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THE EFFECT OF THE CHANGE OF DUST PHENOMENA ON THE RELATIVE HUMIDITY OF THE CENTRAL REGION OF IRAQ

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ABSTRACT:

The study examined the effect of the change of dust phenomena on the relative humidity directions in the central region of Iraq. Eight climatic stations were selected (Baghdad, Al-Hay, Hilla, Rutba, Ramadi, Kerbala, Beiji and Khanaqin). Also, the time series was analyzed for the period (1973-2016), as well as the two halves of the time series of all stations, through which the general direction and the change of the dust phenomena affecting the relative humidity were identified in addition to the general direction and the change of the relative humidity. The topological conformity was also used between the total change rates during the study period of the relative humidity (%) and the total change rates of dust phenomena.

INTRODUCTION:

Dust phenomena are one of the most common weather phenomena occur in arid and semi-arid areas due to wind blowing which leads to low visibility because of the dust it carries. The study area is characterized by the recurrence of these phenomena due to the flatness of its surface and the presence of a large desert in its westward, the low amount of rainfalls on the area, and the lack of vegetation cover, resulting in the disintegration of soil and the increase of dust with wind-blowing. These phenomena have effect on the relative humidity in the study area.

Relative humidity is one of the important topic in climatic studies because it affects climate elements, weather phenomena and air disorders. Water vapor, the source of moisture, is obtained from seas, oceans, forests, soil, rivers, marshes, lakes, living organisms, etc., and the quantity of water vapor varies in air in place and time.

RESEARCH PROBLEM:

1. Does the change and direction of dust phenomena have an effect on the change and direction of relative humidity in the study area?
2. Is there a spatial variance of relative humidity between stations in the study area?

RESEARCH HYPOTHESES:

1. There is an effect of the change and direction of dust phenomena on the change and direction of relative humidity in the study area.
2. There is a spatial variance of relative humidity in the study area.

LOCATION OF STUDY AREA:

The study area is located between two latitudes (35°41`55) and (30°36`39) north of the equator and between two longitudes (38°47`55) and (46°34`25) east of the Greenwich line, which represents the central region of Iraq including seven governorates (Baghdad, Wasit, Babel, Kerbala, Anbar, Salah al-Deen, Diala) as in Map (1). Eight climatic stations distributed in the study area were selected and they were variant in terms of location for latitudes, longitudes and elevation from sea level to cover the study area. The most important stations are (Baghdad, Al-Hay, Hilla, Kerbala, Ramadi, Rutba, Beiji and Khanaqin), as shown in Table (1).

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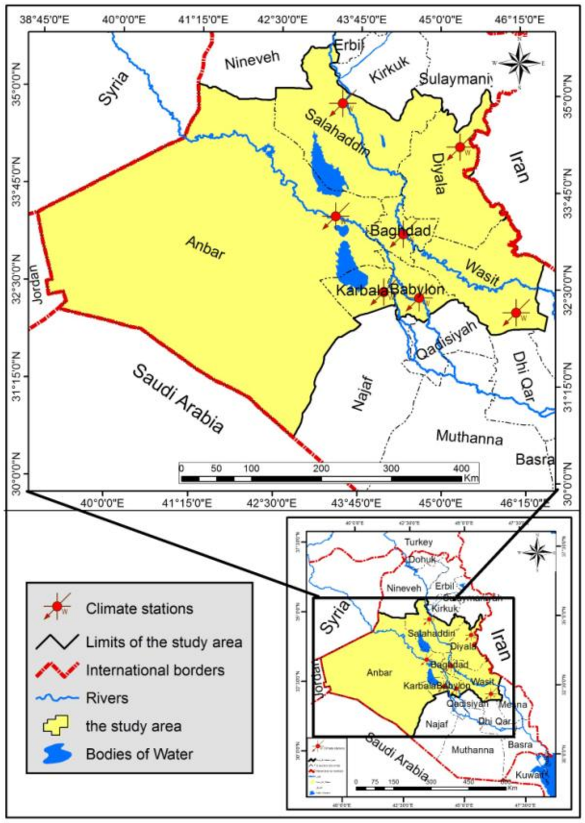
Map (1) Geographical distribution of climatic stations that represent the central region of Iraq



Source: The researcher's work based on: The General Authority of Surveying, Iraq's Administrative Map, Scale 1/1 million, using ARC GIS 10.2 program.

Table (1) The astronomical location of the study area stations, their height and their antenna number

No.	Stations	Astronomical location		Elevation from sea level/m	Station number
		The latitude northward	The longitude eastward		
1	Baghdad	33°18	44°24	31	650
2	Al-Hay	32°08	46°02	17	665
3	Hilla	32°27	44°27	27	657
4	Kerbala	32°34	44°03	29	656
5	Ramadi	33°27	43°19	48	645
6	Rutba	33°02	40°17	630	642
7	Beiji	34°54	43°32	115	631
8	Khanaqin	34°21	45°23	175	637

Source: General Organization of Meteorology and Seismic Monitoring, Climate Section, Baghdad, (unpublished data), 2016.

B. Time limits:

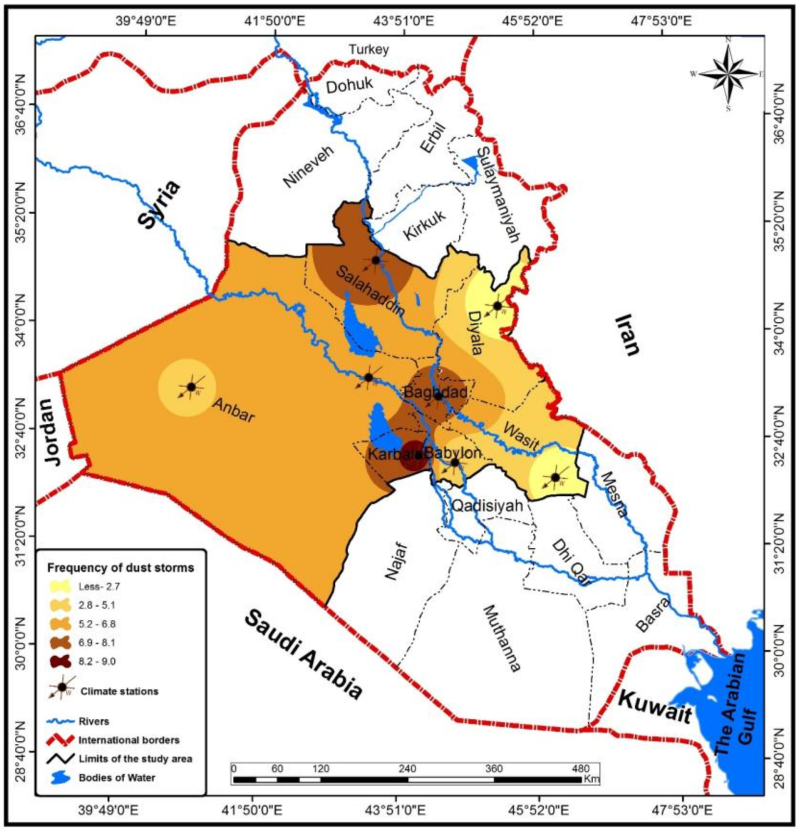
The temporal limits of the study were (44 years) starting from 1973 to 2016.

First: Dust Storms:

They are considered as one of the types of dust phenomena that occur as a result of the rapid wind blowing on a dry, disassembled surface. This wind is loaded with dust particles, leading to the decrease of visibility lower than 1000m. and the dust rises thousands of meters around (4000)m with a wind speed that reaches (7m/sec) or more[i].

It was obvious that there was a clear spatial variance between the stations of the study area in the intensity of the dust storm frequency where the highest average of the total annual frequency of dust storms was registered at Kerbala station by about (9.3) for the period (1973-2016) and the lowest average of frequency was registered in Khanaqin station by about (0.5) for the same period, and this was due to the astronomical and geographical location of Kerbala station, its plain surface, and the low atmospheric pressure rates compared with the rest of stations, see Map (2).

