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Spatial and temporal variation of wind and rain erosion activity in Wasit Governorate

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Abstract
Both the wind and rain erosion processes are among the most prominent morpho-climatic processes, the effects of which are more clearly demonstrated in arid and semi-arid environments. Since the study area is part of these environments, the features of these two processes become clearer, as the rates of precipitation or wind erosion witness a clear increase in their amounts. At very high rates, specifically during the summer (June, July, and August), and annual rates at Badra, Al-Kut, Al-Hay, and Al-Aziziya stations amounted to (2641.8, 7805, 1158.4, 7548.7), respectively. This rise, by nature, is accompanied by strong wind pressure on the surface of the soil, which helps in its disintegration and fragmentation, and annual rates. High, and on the other hand, rain erosion is weak according to the application of equations and statistical methods used for the purpose of measuring it, with the exception of the eastern part of the study area represented by Badra station, which witnessed differences in recording rain erosion rates due to the increase in rainfall amounts compared to other stations.

Keywords: Spatial variation, temporal variation, wind erosion, rain erosion, Wasit Governorate

Introduction
The study of morpho-climatic processes is one of the geographical studies of great importance in nature, and it falls within the classification of geomorphological processes. The study of these processes mainly includes rain and wind erosion of all kinds, and knowing the extent of the impact of these processes on the surface of the Earth as well, through the effects they leave. Thus, the morpho-climatic effect on the region depends on the geographical characteristics. The most prominent of these is the climatic nature, the elements of which were studied, including (Heat, humidity, wind, rain, evaporation), because they are the main driver of the activity or weakness of morpho-climatic processes, as the climatic elements can create special conditions for these processes that differ between parts of the study area. Especially the study of the climatic water budget, which was considered an important indicator through its overflow and deficiency of morpho-climatic processes (Kahar, Abdul Karim Abbas Karim 2019) [1].

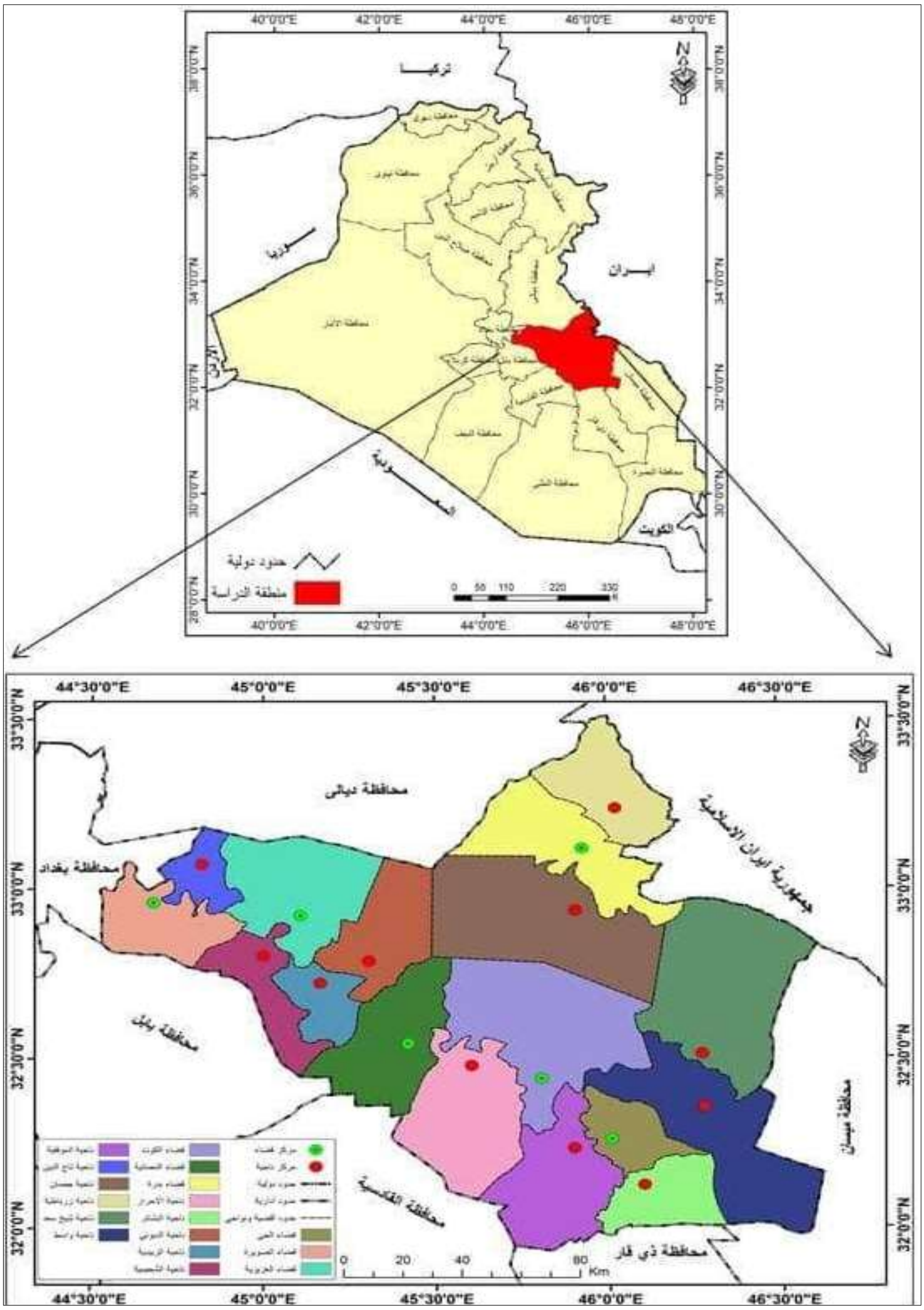
Research problem
The first step of scientific research is the study problem, which can be formulated in the form of a main question centered around secondary problems that need answers, which are as follows: What is the nature of wind and rain erosion activity in the study area?

