INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES
IJPAES

Volume-3, Issue-2, April-June-2013
ISSN 2231-4490

Coden : IJPAES www.ijpaes.com

Received: 1st Mar-2013 *Revised: 10th Mar-2013* *Accepted: 13th Mar-2013*

Research article

RATE OF SOIL AGGREGATES DISINTEGRATION AS AFFECTED BY TYPE AND RATE OF MANURE APPLICATION AND WATER QUALITY

Tariq H. Karim*, Kamal Sh. Qadir** and Salahaddin A. Aziz**

* Soil and Water Science Dept, Agriculture College, Salahaddin University
** Soil and Water Science Dept, Agricultural Sciences Faculty, Sulaimani University

Corresponding author, e-mail: solavtariq@yahoo.com

ABSRACT: This investigation was set up to study the effect of different levels of manure application from three sources, namely, cattle, sheep and poultry on rate of aggregate disintegration of a wide spectrum of soils with different textures. The drop test technique was followed to measure the rate of soil aggregate disintegration using three types of water (rainfall, spring and artificial saline waters). The results indicated there is a gradual increase the amount of energy required to disintegrate soil aggregates over a range of soil organic content from natural soil organic matter content to about 9%, beyond which a slight decrease in the amount of required energy was observed in most of the investigated soils. Among the manure sources sheep manure offered the highest performance. By contrast the cattle manure offered the least performance. The results also indicated that the amount of the required energy for disintegration tended to increase with clay content and with increase in the electrical conductivity of the applied waters. It can be concluded from the obtained results that the nearly all types of manures can be applied to reduce soil erosion risk up to an organic matter level of 9%. Additionally, there is no risk of soil sealing and erosion upon application of saline water with EC of < 2.2 dSm^{-1} via sprinkle irrigation.

Keywords: Drop test technique, Rate of aggregate Disintegration, Manure application

INTRODUTION

Aggregate breakdown influences several aspects of soil physical behavior, such as infiltration, crusting and erosion [1]. The extent of aggregate disintegration by wetting depends on aggregate stability which related to organic matter, sesquioxides and clay content [2]. [3] reported that medium to heavy textured soils, with low organic matter content and low in free iron oxides are continuously subjected to dispersal action of water and air entrapped during rapid wetting. Under these conditions, structural breakdown occurs with attendant runoff and erosion and consequent diminution in agricultural soil productivity [4]. Organic matter acts by changing the wettability of individual aggregates, by increasing aggregate cohesion and by occluding individual aggregate pores sensitive to slaking [5], [6].The composition of manure has a profound impact on the quality of the soil when land-applied, as different manures have different organic matter, salt and element contents. The composition, in combination with the rate of application, can usually be directed to the effects on a particular soil property [7]. Furthermore, [8] have reported the composition of the soil organic matter and the type of organic binding agents influence the stabilization and hydrophobicity of aggregates. [9] assessed aggregate disintegration based on the kinetic energy of simulated raindrops required to detach 1- to 8-mm aggregates at different water potentials and observed that aggregates from forest soils required the highest kinetic energy (> 5.5 µJ) for disintegration, while those from moldboard plow soils the lowest (<1.9µJ). It was observed that the soil organic matter explained 48% of the variability in aggregate disintegration. [10] reported that the maintenance of stable soil structure under application of irrigation water as well as rainwater requires the consideration of the relationship between soil properties and irrigation water quality. In spite of bad consequences of aggregate deterioration, there is scanty of information rate of aggregate disintegration and management practices to improve its stability in the region.

Therefore, this study was initiated with the following objective of: 1) describing the rate of disintegration of aggregates from the dominant soils in the region; 2) to select the suitable source of organic manure at the proper rate to reduce risk of soil degradation and 3) to examine the rate of aggregate disintegration under different water qualities.

MATERIALS AND METHODS

Materials

Bulk samples were collected from the upper 0.3 m of six different locations within Sulaimani Governorate. They were chosen to cover a wide range of soil. Table 1 present some of the selected physical and chemical properties of the investigated soils respectively. The gathered samples were air dried at 30 oC for 72 h, gently crushed and sieved through a 2-mm sieve and kept until use.

Table 1: Some selected physical and chemical properties of the investigated soils.