Map (2) Annual totals of dust storm frequencies (day) in the study area for the period (1973-2016)



Source: The researcher's work based on the data of the General Authority of Iraqi Meteorology, Climate Section, unpublished data, 2016.

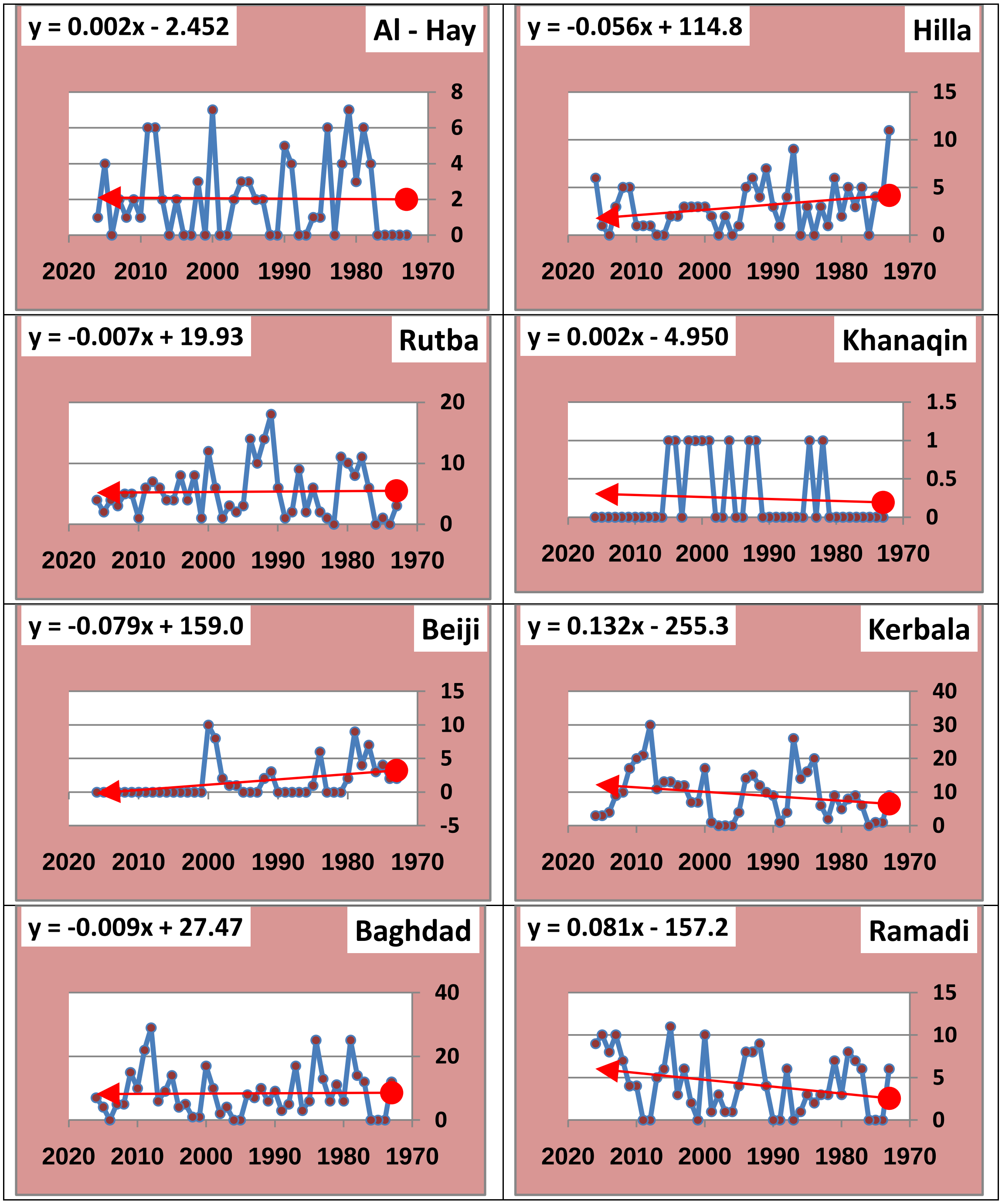
THE CHANGE OF DUST STORM AGGREGATES IN THE STUDY AREA:

During the period (1973-2016), the coefficient of the trend towards increasing was about (0.0023, 0.0026, 0.081, and 0.1327) for each of the stations (Al-Hay, Khanaqin, Kerbala and Ramadi) respectively, while the coefficient of the trend towards decline was about (-0.056, -0.0073, -0.079, and -0.0096) for each of the stations (Hilla, Rutbah, Beiji, and Baghdad), respectively, as in Figure (1).

The analysis of Table (2) for the period (1973-2016) shows that the highest rate of change towards increase was in Kerbala station (64.9) with an annual rate of change (1.5%), while the highest rate of change towards decrease was in Beiji station (-179.2) with an annual rate of change (-4.1%).

As for the mean deviation, the highest deviation coefficient was registered during the period (1973-2016) at Beiji station (6.9), while the lowest deviation coefficient occurred at Khanaqin station (1).

Fig. (1) The general trend of the total annual dust storms (day) for stations of the study area for the period (1973-2016)



Source: The researcher's work based on the data of the General Authority of Meteorology, Climate Section, unpublished data, 2016.

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Table (2) The rate of change and the mean deviation of the annual rates of dust storms (day) in the central region of Iraq for the period (1973-2016)

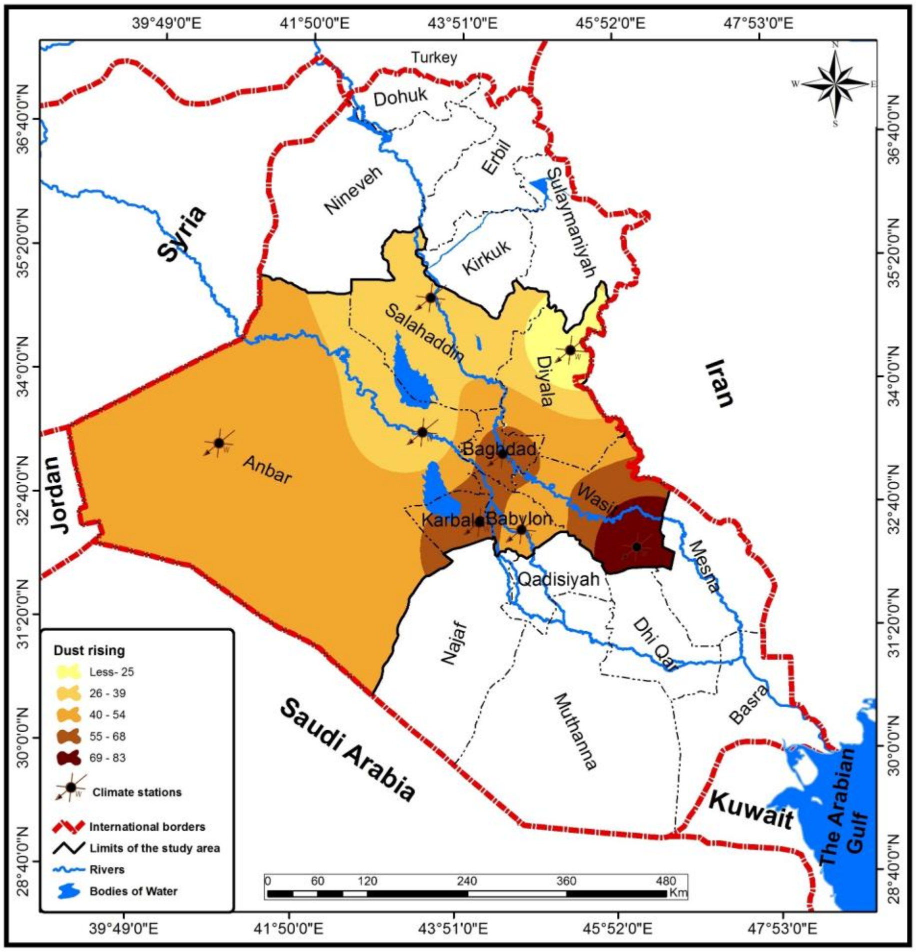
Climatic stations	Annual average	Trend coefficient	Annual change rate(%)	No. of years	Change rate during the study period	Mean deviation
Khanaqin	1	0.002	0.3	44	11.4	1
Rutba	5	-0.01	-0.1	44	-6.4	3.4
Kerbala	9	0.13	1.5	44	64.9	5.7
Beiji	8	-0.33	-4.1	44	-179.2	6.9
Ramadi	6	0.081	0.4	44	59.4	4.6
Baghdad	8	-0.01	-0.1	44	-5.3	5.8

