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The stability of soil aggregates in tilled fallow areas in Hyderabad district, Pakistan

Ahmed TAGAR[1) ABCDEF], Jan ADAMOWSKI[2) ABCDEF]

[1)] Faculty of Agricultural Engineering, Sindh Agriculture University, Tandojam, Pakistan; ahmed_ali_tagar@hotmail.com
[2)] McGill University, Faculty of Agricultural and Environmental Sciences, Department of Bioresource Engineering, Quebec, Canada, H9X 3V9; e-mail: jan.adamowski@mcgill.ca

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Abstract

Arid areas are particularly susceptible to soil erosion due to long dry periods and sudden heavy downpours. This study investigates the aggregate size distribution and aggregate stability of twelve tilled fallow areas of Hyderabad district, Sindh, Pakistan. This study determined aggregate size distribution by dry sieving to evaluate the seedbed condition and aggregate stability using wet sieving to assess the susceptibility of tilled fallow areas to soil erosion. The aggregate size distribution of the soils of the selected areas was highly variable. Gulistan-e-Sarmast had the largest number of clods (51.0%) followed by Kohsar (49.0%), Latifabad # 10 (41.10%) and Daman-e-Kohsar (39.0%). Fazal Sun City, the left side of the Indus River, the Village Nooral Detha and the left side of the Abdullah Sports city had a greater number of large (>8.0 mm) and small aggregates (<0.5 mm). The optimum aggregate size distribution was found in the left side of the channel, which had the largest number of aggregates (50.50%) in the 0.5–8.0 mm sieve size range. Maximum aggregate stability (AS) was found in Gulistan-e-Sarmast (46%), Kohsar (42%) and Latifabad # 10 (34%), while all other soils had minimum aggregate stability (<14%). The minimum aggregate stabilities demonstrate that the tilled fallow areas of Hyderabad district are highly susceptible to erosion. Therefore, the present study suggests investigating potential ways to enhance the aggregate stabilities of soils.

Key words: *aggregate size distribution, aggregate stability, seedbed condition and soil erosion, tilled fallow areas*

INTRODUCTION

Soil structure is a key indicator of soil quality, and the agricultural system more generally [TAGAR *et al.* 2014; 2015a, b]. It supports plants with sufficient water supply, aeration and the release of available nutrients [ALVAREZ *et al.* 2012]. Additionally, it protects organic matter [LÜTZOW *et al.* 2006] and reduces soil erosion [OADES 1984]. However, prolonged exposure of soils associated with insufficient residue inputs may cause declines in aggregation and soil organic matter, both of which make soil susceptible to erosion [PINHEIRO *et al.* 2004].

Soil erosion is defined as the detachment, transportation and deposition of soil particles and soil aggregates by wind and water [LAL 1994]. It is a serious environmental, economic, and social problem in semi-arid and arid regions worldwide, which not only causes severe land degradation and loss of soil productivity, but also threatens the stability and health of society as well as the sustainable development of rural areas [ZHENG *et al.* 2004]. According to LAL [2001], the total land area subjected to soil degradation is estimated at about 2 billion hectares. Of this, about 1100 million hectares (mha) of land area is affected by water erosion and 550 mha of land area is affected by wind erosion. Given the anticipated changes in climate (e.g., ADAMOWSKI *et al*. [2009; 2010; 2012a, b], NALLEY *et al*. [2012; 2013], CAMPISI *et al*. [2012], HAIDARY *et al*. [2013], PINGALE *et al*. [2014], BELAYNEH *et al*. [2014], TIWARI and ADAMOWSKI [2014], RATHINASAMY *et al*. [2014], NOURANI *et al*. [2014]), this situation will likely worsen over the course of the next several decades. In Pakistan, the total land area affected is 79.61 mha, with 7.2 mha land area beingaffected by water erosion and 10.7 mha land area affected by wind erosion.

The evaluation of soil erosion in the field is often expensive and time consuming. Soil aggregate stability is therefore an important property that may quantify and predict erosion [ZHANG, HORN 2001]. AN *et al*. [2009] concluded that the measurements of aggregate stability indicate that the soil water-stable aggregate contents reflect the ability of the soils to resist erosion. This is consistent with LE BISSONNAIS *et al.* [2007], who concluded that aggregate soil stability is closely correlated to the susceptibility of soil to erosion. Indeed, SHEIN *et al*. [2010] concluded that the differences in soil aggregate stability may largely influence soil's susceptibility to erosion.

