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Estimating the amount of soil lost to wind erosion, both temporally and spatially in Basra Governorate, using sand traps

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Abstract:

A field experiment was conducted in three different locations in Basra Governorate (Umm Qasr, Al-Shuaiba, and Al-Qurna). Sand traps were installed at different heights above the soil surface: 0.05, 0.35, 0.70, 1.05, and 2 m. The poles containing the traps were installed, with three replicates for each trap, to estimate the amount of soil lost by vertical distribution, and determine the predominant types of soil particle movement at each location. The amount of soil lost in these traps was calculated at each location, from January 1, 2023, to December 31, 2023. The results showed that the highest value of soil loss was at the Umm Qasr location (5.314 µg ha^{-1} yr^{-1}). The lowest value of soil loss was at Al-Qurna location (0.008 µg ha^{-1} yr^{-1}). As for the different heights where the traps were installed, height H1 (0.05 m) yielded the highest soil loss (6.286 µg ha^{-1} yr^{-1}). Height H5 (2 m) yielded the lowest value (0.041 µg ha^{-1} yr^{-1}).

Keywords: Soil Erodibility, Soil Erosivity, Sand traps, Wind erosion.

INTRODUCTION:

Wind erosion is a physical process, related to the erosive capacity of the wind (erosivity) and the erodibility of the soil. This relationship is controlled by several environmental factors, the most important of which is the climatic factor, which includes wind speed, rainfall, and temperature, it affects the moisture content of the soil surface. The second factor is the soil properties, expressed as the percentage of aggregates in the soil surface, it varies temporally and spatially due to variations in some physical and chemical properties of the soil surface layer, it affects the moisture content of the soil surface (Teshal, 2023).

There are three types of soil particle movement, which depend on the size of the particles and wind speed. Particle movement is determined by their diameter, with diameters between 0.50-2.00 mm are moved by surface creep or rolling. This movement is attributed to relatively large particles, such as coarse and very coarse sand. Jumping movement is attributed to medium-sized soil particles, with diameters ranging between 0.5-0.05 mm, which occurs in fine sand particles. This method is one of the most important methods for soil particle movement by wind, because a large portion of soil particles move in this manner, none of the remaining types of movement could occur without this type of movement (Hudson, 1971).

Suspension movement occurs in soil particles, their sizes are very fine, less than 0.1 mm in diameter. A spoonful can remain in the air for a long time, it accounts for approximately 15% of total soil loss due to wind erosion (Gurjar *et al.,* 2017). Burezq (2020) in a study conducted in the Kuwaiti deserts, identified the three types of soil particle movements (creeping, Satation, and suspension) by wind. At the collecting sixty samples from the surface soil layer and analyzing them to determine the sizes of soil particles, he indicated that the movement of soil particles by jumping is the main mode of movement of the three soil particles. The percentages were as follows: 70% move by jumping, 20% move by creeping, and 10% move by suspension.

A field experiment was conducted in three areas of Basra Governorate (Umm Qasr, Safwan, and Burjisiya), to determine the size distribution of soil particles, sand traps were used at heights of 0.05, 0.35, 0.70, and 1.05 m above the soil surface. The transfer of particles by satation motion accounted for 76.38, 63.13, and 69.73% of the total volume for the locations Umm Qasr, Safwan, and Burjisiya, respectively. There was an interaction between jumping and hanging motions at diameters of 0.05-0.1 mm. The wind intensity controls any movement. The rolling motion, on the other hand, represents the lowest percentage, as it relies on relatively large particles (0.5-2 mm). The percentages ranged from 22.43 to 18.05 mm for Umm Qasr, Safwan, and Burjisiya (Al-Wali, 2006).

The research aims to compare the amount of soil lost through wind erosion measured in the field, using sand traps in three different areas of Basra Governorate, as well as to identify the most significant movements of soil particles through the vertical distribution of soil particles.

MATERIALS AND METHODS:

1. Selecting the Study Area:

After conducting several field and survey trips, three different locations in Basra Governorate were selected as study stations, for the installation of sand traps:

First Location (L1): A farm in the Umm Qasr sub district, located southeast of Al-Zubair District in Basra Governorate, 30 km from the center of Basra Governorate, in an arid area that is an extension of the alluvial plain and falls under the classification of Sandy, mixed, active, calcareous, hyperthermic and typical torripsamments .

