the sedimentation time used for the < 0.02 mm fraction is less than two minutes (Elonen 1971), the amount of time saved by omitting this fraction is negligible. Consequently, unless dealing with clearly sandy or gravelly samples, only the omission of the clay fraction can be recommended.

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SELOSTE

HIENON AINEKSEN VAIKUTUS MAAN RAKEISUUSTUNNUKSIIN

Koska maan raekoostumuksen määritys on eniten aikaa vievä vaihe maanäytteiden rutiinianalyysissä, tutkittiin voitaisiinko tarvittavan työajan lyhentämiseksi jättää saven ja hiesun osuuksien erillinen määritysvaihe pois analyysistä. Aineisto käsitti 70 maanäytettä, joista selvitettiin, miten hienon aineksen määritysarvot vaikuttavat maan rakeisuuskäyrältä saataviin kvartiileihin (Q_1,Q_2 ja Q_3, kuva 1) sekä lajittuneisuusasteeseen $S = \sqrt{Q_3/Q_1}$

Osoittautui, että savipitoisuus näytteissä on yleensä niin pieni, että sen pois jättäminen määrityksestä ei muuta tutkittuja rakeisuustunnuksia. Sen sijaan hiesun pois jättäminen muutti Q_1- ja S-arvoja melko yleisesti hiekkaa hienommissa maalajeissa. Tämän vuoksi voidaan suositella vain saven määrityksen pois jättämistä. Käytännössä tämä merkitsee yli kolmen tunnin säästöä määritysajassa näytettä kohti.