Research hypothesis
The study hypothesis is defined as an initial, unproven solution to the problem, and the main hypothesis represents the following: Wind and rain erosion activity witnesses a temporal variation according to the months of the year and spatially according to the study stations.

Boundaries of Study
- **Spatial boundaries:** The study area is geographically located in the central region, specifically in the southern part of central Iraq, and is bordered to the north by Diyala Governorate, and to the northwest by Baghdad Governorate, and its borders to the west are represented by Maysan Governorate, while to the east it is represented by the political borders between Iraq and Iran. Map (1), as for the location of the study area

astronomically, it is located between two latitudes (-27 325 _ -3 335 north) and two longitudes (-1 445 _ -4 465 east).

- **Temporal limits:** The study was based on varying climate data for stations in the study area, and this period extends between (2010-2020) and these stations varied in their heights according to the topographic nature of the part on which the station was established, and thus Badra station is the highest station in the study area, table (1).



Reference: Based on satellite visualization Land Sat 8, Arc GIS 10.4 software

Map 1: Administrative units of the study area

Table 1: Climatic stations adopted in the study

No.	Station	Astronomical website		Code	Height from level Sea surface (Meters)
		Latitude (north)	Longitude (east)		
1.	Alhay	¯10.°32	¯03.°46	40665	15
2.	Kut	¯30.°32	¯49.°45	40664	19
3.	Badra	¯06.°33	¯57.°45	40662	64
4.	Azizia	¯55.°32	¯04.°45	40660	25

Reference: Ministry of Transport, Iraqi General Authority for Meteorology and Seismic Monitoring, Climate Department, data (unpublished)

Climatic characteristics of the study area

Temperature:

Temperature is one of the most important elements of climate. It exerts a direct effect on the elements of the biological system, and it also affects the rest of the climatic elements such as pressure, wind, evaporation, condensation, relative humidity, and other elements (Landsberg, 1968) [2]. It is clear from Table (2) that daily temperatures witness a clear variation from one month to another in all study stations, as their lowest rates are recorded during the month of January due to the disappearance of the subtropical jet stream and the appearance of the polar jet over Iraq (Al-Samarrai, Qusay Abdel Majeed 2008) [3]. It reached about (11.3, 10.6, 11.5, 11.7) C° for Badra, Al-Aziziya, Al-Kut, and Al-Hay stations, respectively, while the daily temperatures rose to record the highest during the month of July due to the verticality of the sun by (39, 37.2, 37.5, 38.3) C° in Climatic stations of Wasit Governorate, respectively.

Table 2: Monthly averages of daily temperatures (°C) in the study area for the period (2010-2020)

Month Station	January	February	March	April	Mays	June	July	August	September	October	November	December	Annual rate
Badra	11.3	13.8	18.9	25.3	31.4	36.3	39.0	38.6	33.8	27.1	18.1	12.9	25.5
Azizia	10.6	13.6	18.3	24.0	30.3	34.9	37.2	36.9	32.6	26.2	17.5	12.5	24.6
Kut	11.5	13.8	18.1	25.0	30.8	35.0	37.5	36.6	33.0	26.5	18.0	13.0	24.9
Alhay	11.7	14.7	20.3	25.4	31.5	36.3	38.3	37.8	33.9	27.4	18.6	13.3	25.8