Second Location (L2): Al-Shuaiba Farm, located southwest of the center of Basra Governorate, located between latitudes 38' 25' 30' north and longitudes 12' 41' 47' east, it is 11 km from the center of Basra Governorate, in an arid area and falls under the classification of Coarse Loamy, Mixed, Active, Calcareous, Hyperthermic and Typical Torripsamments .

Third Location (L3): Al-Qurna District, Al-Sharsh Demonstration Farm, Department of Agricultural Extension and Training, Iraqi Ministry of Agriculture, located at longitudes 30' 96' 18' north and 47' 44' 56' east, located north of Basra city, 70 km from the center of Basra Governorate, in an arid area that is an extension of the alluvial plain. Classified as Fine clayey, mixed, active, calcareous, hyperthermic and Typical Torrifluvents (Al-Atab, 2008).

2-Laboratory Analysis:

Soil samples were collected from the locations where sand traps were installed, to a depth of 0-5 cm and 0-30 cm, respectively. They were passed through a sieve with aperture diameter of 2 mm to estimate some of the soil's physical and chemical properties (Tables 1, 2 and 3).

Texture was determined using the absorbent method, bulk density using the core method, and total porosity, saturated water conductivity, and soil moisture content were determined as described by Black *et al.* (1965).

3. Chemical properties of soil:

-Carbonate Minerals: carbonate minerals are estimated according to the method described in Jackson (1958).

-Soil pH: The degree of soil reaction in a soil water suspension was measured using a pH-Meter according to the method mentioned by Jakson (1958).

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-Electrical Conductivity: The electrical conductivity of the soil in the leachate was measured using the Ec-Meter and]according to the method provided on page *et al.* (1982).

Table (1) Some physical and chemical properties of the soil of the study station in Umm Qasr area.

Items		Unit	Depth (cm) 0-5	Depth (cm) 0-30
Sand		gm kg^{-1}	838.50	817.01
Silt		gm kg^{-1}	41.80	51.80
Clay		gm kg^{-1}	120.00	131.05
Texture			Sandy Loam	Sandy Loam
Particle density		Mg.m^{-3}	2.75	2.82
Bulk density		Mg.m^{-3}	1.43	1.51
Porosity		%	47.80	46.46
Moisture content		%	0.90	0.95
Saturated hydraulic conductivity		cm.ha^{-1}	14.99	13.54
Organic matter		g.kg^{-1}	2.17	2.00
Total carbonates		g.kg^{-1}	182.20	173.33
pH 1:1		----	7.53	7.83
E.C1:1		ds.m^{-1}	1.98	1.37
Percentage of size distribution of sand particles	More than 1.00	mm	6.71	4.37
	0.50-1.00	mm	22.11	25.81
	0.50-0.25	mm	34.15	37.62
	0.25-0.10	mm	21.18	19.30
	0.10-0.05	mm	15.84	12.17

Table (2) Some physical and chemical properties of the soil of the study station in Al-Shuaiba area.

Items		Unit	Depth (cm) 0-5	Depth (cm) 0-30
Sand		gm kg^{-1}	780.00	720.00
Silt		gm kg^{-1}	103.00	133.20
Clay		gm kg^{-1}	116.68	146.80
Texture			Sandy Loam	Sandy Loam
Particle density		Mg.m^{-3}	2.68	2.70
Bulk density		Mg.m^{-3}	1.33	1.50
Porosity		%	50.43	44.50
Moisture content		%	15.44	19.28
Saturated hydraulic conductivity		cm.ha^{-1}	16.10	14.18
Organic matter		g.kg^{-1}	2.03	1.36
Total carbonates		g.kg^{-1}	170.00	208.33
pH 1:1		----	7.69	7.80
E.C1:1		ds.m^{-1}	10.67	9.00
Percentage of size distribution of sand particles	More than 1.00	mm	11.21	15.15
	0.50-1.00	mm	18.00	23.77
	0.50-0.25	mm	19.71	15.02
	0.25-0.10	mm	28.01	26.00
	0.10-0.05	mm	23.00	20.00

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Table (3) Some physical and chemical properties of the soil of the study station in Al-Qurna District (Al-Sharsh Demonstration Farm).