Source: The researcher's work based on the data of the General Authority of Meteorology, Climate Section, unpublished data, 2016

Second: The Rising Dust

It is minutes of dust which diameter ranges between 1-100 microns, with a wind speed of 15-25 km, and a visibility range between 1-4 km which occurs during the daylight in summer[(ii)], due to the region's exposure to thermal depressions in summer, including the seasonal Indian depression the most frequent one. This type of dust phenomena consists of two ways, the first way is the very high temperature which causes heating the land surface and thus making load currents and instability in the air touching the land surface so the hot air rises to the top carrying with it the rising dust[(iii)]. The second way is when two different air currents meet their temperature at a surface that has irregular relief, causing a spiral wind movement that varies with respect to the nature of the surface[(iv)]. It is obvious that there is a clear spatial variance between the stations of the study area in the intensity of the rising dust frequency, in that the highest total annual recurrence of the rising dust at Al-Hay station (83.1 days) was registered for the period (1973-2016), and the lowest rate of annual frequency at Khanaqin station (9.8 days) was registered, which was due to the astronomical location of Khanaqin station in the east of the study area, the nature of the surface, the height factor, the rainfall and low temperatures in it compared to the rest of the study area stations, see Map (3).

Map (3) The annual aggregates of the rising dust frequency (day) in the study area for the period (1973-2016)



Source: The researcher's work based on the data of the General Authority of Meteorology, Climate Section, unpublished data, 2016.

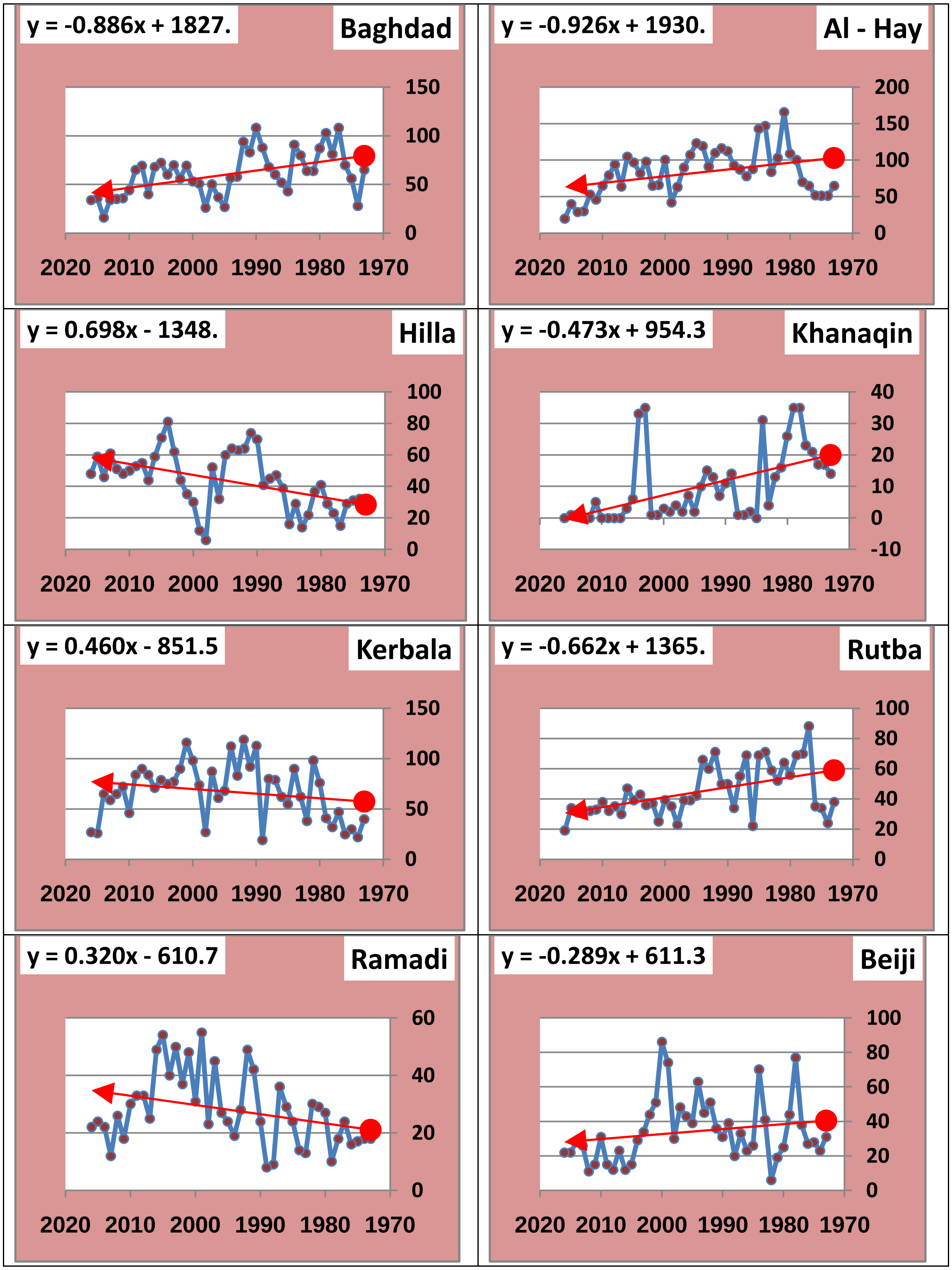
THE CHANGE OF THE RISING DUST AGGREGATES IN THE STUDY AREA:

During the period (1973-2016), the coefficient of the trend towards increase was by (0.698, 0.4606, and 0.3202) for each of the stations (Hilla, Kerbala and Ramadi), respectively, while the coefficient of the trend towards decrease was by (-0.926, -0.886, -0.4736, -0.6622, and -0.2894) for each of the stations (Al-Hay, Baghdad, Khanaqin, Rutbah, and Beiji), respectively, as in Fig. (2).

The analysis of Table (3) shows that the highest change rate for the period (1973-2016) towards increase was at Hilla station (71.4%) with an annual change rate (1.62%), while the highest trend coefficient towards decrease was at Khanaqin station (-208.4) with an annual change (-4.74%).

As for the mean deviation. the highest deviation coefficient registered during the period (1973-2016) was at Al-Hay station (25.9), while the lowest deviation coefficient was at Khanaqin station (9.2).

Fig. (2) The general trend of the total annual rising dust (day) of the study area stations for the period (1973-2016)



Source: The researcher's work based on the data of the General Authority of Meteorology, Climate Section, unpublished data, 2016.