Wind: This is the horizontal movement of air parallel to the surface of temperature, humidity, and atmospheric pressure between one place and another, as it is affected by atmospheric pressure, which changes the wind in terms of speed and direction, as it moves from the centers of high pressure, which are represented by high lands, towards low air pressure, where low places (Ali H. AL Shalash, 1966) [4] It is clear from Table (3) that wind speed rates witness temporal and spatial variation at the study stations during the months of the year, as the lowest wind speed rate is recorded during the month of December due to the frequent occurrence of highlands during this month, which is characterized by calm air, as it reached (2.2, 2.4, 2.7, 2.3) m/s at Badra, Al Aziziyah, Al Kut, and Al Hay stations, respectively, while the months of June and July witness the maximum rates of wind speed due to temperature rise, thus encouraging surface turbulence processes, as they were recorded at (3.6, 4.2, 5.1, 4.3).) m/s during the month of June in the climate stations of Wasit Governorate, respectively.

Table 3: Monthly averages of wind speed (m/s) in the study area for the period (2010-2020)

Month Station	January	February	March	April	Mays	June	July	August	September	October	November	December	Annual rate
Badra	2.4	2.8	2.9	2.8	2.5	3.6	3.4	2.9	2.6	2.4	1.9	2.2	2.7
Azizia	2.7	2.9	3.1	2.9	3.1	4.2	4.2	3.4	3.0	2.6	2.2	2.4	3.0
Kut	2.7	3.0	3.4	3.2	3.6	5.1	4.8	4.4	3.5	2.7	2.5	2.7	3.5
Alhay	2.5	2.7	2.9	2.7	2.9	4.3	3.9	3.4	3.0	2.6	2.1	2.3	2.9

Reference: Researcher, based on: Ministry of Transport, General Authority for Meteorology, Climate Department, data (n.m.), Baghdad, 2021

Rainfall: It is liquid precipitation with a diameter of more than 500 microns. This rain may be light, medium, or heavy depending on the amount that falls during a unit of time and related to the size and speed of its falling droplets. It may be light if the rate of what falls is less than (0.5). mm/hour), and precipitation may be moderate if its quantity ranges around (0.5 mm/hour), but if the amount of rain exceeds (4 mm/hour), the precipitation will be severe (Moussa, Ali Hassan 1994) [5]. Table (4) shows the variation between monthly rainfall amounts. At one station, the most and least months differ from one year to another. This variation between months is part of the nature of rainfall in areas with dry and semi-arid climates, which includes large parts, including the study area, as it recorded the highest An amount of rainfall during the month of January (31.8, 25, 26.4, 29) mm at Badra, Al-Aziziyah, Al-Kut, and Al-Hay stations, while the lowest rates of rainfall were recorded during the months of (June, July, and August), as each of Al-Aziziyah and Al-Kut stations did not record any amount. of rain during those months, while Badra station recorded about (0.1 mm) during the month of August, while the months of June and July were free of rain, and Al-Hay station recorded about (0.1, 0.7) mm during June and July, while the month of August was free of precipitation.

Table 4: Monthly averages of total rainfall (mm) in the study area for the period (2010-2020)

Month Station	January	February	March	April	Mays	June	July	August	September	October	November	December	Annual rate
Badra	31.8	20.9	29.1	18.3	19.1	0.0	0.0	0	3.0	21.4	29.3	23.8	196.7
Azizia	25.0	12.0	20.1	11.9	5.7	0.0	0.0	0	0	20.8	20.6	16.0	132.4
Kut	26.4	10.7	19.5	17.7	11.7	0.0	0.0	0.0	0.0	4.7	28.1	18.2	137.0
Alhay	29	11.2	16.1	16.4	9.0	0	0.7	0	0	5.4	20.6	19.2	128.0

Reference: Researcher based on the Republic of Iraq, Ministry of Transport, Iraqi General Authority for Meteorology and Seismic Monitoring, Climate Department, data (unpublished)

Relative humidity

What is meant by relative humidity is the amount of water vapor actually present in the air at a certain temperature relative to the maximum amount that the air can hold at the same temperature, and this humidity is expressed in percentage, and it is directly affected by temperatures, and since it is Relative humidity is the percentage of water vapor in the atmosphere, and this means that the percentages will change as the temperature changes (Al-Samarrai, Qusay Abdel Majeed 2008) [3]. Table (5) shows that relative humidity rates vary greatly during the months of the year, as their rates increase during the month of January due to the advance of humid air depressions, especially moderate ones that cause rainfall. It recorded a rate of (66.3%) at the Baghdad station, and (65.2, 72, 69.8 and 69.6% at Badra, Al-Aziziyah, Al-Kut and Al-Hay stations, while the month of July witnessed the lowest rate of relative humidity recorded across all study stations due to the concentration of dry continental tropical masses over the region in this month, as it reached (20.5%) at the Baghdad station, and (17.5, 25, 21, 24.2)% at Badra, Al Aziziyah, Al Kut and Al Hai stations.