Soil aggregate stability is the ability of the soil to retain its arrangement of solids and pore spaces after the application of mechanical stress or destructive forces [DIAZ-ZORITA *et al.* 2002]. Maintaining high soil aggregate stability is essential for preserving soil productivity and for minimizing soil erosion and environmental pollution that result from soil degradation. ARSHAD and COHEN [1992] proposed that aggregate stability is one physical soil properties that can serve as a soil quality indicator. HORTENSIUS and WELLING [1996] included aggregate stability in the international standardization of soil quality measurements.

A large number of soils in developing countries are tilled and are left fallow due to the scarcity of water or paucity of funds. However, sudden heavy downpours due to climatic changes erode the top fertile layers of these soils, making them unfertile or not suitable for cropping. This is consistent with LEGOUT *et al*. [2005], who concluded that heavy precipitation events, splash impact and slaking causes soil aggregates to break down into very fine particles and micro-aggregates, which may become highly erodible in water. According to HUSSAIN *et al.* [2010], Hyderabad, Pakistan received 105 mm of rain in 12 hours contributing towards a sudden flood event in February of 2003. 2006 and 2007 followed with close to this record rainfall with an estimated death toll ranging into the hundreds. On July 18, 2009, a total of 110 mm rain lashed the city, setting a new record. Accordingly, the present study was designed to investigate the stability of soil aggregates in tilled fallow areas of Hyderabad district in Pakistan in order to: (i) investigate the effect of tilled fallow areas on aggregate soil size distribution and the structural stability of soil.

MATERIALS AND METHODS

Soil samples were obtained from 12 tilled fallow soils of Hyderabad district of Sindh province, Pakistan. It is located at 68°17'30"–68°38'40" E longitude 25°09'30"–25°33'12" N latitude with an elevation of approximately13 m above mean sea level (MSL). Figure 1 indicates the names and locations of selected sites of Hyderabad district. The climate of Hyderabad is hot and arid with an average annual rainfall of 136.1 mm, average maximum temperature of 40°C and humidity of 55–60%.

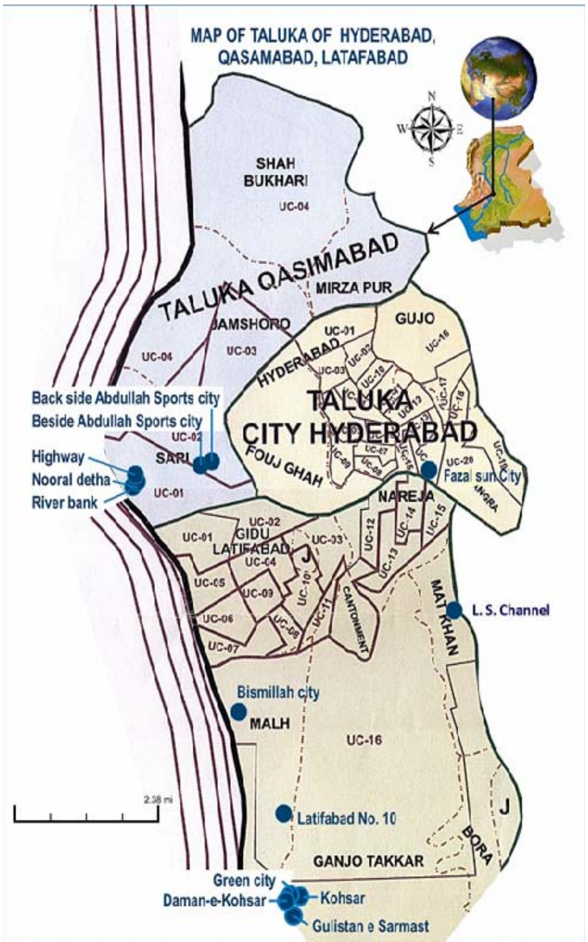

Fig. 1. Names and locations of selected sites of Hyderabad district, Sindh Province, Pakistan; source: own elaboration

SOIL SAMPLING

Three soil samples (one from the center and two from each side) were collected from the top 0–10 cm layer of each site. Litter, rock fragments and surface crusts, were removed prior to sampling. The samples were stored in aluminium containers, labeled and brought to the laboratory and then left for air drying at room temperature for 15 days. Similar soil samples were taken for the determination of soil texture and organic matter.

