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Measuring the Amount of Eroded Soil and Surface Runoff Water in the Field

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Abstract**—**Water erosion is the most important problems of the soil in the Jabel Nefusa area located in northwest of Libya; therefore, erosion station had been established in the Faculty of Veterinary and dryfarming research Station, University of the Al-japel Al-gharbi in Zentan. The length of the station is 72.6 feet, 6 feet width and the percentage of its slope is 3%. The station were established to measure the amount of soil eroded and amount of surface water produced during the seasons 95/96 and 96/97 from each rain storms. The monitoring shows that there was a difference between the two seasons in the number of rainstorms which made differences in the amount of surface runoff water and the amount of soil eroded between the two seasons. Although the slope is low (3%), the soil texture is sandy and the land ploughed twice during each season surface runoff and soil eroded were occurred. The average amount of eroded soil was 3792 grams (gr) per season and the average amount of surface runoff water was 410 liter (L) per season. The amount of surface runoff water would be much greater from Jebel Nefusa upland with steep slopes and collecting of them will save a valuable amount of water which lost as a runoff while this area is in desperate of this water. The regression analysis of variance show strong correlation between rainfall depth and the other two depended variable (the amount of surface runoff water and the amount of eroded soil. It shows also strong correlation between amount of surface runoff water and amount of eroded soil.

Keywords**—**Rain, Surface runoff water, Soil, Water erosion, Soil erosion.

I. Introduction

RAINFALL erosion is a serious problem of farmland over a large parts of the world. It is particularly acute on gently to steeply sloping land of both humid and semiarid areas. In semiarid conditions, serious rain erosion often occurs because the rain, although low in quantity, comes in very severe storms. In other cases, steep slopes and vulnerable soils can lead to quite serious erosion in temperature latitudes [3]. Water erosion occurs in three stages. First, individual soil particles are detached from the soil mass by water drop impact. Second, the detached particles are transported over soil surface by running surface runoff water. Third, the soil particles fall out of suspension and are deposited as sediment on low land sites.

Rainfall erosion research began with the work of Wollny in Germany in the latter half of the nineteenth century, whom is considered the father of soil conservation research. His studies included the relation of erosion to steepness and orientation of slope, density of vegetation and soil type. Erosion research in the Unite state of America (USA) started in 1917 with establishment of plots with a length of 72.6 feet and width of 6 feet and its size is 0.01 acre for study of the effect of soils, slope, and crops on runoff and erosion by Professor Miller of the University of Missouri. Unite State Department of Agriculture (USDA) focus on the problem and established ten Federal-state experiment stations (with the same size used by Professor Miller which became a standard size of erosion plot researches) on the more critical erosion areas of the USA [4]. As a result of all of these field experiments, the main features of the erosion were identified and mathematically enumerated. Research on erosion problems has not confined to America. Africa has been to the fore, with the first runoff plots established at the University of Pretoria by professor Haylett in 1929. Today, a network of field station is in operation in a dozen or more territories. In Libya erosion research started by laboratory work done by Aboufayed, 1990 measuring eroded soil material for three types of Libyan soil [1]. The soil survey study [5] for the western region of Libya the erosion hazardous territory as regards water erosion 747.6 thousand Hectares of surveyed area were affected by water erosion most of it in Jebel Nefusa (it known as also Aljapel Algharbi) upland area. There is different feature of soil erosion and formation of gullies in the area as shown in the Fig. 1. In the region, rainfall season began at the beginning of September and ends by the end of May of the following year and result in various manifestations of soil erosion and the loss of large amounts of rain water by runoff while this area is desperate of this water. Erosion research station was established with standard specifications in Veterinary and rain-fed agriculture Faculty Station, University of the Al-japel Al-gharbi to measure amount of the surface water runoff and amount of eroded soil.

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Fig. 1 Soil water erosion features and formation of gullies in the region

II. Material and Methods

A. Area of Study

The Jabel Nefusa upland represents a plateau, which was formed as a result of tectonic elevation of a primary plain of marine accumulation. The maximum absolute height of the upland is 981.0m within Gharian area. The surface of the plateau is a typical structurally-denudated plain and only in the marginal parts of plateau, in the zone of its scarp, a deep erosion dissection adds to the relief the features of the mountainous one. The morphology of the plateau surface is determined by the nature of erosion dissection: depth, density and pattern of erosion network. The erosion dissection of the plateau various parts depends on, firstly, the distance from denudation basis, secondly the height over the basis, thirdly the geological structure and fourthly the climatic condition. The zone soil types develop on various types of relief. The soil on the accumulative plain has a deeply profile. Localization of soil thickness according to the slope while, soil from alluvial soil material in the bottom of slope the soil on the slope is lithosols. As water erosion denudation energy of relief grows from flat plains to deeply dissected plateau, the soil water erosion grows as well. The soil survey study for the western region of Libya regards that the water erosion hazardous territory as 45% of surveyed area were affected by water erosion most of it in Jabel Nefusa upland area [5].