Table 5: Monthly averages of relative humidity (%) in the study area for the period (2010-2020)

Month Station	January	February	March	April	Mays	June	July	August	September	October	November	December	Annual rate
Baghdad	66.3	57.8	47.3	38.9	29.5	21.7	20.5	22.9	26.7	38.0	57.0	66.3	41.1
Badra	65.2	54.6	43	34.9	26.5	18.7	17.5	18.4	22.2	31.5	53	59.6	37.1
Azizia	72	62	52	45	34	26	25	26	30	41	62	68	45
Kut	69.8	58.6	49.5	40	29.2	21	21	21.8	24.4	36.2	58.7	69.1	41.6
Alhay	69.6	59.4	50.0	43.7	33.3	24.2	22.7	25	28.2	39.6	61.0	68.3	43.8

Reference: Researcher, based on: Ministry of Transport, General Authority for Meteorology and Seismic Monitoring, Climate Department, data (n.m.), Baghdad, 2021

Climate water budget: Climate water budget

It is one of the most important criteria in determining water needs in arid and semi-arid regions, which are characterized by irregular, fluctuating, and seasonal rainfall, as it shows the spatial relationship between the amount of precipitation reaching the surface of the earth and the amount of water that returns to the atmosphere from precipitation due to evaporation and transpiration. That is, it reflects the relationship between the amount of rainfall and the values of evaporation/transpiration. When precipitation is more than evaporation/transpiration, a water surplus is produced in the region, and conversely, when rainfall is less than evaporation/transpiration, it is a climatic water deficit. (Al-Maliki, Abdullah Salem Al-Maliki, Abdul Imam Nassar Diri 2005) [7]. In order to quantitatively estimate the water budget for any region or station, the potential evaporation /transpiration must first be calculated, as the researcher relied on the mathematical equation (Ivanov), through which he relied on studying the relative humidity and temperature in the region, and from then, a mathematical method is used to estimate the water budget. This method is (the amount of monthly rainfall - the amount of potential evaporation /transpiration). If the output is negative, it will be a water deficit, and if the output is positive, there will be a water surplus (Al-Kaabi, Muhannad Hassan Rahaif 2008) [8]. It is clear from Table (6) that the study area suffers from a water deficit in all its stations and during all months of the year. The total annual deficit reached (-3756.7, -3207.9, -3465, -3452.9) mm for Al-Hay, Al-Kut, Badra and Al-Aziziya stations, respectively. Regarding the lowest amounts of water deficit during the months of the year, it was recorded during the month of January, where it reached

Table 6: Water-climatic budget in the study area according to the Ivanov equation

Badra					Azizia				
Month	Amount The rain	Evaporation Possible transpiration	Climate water budget	Disability rate	The month	Amount The rain	Evaporation Possible transpiration	Climate water budget	Disability rate
January	31.8	82.5	-50.7	1.3	January	25	63.9	-38.9	1.2
February	20.9	123	-102.1	2.7	February	12	101.9	-89.9	2.8
March	29.1	197.7	-168.6	4.5	March	20.1	162	-141.9	4.4
April	18.3	296.5	-278.2	7.4	April	11.9	237.7	-225.8	7.0
May	19.1	420.8	-401.7	10.7	May	5.7	363.3	-357.6	11.1
June	0	549.9	-549.9	14.6	June	0	477.9	-477.9	14.9
July	0	608.3	-608.3	16.2	July	0	522.3	-522.3	16.3
Dad	0	594.1	-594.1	15.8	Dad	0	510.4	-510.4	15.9
September	3	484.2	-481.2	12.8	September	0	418	-418	13.0
October	21.4	334.7	-313.3	8.3	October	20.8	278.4	-257.6	8.0
November	29.3	157.2	-127.9	3.4	November	20.6	123.5	-102.9	3.2
December	23.8	104.5	-80.7	2.1	December	16	81	-65	2.0
total	196.7	3953.4	-3756.7	100	The total	132.4	3340.3	-3207.9	100
Kut					**Alhay**				
Month	Amount The rain	Evaporation Possible transpiration	Climate water budget	Disability rate	The month	Amount The rain	Evaporation Possible transpiration	Climate water budget	Disability rate
January	26.4	72.4	-46	1.3	January	29	73.7	-44.7	1.3
February	10.7	112.2	-101.5	2.9	February	11.2	115.2	-104.0	3.0
March	19.5	168.9	-149.4	4.3	March	16.1	184.7	-168.6	4.9
April	17.7	270	-252.3	7.3	April	16.4	257.4	-241.0	7.0
May	11.7	396.8	-385.1	11.1	May	9	383.3	-374.3	10.8
June	0	511.9	-511.9	14.8	June	0	512.7	-512.7	14.8
July	0	555.5	-555.5	16.0	July	0.7	557.5	-556.8	16.1
Dad	0	534.1	-534.1	15.4	Dad	0	532.4	-532.4	15.4
September	0	457.8	-457.8	13.2	September	0	448.4	-448.4	13.0
October	4.7	304.6	-299.9	8.7	October	5.4	298.5	-293.1	8.5
November	28.1	137.5	-109.4	3.2	November	20.6	133.4	-112.8	3.3
December	18.2	80.3	-62.1	1.8	December	19.2	83.7	-64.5	1.9
The total	137	3602	-3465	100	The total	128	3580.9	-3452.9	100

