Determination of soil aggregate disintegration dynamics using laser diffraction

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ABSTRACT: A new practical and precise method for determining soil aggregate stability is described. Four air-dry aggregate fractions (<0.25, 0.25–0.5, 0.5–1.0 and 1.0–2.0 mm) were added to thoroughly stirred water in a Mastersizer 2000 laser diffractometer. The suspension obtained was passed directly through the measuring system. The dynamics of median (equivalent diameter \(d_{50}\)) particle-size distribution decrease (interpolated with a logarithmic function) was assumed to be the measure of soil aggregate stability. In order to show the applicability of the new method, the results obtained (for selected and diverse soils) were compared with those from the wet sieving standard method. The main conclusion is that the proposed method is convenient and can be successfully used for the estimation of soil aggregate stability. Moreover, it has wider application because standard sieving methods are restricted to aggregates >0.25 mm whereas, with the use of the laser diffraction method, smaller aggregates can be measured. The energy delivered to the aggregates in the process of aggregate disintegration is more reproducible in the method described here. The method also provides an opportunity to verify that the soil aggregates are completely destroyed (lack of the change in the median value shows the end of soil aggregate disintegration).

KEYWORDS: soil aggregate stability, laser diffraction, dynamics, soil aggregate disintegration.

Resistance of structural components of soils, soil aggregates, to the effect of external agents depends primarily on the physical and chemical properties of sticky substances, i.e. clay and organic matter (Gorbunov, 1987; Dexter & Czyż, 2000; Shein & Goncharov, 2006; Calero et al., 2008). Various indices have been proposed to express the distribution of aggregate sizes; if a single characteristic parameter is required, a method should be adopted to assign an appropriate weighting factor to each size range of aggregates (Hillel, 1998; Kutilek & Nielsen, 1994; Niewczas & Witkowska-Walczak, 2003, 2005). Some indices still in use are: the ‘mean weight diameter and its change before and after the water acting, the geometric mean diameter, the coefficient of aggregation, the weighted mean diameter, the change in mean weight diameter, the slaking loss, etc.’ (De Boodt, 1967). Gardner (1956) reported that the aggregates of many soils exhibit a logarithmic-normal distribution, which can be characterized by two parameters, namely the ‘geometric mean diameter and the log standard deviation’. Bryan (1971) tested some aggregation indices for English and Canadian soils and proved that although several indices were clearly efficient at distinguishing differences, none was adequate for measurement or description of the complete

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disaggregation characteristics of a soil. Many indices used today were proposed many years ago (Rewut, 1969). They are time consuming, far from perfect and none of them is universally preferred. Comparison of materials described by different indices is limited or impossible (Dexter, 1988; Niewczas & Witkowska-Walczak, 2003; Roth & Witkowska-Walczak, 1992; Walczak & Witkowska, 1976)

In the 1980s a new technique for measuring the particle-size distribution was described — the laser diffraction method. Immediately, applications of the method in soil science were found (Cooper et al., 1984) and since then the technique has been improved (Buurman et al., 1997; Chappell, 1998; Sperazza et al., 2004). The method is commonly used in soil laboratories to determine the particle-size distribution of soils but there are limitations in its use, the main one being the problem with measuring the finest fractions of soil (Taubner et al., 2009).

In work done so far the laser diffraction method has only been used to determine the soil particle-size distribution (Arriga et al., 2006; Goossens, 2008). Because the soil particle-size distribution characterizes the size of elementary particles in soil aggregates, the limitation mentioned above should be eliminated as in classical sedimentation methods (Pini & Guidi, 1989). The aggregate disintegration in the soil particle-size distribution measurements, i.e. dispersion of the soil sample, is usually carried out using a solution of sodium hexametaphosphate or by the ultrasonic method (Levy et al., 1993; Mayer et al., 2002; Mentler et al., 2004; Tippkötter, 1994; Zobeck, 2004).

The same problem was encountered in the present study, i.e. the disintegration of soil aggregates during measurement of soil particle-size distributions. These effects provide an opportunity for characterization of soil aggregate disintegration.

The aim of this study was to develop a new, easy and reliable method of characterizing soil aggregation stability. The method is based on the analysis of the unsteady state during mechanical disintegration of air-dry soil aggregates by stirring under controlled conditions. The principle of the proposed method is the observation of changes in the median of the particle-size distribution as a function of disintegration time. To confirm the advantages of the new method, the results were compared with those obtained for the same soils by the standard wet sieving method.