Table (3) The change and mean deviation of the rising dust aggregates (day) in the Central Region of Iraq for the Period (1973-2016)

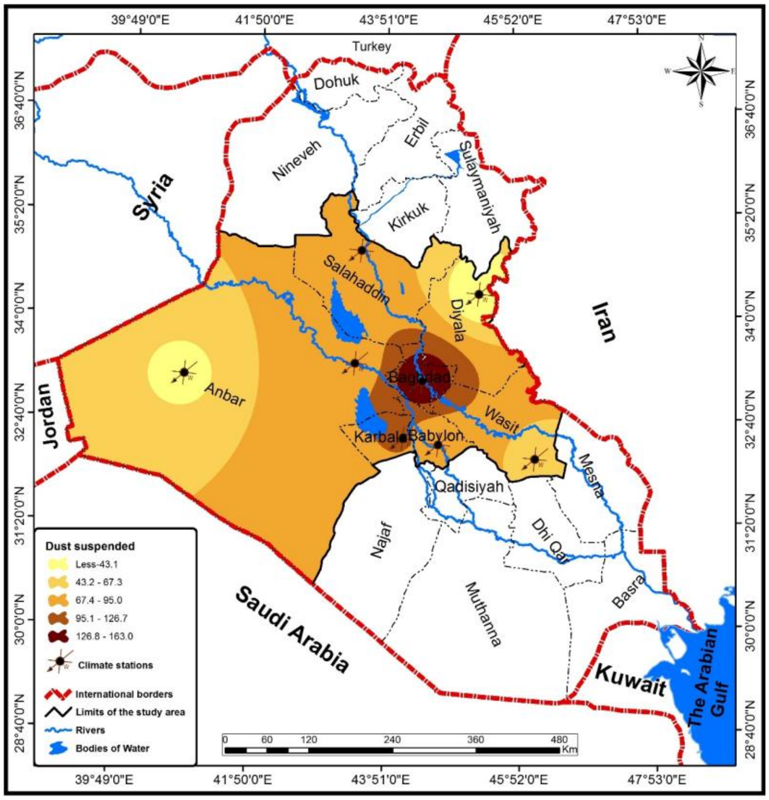
Climatic stations	Annual average	Trend coefficient	Annual change rate(%)	No. of years	Change rate during the study period	Mean deviation
Khanaqin	10	-0.474	-4.74	44	-208.4	9.2
Hilla	43	0.698	1.62	44	71.4	14.9
Rutba	45	-0.662	-1.47	44	-64.7	14
Kerbala	67	0.461	0.69	44	30.2	22.5
Beiji	34	-0.289	-0.85	44	-37.5	13.9
Ramadi	28	0.320	1.14	44	50.3	9.9

Source: The researcher's work based on the data of the General Authority of Meteorology, Climate Section, unpublished data, 2016

Third: The Suspended Dust:

This type of dust is formed after the occurrence of dust storms and the rising dust, which is small size and light weight particles of clay and silt with a diameter of no more than one micron, and the speed of light and quiet wind has the ability to carry them and make them stay in the air for a period ranging between (1-15 hours)[v]. The dust stays suspended in the air due to its small size particles and its duration of existence varies according to the intensity of the storm, and the gravity does not affect them as long as there are strong winds or active load currents, even if these particles become heavy due to the accumulation of moisture around them[vi]. The annual frequency decreases towards the north-east direction in the study area, as in Khanaqin station, as well as towards the west direction as in Rutba station, while its increases in the middle of the central region as in Baghdad station, note Map (4).

Map (4) The Annual aggregates of the suspended dust frequency (day) in the central region of Iraq for the period (1973-2016)

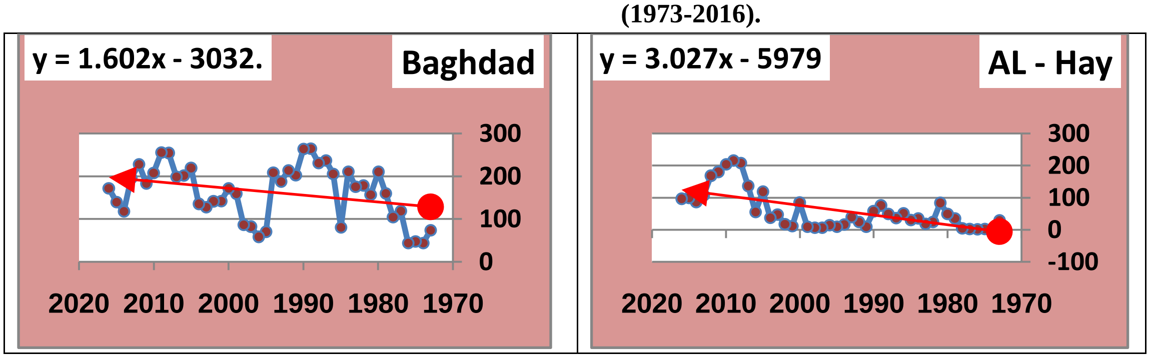


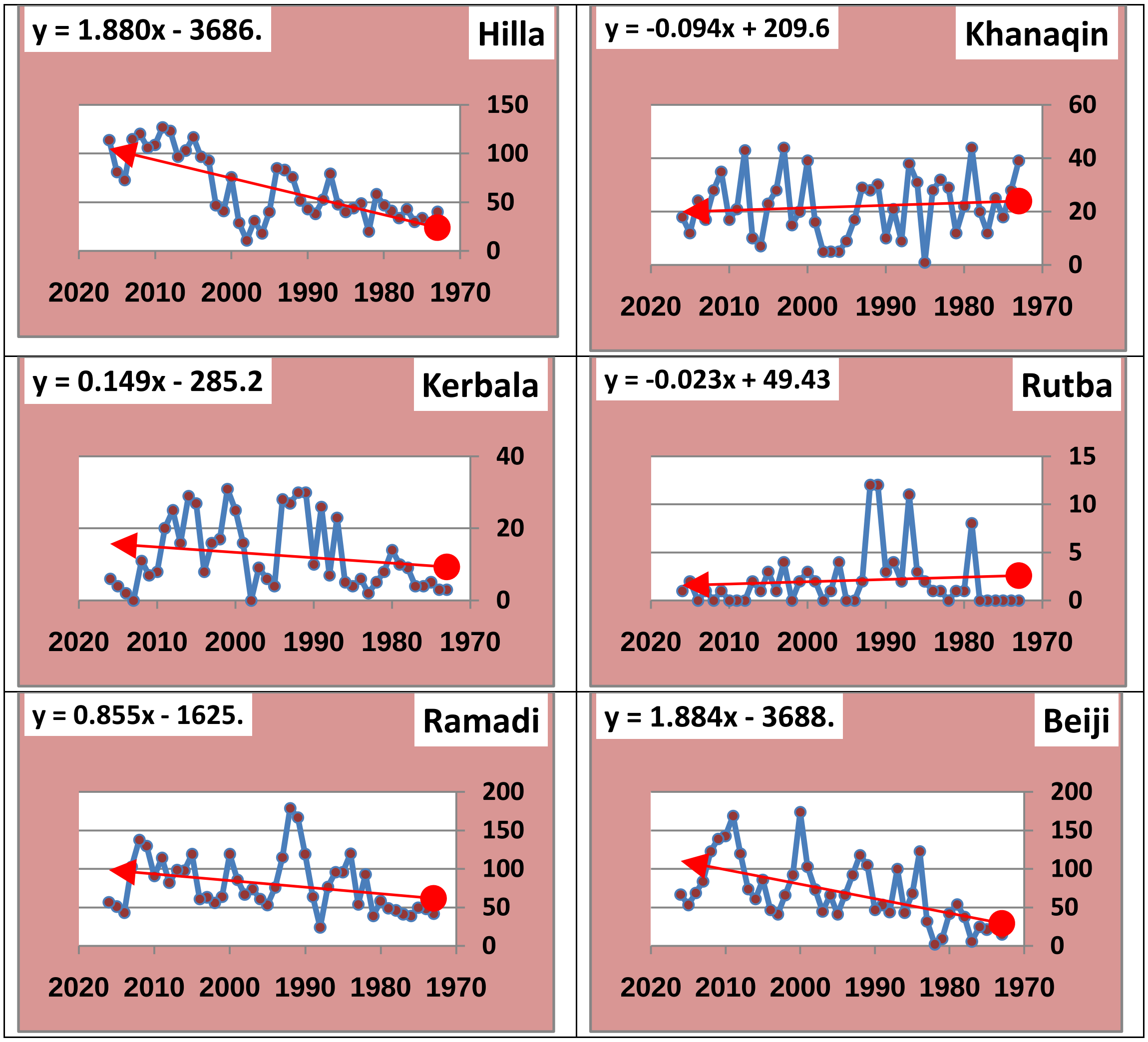
Source: The researcher's work based on the data of the General Authority of Meteorology, Climate Section, unpublished data, 2016.

