Střelcová, K., Škvarenina, J. & Blaženec, M. (eds.): "BIOCLIMATOLOGY AND NATURAL HAZARDS"
International Scientific Conference, Poľana nad Detvou, Slovakia, September 17 - 20, 2007, *ISBN 978-80-228-17-60-8*

Effects of some soil physical and chemical attributes on three aggregate stability indices

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Abstract In the current study aggregate stability were determined using three methods of Kemper and Rosenau (1986), Le Bissonnais (1996), and Levey and Miller (1997). The stabilities are expressed in terms of three indices as water aggregate stability (WAS), mean weight diameter (MWD) and stability ratio (SR), respectively. Nineteen soils with broad range of organic carbon content (OC), calcium carbonate equivalent (CCE), (ECe), SAR and texture were employed. Purposes were to evaluate a) effects of the above soil parameters on three stability indices, b) to examine the limitations may rise practically in the measurements and c) to compare degree of agreement between the three indices. WAS for the soils varied from 6% to 89%; 64% of the variation (R = 0.80**) resulted by the variation in OC. WAS significantly was negatively affected by CCE (R = –0.62**) and SAR (R = –0.52*). In spite of wide variation is soil texture among 19 soils, it did not produced significant effect on WAS. Due to an ease and speed of measurement, mean weight diameter measured by fast prewetting of the aggregates (MWDf) appears to be accurate enough as a stability index of Le Bissonnais method. MWDf ranged from 0.32 to 1.17; OC attributed to 84% (R = 0.91) of its variation, implying that MWDf basically was dependent to OC. In contrast to WAS, MWDf was not statistically correlated to either CCE or SAR, but instead was significantly affected by sand (R = 0.74**) and clay (R = –0.61**) contents of the soils. SR ranged from 0.30 to 0.89 (theoretical range is 0 to 1) and its response to soil parameter variations was quite similar to MWDf. Between the three indices, there was more close agreement (R = 0.87**) between SR and WAS than between MWDf and WAS (R = 0.71**). Using SR, 12 examined soils could be grouped in three qualitative structure stability classes namely highly stable (SR>0.81), moderately stable (SR>0.42) and poorly stable (SR<0.42). These ranges are, however, arbitrary and their generalization for a reasonable justification about the structure behavior in response to management needs a broad investigation.

Introduction

Many researches have been carried out to understand soil structure from various aspects and several methods including Kemper and Rosenau (1986), Le Bissonnais (1996), and Levy and Miller (1997) have been developed to assess soil structure stability. Outcome of the above methods were to introduce some stability indices such as water aggregate stability (WAS), mean weight diameter (MWD), and stability ratio (SR), respectively. Wetting aggregates first, and then sieving them in a liquid are the common procedures in most of the methods; the difference arise from selecting aggregate size, manner of their pre-wetting and composition of the liquid in which the sieving is accomplished. Responses of structure stability to various soil characters have also been investigated. Curtin and Mullen (2002) have demonstrated organic carbon as the most important soil parameter affecting MWD. Adverse effects of SAR and positive contribution of EC on WAS were clarified by Tajik et al. (2002). Seybold and Herrik (2001) work showed that increase in clay fraction significantly improved WAS. Purpose of the current study is to evaluate WAS, MWD and SR in soils with broad range of chemical and physical characters.

Materials and methods

In the current study 19 soils with wide range of texture, organic carbon (OC), calcium carbonate equivalent (CCE), SAR and EC were selected. The above- mentioned characters were measured using routine laboratory methods. After separating aggregates into various size class, three parameters of structure stability (WAS, MWD, and SR) were determined according to the procedures described by Kemper and Rosenau (1986). Le Bissonnais (1996), and Levy and Miller (1997). The results were interpreted using appropriate statistical analysis.

Results and discussion

Chemical and physical characteristics of 19 soils examined are shown in table 1. Their variation and range are large enough to depict the degree and nature of the structural stability to the soil characters.

Table 1. Mean, coefficient of variation and range of measured parameters of 19 examined soils.

Soil variants	Sand (%)	Silt (%)	Clay (%)	OC (%)	CCE (%)	SAR	EC (dS m^{-1})
Mean	40.9	35.7	18.9	1.36	14.6	19.6	14.0
CV (%)	55.5	48.5	53.3	105.7	119.2	48.1	125.1
Range	8–75	15–72	6–46	0.26–5.4	1.1–59	2–30	0.6–67

Table 2. Mean (3 replicates), coefficient of variation and range of the structure stability.

Stability	WAS (%)	MWD_f (mm)	MWD_s (mm)	MWD_{sh} (mm)	SR
Mean	30.7	0.62	0.76	0.64	0.52
CV	79.7	45.3	30.0	37.4	35.8
Range	6-84	0.32–1.26	0.45–1.27	31–1.18	0.29–0.89

Table 3. Linear correlation coefficients between structure stability indices and soil characters.

Soil variants	WAS (%)	MWD_f (mm)	MWD_s (mm)	MWD_{sh} (mm)	SR
OC (%)	0.80**	0.91**	0.86**	0.87**	0.78**
CCE (%)	–0.62**	ns	ns	ns	ns
SAR	–0.52*	ns	ns	ns	ns
EC_e (dS m^{-1})	ns	ns	ns	ns	ns
S (%)	ns	0.74**	0.76**	0.65*	0.57*
Si (%)	ns	–0.70*	–0.73**	ns	–0.41*
C (%)	ns	–0.61*	–0.60*	–0.63	–0.54*

Table 2 summarizes the statistics of the three structural stability criteria among the soils were investigated. WAS showed wider variation than Le Bissonais MWD and Levy and Miller SR, implying that WAS seems to be more responsive to the variation in soil characters than MWD and SR.

Less MWD_s comparing to MWD_f and MWD_{sh} clarifies that under slow wetting, aggregates becomes less disturbed initially and preserve their stability. Table 3 obviously indicates the dominant influence of %OC in structural stability, a finding that is has been reported by other scientists. Positive and significant correlation of MWD and SR to soil texture, particularly to %S (Table 3), implies that MWD and SR may be more appropriate criteria in structural stability assessment than WAS among soils that their differences primarily arise from texture because WAS did not correlate to soil texture. In contrast, WAS was significantly correlated to CCE and SAR (Table 3), while MWD and SR were not; implication is that in soils with close texture but with wide range of SAR and carbonates WAS would be a more suitable as a stability criterion. Surprisingly WAS, MWD, or SR none was correlated to EC (Table 3) even with its variation from .6 to 67 dS/m probably because of strong correlation between EC and SAR; sodium chloride was the major solute constituent in the examined soils. Even though the adverse effect of SAR on the structural stability is well documented according to Table 3, however, only WAS has been adversely affected by SAR ($R = –0.52$). Why MWD and SR remained unaffected by SAR is not so clear and deserves more investigation.

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