Items		Unit	Depth (cm)	
			0-5	0-30
Sand		gm kg^{-1}	299.00	260.80
Silt			310.40	339.90
Clay			390.60	399.30
Texture			Clay Loam	Clay Loam
Particle density		Mg.m^{-3}	2.67	2.68
Bulk density		Mg.m^{-3}	1.30	1.33
Porosity		%	51.36	49.93
Moisture content		%		
Saturated hydraulic conductivity		cm.ha^{-1}	0.57	0.25
Organic matter		g.kg^{-1}	7.20	6.11
Total carbonates		g.kg^{-1}	243.69	159.24
pH 1:1		~~~	7.20	6.11
E.C1:1		ds.m^{-1}	8.00	7.19
Percentage of size distribution of sand particles	More than 1.00	mm	8.00	18.00
	0.50-1.00		19.71	22.19
	0.50-0.25		20.11	24.00
	0.25-0.10		19.00	18.30
	0.10-0.05		22.00	17.50

Estimating the Quantity of Soil Lost by Wind Erosion:

The quantity of soil lost by wind erosion was estimated at the three study locations. Sand traps were installed at these locations. The method described by Al-Ali (2000) was used. Sand traps consist of a 2-meter-long metal pole, part of which was buried in the ground for stability. Locally manufactured containers with side openings of 0.017 m² were used. They were suspended at heights of 0.05, 0.35, 0.70, 1.05, and 2 m, facing the prevailing northwesterly wind direction in the region. Three such poles were distributed along the perimeter of a triangle with a side length of 60 m at the six aforementioned locations. These traps were installed oppolocation the prevailing wind direction in the region, with three replicates. The depolocationd material was

collected monthly, starting from January 1, 2023, until January 1, 2023. 12/31/2023.

RESULTS AND DISCUSSION

Vertical Distribution of Soil Lost by Wind Erosion

Figure (1) shows that traps placed at heights of 0.05 and 0.35 m significantly outperformed traps placed at different heights in the amount of wind-blown sediment they collected. The average amounts collected by these traps were 6.286 and 3.255 µg ha^{-1} yr^{-1}, respectively, this is attributed to the higher proportion of coarse and medium sand in the traps close to the ground compared to the other heights. The lowest amounts of soil lost by wind erosion were recorded at heights of 0.70, 1.02, and 2 m, reaching 1.028, 0.410, and 0.041 µg ha^{-1} yr^{-1}. This is attributed to the increased proportion of fine and very fine sand. Good sorting depends on the movement of medium-sized particles by jumping and soft particles by hanging (Ariyasena *et al.*, 2024).

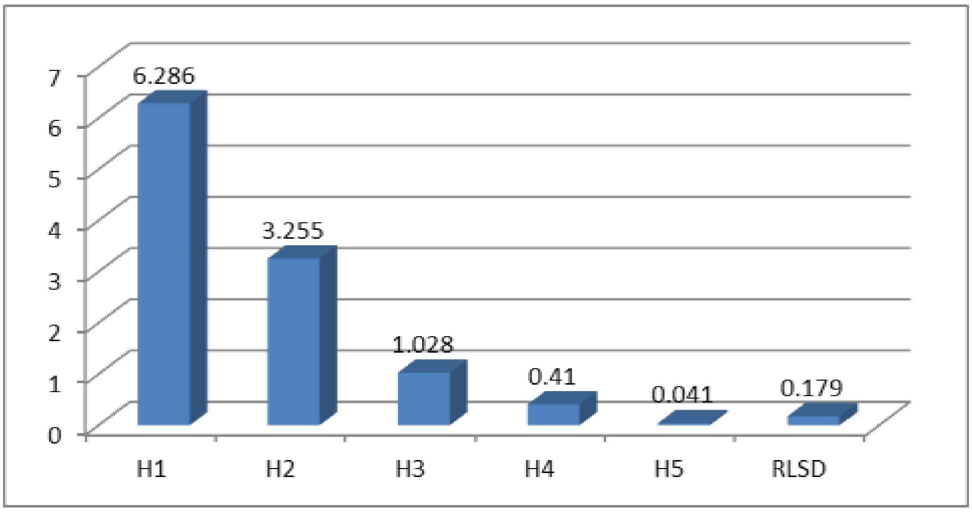

Figure (1) shows the rate of soil loss (µg.ha^{-1}.yr^{-1}) measured by the field method according to the height above the ground surface.