THE CHANGE OF SUSPENDED DUST AGGREGATES IN THE STUDY AREA:

The highest trend coefficient for the period (1973-2016) was at Al-Hay station (3.275), while some of the stations witnessed a trend coefficient moving towards the decrease, and the highest trend coefficient towards decrease was at Khanaqin station around (-0.094), as shown in Fig. (3).

Figure (3) The general trend of the total annual suspended dust (day) of the stations of the study area for the period (1973-2016).





Source: The researcher's work based on the data of the General Authority of Meteorology, Climate Section, unpublished data, 2016.

Table (4) The change and mean deviation of the suspended dust aggregates (day) in the Central Region of Iraq for the Period (1973-2016)

Climatic stations	Annual average	Trend coefficient	Annual change rate(%)	No. of years	Change rate during the study period	Mean deviation
Al-Hay	5.9	3.03	51.31	44	2257.8	46.6
Baghdad	163	1.60	0.98	44	43.2	53.1
Khanaqin	22	-0.09	-0.43	44	-18.8	9.9
Hilla	64	1.88	2.94	44	129.3	29.5
Rutba	38.2	-0.02	-0.06	44	-2.7	14.6
Kerbala	97.6	2.30	2.36	44	103.7	51.4
Beiji	69.7	1.88	2.70	44	119.0	33.3
Ramadi	80	0.86	1.07	44	47.0	29.3

Source: The researcher's work based on the data of the General Authority of Meteorology, Climate Section, unpublished data, 2016.

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The analysis of Table (4) shows that the rate of change for the period (1973-2016) was the highest trend rate towards increase at Al-Hay station about (2257.8) with an annual rate of change around (51.31%), while the highest trend rate towards decrease was at Khanaqin station around (-18.8%) with an annual rate of change about (-0.43%).

The mean deviation had its highest value during the period (1973-2016) at Baghdad station (53.1), while the lowest deviation coefficient was obtained at Khanaqin station (9.9).

Relative Humidity:

It means the percentage between the amount of water vapor present in a particular volume of air and the amount of water vapor required to saturate the same volume of air at the same temperature(vii). In other words, it is the air energy to carry the water vapor, for example, when air at 30°C can carry 8 particles of water vapor per cubic meter, it actually carries 6 particles of water vapor of the same size. The relative humidity in this case is 6/8*100 (75%)(viii). Relative humidity is used as a measure of the amount of water vapor present in the atmosphere because, by knowing the relative humidity and air temperature, the absolute humidity value can be deduced(ix). Relative humidity helps to warm the atmosphere because it has the ability to absorb solar energy and release it to the atmosphere for its ability to absorb the solar energy and release it again to the air, if the water vapor condense. Also, relative humidity helps to reserve earth radiation because it is considered as one of the factors affecting the temperature in terms of its ability to retain the air heat and extenuate it(x).

The relative humidity in the gaseous atmosphere changes in one of the following ways:

1- Evaporation increase from water bodies, which is a slow process during which the rise of water molecules occurs and spreads in the atmosphere(xi).

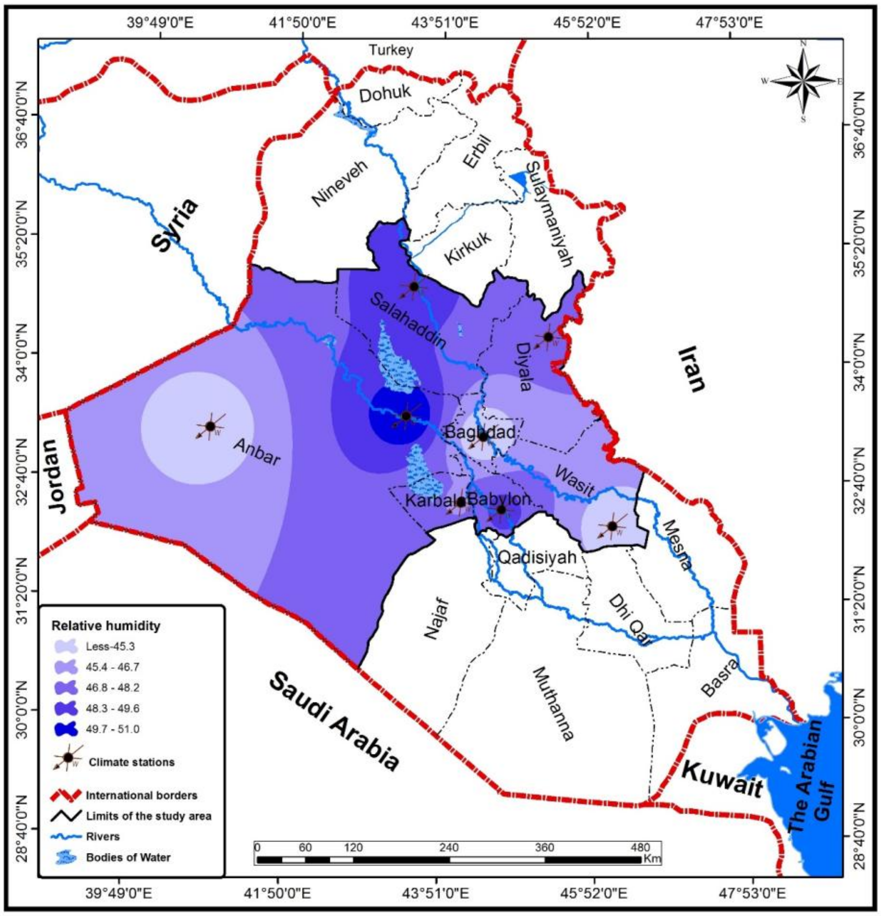
2- The change in temperature, when the temperature drops, it leads to high relative humidity, because the ability of the air to keep water vapor decreases by coldness, making the amount of water vapor of high percentages compared to the total air capacity, and vice versa occurs when temperatures rise, because water vapor is spreading far away in the air due to high temperatures(xii).

3- Wind speed and direction, when the wind is fast and dry, it leads to reduce the relative humidity, unlike the wet wind of quiet speed which increases the amount of relative humidity(xiii).

Accordingly, the main source of water vapor in the atmosphere is seas and oceans, and there are other sources but less important such as dry wetland syrfaces, small water bodies and vegetation, but vegetation in some areas is a major source of moisture in the air through the process of transpiration made by plants(xiv).

The analysis of the relative humidity climatic data in the central region of Iraq shows that there is a spatial and temporal variance in humidity, in that it was shown through Map (5), there is a spatial variance between the stations of the study area for the annual moisture rates for the period (1973-2016), where the highest rate of relative humidity was registered at Ramadi station by (51%), followed by Hilla and Beiji stations by a rate of (49%), while the lowest rate was recorded at Baghdad and Rutba stations by (44%), therefore; the study area is classified within dry areas due to low relative humidity rates in it. The reason for this decline is attributed to several factors, including the geographic location of the area where it is prevailed by the continental characteristic due to its distance from water bodies, the prevelance of dry north-west winds in the region, and the low area of vegetation in the region, as well as high rates of temperatures (the maximum, minimum and normal) in the area during the period (1973-2016), for there is an inverse relationship between the relative humidity and temperatures.