Soil textural class was determined by the hydrometer method [BOUYOUCOS 1927], in which 50 g of oven dry soil was sieved through a 2 mm sieve and added to a dispersing cup, with 400 mL of distilled water. 100 mL of sodium hectametaphosphate was then added to the cylinder, which was filled to the one liter mark with distilled water. The first reading of the hydrometer was taken after 40 seconds, and a second reading taken after 2 hours to determine the percentages of sand, silt and clay. To measure the dry bulk density of tilled soils, aggregates were placed in an empty container (100 mL), slightly compacted to remove empty spaces, and weighed with a digital balance to the nearest 0.0001 g. The soil weight was then divided by the total volume of the container to obtain the dry bulk density, following the method adopted by ZHANG *et al.* [2012].

Organic matter content was determined using the WALKLEY and BLACK [1934] method. 1 g of soil was passed through a 2 mm sieve and weighed into a 500 mL conical flask. 10 mL of 1 N $K_2Cr_2O_7$ was added; the flask was swirled, and concentrated H_2SO_4 (20 mL) was rapidly added and the flask again swirled for one minute. The flask was allowed to stand on an insulating (asbestos) sheet for 30 minutes, after which deionized water (200 mL) was added to the flask followed by three to four drops of o-phenanthroline indicator solution. Titration was conducted with Fe $(NH_4)2$ $(SO_4)2$ (0.5 M) solution. A blank was also run in the same manner without soil to standardize $K_2Cr_2O_7$. The organic carbon content in the soil was then calculated using the following equation:

$$O.C(\%) = \frac{(B - S) \cdot N \cdot 0.003 \cdot 100}{Wt \text{ of soil}} \qquad (1)$$

where:
B = the volume of standard 0.5 N ferrous ammonium sulphate required to titrate the blank;
S = is the volume of standard 0.5 N ferrous ammonium sulphate required to titrate the soil sample;
N = the normality of standard ferrous ammonium sulphate (0.5 N);
Wt = oven-dry weight of soil, g.

Table 1 indicates soil organic matter, dry bulk density and textural class of selected sites.

Table 1. Soil organic matter, dry bulk density and textural class of selected sites

Name of sites	Particle size distribution (%)			Textural class	Dry bulk density g·cm^{-3}	Soil organic matter %
	sand (0.05–0.2 mm)	silt (0.002–0.05 mm)	clay <0.002 mm			
Kohsar	35.4	22.3	42.3	clay	1.23	1.61
Near Fateh Farm	40.4	35.7	23.9	loam	1.21	0.69
Daman-e-Kohsar	51.3	22.3	26.4	sandy clay loam	1.25	0.53
Latifabad # 10	47.0	29.1	23.9	loam	1.20	1.49
Back side of the Abdullah sports city	45.4	30.7	23.9	loam	1.24	0.52
Fazal Sun City	54.5	10.7	34.8	sandy clay loam	1.26	0.56
Left side of the Abdullah sports city	57.9	13.2	28.9	sandy clay loam	1.25	0.59
Left side of the channel	42.0	10.7	47.3	clay	1.22	0.65
Gulistan-e-Sarmast	39.5	20.7	39.8	clay loam	1.23	2.19
Green city	37.0	33.2	29.8	clay loam	1.27	0.51
Left side of the Indus River	40.4	30.7	28.9	clay loam	1.21	0.54
Village Nooral Detha	37.9	33.2	28.9	clay loam	1.22	0.51

Source: own elaboration.

AGGREGATE SIZE DISTRIBUTION

Mean weight diameter (*MWD*) was used to determine the aggregate soil size distribution. Through this method, soil samples were passed through a nest of nine (9) sieve size classes: 32–25, 25–12, 12–8, 8–4, 4–2, 2–1, 1–0.5, 0.5–0.25 and <0.25 mm, respectively. The proportion of soil aggregates retained on each size class was collected and weighed. Mean weight diameter (*MWD*) was calculated using following formula [VAN BAVEL 1949]:

$$MWD = \sum x_i w_i \qquad (2)$$

where:
MWD = the mean weight diameter;
x_i = the mean diameter of the *i*th sieve size;
w_i = the proportion of the total aggregates in the *i*th fraction.

AGGREGATE STABILITY (*AS*)

Aggregate stability of the soil was determined using the wet sieving method of KEMPER and ROSENAU [1986]. In this method 50 g of air dried soil passed through an 8 mm sieve was pre-soaked for 30 minutes with distilled water and then transferred to the top most of the nest of sieves of 2.00, 1.00, 0.50, and 0.25 mm mesh sizes respectively. Subsequently soil in the nest of sieves was oscillated in distilled water at 30 oscillations per minute for a period of ten minutes. The aggregate stability was evaluated using the following formula [PICCOLO, MBAGWU 1999]:

$$AS = \frac{WSA > 0.25 \text{ mm} - Wt \text{ of sand}}{Wt \text{ of soil} - Wt \text{ of sand}} \cdot 100 \qquad (3)$$

where:
AS = aggregate stability, %;
WSA = water stable aggregates;

Wt of sand = oven-dry weight of sand, g;
Wt of soil = as in eq. (1).