Site	EC_e (dS / m)	pH	O.M (g/kg)	CEC (mmole$_c$/kg)	$CaCO_3$ (g / kg)	Soluble cations and anions (mmole$_c$ / 1)								Clay (g / kg)	Silt (g / kg)	Sand (g / kg)	Textural Class
						Ca^{2+}	Mg^{+2}	Na^{+1}	K^{+1}	Cl^{-1}	SO_4^{-2}	HCO_3^{-2}	CO_3^{-2}				
Chwarqrna	0.71	7.85	1.40	4.65	57.0	4.90	1.67	0.50	0.16	0.80	0.52	2.80	0.00	10.85	21.06	68.09	SL
Sangaw	0.45	7.29	0.46	14.07	26.5	3.53	1.86	1.11	1.21	1.40	2.53	2.60	0.00	23.02	52.50	24.48	SiL
Taqtaq	0.69	7.62	1.37	31.19	30.53	4.51	2.45	0.54	0.26	4.60	6.85	5.80	0.00	29.63	57.80	12.57	SiCL
Arbat	0.54	7.37	2.50	31.96	20.45	4.90	1.37	0.30	0.15	0.80	2.42	5.40	0.00	36.15	49.05	14.80	SiCL
Dokan	0.85	7.77	1.85	32.68	11.00	5.70	2.51	0.33	0.15	0.60	3.12	6.80	0.00	45.67	37.66	16.67	C
Saidsadiq	0.56	7.55	2.77	53.87	21.95	10.0	2.07	0.92	0.18	0.32	0.51	4.20	0.00	60.48	37.86	1.66	C

Preparation of additives or amendments

Sufficient quantity of each material was oven dried at 65^{o}C and finely ground to pass a 0.425 mm sieve. Subsequently, they were stored in plastic containers until use. The amendments encompassed (sheep, cattle and poultry manures). Table 2 shows some selected properties of the applied manures.

Table 2: Some selected chemical properties of the applied manures.

Manure	pH	EC Dsm^{-1}	Ions (mg/kg)				C%	N%	C/N-Ratio
			N	P	K	C			
Sheep	6.9	89.4	10.2	6.0	3.0	224.0	22.40	1.02	22.4:1
Poultry	6.8	45	16.0	4.0	4.0	214.1	21.41	2.18	9.82:1
Cattle	8.2	16.6	3.0	3.0	3.0	193.8	19.38	2.37	8.18:1

Soil treatment

Seven splits of 5- kg were made from each soil and placed in 7 plastic containers. Subsequently, predetermined quantity of each amendment was mixed thoroughly with the soil of each container to obtain the desired soil organic matter level. The organic matter content of each soil encompassed the following levels: 3, 5, 7, 9, 11, 13 and 15 % besides the control (without addition of additive). The soil water content of each treatment was brought to a 75% of field capacity and set in a room at 24 ± 3^{o}C for period of four months before obtaining samples of soil aggregates from each treatment.

Preparation of soil aggregates

At the end of the incubation period and, a sample of soil aggregates was prepared for each treatment by gently breaking the soil clods at a soil moisture content nearly equivalent to plastic limit into pieces. Thereafter, they were air dried and a subsample was obtained from the materials, each weighing a 0.75 g. The selected aggregates were placed in desiccators for complete drying.

Measuring the energy required for Aggregate disintegration using raindrop simulator

The raindrop simulator consisted of a 50-ml burette installed at 1-m height to form raindrops of 0.1 ml in volume. Three types of water have been used, viz., rainfall, spring and artificial waters (Table 3). Before performing the test, the drops strike it was identified. The number of simulated rain drops required to disintegrate an individual aggregate 0.75 gm in weight and to pass through the 2.8 mm sieve was recorded. This test was known as counting the number of drop compacts (CND) [11]. This test was replicated five times. Further, the required kinetic energy to disintegrate the individual aggregate was calculated from the number and weight of water drop and the height of fall. Appendices of 1 to 10 present the number of drops and total energy required to disintegrate the aggregates of investigated soils under different combination of manure source, soil organic matter level and water type

Table 3: Some selected chemical properties of water from different sources.