The study stations (Al-Hay, Al-Kut, Badra, and Al-Aziziyah) reached about (-50.7, -38.9, -46, -7.44) mm, respectively, with deficit rates of (3.1, 1, 1.2, 3.1, 1.3)%, respectively. This small percentage of the deficit is due to the small amounts of solar radiation, which results in lower temperatures, in addition to the increased amounts of rainfall, which led to an increase in the moisture content of the soil. As for the highest amount of water deficit, it was during the month of July, when it reached (-608.3, -3,522).,-5,555,-8,556) mm, with deficit rates ranging from (16.2, 16.3, 16.0, 16.1)% for each of Al-Hay, Al-Kut, Badra, and Al-Aziziya stations, respectively. This increase in deficit rates is due to the increase in the angle of incidence of solar radiation during this month, which resulted in It depends on the actual and theoretical length of the day, and thus high temperatures and evaporation values, in addition to the lack of rainfall and thus a decrease in the moisture and mineral content of the soil.

Rain erosion deposits: Many equations are used to measure the extent of erosion due to rain, and among these equations is the Douglas equation. (R.U. Cook, 1973:393)

$$S = \frac{1.65\,(0.03937\,PE)^{2.3}}{1+0.0007(0.03937PE)^{3.3}}$$

Since

S = erosion volume (m3/km^2/year)

PE = effective precipitation extracted according to CROPWAT 8.0 program.

Based on the climatic data of the study stations, the results were extracted and included in Table (7). It becomes clear that the annual rate of erosion due to rain was somewhat similar in the study area, as it reached (Badra, Al-Aziziyah, Al-Kut, and Al-Hay) stations about (108.59, 59.50, 63.3, 55.77) respectively, and this reflects the amount of rainfall falling, while the amount of rain erosion is maximum in Badra, and this increase is due to the fact that the amount of rain is greater than in other stations, while at the level of months, the month of January witnessed the maximum amounts Rain erosion sediments amounted to about (2.45, 1.44, 1.63, 2.01) for each of Badra, Al-Aziziyah, Al-Kut and Al-Hay stations, respectively, due to the high amounts of rainfall and the presence of frequent rainstorms during it, while no presence of sediments was recorded during the summer months of June, July and August due to the lack of rainfall during the months. This season, excluding the Hay station during the month of June, the sediment was estimated at approximately (0.0004).

Table 7: Monthly rainfall sediment amounts at the study stations

Badra			Azizia		
Month	**P**	**E**	**The month**	**P**	**E**
January	30.2	2.45	January	24	1.44
February	20.2	0.97	February	11.8	0.28
March	27.7	2.01	March	19.5	0.89
April	17.8	0.72	April	11.7	0.27
May	18.5	0.79	May	5.6	0.05
June	0	0	June	0	0
July	0	0	July	0	0
Dad	0	0	Dad	0	0
September	3	0.01	September	0	0
October	20.7	1.03	October	20.1	0.96
November	27.9	2.04	November	19.9	0.94
December	22.9	1.29	December	15.6	0.53
Annual erosion volume	188	108.59	Annual erosion volume	128.1	59.50
Kut			**Alhay**		
Month	P	E	Month	P	E
January	25.3	1.63	January	27.7	2.01
February	10.5	0.21	February	11	0.24
March	18.9	0.83	March	15.7	0.54
April	17.2	0.67	April	16	0.56
May	11.5	0.26	May	8.9	0.14
June	0	0	June	0	0
July	0	0	July	0.7	0.0004
Dad	0	0	Dad	0	0
September	0	0	September	0	0
October	4.7	0.03	October	5.4	0.04
November	26.8	1.86	November	19.9	0.94
December	17.7	0.71	December	18.6	0.80
Annual erosion volume	132.5	63.3	Annual erosion volume	123.8	55.77

Climatic capacity for rain erosion

Many studies have been conducted for the purpose of developing comprehensive equations in order to calculate the erosion capacity and to know the rain's ability to erode. Among the most important equations that have been developed are the (Fournier-Arnolis F.A.I) rates, and this equation is known as being simple. In its calculation, the determination and calculation of this equation depends entirely on the monthly rainfall rates and their annual total.

$$F.A.I = \frac{(Pi)^2}{P}$$

As it represents: F.A.I = eroding capacity of rain.