B. Erosion Station

Erosion station established in the field with the standard specifications in research station of Veterinary and rain-fed agriculture faculty - University of the Al-Japel Al-gharbi for measuring amount of surface water runoff and the amount of soil eroded from their space in a field. Where the whole field was planted with olives trees and ploughing twice in the season, the first is in the fall season at the beginning of the rainfall and the second is in the spring by the end of the rainfall season. The agricultural operations were done in the research plot station the same as the rest of the field. The station size equals 0.01 acre with length of 72.6 feet and width of 6 feet; and the slope percentage of the plot was estimated and equal to 3%. The plot were isolated hydrologically by a soil barrier, and at the end of the slope a concrete barrier were set up with a pipe in the middle to permit collection of surface water runoff and eroded soil material. As shown in the following Fig. 2.

Fig. 2 The station in the field for measuring erosion and surface runoff

After every rainstorm, which produces runoff and cause soil erosion, the amount surface water runoff and soil eroded were collected in steel tank and measured their quantities and the amount of rainfall data of every rainstorm were received from the Zentain air condition station located in Faculty research station. The rainfall data, the amount of surface runoff produced and the amount of soil eroded by the rain were recorded in Table I. Three soil samples were collected from the research station for mechanical analysis using (Pipette method) and different sizes of sand were estimated using (Sieving analysis); according to the U.S. Department of Agriculture classification and the analysis results were recorded in Table II. Using linear regression analysis the relationship between the rainfall depth in (mm) and the two depended variables (the amount of surface runoff water produced and the amount of soil eroded). The relationship of the amount of water surface runoff and the amount of eroded soil are as shown in Figs. 3, 4 and 5.

III. Results

This is the first quantification of the surface runoff and the resulting amount soil erosion by rainfall at the field level in Libya. The following table shows the rainfall depth for each rainstorm and it's quantity over the whole plot, the resulting surface water runoff and its percent from the rain quantity and the eroded soil amount of each rain storm.

TABLE I
THE AMOUNT OF RAINFALL AND AMOUNT OF SURFACE RUNOFF AND AMOUNT OF ERODED SOILS

Season	Rain Storm No	Rain Depth (mm)	Rain Amount (L)	Surface Runoff Amount (L)	Surface Runoff %	Eroded Soil Amount (gm)
95/ 96	1	17.6	1161.6	85	7.3	2000
	2	23.0	1518.0	104	6.9	500
	3	30.5	2013.0	72	3.6	250
	4	7.0	462.0	64	13.7	53
Total of the season 95/96		87.1	5154.6	325	33.1	2803
Mean of the season 95/96		21.8	1288.65	81.25	6.3	700.75
96/97	1	8.2	541.2	12	2.2	16
	2	13.2	871.2	40	4.6	120
	3	6.3	415.8	20	4.8	62
	4	32.6	2151.6	120	5.6	2620
	5	5.4	356.4	30	8.4	65
	6	6.3	415.8	50	12.0	86
	7	57.7	3808.2	223	5.9	1811
Total of the season 96/97		118.0	7788.0	495	43.5	4780
Mean of the season 96/97		16.85	1112.6	70.7	6.4	682.9
Total of the two seasons		205.0	12942.6	820	6.3	7583
Mean		102.5	6471.3	410	6.35	3792

The results show that the number of rainstorms that led to the runoff and cause erosion to the soil were seven storms in the second season while there were only four in the first season, and the total rainfall depth in the second season were greater than the first season (118.0mm, 87.1mm). This reflected on the amount of water surface runoff which was 495 L and 325 L, and the amount of soil eroded which was 4780 gm and 2803 gm. Formation of the thin crust layer, which caused by rain fall drops impact, were noticed at the soil surface that led to reduce soil erosion and increase the amount of surface runoff. This confirms the findings of the [6], [2]. Despite the low percentage of the station slope and the soil texture is sandy and ploughing the surface runoff occurred. This confirms that large quantity of water from steep slopes of Jepel Nefousa upland could be collected. The analysis of soil particle distribution shows very high content of sand (%91.6) and the most of it from fine and very fine sand particles (56.7, 27.8) and very low in clay content (1.4) as shown in Table II which mean that the soil has high ability to erosion. Although the rain was very low, the texture of the soil is sandy, the slope percent is low and soil was ploughed twice each season, soil erosion occurred each season. This confirms what mentioned by [2], [7] that the soil with low content of clay and high content of fine sand has high ability to erosion.

TABLE II
SHOW SOIL PARTICLE SIZE DISTRIBUTION AND TEXTURE OF STATION SOIL

Sample No	% Clay	% Silt	% Sand	% of different sand size VCS	CS	MS	FS	VFS	Texture
1	1.1	8.4	90.5	0.8	0.4	0.4	62.9	26.0	Sandy
2	1.8	6.4	91.9	0.2	0.1	0.1	58.3	33.7	Sandy
3	1.3	6.4	92.4	0.6	0.9	0.1	49.0	23.8	Sandy
Mean	1.4	7.0	91.6	0.5	0.5	0.2	56.7	27.8	Sandy

Where: VCS:Very Coarse Sand: CS;Coarse Sand: MS;Medium Sand: FS;Fine Sand: VFS; Very Fine Sand

The analysis of simple linear regression, shows that the relationship between the rain depth in (mm) and the amount of surface runoff water in liter (L) is very strong (r=0.99) and the amount of water surface runoff can be determined based on rainfall depth (Runoff Q= 4.0 (rainfall Depth)- 0.3 (r^2=0.99)) as shown in Fig. 3. Fig. 4 shows strong relationship between the amount of rainfall and the amount of eroded soil and the determination equation (Eroded soil Q=37.5 (rainfall Depth)-31.0 (r^2=0.92)) .