Source of water	Ec ds/m	pH	Soluble cations and anions (mmole/L)								
			Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1}	Cl^{-1}	So_4^{-2}	CO_3^{-2}	HCO_3^{-1}	SAR
Rainfall	0.12	7.40	1.03	0.04	0.11	0.01	0.50	0.05	0.00	0.64	0.15
Sarchnar stream	0.27	8.10	2.36	0.39	0.07	0.02	0.06	1.43	0.00	1.32	0.06
Saline water	2.20	6.90	8.04	3.00	10.87	0.09	20.0	1.80	0.00	0.20	4.60

RESULTS AND DISCUSSION

Figs 1 through 3 present the effect of different levels of organic manure from three different sources on the energy required to disintegrate aggregates of different textured soils after performing water drop impact tests. Most outstanding conclusion that can be drawn from these figures is an increase in the amount of energy required to disrupt soil aggregates over a range of soil organic matter content from the natural soil organic content (Usually less than 2 %) to about 9% under most cases. A slight decrease in the amount of energy required to disintegrate soil aggregates was noticed to beyond 9%. This true in the majority of the investigated soils upon treatment with different sources of soil organic content and after subjecting to different types of water. These results are in harmony with the findings of Morgan who found that there is an increase in soil erodibility beyond a level of 10%. High rates of manures application results in high salt content [12]. It was also seen that the discrepancies between different sources beyond 9%. It can inferred from the above results that the application of manure over 9% did not bring further increase in the amount of the required energy to disrupt the soil aggregates. An examination of Fig. 4 revealed that the cattle and sheep manures offered the lowest and highest performance respectively when subjected to water drop impact from different sources. Overall the average amount of energy required ranged from as low as 540.87 µJ for cattle treated soil under rainfall drops to as high as 673.70 µJ for sheep manure treated soil subjected to saline water drops have observed that easily decomposable materials like sheep manure increased aggregate stability [13]. The in the amount of energy under application of different manure sources tended to decrease with an increase in the electrical conductivity of the used water. Inspection of Fig. 5 that there is a gradual increase in the amount of energy required of aggregate disintegration with an increase in the electrical conductivity of the applied waters. This mean that the rainfall and artificial saline water offered the lowest and highest performance respectively.

It is also apparent from these results that there is the possibility of application of saline water (EC < 2.2 dSm-1) via sprinkler irrigation without introducing sealing and erosion hazards from soil conservation standpoint. The result is in harmony with the finding of [14], who observed that in case of washing soil with distilled water the concentration gradient, exists during washing. It causes solution movement from micro pores and consequently gives rise to destruction of aggregates and soil dispersion. Fig. 6 displays the amount of energy required to disintegrate soil aggregates as affected by interactive effect of soil type (clay content) and type of water. It is obvious from Fig. 6 that with a few exceptions that there is a gradual increase in the amount of energy required to disrupt aggregates with an increase in soil fineness. Similarly, [15] showed that increase in clay fraction significantly improved water aggregate stability. This is due to the fact that under some conditions, the silicate clay acts as cement holding particles together [16]. Additionally, it is elucidated that the Chwarqurna sandy loam soil exhibited the least the amount of required energy and by contrast the Saisadiq soil offered the highest amount of required energy. Close examination of Fig. 6 also reveals that the Sangaw silt loam soil deviated from the dominant trend offered the highest amount of required energy after treatment with poultry manure and subjects to impacts of spring and artificial saline water.