STATISTICAL ANALYSIS

Statistical analysis was performed using statistical software package SPSS-16.0 [SPSS 2007]. One way analysis of variance (ANOVA) was used to determine the effect of tilled fallow areas on mean weight diameter, aggregate stability, water stable aggregates and aggregate size distribution. The means were compared by the least significant difference method (*LSD*) at $P = 0.05$.

RESULTS AND DISCUSSION

Statistical analysis of the results revealed that the tilled fallow areas had significant ($P < 0.05$) effects on mean weight diameter, aggregate stability, water stable aggregates and aggregate size distribution. Tables 2–5 show the descriptive statistics in the form of mean, standard deviation, range, *F*-values and *P*-values of mean weight diameter, aggregate stability, water stable aggregates and aggregate size distribution for selected sites of Hyderabad district. Previous studies have reported that a healthy seedbed should have more than 50% of soil aggregates by weight in the range of 0.5–8.0 mm [BRAUNACK, DEXTER 1989]. This is consistent with MUNKHOLM [2002], who concluded that a very large fraction of small aggregates (i.e. <0.5–1.0 mm) is not desirable, because of increased risk of wind and water erosion, while a very large fraction of aggregates larger than 8 mm is not desirable due to a reduction in the soil/root contact area and a higher impedance to root penetration. Indeed ADAM and ERBACH [1992] concluded that large proportions of very fine soil aggregates and clods in the seedbed can cause poor seed germination and delayed seedling emergence. Therefore in this study, the optimum seedbed was assumed to produce greater than 50% of aggregates by weight in the range of 0.5 to 8.0 mm. Figure 2 illustrates the mass fraction (%) of soils of selected sites from different sieve sizes (mm) obtained by dry-sieving. Gulistan-e-Sarmast had largest number of clods (51.0%) followed by Kohsar (49.0%), Latifabad # 10 (41.10%) and Daman-e-Kohsar (39.0 %). Fazal Sun City, the left side of the Indus River, Village Nooral Detha and the left side of the Abdullah Sports city had a greater number of large (>8.0 mm) and small aggregates (<0.5 mm). The optimum aggregate size distribution was found in left side of channel, which had the largest number of aggregates (50.50%) in the 0.5–8.0 mm sieve size range. These differences may be the result of different land use and tillage practices. This is consistent with HEVIA *et al.* [2007], who found differences in aggregate soil size distribution in different soils associated with different tillage practices. GAJIĆ *et al.* [2013] reported more than 33% of the dry aggregates in grassland habitats and only 20% of those in the arable soil to fall within the 1–5 mm sieve size range. Further, our results are comparable to COTCHING *et al.* [2002], who concluded that a significantly higher content of dry soil aggregates at a depth of 75 mm of cultivated soils as compared to a similar depth zone for long-term pasture soils. Indeed BROERSMA *et al.* [1997] concluded that the Gray Luvisolic soil in Canada had fewer large aggregates and more small aggregates than other cropping systems.

Table 2. Mean, standard deviation, range, *F*-values and *P*-values of mean weight diameter for selected sites of Hyderabad district

Name of sites	Mean weight diameter				
	mean	standard deviation	range	*F*-value	*P*-value
Kohsar	8.7033	0.04726	0.09	369.242	0.000
Near Fateh Farm	7.4767	0.03055	0.06		
Daman-e-Kohsar	7.3333	0.04726	0.09		
Latifabad # 10	8.3000	0.20000	0.40		
Back side Abdullah sports city	7.1533	0.03215	0.06		
Fazal Sun city	5.9500	0.03000	0.06		
Left site of the Abdullah sports city	7.4467	0.01528	0.03		
Left site of the channel	6.4700	0.03606	0.07		
Gulistan-e-Sarmast	9.0467	0.03786	0.07		
Green city	7.4767	0.03055	0.06		
Left site of the Indus River	5.0000	0.26458	0.50		
Village Nooral Detha	7.3533	0.04726	0.09		

Source: own study.