**MATERIAL AND METHODS**

**Soils**

The material for the study included aggregates from the arable horizon of three types of soils which are significantly different, i.e. they have different granular composition and stability of aggregates (Niewczas & Witkowska-Walczak, 2003); black earth derived from light sandy loam (Mollic Gleysol), proper rendzina formed from calcereous rock (Calcaric Cambisol) and chernozem formed from loess (Haplic Phaeozem). The basic properties of the investigated soils are shown in Table 1. Four fractions of aggregates of air-dry soil were investigated: ≤0.25, 0.25–0.5, 0.5–1 and 1–2 mm. These were obtained by sieving and the water resistance of the aggregates was determined by standard wet sieving methods (Savinov, 1936; Yoder, 1936).

<table>
<thead>
<tr>
<th>Soil</th>
<th>Grain-size distribution* (% (diameter in μm))</th>
<th>C&lt;sub&gt;org&lt;/sub&gt; (wt.%)</th>
<th>CaCO&lt;sub&gt;3&lt;/sub&gt; (wt.%)</th>
<th>pH&lt;sub&gt;KCl&lt;/sub&gt;</th>
<th>SSA** (m&lt;sup&gt;2&lt;/sup&gt;g&lt;sup&gt;−1&lt;/sup&gt;)</th>
<th>Bulk density (g cm&lt;sup&gt;−3&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mollic Gleysol</td>
<td>53 34 13</td>
<td>3.1 0.14</td>
<td>6.5</td>
<td>51</td>
<td>1.34</td>
<td></td>
</tr>
<tr>
<td>Calcaric Cambisol</td>
<td>37 35 28</td>
<td>2.7 18.2</td>
<td>7.0</td>
<td>87</td>
<td>1.20</td>
<td></td>
</tr>
<tr>
<td>Haplic Phaeozem</td>
<td>13 73 14</td>
<td>3.0 0.12</td>
<td>6.8</td>
<td>79</td>
<td>1.15</td>
<td></td>
</tr>
</tbody>
</table>

* Analysed by areometric method

** Specific surface area (measured by water vapour)**
Apparatus

The dynamics of soil aggregate disintegration was determined using the Mastersizer 2000 instrument from the Malvern Company (Malvern Operators Guide, 1999), designed for standard determination of the grain-size distribution of particles within the size range of 0.02 μm–2 mm. The Mastersizer 2000 makes use of laser light scattered by the particles being measured and calculates particle-size distributions. The measuring setup is shown in Fig. 1.

In our investigations we used the Hydro MU attachment to the Mastersizer 2000 which enabled us to carry out the measurements in ~800 cm³ water suspension using distilled water as the continuous phase.

Measuring procedure

Air-dry aggregates (each fraction separately) were metered out directly into a measurement beaker with distilled water. Measurements were made over six replications (as each replication was in progress, a new portion of air-dry soil was poured into the measuring system). To take into consideration one of the main sources of uncertainty, i.e. inaccuracies during the measuring procedure, the measurements were carried out in two separate series (with three replications in each series) by two investigators. For subsequent analyses, the results of all six measurements were averaged.

To improve the credibility of the results, the measurement procedure employed by the Mastersizer 2000 apparatus eliminates the so-called background particles contained in the continuous phase.

Measurement options

The software of the Mastersizer 2000 permits several options depending on the investigated objects – the model/theory of recalculation of images registered on the detectors into particle-size distributions, the homogeneity of the samples and the shapes of particles.

Calculations related to the determination of the aggregate-size distribution by laser diffraction using the Mastersizer 2000 instrument were carried out on the basis of the Mie theory (adopting a refractive index of 1.577 and absorption index of 0.1 – indices recommended for clay by the producer). The laser light wavelength in the apparatus was 466 nm for blue light and 633 nm for red.

Measurements (averaging of 30,000 images of laser light diffraction recorded by the detectors) lasted 60 s (30 s for blue and 30 s for red light) and were carried out consecutively.

The following algorithms were selected for the measurements: (1) general purpose analysis – a calculation procedure recommended by the apparatus producer for objects with unknown properties or containing a large number of fractions; (2) irregular shape ratio – although one of the assumptions of the method is sphericity of particles, the manufacturer has provided a module permitting greater accuracy of results when the particles under study are not perfect spheres.

The speed of the stirrer and the integrated pump was determined experimentally and fixed at 2500 rotations per minute. This speed was selected to ensure that the mixture did not suffer from gravitation segregation of particles (slow speed) or formation of air bubbles in the stirred mixture (fast speed).