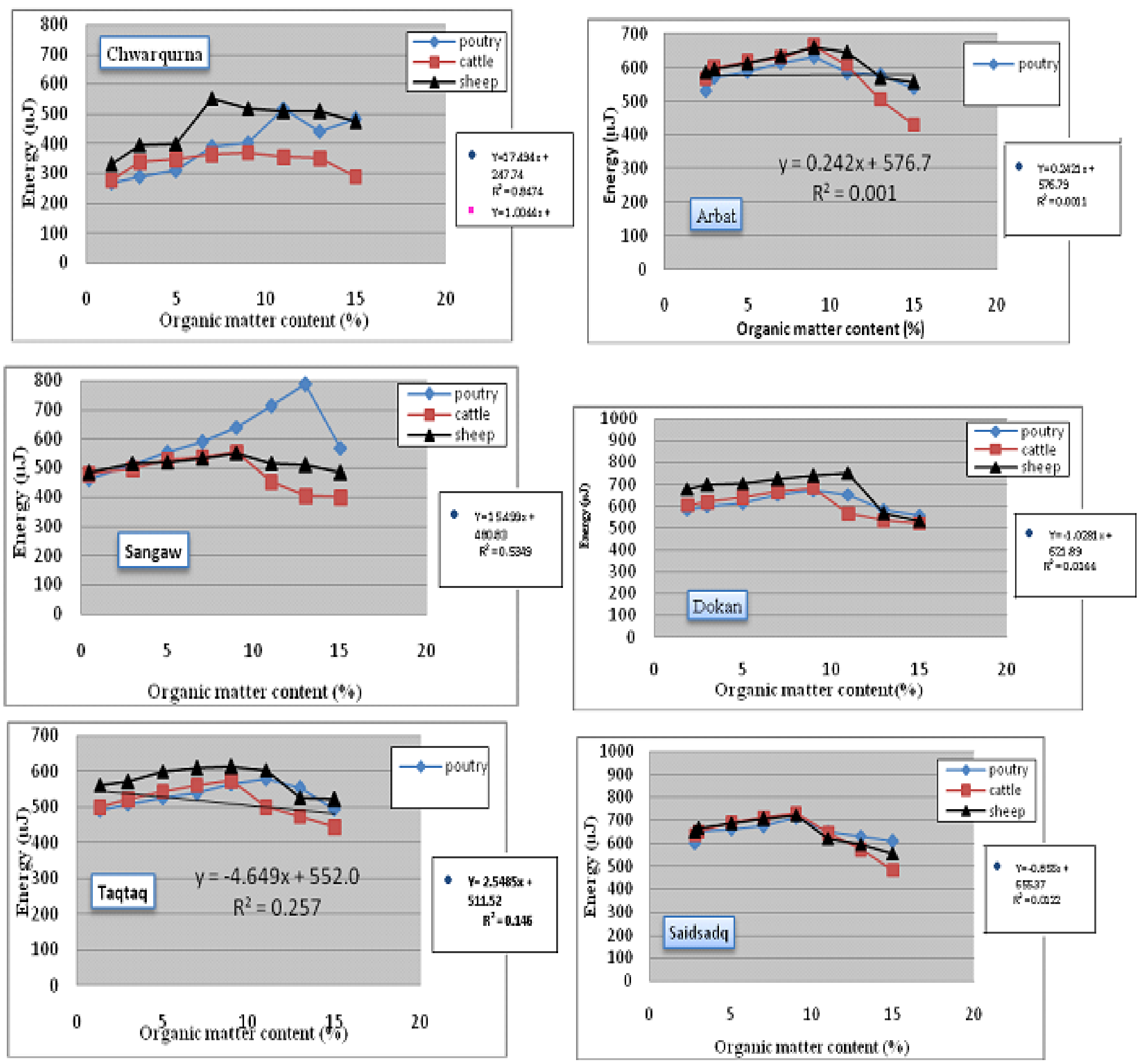


Fig.1: Effect of different levels of organic manures from different sources on the amount of energy required to disintegrate the aggregates of different textured soils under rainfall drops.