Table 3. Mean, standard deviation, range, *F*-values and *P*-values of aggregate stability for selected sites of Hyderabad district

Name of sites	Aggregate stability				
	mean	standard deviation	range	*F*-value	*P*-value
Kohsar	41.9667	2.13620	4.00	427.535	0.000
Near Fateh Farm	9.5167	0.03055	0.06		
Daman-e-Kohsar	12.0000	1.77325	3.38		
Latifabad # 10	34.0000	1.63377	3.16		
Back side Abdullah sports city	5.5967	0.01528	0.03		
Fazal Sun city	5.2367	0.05033	0.10		
Left site of the Abdullah sports city	10.4033	0.02082	0.04		
Left site of the channel	13.3033	0.04041	0.08		
Gulistan-e-Sarmast	46.0000	2.64575	5.00		
Green city	12.2033	0.04041	0.08		
Left site of the Indus River	9.2033	0.02082	0.04		
Village Nooral Detha	11.4033	0.02517	0.05		

Source: own study.

Table 4. Mean, standard deviation, range, *F*-values and *P*-values of water stable aggregates for selected sites of Hyderabad district

Name of sites	Water stable aggregates									
	mean		standard deviation		range		*F*-value		*P*-value	
	0.25–2.0 mm	<0.25 mm	0.25–2.0 mm	<0.25 mm	0.25–2.0 mm	<0.25 mm	0.25–2.0 mm	<0.25 mm	0.25–2.0 mm	<0.25 mm
Kohsar	18.963	81.00	1.788	2.000	3.35	4.00	133.86	100.74	0.000	0.000
Near Fateh Farm	4.757	95.24	0.030	0.030	0.06	0.06				
Daman-e-Kohsar	6.003	94.00	1.641	1.951	3.19	3.82				
Latifabad # 10	17.000	83.00	2.216	2.062	4.30	3.90				
Back side Abdullah sports city	2.797	97.20	0.038	0.021	0.07	0.04				
Fazal Sun city	2.623	97.38	0.021	0.026	0.04	0.05				
Left site of the Abdullah sports city	5.203	94.80	0.050	0.030	0.10	0.06				
Left site of the channel	6.640	93.36	0.036	0.040	0.07	0.08				
Gulistan-e-Sarmast	22.997	77.00	1.398	1.977	2.79	3.79				
Green city	6.103	93.90	0.021	1.008	0.04	1.98				
Left site of the Indus River	4.603	95.40	0.030	0.036	0.06	0.07				
Village Nooral Detha	5.703	94.30	0.021	0.056	0.04	0.11				

Source: own study.

Table 5. Mean, standard deviation, range, *F*-values and *P*-values of aggregate size distributions for selected sites of Hyderabad district

Name of sites	Aggregate size distributions														
	mean			standard deviation			range			*F*-value			*P*-value		
	>8.0 mm	0.5–8.0 mm	<0.5 mm	>8.0 mm	0.5–8.0 mm	<0.5 mm	>8.0 mm	0.5–8.0 mm	<0.5 mm	>8.0 mm	0.5–8.0 mm	<0.5 mm	>8.0 mm	0.5–8.0 mm	<0.5 mm
Kohsar	49.0	41.4	9.6	0.9	1.7	0.05	1.9	3.4	0.10	92.5	26.4	844.9	0.00	0.00	0.00
Near Fateh Farm	38.9	45.4	15.7	1.2	0.9	0.05	2.3	1.8	0.10						
Daman-e-Kohsar	39.0	39.4	21.6	1.1	2.0	0.06	2.2	3.9	0.12						
Latifabad # 10	41.1	47.2	11.6	1.2	1.8	0.05	2.3	3.7	0.09						
Back side Abdullah sports city	34.1	44.2	20.8	1.1	1.8	0.03	2.2	3.4	0.06						
Fazal Sun city	27.6	36.3	36.0	1.7	1.5	1.7	3.2	3.0	3.0						
Left site of the Abdullah sports city	38.0	38.3	23.7	1.0	0.9	0.05	2.0	1.9	0.10						
Left site of the channel	30.3	50.5	19.2	2.1	1.5	0.03	4.04	2.9	0.05						
Gulistan-e-Sarmast	51.0	36.7	12.3	1.7	1.5	0.05	3.5	2.9	0.10						
Green city	38.9	37.8	23.3	1.1	1.6	0.04	3.9	3.1	0.07						
Left site of the Indus River	21.8	44.6	33.6	1.3	1.4	0.04	2.6	2.8	0.08						
Village Nooral Detha	36.1	37.8	25.1	1.8	1.6	0.03	3.35	3.3	0.06						

Source: own study.