Pi = average rainfall for a month expressed in (mm).
P = total annual rainfall.
The (F.A.I) factor states the following: If it is (less than 50), then the severity of the erosion is weak, and between (50-500), then the severity of the erosion is moderate, and if it is from (500-1000), then it is high, and if it is more than (1000), then it becomes severe. The shelf is very high. (Fournier. F., Climate, 1960) [9].
When this equation was applied to the study stations, it became clear that the weak capacity of rain erosion in all parts of the region, as the results of the equation in Table (8), all of them fall into the first category (less than 50), and the value of rain erosion reached its maximum value in the month of January. It reached about (5.14, 4.72, 5.09, 6.57) for each of Badra, Al-Aziziyah, Al-Kut, and Al-Hay stations, respectively, while the value of rainfall reached (zero) during the months of June, July, and August, and this is due to the lack of rain and its non-fall, and these equations do not reflect the reality of rain. And the extent of its ability to erode, because the equation is based in its calculation on the monthly rates of rain, and this means that the reality of the rain and the intensity of its erosion in the study area does not appear, because the rain there may fall half of its monthly amounts within two days or a day, and thus it performs its work on severe erosion that may exceed The equivalent of rain erosion for several months.

Table 8: Climatic susceptibility to rain erosion at the study stations

Badra				**Azizia**			
The month	**Pi**	**F.a.i**	**The intensity of erosion**	**The month**	**Pi**	**F.a.i**	**The intensity of erosion**
January	31.8	5.14	Weak	January	25	4.72	Weak
February	20.9	2.22	Weak	February	12	1.09	Weak
March	29.1	4.30	Weak	March	20.1	3.05	Weak
April	18.3	1.70	Weak	April	11.9	1.07	Weak
May	19.1	1.85	Weak	May	5.7	0.25	Weak
June	0	0.00	Weak	June	0	0.00	Weak
July	0	0.00	Weak	July	0	0.00	Weak
Dad	0	0.00	Weak	Dad	0	0.00	Weak
September	3	0.05	Weak	September	0	0.00	Weak
October	21.4	2.33	Weak	October	20.8	3.27	Weak
November	29.3	4.36	Weak	November	20.6	3.21	Weak
December	23.8	2.88	Weak	December	16.00	1.93	Weak
Annual erosion volume	196.8	24.83	Weak	Annual erosion volume	132.4	18.58	Weak
Kut				**Alhay**			
The month	Pi	F.a.i	The intensity of erosion	The month	Pi	F.a.i	The intensity of erosion
January	26.4	5.09	Weak	January	29	6.57	Weak
February	10.7	0.84	Weak	February	11.2	0.98	Weak
March	19.5	2.78	Weak	March	16.1	2.03	Weak
April	17.7	2.29	Weak	April	16.4	2.10	Weak
May	11.7	1.00	Weak	May	9	0.63	Weak
June	0	0.00	Weak	June	0	0.00	Weak
July	0	0.00	Weak	July	0.7	0.00	Weak
Dad	0	0.00	Weak	Dad	0	0.00	Weak
September	0	0.00	Weak	September	0	0.00	Weak
October	4.7	0.16	Weak	October	5.4	0.23	Weak
November	28.1	5.76	Weak	November	20.6	3.32	Weak
December	18.2	2.42	Weak	December	19.2	2.88	Weak
Annual erosion volume	137	20.33	Weak	Annual erosion volume	128	18.74	Weak