Quantity of the sample

The amount of soil taken for measurement was chosen so that the obscurance (the fraction of light obscured by the analysed suspension) measured by the Mastersizer 2000 at the beginning of the measurement cycle was ~10%, which is within the recommended range (10–20%). At lower obscurance the quality of images reproduced on the detectors is too weak, causing a high level of measurement uncertainty. At obscurance levels >20%, the laser light beam may be subject to multiple reflections from successive soil particles, introducing errors in the results. In practice, the
mass of soil samples was in the range of 0.5 to a few grams.

**Procedure for reducing obscurance in the course of measurement**

In the course of measurements of soil particle size distribution, conducted in a water medium with the use of the Mastersizer 2000 apparatus, a methodological problem arose. Because of the soil aggregate disintegration during the measurement, the obscurance increased to over the 20% figure recommended by the manufacturer.

To eliminate this problem, a procedure was developed for the removal of excess particles in the course of measurement, thereby reducing the degree of obscurance. The basic criterion that the procedure had to meet was the proportional removal of all aggregate fractions from the measurement system to avoid the necessity of stopping the stirring of the suspension circulating within the measurement system. Stopping the stirring results in the settlement of larger particles, with the smaller particles remaining in the suspension; an attempt at separation of such a suspension would cause an alteration of the quantitative relations between the particular aggregate size fractions. Therefore, when obscurance exceeded 20% in the course of measurement, the recording of laser beam diffraction on the detectors was stopped without stopping the suspension stirring system and the flow through the measurement cell. While the pump stirring the sample continued to run, the hose provided for draining the tested mixture from the measurement cell to the flask was disconnected (Fig. 1). This permitted a part of the tested mixture to be drained into a separate vessel and removed from the measurement system, reducing the obscurance. Then the volume was supplemented with distilled water up to 800 cm³. This operation was repeated until the proper obscurance level of was obtained. Following this procedure, the drain hose was reconnected to the measurement system and the measurement process was resumed. If necessary, the procedure could be repeated any number of times, ensuring that the signal recorded in the tested suspension did not drop below the background signal recorded prior to the measurement. This procedure did not disturb the measurement, as the system was dynamically stirred all the time. This is confirmed by the results presented in Fig. 2 which show an example of changes in the course of measurement of the equivalent diameter \( d_{50} \) (median) for the Calcaric Cambisol fraction 0.25–0.5 mm (Fig. 2a), and changes in obscurance for the same measurement (Fig. 2b). It is clear that no changes occurred in the smooth charge of the equivalent diameter \( d_{50} \) when the obscurance adjustment was made.

**Measure of soil aggregate disintegration**

The changes of the median of the particle-size distribution can be the measure of soil aggregate disintegration. The median, sometimes called the equivalent diameter, \( d_{50} \), defines the limit that 50% of the population of particles have diameters \( >d_{50} \), and 50% of the population have particle diameters \( <d_{50} \). Analysing changes in the value of \( d_{50} \), one can easily observe changes within the whole population.

The dynamics of aggregate disintegration expressed as changes of the median during mechanical stirring was interpolated using the logarithmic function:

\[
y = a \ln x + b
\]

The logarithmic function was tested on the basis of experimental results obtained during a period of 30 min (30 measurements).

The soil aggregate water stability was determined using the most popular varieties of the standard (classic) wet sieving methods (Savinov, 1936; Yoder, 1936). The soil aggregate distributions before and after water impact were expressed as the mean weighted diameter (MWD), whereas its differences were expressed as a change of mean weighted diameter (CMWD) (De Boodt, 1967). The time of measurements was 12 min for the Savinov method and 30 min for the Yoder method.

**RESULTS AND DISCUSSION**

**Results**

The dynamics of the process of soil aggregate disintegration for four fractions of the investigated soil are shown in Fig. 3. The larger aggregate has lower water stability. This lack of stability appears in the first second of the measurement. Because the time of measurement was 1 min (30 s for the measurement at each of two wavelengths), the first measurement in each series is associated with the largest error. This does not influence the final result because the trend is repeatable.
Values of the parameters of the interpolated logarithmic functions and the statistical study are given in Table 2. It can be concluded from the analysis of the data contained in Fig. 3 and Table 2 that the greatest rate of aggregate disintegration of the investigated soils was for Calcaric Cambisol whereas the smallest was for Haplic Phaeozem; this could be expected from the physical and chemical properties of the soils. It was also expected that the largest dynamic changes would occur for the coarser fraction.