Figure 3 shows the mean weight diameter of soils of selected sites. Gulistan-e-Sarmast (9.05 mm) had the highest mean weight diameter (*MWD*) followed by Kohsar (8.7 mm), and Latifabad # 10 (8.30 mm); while the Fateh Farm, Daman-e-Kohsar, backside of the Abdullah Sports city, left side of the Abdullah Sports city, Green city and the village Nooral Detha had mean weight diameters ranging from 7.0 to 7.5 mm. Fazal Sun city had 5.95 mm *MWD* and the left side of Indus River had 5.0 mm *MWD*. Mean weight diameter (*MWD*) of Gulistan-e-Sarmast, Kohsar and Latifabad # 10 was greater than other soils as shown in Figure 3. This is attributable the soil organic matter content. ROBERSON *et al.* [1991] concluded that mean weight diameter increases with soil organic matter (SOM) accumulation. This finding is also consistent with CASTRO-FILHO *et al.* [2002], who reported that 50% or higher *MWD* in topsoil was associated with increased soil organic matter.

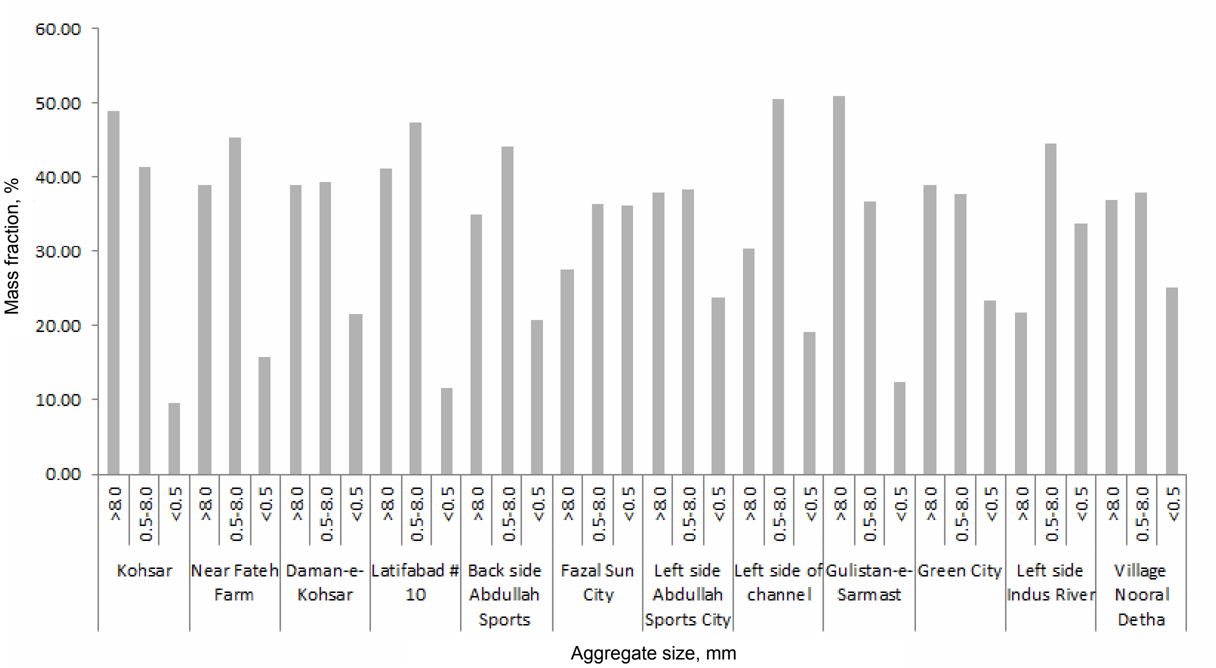

Fig. 2. Mass fraction (%) of soils of selected sites in different sieve sizes (mm) obtained by dry sieving; source: own elaboration

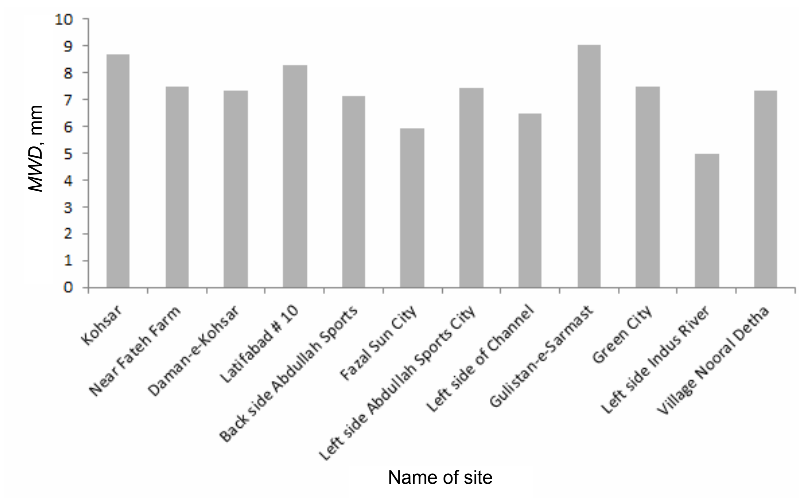

Fig. 3. Mean weight diameter (*MWD*) of soils of selected sites; source: own study