Figure (2) shows that the percentage of soil particles transported by the three movements (crawling, jumping, and hanging) reached 57.04, 38.86, and 4.09%, respectively, agreed with of Al-Askar and Al-Bashi (2010). The amount of soil lost by wind erosion and accumulated, using Big Spring Number Eight (BSNE) devices is inversely proportional to the height of the traps above the ground. 85% of the particles transported by wind are at a height of 10 cm, 11% of the particles transported by wind are at a height of 40 cm, 3.5% of the particles transported by wind are at a height of 75 cm, and 0.5% of the particles transported by wind are at a height of 150 cm.

Figure (2) shows the variation in the amount of soil lost due to wind erosion between the study months, a significant effect of the amount of soil lost, with July recording the highest amount of soil loss, compared to the rest of the year, it reached 7.536 µg ha^{-1} using sand traps, this was followed by June, which recorded 5.009 µg ha^{-1}, then, August recorded a value of 4.512 µg. ha^{-1}. This difference in the calculated quantities between the months of the year is due to climatic and soil conditions. The increase in temperature, as well as increased evaporation rates, increased wind speed, the frequency of northwesterly winds, and the increase in their effective hours, especially in July, increases the amount of mobile sediment. The lowest values for the amount of soil lost through wind erosion were recorded in December and January, reaching 0.038 and 0.051 µg ha^{-1}, respectively. This is attributed to the increased soil moisture resulting from the increased rainfall during these months. There is an inverse relationship between soil moisture and the movement of soil particles through wind erosion, which is consistent with what was found by (Al-Hamdawi, 2021).

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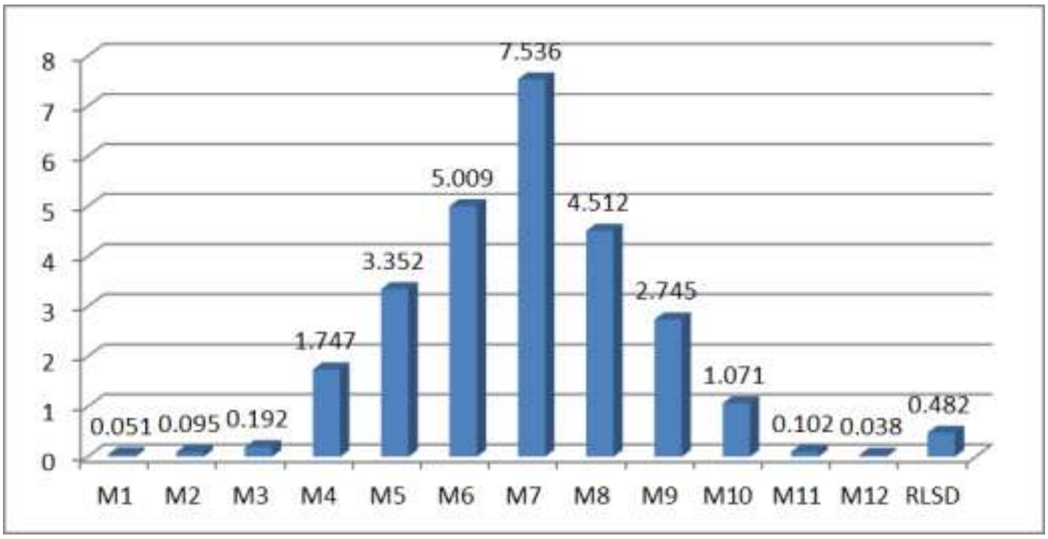

Figure (2) The amount of lost soil (μg. ha^{-1}) measured by the field method according to the months of the year.

Figure (3) indicates significant differences in the amount of soil lost through wind erosion between the study locations. Location L1 (Umm Qasr) recorded the highest annual soil loss value, 5.314 μg ha^{-1} yr^{-1}. Location L2 (Al-Shuaiba) followed, recording a value of 1.291 μg ha^{-1} yr^{-1}. Location (Al-Qurna) recorded the lowest annual loss value, 0.008 μg ha^{-1}. yr^{-1}, respectively. This is due to soil erodibility and the difference in the percentage of aggregates larger than 1 mm in the soil, led to significant differences between the study stations. Umm Qasr and Al-Shuaiba locations have a lower percentage of soil aggregates (>1 mm) in their surface soil, compared to Al-Qurna location, the percentage of soil aggregates (>1 mm) is larger, therefore, the amount of soil lost to wind erosion is lower compared to the other locations, there is also an increased percentage of fine particles in the sediments of these areas (Tables 1, 2, 3). The increased clay content in these two locations, leads to the formation of large, clay-rich soil aggregates. Consequently, these aggregates are difficult to transport by air currents, this increases their stability and cohesion (Abdul Rahman and Abu Ras, 2023).

