Dynamics of Aggregate Stability under Drying and Wetting Cycles for Yellow Soil in China

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Soil aggregate stability is an essential soil property, influencing many soil behaviors. However, the relationships between drying and wetting cycles and aggregate stability dynamics with different initial aggregate size classes have not been clarified. This study was conducted to investigate the effects of drying and wetting cycles on aggregate stability under different breakdown mechanisms, and determine the effects of initial aggregate sizes on soil aggregate stability. A simulation experiment was performed on four initial aggregate sizes without organic matter amendment. Aggregate stability was measured by the method proposed by Le Bissonnais (1996), and the fragment size distribution was obtained simultaneously.

Initial aggregate sizes showed significant effects on the mean weight diameter (MWD) and no significant effects on normalized mean weight diameter (NMWD). Even for the same soil, aggregate stability varied greatly among different aggregate classes according to MWD. In contrast to the MWD, NMWD suggested that aggregate stability increases with decreasing aggregate size (Figure 1). This can be explained by the principle of porosity exclusion (Currie, 1966; Dexter, 1988), which suggests that large aggregates have larger pores and are less dense than the small aggregates, and stronger attractive forces is needed to bridge the pores between small aggregates composing large aggregates.

Drying and wetting cycles significantly influenced aggregate stability for all initial aggregates (Table 1), and differences in the cumulative effects were found between different aggregate stability tests. In the fast wetting (FW), the first two cycles increased MWD by 5%-36%. However, the positive effects on aggregate stability were transient and later the MWD returned back to its initial state or even less. In the slow wetting (SW) and shaking test (ST), the drying and wetting cycles significantly decreased MWD by 53%-70% and 69%-80%, respectively. Moreover, the size fraction where the peak point appeared become larger as the aggregate size classes increased, indicating that the large size aggregates produced coarser fragments than the small size aggregates. The proportions of >0.5 mm fractions increased slightly during the first two drying and wetting cycles, followed by a significant decrease after the 3rd cycle to a progressive decrease with further cycles (Figure 2). This indicated that the >0.05 mm size fraction is progressively broken down into finer fragments.

Different soil aggregate breakdown mechanisms illustrated greater uncertainty among different initial soil aggregate classes. Impact of initial soil moisture on aggregate stability was also found; it showed that the slaking effect was weakened as initial soil moisture increased. The decrease in the process of the slacking effect showed obvious periodic behaviors, with three stages: I) high-intensity slaking stage, with the initial soil moisture less than 10%, II) sharply decreasing stage, with initial soil water content between 10% and 20%, and III) stable stage, where the slacking effect nearly ends, with initial soil moisture greater than 20%. The dominant soil aggregate breakdown mechanisms were slaking and swelling for the research area, and the order of their affected degree on breaking soil aggregates was as follows: slaking > swelling > mechanical breakdown effect.

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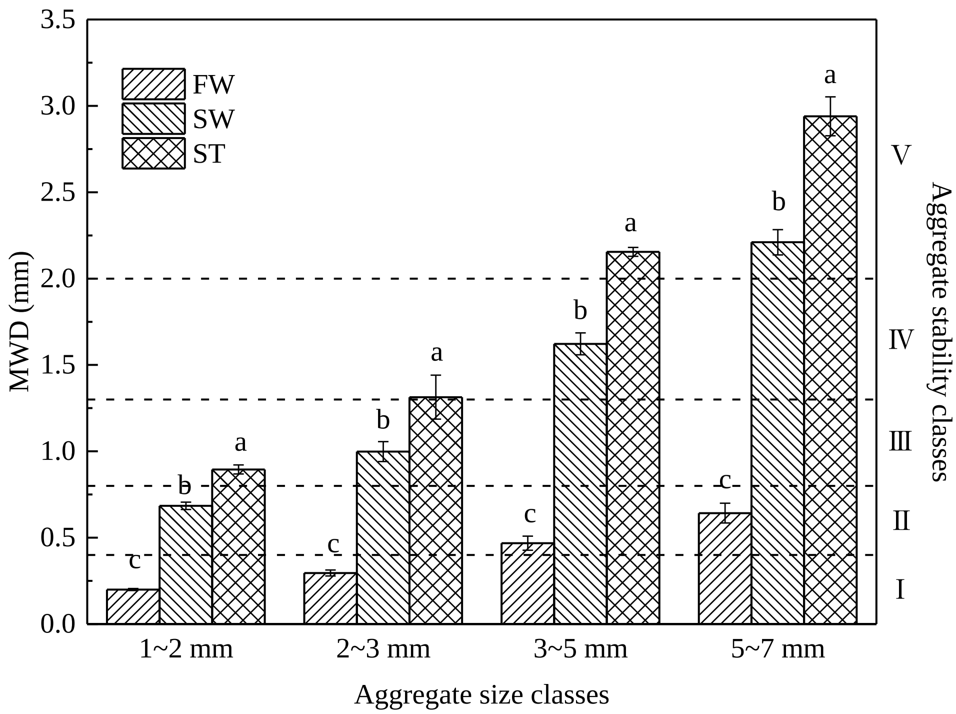