Figure 4 shows the mass fraction (%) of soils of selected sites in different sieve sizes (mm) obtained by wet sieving. The largest number of water stable aggregates (WSA) was found in Gulistan-e-Sarmast (23.0%) followed by Kohsar (19.0%) and Latifabad # 10 (17.0%), while all other soils had smaller amounts of water stable aggregates (i.e. <6.65%). Figure 5 indicates aggregate stability (%) of soils of selected sites. Maximum aggregate stability was found in Gulistan-e-Sarmast (46%) followed by Kohsar (42%), and Latifabad # 10 (34%), while all other soils had minimum aggregate stability (i.e. <14%). BROERSMA *et al.* [1997] found only 22–27% water stable aggregates (>2.0 mm) in the cultivated Gray Luvisolic soils. Similarly MARTENS *et al.* [2003] reported much lower aggregate stability of cultivated soils compared to forest and pasture soils. This is consistent with GAJIC and ZIVKOVIC [2006], who concluded that long term tilled soil had the lowest water stable aggregate (>0.25 mm) percentage. Indeed, EYNARD *et al.* [2004] concluded that the stability of soil aggregates usually decreased with cultivation. The higher aggregate stability in Gulistan-e-Sarmast, Kohsar and Latifabad # 10 may be associated with the higher organic matter content. As was found by WOHLENBERG *et al.* [2004], this is attributable to higher water stable aggregates (*WSA*) and soil aggregate stability (*AS*) values in the surface layer (0.00–0.50 mm) associated with higher soil organic matter content. TISDALL and OADES [1982] reported that organic matter in the soil promotes aggregate stabilization through organic binding agents.

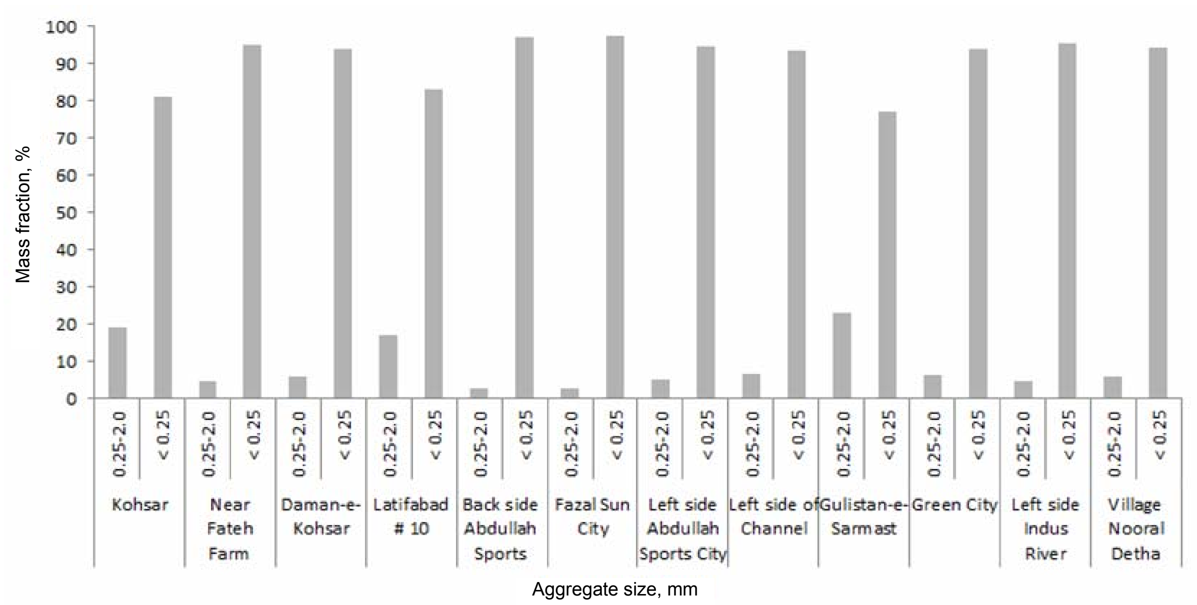

Fig. 4. Mass fraction (%) of soils of selected sites in different sieve sizes (mm) obtained by wet sieving; source: own study