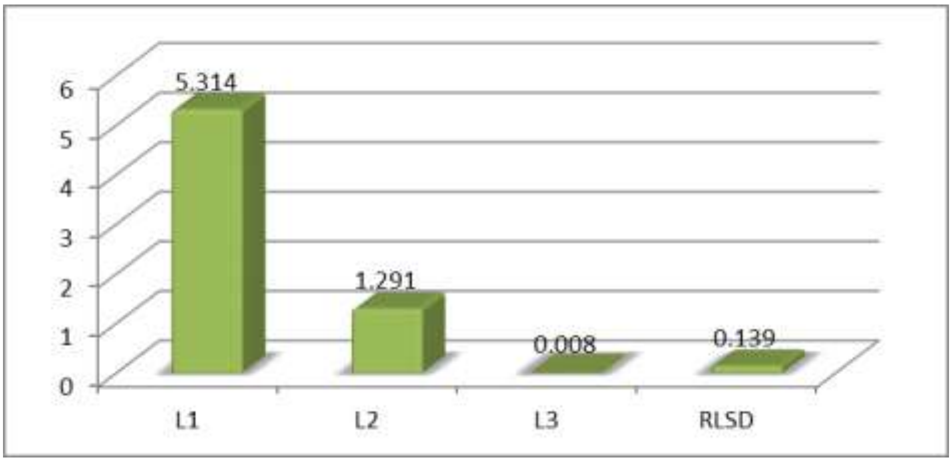

Figure (3) Average amount of lost soil (μg ha^{-1} yr^{-1}) measured by the field method according to the study locations.

Table (4) shows a significant effect of the two-way interaction between the study locations and elevation above the soil surface. Umm Qasr location, at elevation H1, recorded the highest annual soil loss, reaching 14.386 μg ha^{-1} yr^{-1}. This is due to the fact that the location's surface soil contained a lower percentage of soil aggregates >1 mm, which are important indicators of wind erosion. The soil erosion susceptibility factor depends primarily on the percentage of soil particles larger than 1 mm (Al-Taghlabi and Al-Dulaimi, 2018). This is also due to the direct relationship between soil texture and soil erosion susceptibility, therefore, the values of the amount of soil lost by wind erosion at this location are high, due to the predominance of coarse soil particles compared to other locations. Meanwhile, Al-Qurna location, at elevation H1, recorded the lowest annual soil loss, reaching 0.017 μg ha^{-1} yr^{-1}. This is due to the surface soil containing a higher percentage of soil aggregates (>1 mm), due to the direct relationship between soil texture and soil erosion susceptibility. The increased clay content in this location leads to increased soil aggregates.

Table (4) Values of the amount of lost soil (μg ha^{-1}. yr^{-1}) for the study locations according to the vertical distribution of sand traps.

Location	Vertical distribution				
	H1	H2	H3	H4	H5
Umm Qasr	14.385	8.288	2.832	1.074	0.091
Al-Shuaiba	4.455	1.470	0.347	0.151	0.030
Al-Qurna	0.017	0.009	0.006	0.005	0.003
$RLSD_{0.05}$			0.311		

Figure (4) shows the two-way interaction between the months of the year and the height of the soil loss measured by the field method. There is a significant effect on the amount of soil lost by wind erosion. July recorded the highest amount of soil loss, reaching 21.264 μg ha^{-1} at altitude H1. The lowest amount of soil lost by wind erosion was in December at altitude H5, reaching 0.009 μg ha^{-1}. This is due to the high average wind speed in July, which reached 3.52 m s^{-1}.