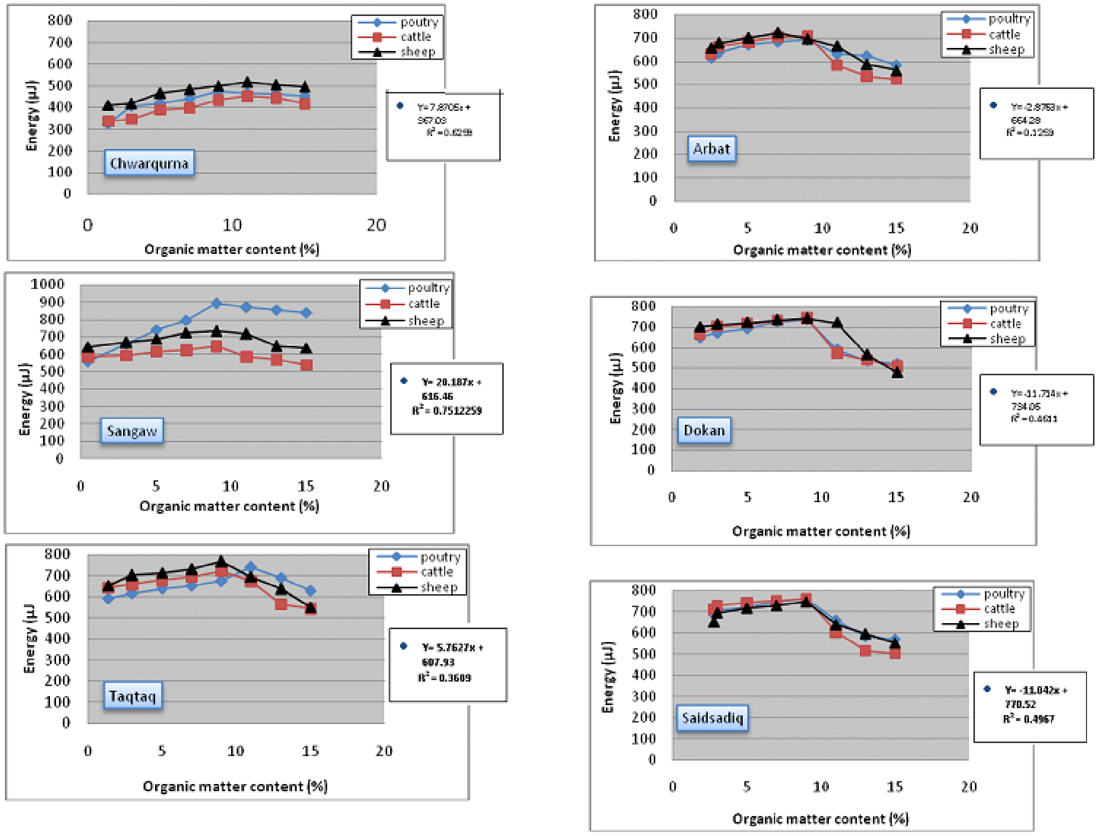


Fig.2 Effect of different levels of organic manures from different sources on the amount of energy required to disintegrate the aggregates of different textured soils under spring water drops.

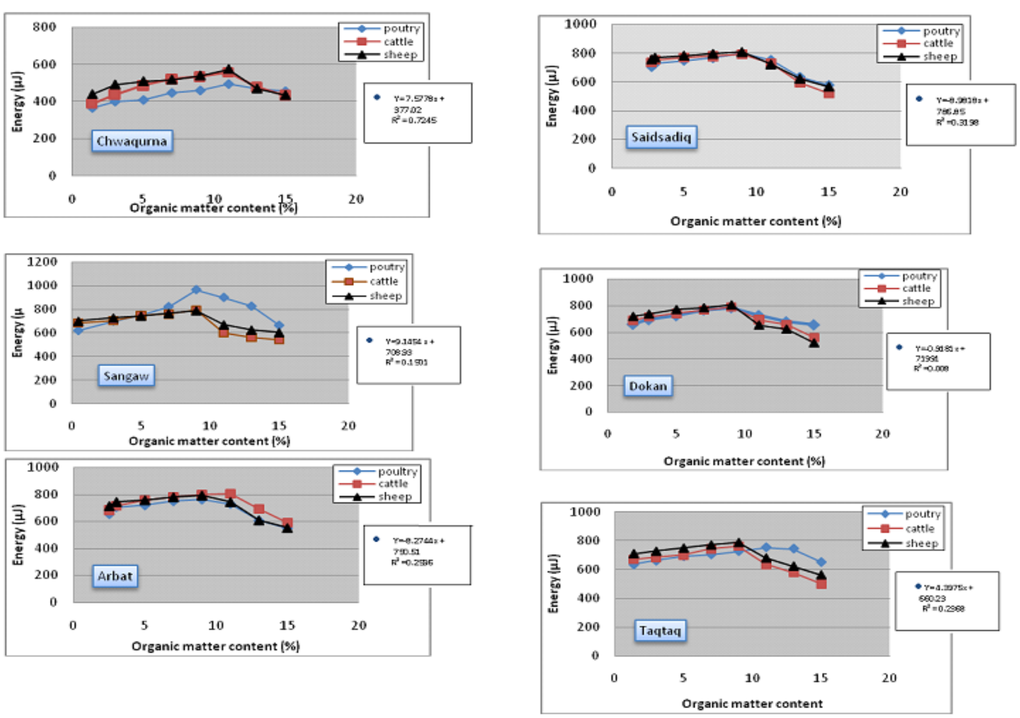
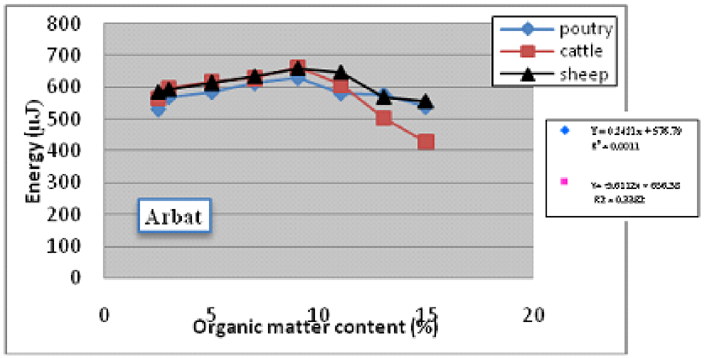
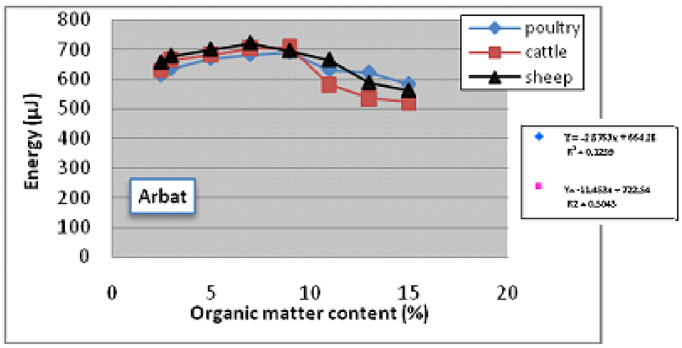