Because the mean values in Table 2 are obtained from six replications they can be used to determine statistical significance. For instance, the $a$ parameter from the logarithmic equation for the two fractions 0.5–1.0 (−28.620) and 1.0–2.0 (−24.317) mm of Mollic Gleysol are not statistically different (for $\alpha = 0.05$), while for other fractions of the same soil they differ statistically.

Because, as mentioned earlier, the aim of this paper was not to characterize the soil but to describe a new method for determination of the dynamics of soil aggregate disintegration, the discussion will concentrate on aspects of this method.

**Interpolated function**

Initially, the problem of selection of the mathematical function should be discussed. From the shape of the relationship and from experience one can expect that the best function would be a logarithmic or power function. The equation of the power function is:

$$y = cx^{-d}$$  \hspace{1cm} (2)

The power function was rejected in our approach. The reasons were its limits: when $x$ approaches 0
(x→0) then y approaches infinity (y→∞). This is equivalent to the assumption that the soil aggregates have infinite sizes; when x approaches ∞ (x→∞) then y approaches 0 (y→0). This is equivalent to the assumption that the aggregates completely dissolve in water. Both assumptions are evidently false.

The measure of good fitting of the interpolated logarithmic function can be the coefficient of determination, $R^2$ (or $r$, the correlation coefficient). From data presented in Table 2, it can be concluded that $R^2$ occurs in the range 0.704 to 0.994 (corresponding to $r$ in the range 0.839–0997). Statistical tests showed the significance for all correlations in Table 2.

Somewhat surprisingly, the largest values of $R^2$ are for Calcaric Cambisol (for all granulometric fractions). The methodical problems of measuring the grain-size distribution of this soil type are reported in the literature (Kalicka et al., 2008).

However, it is not surprising that the largest values of $R^2$ were obtained for the finest fraction of all soils. The explanation is that the number of aggregates in this fraction is the smallest and because the aggregates are not large, their disintegration is repeatable.

The information on the dynamics of disintegration of aggregates is included in the $a$ parameter of the logarithmic equation. The smaller the value of $a$, the larger the dynamics of disintegration. The $b$ parameter indicates the shift of the graph along the Y axis and is a measure of the aggregate size at the start of the disintegration process (just after the addition of the soil to the measuring system).

![Fig. 3 (above and facing page). Changes in the equivalent diameter (median), $d_{50}$, over time for the aggregate fractions under study. The graphs are averages of six replications.](image-url)
Reproducing

Because the six replications were carried out in two series by two operators, the standard deviation and coefficient of variation reflect the reproducibility of measurement rather than repeatability. When analysing data from Table 2 it can be stated that the average coefficients of variation are equal: 0.096 for a; 0.047 for b (both parameters from equation 1). The repeatability of results obtained by one operator in a short time is desirable, but we decided to include this source of uncertainty because this situation can occur when comparing results from different laboratories.

In discussing the reproducibility of results expressed by the coefficient of variation it should be stated that for the majority of cases the smallest values of these coefficients were obtained for the finest class and the largest values for the coarsest class. This would be expected because the number of coarser aggregates is larger. Moreover, the aggregates consist of soil particles of different shape and size. During disintegration these soil particles are free and their heterogeneity increases the statistical dispersion, reflected in an increase of the coefficient of variation.