Wind pressure force: The following equation was used to explain this force: (Abu Al-Enein, Hussein Sayed Ahmed 1996) [10].
Wind pressure force (kg/m^2) = 0.006 x wind speed squared (km/h).
By applying the following equation, the results in Table (9) showed that the amount of wind pressure on the surface soil increases with increasing wind speed, as the wind speed begins to increase gradually starting in the month of March and has reached (2.9, 3.1, 3.4, 2.9 m/s) for Badra station, Al-Aziziyah, Al-Kut, and Al-Hay, respectively, while the maximum wind speed is during the months (June, July, August). During these months, Badra station recorded speed rates that reached (3.6, 3.4, and 2.9 m/s), which made the amount Wind pressure on the soil during the same months (1.01, 0.90, 0.65 kg/m^2), and as for Al-Aziziya station, the wind speed rates were (4.2, 4.2, 3.4 m/s) and the amount of wind pressure was about (1.37, 1.37, 0.90 kg/m^2) At Al Kut station, the wind speed was (5.1, 4.8, 4.4 m/s), while the wind pressure values were about (2.02, 1.79, 1.51 kg/s), while the wind speed rates in the same months for Al Hay station were about (4.3)., 3.9, 3.4 m/s), which caused the amount of wind pressure to record (44.1, 18.1, 0.90 kg/m^2), and this increase in the amount of wind pressure strength is due to the fact that the soil during the summer is dry, fragile and exposed to wind erosion. Due to the increase in temperature rates, evaporation values, and high wind speeds (Shamkhi, Afrah Ibrahim 2017) [11]. While the lowest amount of wind pressure on the soil is during the winter months, the month of December recorded the lowest rates of wind speed, as it reached about (2.4, 2.7, 2.7, 2.5 m/s) for Badra, Al-Aziziya, Al-Kut, and Al-Hay stations, respectively. The wind on the soil is about (45.0, 57.0, 57.0, 49.0 kg/m^2), and this decrease is due to low wind speed rates, as well as increased rainfall rates, which leads to increased soil moisture, and also higher density. Natural plants that lead to the cohesion of soil atoms and particles, making the amount of wind pressure weak compared to the summer.

Table 9: Monthly and annual averages of wind speed and wind pressure magnitudes at the study stations

Badra				Azizia			
Month	**Wind speed m/s**	**Wind speed km/h**	**Wind pressure force**	**Month**	**Wind speed m/s**	**Wind speed km/h**	**Wind pressure force**
January	2.4	8.64	0.45	January	2.7	9.72	0.57
February	2.8	10.08	0.61	February	2.9	10.44	0.65
March	2.9	10.44	0.65	March	3.1	11.16	0.75
April	2.8	10.08	0.61	April	2.9	10.44	0.65
May	2.5	9	0.49	May	3.1	11.16	0.75
June	3.6	12.96	1.01	June	4.2	15.12	1.37
July	3.4	12.24	0.90	July	4.2	15.12	1.37
Dad	2.9	10.44	0.65	Dad	3.4	12.24	0.90
September	2.6	9.36	0.53	September	3	10.8	0.70
October	2.4	8.64	0.45	October	2.6	9.36	0.53
November	1.9	6.84	0.28	November	2.2	7.92	0.38
December	2.2	7.92	0.38	December	2.4	8.64	0.45
Annual erosion volume	2.7	9.72	0.57	Annual erosion volume	3	10.8	0.70
Kut				**Alhay**			
The month	**Wind speed m/s**	**Wind speed km/h**	**Wind pressure force**	**The month**	**Wind speed m/s**	**Wind speed km/h**	**Wind pressure force**
January	2.7	9.72	0.57	January	2.5	9	0.49
February	3	10.8	0.70	February	2.7	9.72	0.57
March	3.4	12.24	0.90	March	2.9	10.44	0.65
April	3.2	11.52	0.80	April	2.7	9.72	0.57
May	3.6	12.96	1.01	May	2.9	10.44	0.65
June	5.1	18.36	2.02	June	4.3	15.48	1.44
July	4.8	17.28	1.79	July	3.9	14.04	1.18
Dad	4.4	15.84	1.51	Dad	3.4	12.24	0.90
September	3.5	12.6	0.95	September	3	10.8	0.70
October	2.7	9.72	0.57	October	2.6	9.36	0.53
November	2.5	9	0.49	November	2.1	7.56	0.34
December	2.7	9.72	0.57	December	2.3	8.28	0.41
Annual erosion volume	3.5	12.6	0.95	Annual erosion volume	2.9	10.44	0.65

Climatic susceptibility to wind erosion

The climatic susceptibility to wind erosion can be estimated through climate data (temperature rates, wind speed, and amount of rain) for stations in the study area (Badra, Al-Kut, Al-Hay, and Al-Aziziyah), by applying the (Chepil) equation as follows: (Chepil. W.S. Sdidoway. F.H. Armbrust, D.V. Climatic, 1962).: 163) [6].

C = 〖386×V〗 ^3/ 〖(PE)〗 ^2

Where C = climatic susceptibility to erosion.
V = average wind speed (miles per hour) Wind speed is converted by the relationship.

The following: Average wind speed m/s x 3600 ÷ 1.56

PE = effective precipitation extracted according to CROPWAT 8.0 program.