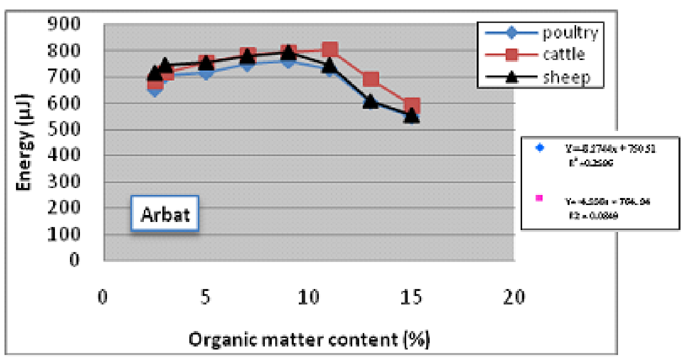
Fig.3 Effect of different levels of organic manures from different sources on the amount of energy required to disintegrate the aggregates of different textured soils under saline water drop



Sub-fig. of Rainfall water



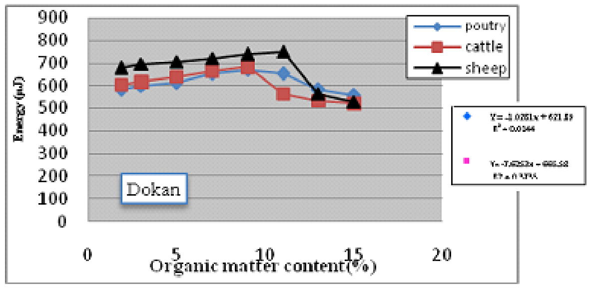
Sub-fig. of spring water



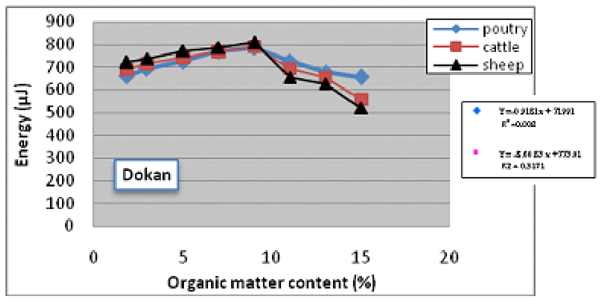
Sub-fig. of Saline water

Fig. 4 : Revealed that the cattle and sheep manures offered the lowest and highest performance when subjected to rainfall , spring and saline water drops respectively

Fig. 7 exhibits the interactive effects of type of soil, source of manure and type of water on the amount of energy required to disintegrate. It is clear from Fig. 7 that the cattle treated sandy loam from Chwarqurna site subjected to rainfall drop impacts offered the lowest amount of required energy (337.48 µJ). the reverse was true for the Sangaw silt l`oam soil treated with poultry manure and subjected to saline water drop impact. The energy required under this combined effect is 781.48 µJ. it is also clear from the presented results of Fig. 7 that the Sangaw silt loam Saisadiq clay soil offered the second highest amount of energy required for aggregate disintegration. Close examination of Fig. 7 indicated that the effect of source of manure diminish with increase in the electrical conductivity of the applied waters. Under the influence of rainfall drops, a substantial difference in the amount of energy required to disintegrate soil aggregates can be depicted due to application of different source of manures. Apart from this difference tends to narrow when the soil aggregates were subjected to spring and saline water drops.