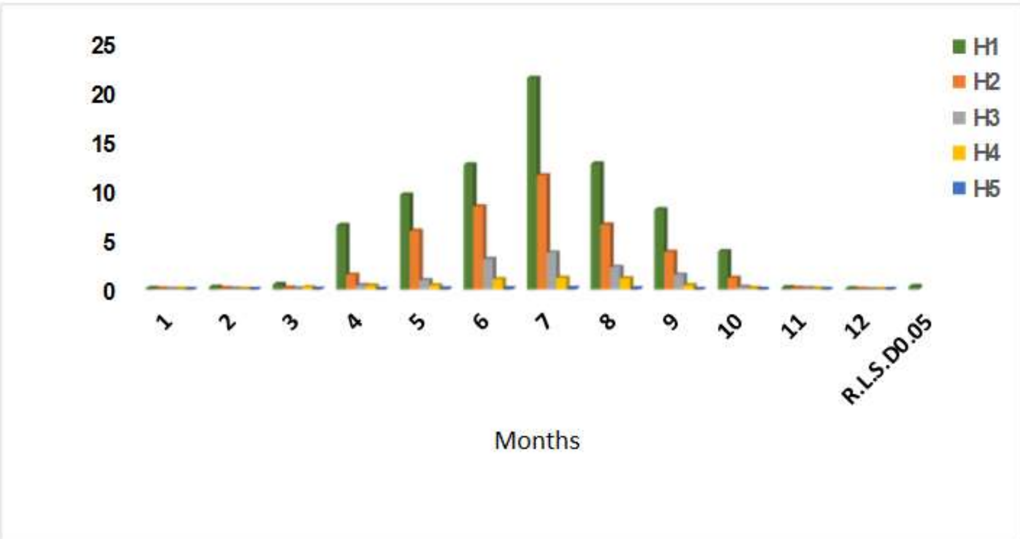

Figure (4) The binary interaction between the months of the year and the increase in the amount of lost soil (μg ha^{-1}) measured by the field method.

Regarding the three-way interaction (Table 4) between the study location and elevation by month of the year in the amount of soil lost to wind erosion, the statistical analysis results showed a significant difference in the amount of soil lost to wind erosion, measured by the field method. Umm Qasr location, at an elevation of 0.05 m, produced the highest amount of soil lost in July, reaching 45.302 µg ha^{-1}.

Table (5) The triple interaction between the study location, elevation, and months of the year in the amount of soil lost by wind erosion.

Location	High	Months											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Umm Qasr	**H1**	0.240	0.540	1.168	17.125	21.798	29.241	45.302	29.233	17.078	10.257	0.449	0.195
	H2	0.121	0.244	0.351	3.619	16.651	22.218	29.553	15.253	8.213	2.839	0.311	0.083
	H3	0.079	0.121	0.185	1.181	2.330	8.205	9.708	5.972	4.140	0.561	0.237	0.063
	H4	0.070	0.082	0.547	1.062	1.134	2.660	2.940	2.754	1.153	0.280	0.150	0.055
	H5	0.044	0.049	0.056	0.063	0.122	0.179	0.253	0.179	0.053	0.045	0.034	0.017
Al-Shuaiba	**H1**	0.081	0.192	0.346	2.189	6.696	8.394	18.436	8.618	7.057	1.218	0.164	0.070
	H2	0.053	0.079	0.082	0.780	0.963	2.773	4.826	4.258	3.059	0.631	0.079	0.054
	H3	0.043	0.050	0.057	0.059	0.435	0.926	1.346	0.735	0.286	0.135	0,071	0.017
	H4	0.028	0.038	0.041	0.046	0.049	0.398	0.504	0.539	0.081	0.054	0.028	0.008
	H5	0.014	0.023	0.027	0.031	0.037	0.050	0.065	0.059	0.021	0.017	0.014	0.010
Al-Qurna	**H1**	0.000	0.000	0.008	0.021	0.025	0.034	0.053	0.045	0.012	0.006	0.000	0.000
	H2	0.000	0.000	0.005	0.009	0.020	0.025	0.022	0.012	0.006	0.005	0.000	0.000
	H3	0.000	0.000	0.007	0.008	0.013	0.012	0.015	0.008	0.005	0.005	0.000	0.000
	H4	0.000	0.000	0.005	0.006	0.007	0.012	0.011	0.005	0.005	0.004	0.000	0.000
	H5	0.000	0.000	0.001	0.004	0.006	0.005	0.006	0.003	0.004	0.003	0.000	0.000

CONCLUSIONS

The values of the amount of soil lost by wind erosion in Umm Qasr study area were higher than in the other study locations, due to the soil texture type. The values of the amount of soil lost were higher in June, July, and August at all study locations compared to the rest of the year. By calculating the percentage of soil particle movement, we note that creep movement predominated, accounting for 57.07%, followed by jump movement at 38.86%, while suspension movement accounted for 4.09%.

RECOMMENDATIONS

Other methods can be used to calculate the amount of soil lost using vertical distribution and to diagnose the movement of soil particles. Select other locations suffering from wind erosion and soil loss.

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