After completing the climate information required for the Chepil equation, the results of the equation were shown in Table (10), where the wind erosion index reached its highest values at the Badra, Al-Kut, Al-Hay and Al-Aziziyah stations, reaching (2641.8, 7805, 1158.4, 7548.7) respectively, and this increase in The susceptibility to wind erosion is due to the lack of natural vegetation, in addition to the high values of evaporation and temperatures, as the lowest values of climatic susceptibility to wind erosion were recorded at Badra station, and this decrease in the values of wind erosion in this station compared to the other study stations is primarily due to an increase in Effective rain values, which led to an increase in soil moisture with the growth of vegetation in Badra Alhay. While at the level of months, the month of January witnessed the maximum amounts of wind erosion sediments at about (1023.7, 1621.0, 1522.8, 9659.9) for Badra, Al-Aziziyah, Al-Kut, and Al-Hay stations, respectively, due to high soil moisture during this month as a result of rainfall.

Table 10: Monthly and annual rates of wind erosion at the study stations

B				Azizia			
Month	**Wind speed m/s**	**Wind speed mph**	**Amount of erosion**	**Month**	**Wind speed m/s**	**Wind speed mph**	**The amount of erosion**
January	2.4	5538.5	1023.7	January	2.7	6230.8	1621.0
February	2.8	6461.5	2552.0	February	2.9	6692.3	8309.ع
March	2.9	6692.3	1507.6	March	3.1	7153.8	3716.4
April	2.8	6461.5	3286.6	April	2.9	6692.3	8451.6
May	2.5	5769.2	2165.6	May	3.1	7153.8	4506.3
June	3.6	8307.7	0	June	4.2	9692.3	0
July	3.4	7846.2	0	July	4.2	9692.3	0
Dad	2.9	6692.3	0	Dad	3.4	7846.2	0

September	2.6	6000.0	9264.0	September	3	6923.1	0
October	2.4	5538.5	1530.4	October	2.6	6000.0	2063.7
November	1.9	4384.6	4179.9	November	2.2	5076.9	1275.4
December	2.2	5076.9	9631.9	December	2.4	5538.5	2694.7
Annual erosion volume	2.7	6230.8	2641.8	Annual erosion volume	3	6923.1	7805.3
Kut				**Alhay**			
Month	**Wind speed m/s**	**Wind speed mph**	**The amount of erosion**	**The month**	**Wind speed m/s**	**Wind speed mph**	**The amount of erosion**
January	2.7	6230.8	1522.8	January	2.5	5769.2	9659.9
February	3	6923.1	1162.0	February	2.7	6230.8	7716.7
March	3.4	7846.2	5219.6	March	2.9	6692.3	4693.6
April	3.2	7384.6	5254.2	April	2.7	6230.8	3647.3
May	3.6	8307.7	1673.5	May	2.9	6692.3	1460.6
June	5.1	11769.2	0	June	4.3	9923.1	0
July	4.8	11076.9	0	July	3.9	9000.0	5742.7
Dad	4.4	10153.8	0	Dad	3.4	7846.2	0
September	3.5	8076.9	0	September	3	6923.1	0
October	2.7	6230.8	5049.8	October	2.6	6000.0	2859.2
November	2.5	5769.2	1031.9	November	2.1	4846.2	1109.3
December	2.7	6230.8	2980.3	December	2.3	5307.7	1668.3
Annual erosion volume	3.5	8076.9	1158.4	Annual erosion volume	2.9	6692.3	7548.7

Conclusion

- The study area suffers from a water deficit in all its stations and during all months of the year. The total annual deficit reached (-3756.7, -3207.9, -3465, -3452.9) mm for Al-Hay, Al-Kut, Badra and Al-Aziziya stations, respectively.
- The evidence of wind erosion reached its highest values at Badra, Al-Kut, Al-Hay and Al-Aziziyah stations, reaching (2641.8, 7805, 1158.4, 7548.7) respectively. This increase in the susceptibility to wind erosion is due to the lack of natural vegetation, in addition to the high values of evaporation and temperatures.
- The amount of wind pressure on the soil during January was about (45.0, 57.0, 57.0, 49.0 kg/m^2), and this decrease is due to the low rates of wind speed, as well as the increase in rain rates, which leads to Increased soil moisture, as well as a high density of natural plants, lead to the cohesion of soil particles and particles, making the amount of wind pressure weak compared to the summer.
- It became clear that the rain erosion capacity was weak in all parts of the region, as they all fall within the first category (less than 50), and the value of rain erosion reached its maximum values in the month of January, reaching about (5.14, 4.72, 5.09, 6.57) for each of Badra station. And Al-Aziziyah, Al-Kut and Al-Hayy respectively.

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