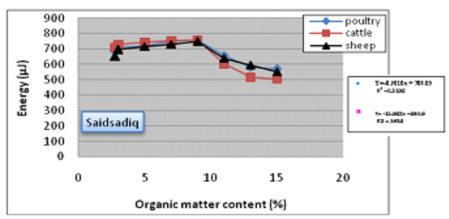


Sub-fig. of Rainfall water

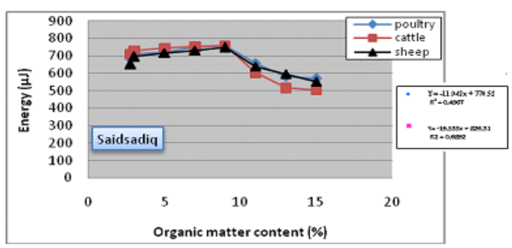


Sub-fig. of Saline water

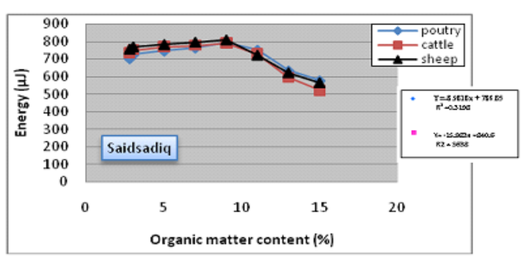
Fig. 5. Effect of electrical conductivity on rainfall and artificial saline water on gradual increase in the amount of energy required to aggregate disintegration.



Sub-fig. of Rainfall water

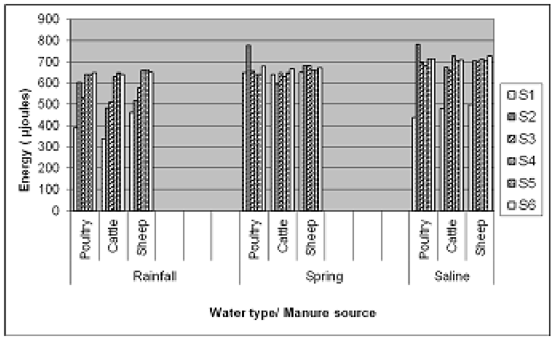


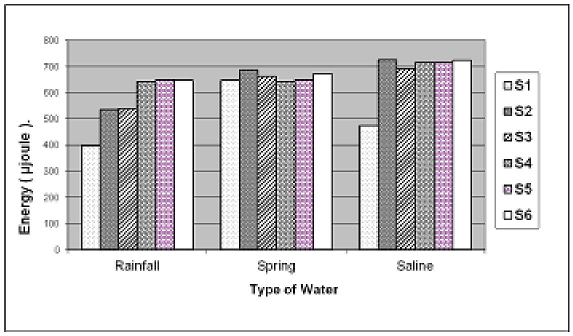
Sub-fig. of spring water



Sub-fig. of saline water

Fig.6 Effect of soil type (clay content) and type of water on the amount of energy requited to disintegrate soil aggregates.





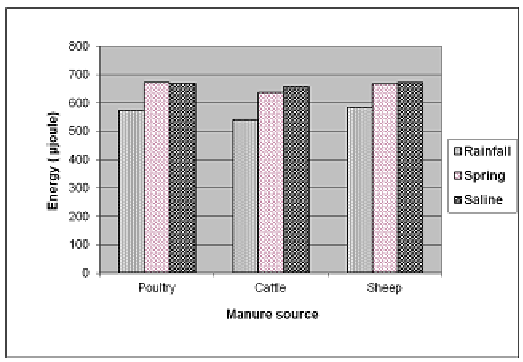


Fig. 7. Interactive effect of type of water and source of manure on the amount of energy required to disintegrate soil aggregates