Map (5) Annual rates of relative humidity (%) for the study area stations for the period (1973-2016)



Source: The researcher's work based on the data of the General Authority of Meteorology, Climate Section, unpublished data, 2016.

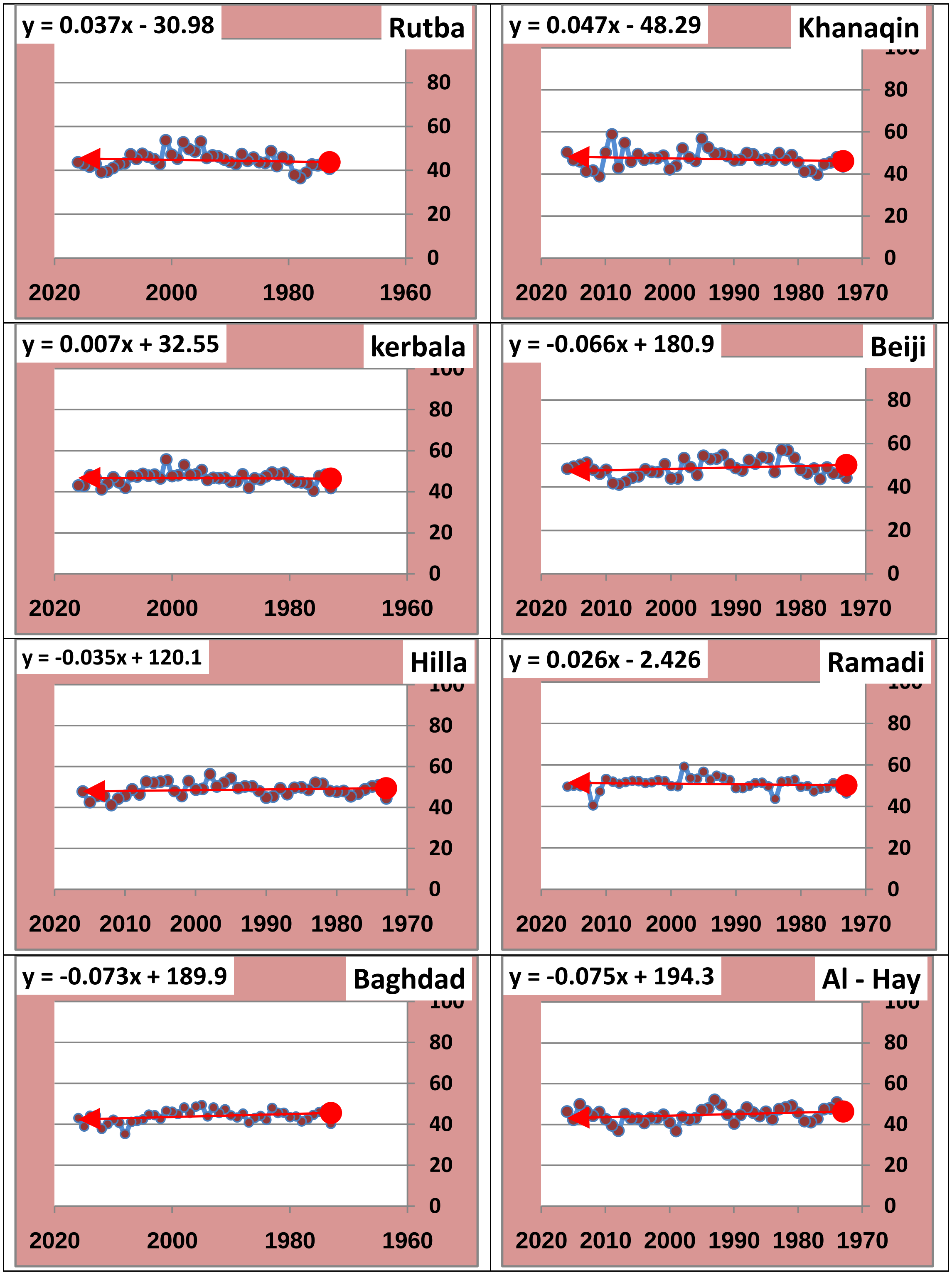
THE CHANGE OF RELATIVE HUMIDITY IN THE STUDY AREA:

The trend coefficient during the period (1973-2016) varies and differs between increase and decrease in the stations of the study area, where the highest trend coefficient towards increase was at Khanaqin station (0.0479), while the highest trend coefficient towards decrease occurred at Al-Hay station by (-0.0751), as shown in Fig. (4).

Analysis of Table (5) shows that the change rate for the period (1973-2016) was the highest towards increase at Khanaqin station by (4.48%) with an annual change rate (0.10%), and the highest change rate towards decrease was at Al-Hay station (-7.34%) with an annual change rate of (-0.17%).

As for the mean deviation, it had the highest value during the period (1973-2016) at Beiji station (3.2), while the lowest deviation coefficient recorded during the same period was in Ramadi station by (2.2).

Fig. (4) The general trend of the annual rates of relative humidity (%) in the study area stations for the period (1973-2016)



Source: The researcher's work based on the data of the General Authority of Meteorology, Climate Section, unpublished data, 2016.

Table (5) The change and mean deviation of the annual rates of the relative humidity (%) in the Central Region of Iraq for the Period (1973-2016).

Climatic stations	Annual average	Trend coefficient	Annual change rate (%)	No. of years	Change rate during the study period(%)	Mean deviation
Baghdad	44	-0.0732	-0.17	44	-7.32	2.3
Beiji	49	-0.0663	-0.14	44	-5.95	3.2
Ramadi	51	0.0267	0.05	44	2.30	2.2
Kerbala	47	0.007	0.01	44	0.66	2.3
Khanaqin	47	0.0479	0.10	44	4.48	3.1
Al-Hay	45	-0.0751	-0.17	44	-7.34	2.7
Hilla	49	-0.0358	-0.07	44	-3.21	2.6
Rutba	45	0.0379	0.08	44	3.71	2.9

Source: The researcher's work based on the data of the General Authority of Meteorology, Climate Section, unpublished data, 2016.

TOPOLOGICAL OVERLAY BETWEEN DUST PHENOMENA AND RELATIVE HUMIDITY RATES:

Topological overlay is regarded as the best method to obtain spatial relations maps through spatial analysis* between the independent variable (relative humidity) and the variables of the study (elements and climatic phenomena) using GIS. Hence, overlay can be defined as a group of spatial linking relations between the phenomena on subject layers on the one hand and their data on the other(xv).

The overlay is defined by King as a branch of mathematics using GIS applications to show spatial relationships existent between the phenomena and the geometric shapes(xvi).

The overlay was used in the study to illustrate the relationship between the change rate of relative humidity and the change rates of dust phenomena in the study area using geographic information systems, which represents the spatial analysis, see table (6).

Table (6) The Topological Overlay between the relative humidity and dust phenomena in the study area for the period.