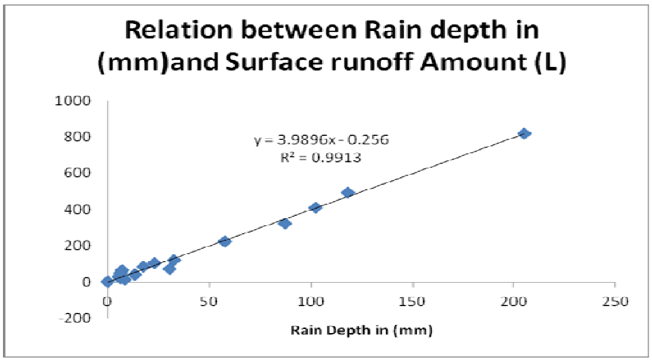

Fig. 3 The relationship between the rainfall depth in (mm) and the amount of surface runoff in (L)

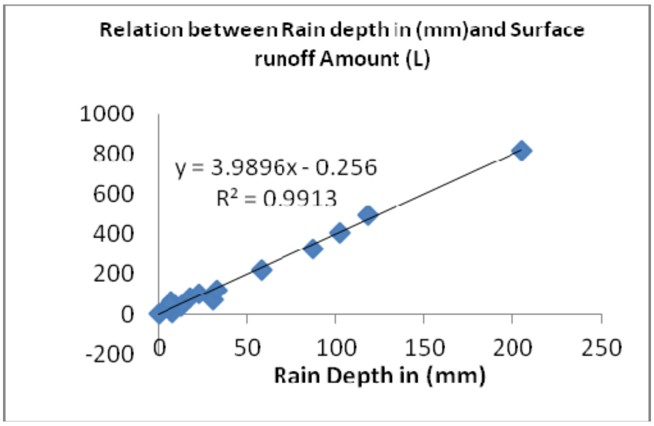

Fig. 4 The relationship between rainfall depth in (mm) and the amount of eroded soil in (gm)

The linear regression analysis showed also that the relationship between the amount of surface runoff water and the amount of eroded soil is strong relationship and the determination equation (Eroded soil Q=9.4 (Surface Runoff)-29.0 (r^2=0.93)) as shown in Fig. 5.

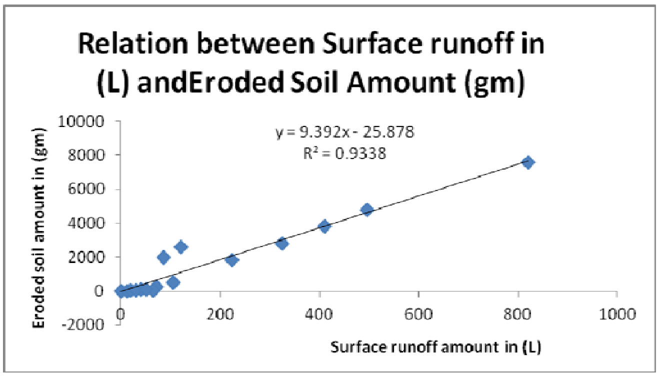

Fig. 5 The relationship between the amount of water runoff and the amount of eroded soil

IV. Conclusion

Although the rain was very low, the texture of the soil is sandy, the slope percent is low and soil was ploughed twice each season surface water and soil erosion were occurred each season. The surface water runoff will be valuable from the step slopes of Nefousa upland, and collecting of them will save a valuable amount of water which lost as a runoff while this area is in desperate of this water.

References

[1] Aboufayed, A.F. (2007) Measurement of the rate of soil erosion by water for three types of Libyan soils. Arab Environmental journal no: 9;32-37.
[2] Aboufayed, A.F. (1998) Relation of Libyan soils properties to its erodiability factor. Arab universities journal of applied science- Libya. vol.1.no.3; 40-51.
[3] Hudson, N. (1979) Soil conservation. 1st ed. B T Batasford Limited
[4] Smith, D. D. and W. H. Wischmeier. (1962) Rainfall erosion. Advances in Agron. 14: 109- 148.
[5] Soil ecological expedition v/o (Selkozprom Export) USSR. (1980) Soil studies in the western zone of Libya. Secretariat for Agriculture Reclamation and land Development. Tripoli.
[6] Tacket, J. L., and R. W. Person (1965) Some characteristics of soil crusts formed by simulated rainfall. Soil Sci. 99:407-413.
[7] Wischeier, W. H. (1978) Predicting rainfall erosion losses aguid to conservation planning. Agr. Handbook. No. 537.U. S. Dept. Agri. Washington, D. C. 58pp.