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Sourse of manure	2	547648.5	273824	7.8812	0.0004
Manure level	7	3348073.6	478296	13.7663	<.0001
Type of water	2	2333861.5	1166931	33.5866	<.0001
Type of soil	5	9960400.5	1992080	57.3361	<.0001
Sourse of manure*Type of water*Manure level	28	883386.9	31550	0.9081	0.6041
Sourse of manure*Type of soil*Manure level	70	2618049.8	37401	1.0765	0.3181
Type of water*Type of soil*Manure level	70	2743116.7	39187	1.1279	0.2279
Sourse of manure*Type of water*Type of soil	20	784020.4	39201	1.1283	0.3136
Sourse of manure*Manure level	14	1134839.5	81060	2.3331	0.0037
Sourse of manure*Type of water	4	201601.5	50400	1.4506	0.2154
Sourse of manure*Type of soil	10	965441.4	96544	2.7787	0.0022
Type of water*Manure level	14	701516	50108	1.4422	0.1271
Type of soil*Manure level	35	2807033.6	80201	2.3083	<.0001
Type of water*Type of soil	10	989551	98955	2.8481	0.0017
Sourse of manure*Type of water*Type of soil*Manure level	140	4912026.3	35086	1.0098	0.4574
Error	864	30018726			

CONCLUSION

The results of the investigated study revealed that sheep manure is the most effective type of manure compared with other sources from erosion and sealing standpoint. A slight decrease in the amount of energy required to disintegrate aggregates was observed upon application of different manures beyond 9%. Additionally, there is indication of increase of soil aggregates resistance against integration with increase in the electrical conductivity of water drop in the range of 0.12-2.2 dSm-1.

REFERENCES

[1] Farres, P.J. 1987. The dynamics of rainsplash erosion and the role of soil aggregates stability. Catena, 14:119 - 130

[2] Kay, B.D. and D.A. Anger. 1999. Soil structure: IN: Sumner M. E. (Ed.) Handbook of Soil Science, CRC Press, New York: 229 – 269.

[3] Ahmad, N. and A.J. Roblin. 1971. Crusting of river estate soils, Trinidad, and its effect on gaseous diffusion, percolation and seedling emergence. J. Soil Sci. 22:23 – 31.

[4] Wuddivira, M.N., R.J. Stone and E.I. Ekwue. 2006. Soil texture, clay mineralogy and organic matter effects on structural stability and hydraulic characteristics of selected Trinidad soils after rainfall. Trop.Agric. 83:69 -78.

[5] Chenu, C., Y. Le bissonnais and D. Arrouays. 2000. Organic matter influence on clay wettability and soil aggregate stability. Soil Sci.Soc.Am.J. 64:1479- 1486.

[6] Zaher, H., J. Caron and B. Ouaki. 2005. Modeling aggregate internal pressure evolution following immersion to quantify mechanisms of structural stability. Soil Sci.Soc.Am.J. 69:1 -12.

[7] Schoenau, J.J. S.P. Mooleki, S.S. Malhi and G. Hultgreen. 2004. Strategies for maximizing crop recovery of nutrients applied as liquid in manure. Great Plains Soil Fertility Conference Proceedings. Denver Co. pp:8-14.

[8] Tisdall, J.M. and J.M. Oades. 1982. Organic matter and water stable aggregates in soils. J.Soil Sci. 33:141 – 163.

[9] Blanco-Canqui, H, R.La, L.B. Owens, W.M. Post and M.J. Shipitalo. 2007. Soil hydraulic properties influenced by corn stover removal from no-till corn in Ohio. Soil Tillage Res. 92: 144 - 155.

[10] Memon, R. A. 2011. Conflict management in water sharing and storage. Sindh Agriculture University, Tardo Jam, Pakistan, http:// www. Sanalist.org/Kelabagh / D-18 html. Accessed 11 Mar. 2011.

[11] Imeson, A.C. and M. Vis. 1984. Assessing soil aggregate stability by water drop impact and ultrasonic dispersion. Geoderma D. Reidel Publishing, Dordrecht, 34: 185 – 200.

[12] Mathers, A.C. and B.A. Stewart. 1980. The effect of feedlot manure on soil physical and chemical properties. P.159-162. Livestock wastes. A renewable Resource. American Society of Agricultural Engineers, Amarillo, Texas.

[13] Tisdall, J.M., B Cockroft. and N.C. Uren. 1978. The stability of soil aggregates as affected by organic materials, microbial activity and physical disruption. Aust. J. Soil Res. 16:9-17.

[14] Morgenstem, N.R. and B.I. Balasubromonial. 1996. Effect of pore fluid on the swelling of Clay shale. Proc 4^{th} Int Conf.