Climatic phenomena	Type of overlay	Overlay area (km^2)	Percentage of overlay (%)
Overlay of relative humidity (%) and dust storms (day)	Strong overlay	159793.4	75.2
	Middle overlay	36445.44	17.1
	Weak overlay	16347.57	7.7
Overlay of relative humidity (%) and the rising dust (day)	Strong overlay	138439.8	65.1
	Middle overlay	15350.6	7.2
	Weak overlay	58792.46	27.7
Overlay of relative humidity (%) and the suspended dust (day)	Strong overlay	7739.927	3.6
	Middle overlay	41085.51	19.3
	Weak overlay	163760.9	77.0

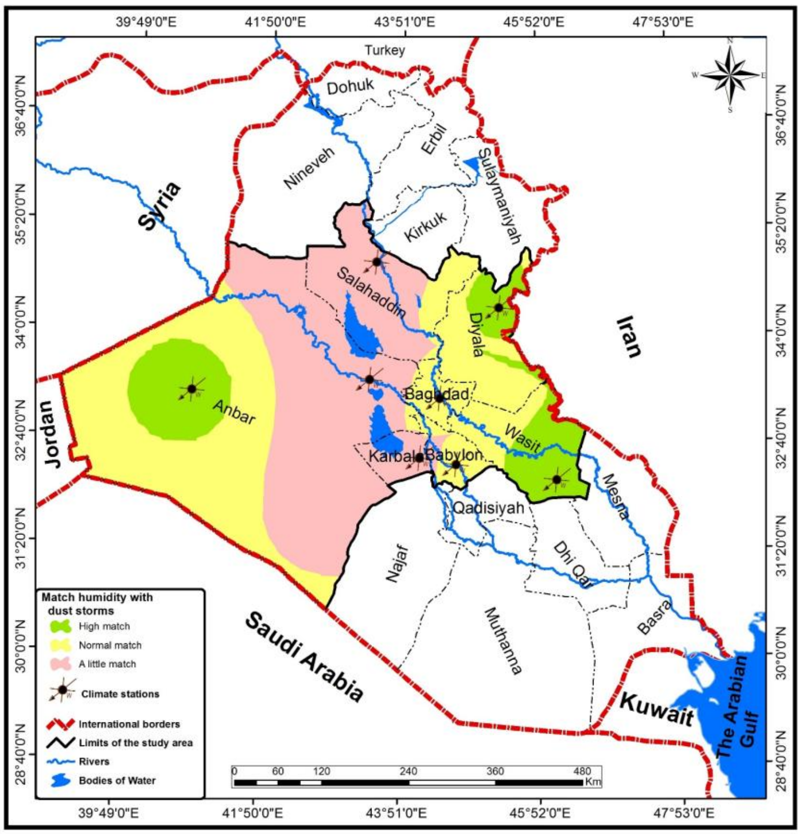
Source: The researcher's work based on the program Gis.

- The Spatial Analysis between the Change of Dust Phenomena (Day) and the Change of Relative Humidity (%):

A. The Spatial Analysis between the Change of Dust Phenomena (Day) and the Change of Relative Humidity:

Table (6) shows that there are three categories representing the overlay between the relative humidity and dust storms, where the first category is the strong overlay with a percentage of (75.2%) of the area of the study area. This category included Baghdad, Al-Hay, and Hilla stations, while the last category, which represents the weak overlay in the area, accounted for (7.7%), including Khanaqin and Ramadi stations. Thus, the highest percentage in the study area was the strong overlay category in the study area, while the lowest category was the weak overlay in the study area, see Map (6).

Map (6) Areas of overlay between the change of relative humidity and the change of dust storms in the study area for the period (1973-2016)

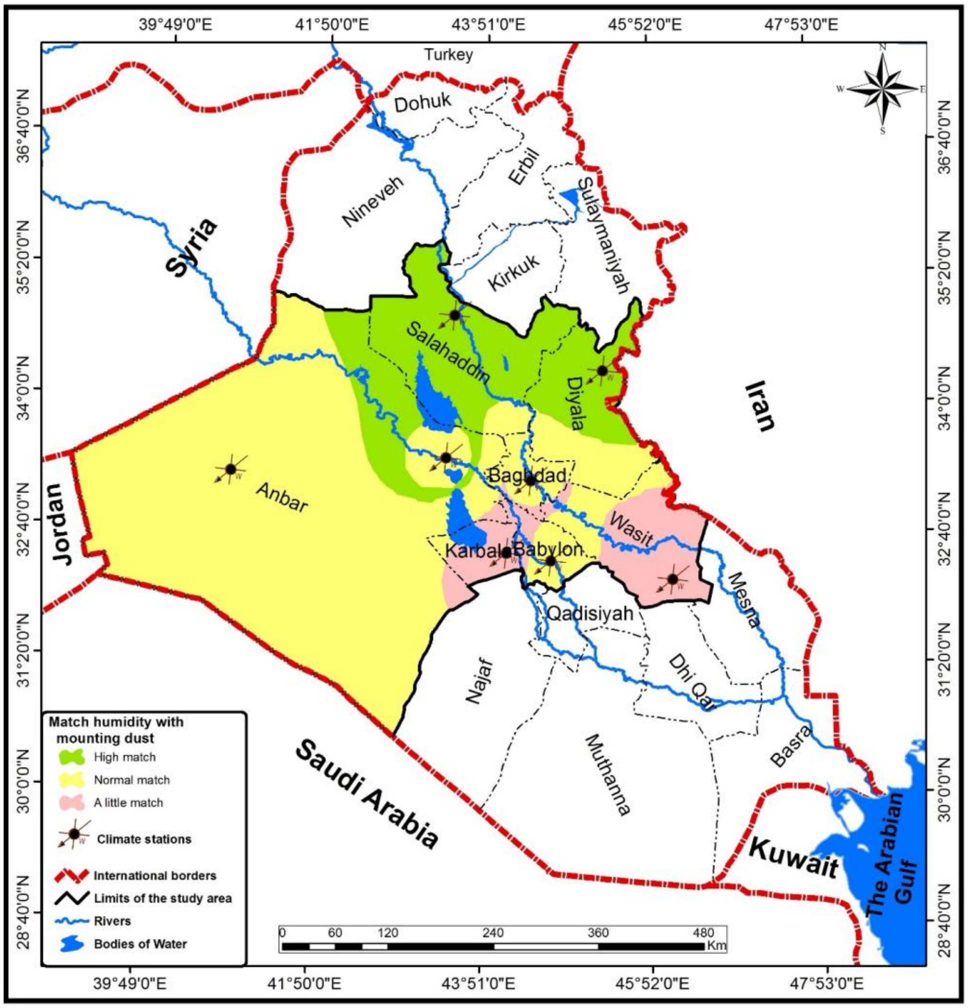


Source: The researcher's work based on the data of the General Authority of Meteorology, Climate Section, unpublished data, 2016.

B. The Spatial analysis between the change of the rising dust and the change of relative humidity:

Table (6) and Map (7) show that the first category the strong overlay accounted for a percentage of (65.1%) of the area of the study area. This category included Baghdad, Al-Hay, and Beiji, while the second category had a percentage of (7.2%), whereas the last category which represents the weak overlay in the area had a percentage of (27.7%), including the stations of Khanaqin, Ramadi and Kerbala.

Map (7) Overlay areas between the change of relative humidity and the change of rising dust in the study area.