Mechanism of disintegration

Two mechanisms are responsible for the disaggregation of air-dry aggregates during the measurement on contact with the intensively stirred water: wetting and mechanical energy of stirring. It is not possible to separate the effects of each of these, but in this procedure separation is not necessary. The most important factor is the repeatability of disintegration conditions. This repeatability can be ensured by using a similar volume of dispersion water and the same speed of the stirrer and the pump in the measuring system. Because the
<table>
<thead>
<tr>
<th>Soil</th>
<th>Equation parameter</th>
<th>— Fraction &lt;0.25 mm —</th>
<th>— Fraction 0.25–0.5 mm —</th>
<th>— Fraction 0.5–1.0 mm —</th>
<th>— Fraction 1.0–2.0 mm —</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean value of parameter</td>
<td>SD*</td>
<td>CV**</td>
<td>Mean value of parameter</td>
<td>SD</td>
</tr>
<tr>
<td>Mollic Gleysol</td>
<td>( a )</td>
<td>(-6.598)</td>
<td>0.419</td>
<td>0.063</td>
<td>(-10.540)</td>
</tr>
<tr>
<td></td>
<td>( b )</td>
<td>77.625</td>
<td>1.589</td>
<td>0.020</td>
<td>233.267</td>
</tr>
<tr>
<td></td>
<td>( R^2 )</td>
<td>0.979</td>
<td>0.004</td>
<td>0.004</td>
<td>0.704</td>
</tr>
<tr>
<td>Calcaric Cambisol</td>
<td>( a )</td>
<td>(-16.583)</td>
<td>1.269</td>
<td>0.077</td>
<td>(-51.050)</td>
</tr>
<tr>
<td></td>
<td>( b )</td>
<td>134.583</td>
<td>1.634</td>
<td>0.012</td>
<td>277.567</td>
</tr>
<tr>
<td></td>
<td>( R^2 )</td>
<td>0.968</td>
<td>0.007</td>
<td>0.007</td>
<td>0.983</td>
</tr>
<tr>
<td>Haplic Phaeozem</td>
<td>( a )</td>
<td>(-6.585)</td>
<td>0.360</td>
<td>0.055</td>
<td>(-17.433)</td>
</tr>
<tr>
<td></td>
<td>( b )</td>
<td>62.265</td>
<td>1.824</td>
<td>0.029</td>
<td>94.487</td>
</tr>
<tr>
<td></td>
<td>( R^2 )</td>
<td>0.980</td>
<td>0.009</td>
<td>0.009</td>
<td>0.778</td>
</tr>
</tbody>
</table>

* SD, standard deviation
** CV, coefficient of variation
reproducibility of experimental conditions is realized in the Mastersizer 2000, the information on these parameters should be included in the experiment description.

**Dynamics of disintegration**

It is obvious that the dynamics of disintegration is most rapid immediately after pouring air-dry soil aggregates into the measurement system. Considering Fig. 3, one can observe that a point is reached where the changes are slight and the values of the equivalent diameter stabilize at a specific level. Therefore, the frequency of measurements and the time of individual measurement should be considered.

The Mastersizer 2000 software permits the time of individual measurement to be set from 0.5 to 65.5 s for each laser (blue and red). This implies that the real time of individual measurement is twice as long. Taking into account the monitoring of changes at the start of the disintegration process one can expect the measuring time to be as short as possible, but the meaning of ‘shortest time’ needs to be discussed.

When measuring time is too short, the problem of the representativeness of the measurement arises. When there are only few larger particles (aggregates or disaggregated soil particles), statistically they will enter the measuring cell less frequently than smaller particles and the measuring system will fail to identify them.

An additional argument for not shortening the measuring time is the necessity for using the obscuration reducing procedure (described in the Material and methods section above). This procedure was often used in measuring large aggregates of Calcaric Cambisol and Mollic Gleysol. When the measuring time is very short compared with the time interval necessary for reducing obscuration, it strongly influences the dynamics of aggregate disintegration and, in consequence, the determination of the coefficient of the interpolated function.

We decided, on the basis of experience, to set the individual measurement interval to 60 s (2 x 30 s). In our opinion, this measurement parameter is not critical because rapid changes of the median in the first few seconds do not influence the parameters of the interpolated equations significantly. Of course, for other applications, monitoring for shorter periods can be used. However, it seems better to interpolate the changes in this short time by a linear function.

**Problem of initial preparation of the soil sample**

The prior preparation procedures for the soil samples could lead to errors in the results obtained. For instance, using moist aggregates would cause inaccuracies because the water would cause disaggregation. The extent of this prior disintegration would be difficult to estimate as it depends on the soil type, amount of water used, possible mixing, etc. The use of an ultrasonic probe built into the apparatus can accelerate the speed of aggregate disintegration and in the experimental conditions make it impossible to monitor the changes of the median. These problems led us to use dry soil.

**Comparison of dynamics of soil aggregate disintegration with the standard wet-sieving method**

Comparisons of water-resistance results obtained by the laser diffraction method and the standard wet sieving method are shown in Table 3.

Our first conclusion drawn from Table 3 is that it is not possible to use the standard wet-sieving method for ~0.25 mm fractions. However, in the laser diffraction method it is possible.

It can be seen from the data in Table 3 that there is a characteristic relationship for all fractions of all soils. The values of the measured parameters decrease in the following order: from the largest value for MWD_{12}, through MWD_{30}, median_{12} to the smallest value of median_{30}. It is obvious that MWD_{30} (30 min of soil aggregate disintegration) is smaller than MWD_{12} (12 min of soil aggregate disintegration). A similar situation occurs in laser measurements when the median is smaller after 30 min than after 12 min. However, the relatively large difference between values of MWD (weighted average) and the median should be stressed. Both quantities express different statistical parameters but the general trend shows that the aggregate-destruction energy during laser diffraction measurements is markedly higher than in the sieve method.