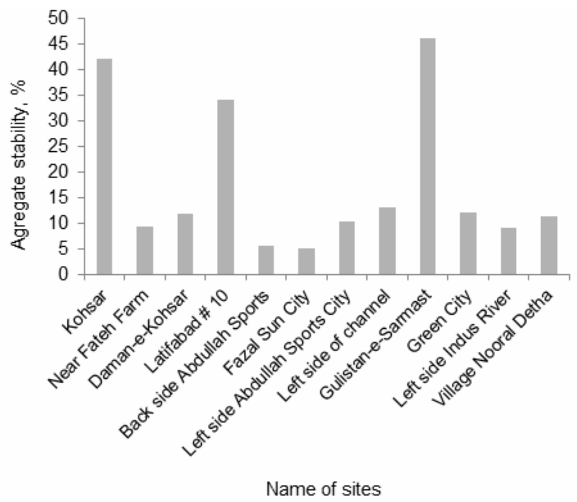

Fig. 5. Aggregate stability (*AS*) of soils of selected sites; source: own study

CONCLUSIONS

The aggregate size distribution of soils of selected areas was highly variable. Gulistan-e-Sarmast had the largest number of clods followed by Kohsar, Latifabad # 10 and Daman-e-Kohsar. Fazal Sun City, the left side Indus River, Village Nooral Detha and the left side Abdullah Sports city had a greater number of large (i.e. >8.0 mm) and small aggregates (i.e. <0.5 mm). The optimum aggregate size distribution was found in the left side of channel, which had largest number of aggregates (50.50%) in the 0.5–8.0 mm sieve size range. The maximum aggregate soil stability (AS) was found in Gulistan-e-Sarmast, Kohsar and Latifabad # 10, while all other soils had minimum aggregate stability. Lastly, Gulistan-e-Sarmast, Kohsar and Latifabad # 10 had the greatest resistance to soil erosion, while all other soils were found highly susceptible to soil erosion. It is hoped that the information and results provided in this paper will help stakeholders transition to more sustainable natural resources management [HALBE *et al.* 2013; KOLINJIVADI *et al.* 2014a, b; SAADAT *et al.* 2011; STRAITH *et al.* 2011; INAM *et al.* 2015; BUTLER, ADAMOWSKI 2015].

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Ahmed TAGAR, Jan ADAMOWSKI

Trwałość agregatów glebowych na terenach użytkowanych rolniczo w dystrykcie Hyderabad, Pakistan

STRESZCZENIE

Słowa kluczowe: *grunty uprawne, rozkład wielkości agregatów glebowych, trwałość agregatów, warunki wysiewu i erozja gleby*

Obszary o klimacie zwrotnikowym suchym są szczególnie podatne na erozję gleby z powodu długich okresów suszy i nagłych ulewnych opadów deszczu. W pracy przedstawiono wyniki badań rozkładu wielkości agregatów glebowych i ich trwałości w dwunastu uprawianych gruntach dystryktu Hyderabad w Sindh w Pakistanie. Rozkład wielkości agregatów oznaczano poprzez przesiewanie suchej gleby, a trwałość agregatów określano metodą przesiewania na mokro. Wielkości te charakteryzują podatność gleb uprawnych na erozję. Rozkład granulometryczny gleb na badanym obszarze był silnie zróżnicowany. Największą liczbę agregatów (51,0%) zawierała gleba w Gulistan-e-Sarmast, mniejszą – gleba w Kohsar (49,0%), Latifabad (41,1%) i Daman-e-Kohsar

(39,0%). Gleby na terenie miasta Fazal Sun na lewym brzegu Indusu, gleby we wsi Nooral Detha i mieście Abdullah Sports charakteryzowały się znaczną liczbą dużych (>8 mm) i małych (<0,5 mm) agregatów. Optymalny rozkład wielkości agregatów glebowych stwierdzono na lewym brzegu kanału, gdzie gleba zawierała najwięcej (50,5%) agregatów w przedziale wielkości 0,5–8,0 mm. Maksymalną trwałość agregatów wykazywały gleby w Gulistan-e-Sarmast (46%), Kohsar (42%) i Latifabad (34%), trwałość agregatów pozostałych gleb była minimalna (<14%). Stwierdzona minimalna trwałość agregatów świadczy, że gleby użytkowane rolniczo w dystrykcie Hyderabad są silnie podatne na erozję. Wyniki przedstawionych badań sugerują potrzebę poszukiwania sposobów na zwiększenie trwałości agregatów glebowych.