Figure 1. MWD values for the control soil (Cycle 0). FW, SW, ST indicates the fast wetting, slow wetting, and shaking tests, respectively. Bars in same size class with same lower case letter are not significantly different (*P*< 0.05). Brackets at top of bars represent standard deviation.

Table 1. Analysis of differences in mean of MWDs between different drying and wetting cycles.

Stability tests	Aggregate size classes	Drying and wetting cycles							
		0	1	2	3	5	7	10	15
FW	1~2 mm	a	a	a	bc	b	b	bc	c
	2~3 mm	a	ab	a	cd	bcd	abc	bcd	d
	3~5 mm	ab	ab	a	bc	ab	ab	ab	c
	5~7 mm	bc	ab	a	c	bc	bc	c	c
SW	1~2 mm	a	b	c	d	d	de	ef	f
	2~3 mm	a	b	bc	c	c	c	c	d
	3~5 mm	a	b	b	bc	cd	de	de	e
	5~7 mm	a	a	ab	b	c	c	c	c
ST	1~2 mm	a	a	a	a	b	b	bc	c
	2~3 mm	a	b	c	d	d	d	de	e
	3~5 mm	a	b	c	cd	de	e	f	f
	5~7 mm	a	a	c	d	d	e	e	e

*Same letter indicates no significant difference (*P*<0.05) between different drying and wetting cycles.

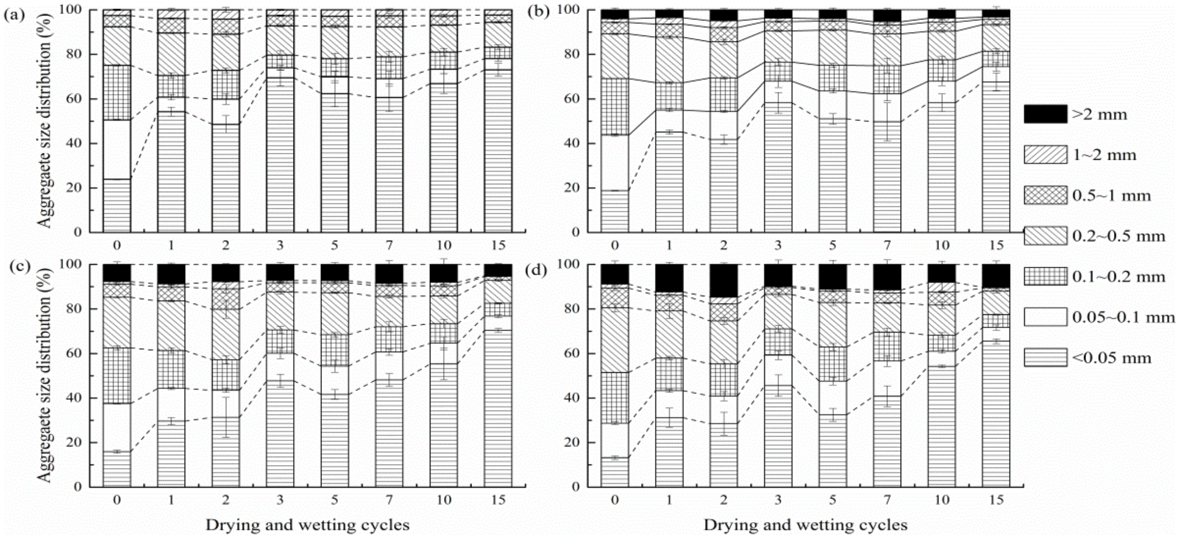

Figure 2. Soil aggregate size distributions after FW test during drying and wetting cycles. (a) 1~2 mm size class, (b) 2~3 mm size class, (c) 3~5 mm size class, (d) 5~7 mm size class.

References

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