The main reason for the lack of repeatability in the sieve method is the fact that the manner and speed of mixing is different in the different methods. There are numerous pieces of equipment for the measurement of the aggregate water stability of soils but they differ in construction and in the relationship between mass of soil samples and...
volume of water. Also, relations between sieves and water are different. The sieves can be immovable (water flows); these can be moved up and down or deviate from the perpendicular together with the container by up to 60º (De Boodt, 1967; Walczak & Witkowska, 1976).

Soil aggregate disintegration determinations using the laser diffraction method are repeatable because in modern devices the speed of stirrer can be programmed. This parameter should be defined in the description of the method.

Most of the methods of measurement of soil aggregate stability (including the sieve method) do not provide an opportunity to verify the accuracy of the measurement. A strict compliance with the operating procedure decreases the measurement uncertainty. In the laser diffraction method the operator is able to verify if the measurement is acceptable and complete. This verification can be achieved by observing changes of the median during the measurement. The stabilization of the median indicates that the process of soil aggregate disintegration is completed. Therefore, for some soils, it is possible to extend the measurement to materials which are impossible with the sieve method.

A further observation from Table 3 is that the largest median after 12 and 30 min in all cases is for finer fractions (0.25–0.50 mm) and not for coarser ones (0.5–1.0 and 1.0–2.0 mm) as could be expected (as shown in MWD_{12} and MWD_{30}). This can be caused by the large rate of disintegration of coarser aggregates at the time of addition of soil to the measuring system. When the speed of the pump and stirrer is 2500 r.p.m., and when the measurement interval is 1 min in the laser diffraction method, it is impossible to observe the starting dynamics of aggregate disintegration (in the initial seconds when the rate is greatest). This can be confirmed by examining Fig. 3. The median of the coarser fraction in the first minute is much greater than the median for the finest fraction. Simultaneously, a sudden decrease of the median for coarser fractions can be observed and after a few minutes they are smaller than for the 0.25–0.50 mm fraction.

Comparing the stability of soil aggregates expressed by parameters CMWD_{12} and CMWD_{30} (Table 3) with the dynamics of aggregates disintegration expressed by parameter a from the logarithmic equation 1 (Table 2) shows that values of CMWD for both methods are directly correlated.
with the size of the fraction. A different situation arises in the case of the $a$ parameter. The monotonicity can be observed only for Calcaric Cambisol (the increase of fraction size and decrease of $a$ parameter (from $-16.583$ to $-101.650$) which means that the dynamics of disintegration increases). For Mollic Gleysol the greatest rate of disintegration occurs for the $0.5–1.0$ mm fraction and, for Haplic Phaeozem, for the $0.25–0.5$ mm fraction. For the coarser fractions of both soils the values of the $a$ parameter are similar. The differences obtained for the sieving and laser diffraction methods do not mean there is an error in either of them. The sieve method permits estimation of the difference before and after the disintegration process and the $a$ parameter describes the dynamics of change but not the difference.

Laser diffraclometry was used for the assessment of micro-aggregation by Beuselinck et al. (1999). They obtained good correlation with the sieve method and their results can be a good supplement to the data presented in this paper but they cannot be compared directly. They used the laser diffraction method for the measurement of the grain-size distribution of previously dispersed soil. Because of this, their work was rather a comparison of the results obtained by the sieve and laser diffraction methods than an investigation of the dynamics of soil aggregate disintegration.

CONCLUSIONS

(1) The laser diffraction method for grain-size distribution can be used successfully for the determination of the dynamics of soil aggregate disintegration. This can be achieved by analysing the median changes during the mechanical disintegration of aggregates in water.

(2) Use of the laser diffraction method provides an opportunity to measure the water resistance of all fractions of aggregates when standard sieve methods preclude the measurement of the finer fractions.

(3) Soil aggregate disintegration is more repeatable in the laser diffraction method than in standard sieve method. This gives less uncertainty of measurement.

(4) With the laser diffraction method it is possible to verify if the soil aggregates were completely destroyed. This is achieved by observing changes of the median of grain-size distribution. Lack of the changes of the median values indicated the conclusion of soil aggregate disintegration. This is largely impossible in previously described methods (including sieve methods).

(5) Changes of the median of grain-size distribution can be interpolated satisfactorily by a logarithmic function.

REFERENCES