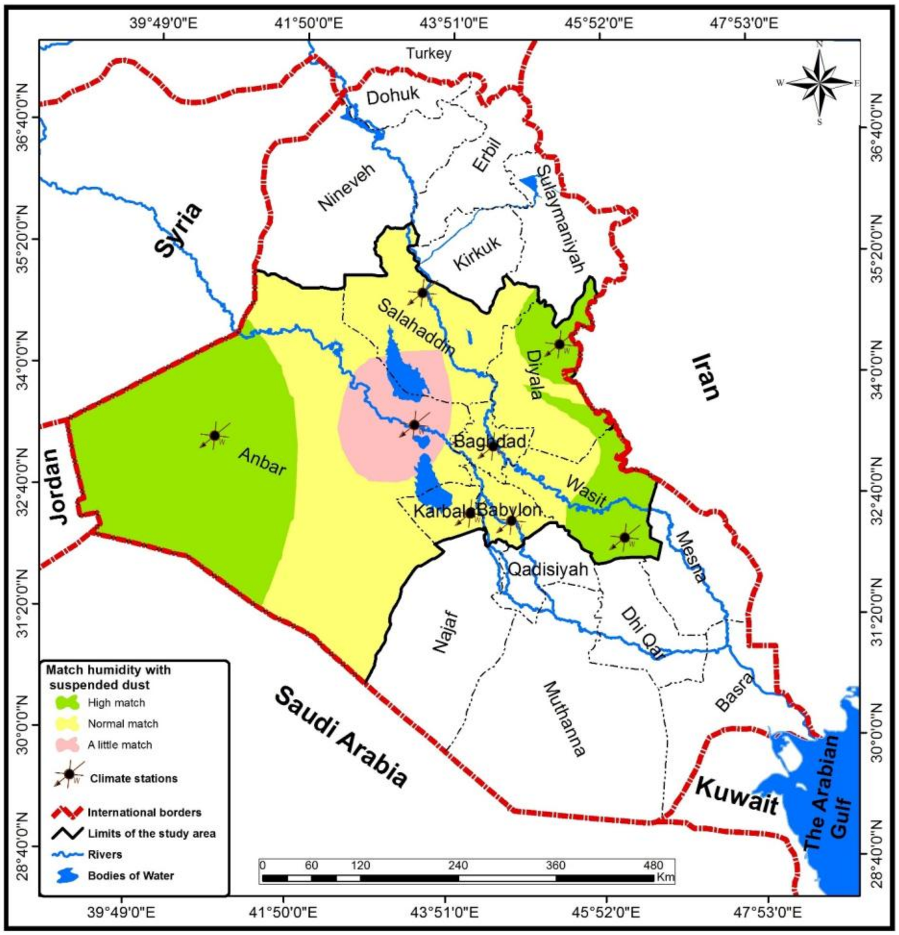


Source: The researcher's work based on the data of the Iraqi General Authority of Meteorology, Climate Section, unpublished data, 2016.

C. The Spatial Analysis between the Change of Suspended Dust and the Change of Relative Humidity:

Table (6) and Map (8) show that the first category, the strong overlay, was of a percentage (3.6%) of the area of the study area, while the second category was of a percentage (19.3%), whereas the last category which represents the low overlay was of a percentage (77.0%), including the stations of Rutba, Khanaqin, Ramadi and Kerbala. Accordingly, the highest in the study area was for the low overlay category, while the lowest category was the high overlay in the study area.

Map (8) Overlay areas between the change of relative humidity and the change of suspended dust in the study area for the period (1973-2016).



Source: The researcher's work based on the data of the Iraqi General Authority of Meteorology, Climate Section, unpublished data, 2016.

CONCLUSIONS:

1- The overall trend was variant between the increase and decrease of dust storms (day) during the period (1973-2016), where the highest total change rate towards increase was at Khanaqin station by (77.0%) compared to a total change rate of relative humidity at Khanaqin station by (4.48%), while the highest total change rate towards decrease for dust storms was at Beiji station by (-179.2%) compared to a total change rate of relative humidity by (-5.95%).

2. The overall trend was towards decrease for the rising dust during the period (1973-2016), except for Hilla and Kerbala stations and the trend towards increase with a total change rate was (71.4% and 30.2%) for each of them, respectively, while the highest total change rate towards decrease for the rising dust during the period (1973-2016) was at Khanaqin station about (-208.4%) compared to a total change rate of relative humidity at Khanaqin station about (4.48%).

3. The general trend was towards the increase of suspended dust during the period (1973-2016), except for Khanaqin and Rutba stations, and the trend towards decrease with a total change rate was (-18.8% -2.7%) for each of them, respectively, while the highest total change rate towards the increase of suspended dust during the period (1973-2016) was at Al-Hay station about (2257.8%), compared to the total change rate of relative humidity at Al-Hay station by (-7.34%).

4. Through the topological overlay between the change rates of relative humidity and climatic phenomena in the study area for the period (1973-2016), it was shown that there are three categories representing the overlay as follows:

A) The strong overlay category occupied the highest percentage by (75.2%) at Baghdad, Al-Hay and Hilla stations, representing the overlay between the change rate of relative humidity (%) and the change rate of dust storms (day).

B) The middle overlay category occupied the highest percentage by (19.3%) at Hilla and Rutba stations, representing the overlay between the change rate of relative humidity (%) and the change rate of suspended dust (day).

C) The weak overlay category occupied the highest percentage in the are by (77.0%) at Khanaqin, Ramadi, Rutba and Kerbala stations, representing the overlay between the change rate of relative humidity (%) and the change rate of suspended dust (day).

REFERENCES

(i) Dhiyaa Sa'ib Ahmed Ibrahim Al-Alousi, Elements and phenomena of the climate of Iraq and their characteristics and modern trends, PhD, University of Baghdad, College of Education-Ibn Rushd, 2009, p.131.

(ii) Salam Hatif Ahmed Al-Jubouri, The effect of climate in the recurrence of dirt storms and dust storms on Baghdad Governorate, Journal of the Iraqi Geographical Society, Department of Geography, College of Education-Ibn Rushd, Vol.1, No.54, 2008, p. 147.

(iii) Hussein Ali Al-Shammari, Climatic Changes and Dust Storms in Baghdad, Journal of Geographical Researches, Kerbala University, College of Education, No.18, p.402.

(iv) Ibid, p.402.

(v) Ali Sahib Talib Al-Musawi, Batoul Nouri Muhsen, The spatial relationship between the relative humidity and dust phenomena in Iraq, Journal of Geographical Researches, No. 21, 2015, p. 31.

(vi) Salam Hatif Ahmed Al-Jubouri, The effect of climate on the recurrence of dirt storms and dust storms on Baghdad Governorate, Op.Cit., p.148.

(vii) Jawdat Hasanen Jawdat, Climatic and botanical geography, Dar al-Ma'rifa al-Jamiy'a for Printing, Publishing and Distribution, Alexandria University, 2012, pp. 225-226.

(viii) Yousef Abdul Majeed Fayid, Geography of Climate and Plants, Dar Al-Fikr Al-Arabi for Printing and Publishing, Cairo, 2005, p.72.

(ix) Abdul Qader Mohammed Al-'Amali, Khalil Abdul Fattah Khalil, Meteorology of Flight, 1st ed., Al-Dar Al-Qaumiya for Printing and Publishing, Cairo, 1965, p. 32.

(x) Mohamed Zakariya Abbat Al-Layl, The Geographical Analysis of Temperatures in the West Bank- An Applied Study Using GIS, Master Thesis, Gaza, The Islamic University, College of Arts, 2012, p.89.

(xi) Ibrahim bin Sulaiman, Introduction to Weather, Climate and Climatic Geography, Imam Muhammad bin Saud Islamic University, Riyadh, No Year, p.389.

(xii) Salam Hatif Ahmed Al-Jubouri, The fluctuation of relative humidity and its direction in the cities of Baghdad and Mosul for the period 1982-2011, Journal of Arts, No. 107, 2014, p.215.

(xiii) Salam Hatif Ahmed Al-Jubouri, Climate Geography, Dar Al-Raya for Publishing and Distribution, Amman, Jordan, 2016, p. 232.

(xiv) Iyad Shather Abd Azzouz, The frequency of summer humidity waves affecting the climate of Iraq, Master Thesis, Al-Mustansiriyah University, College of Education, 2016, p.70.

(*) Spatial analysis in geographic information systems (GIS) means the spatial linking process of the digital geographic data elements known as topology through which raw data are converted into useful data.

For more information, see: Ali Abd Abbas Al-Azzawi, 'Ahed Thannoun Al-Hamami, The Topological Overlay between Wheat Productivity and the Most Prominent Natural Factors in Nineveh Governorate Using GIS for 2005, Journal of Education and Science, Vol. 14, No. 4, 2007, p. 364.

(xv) Munaf Mohammed Al-Sudani, The Topological Overlay between Grain Farming and Some Natural and Human Factors in Basrah Governorate Using Geographical Information Systems, Journal of the College of Arts, No. 96, Baghdad, p.245.
(xvi) Chang, K, T, Introduction to Geography Information Systems, McGraw Hill, 2002, p13-14.