Variation of Rainfall with Space and Time in Duhok Government

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الخلاصة

تحليل معلومات الأمطار الساقطة مهمة في عدة ميادين منها: التخطـيط الزراعـي، تخطيط الموارد المائية، التنبؤ بالسيح، الدراسات المناخية، الدراسات البيئية، تخمين تصاريف المجاري المائية ونشاطات وفعاليات الإنسان.

ثم دراسة التغاير الزماني والمكاني للأمطار الساقطة في محافظة دهوك. ثـم إيجـاد المعدلات الشهرية والفصلية والسنوية للأمطار الساقطة في محطات الانوائية التالية (دهـوك، زاخو، سميل زاويتة، سرسنك، عمادية، عقرة).

أشهر الشتاء أعطت ساقط مطري يمثل (45-55%) من الأمطار السنوية الـساقطة. المحطات أعطت تباين عالي في قيم الأمطار السنوية الساقطة. ثم استخدام طريقـة الخطـوط الكنتورية المطرية في إيجاد المعدلات الشهرية والمعدلات السنوية للأمطار الـساقطة علـى عموم محافظة دهوك.

تم إيجاد علاقات الانحدار الخطي البسيط والمتعدد بين الأمطار الـساقطة ومختلـف العناصر المناخية.

Abstract

Rainfall analysis is important in different domains such as: agricultural planning, water resources plannings, runoff prediction, climatological studies, environmental studies, stream flow estimation and human life activities. Variation of rainfall with space and time were studied in Duhok Governorate, Mean monthly, seasonal and annual values of rainfall were found in different weather stations (Duhok, Zakho, Semel, Zawaite, Sersing, Amedy and Akre station). Winter months represent about 45-55% of the total annual rainfall. The annual variability of rainfall in all these stations are high. Isoheytal method was used to estimate the mean monthly values and mean annual values of

rainfall over Duhok Governorate. Simple and Multiple Regression Equation were found between rainfall and different meteorological elements.

Introduction

Rainfall varies with space and time at various rates, some times very rapidly. This variation is measured either at a number of points using raingauges or areally, using radar and satellites (1.2).

Rainfall being the predominant form of precipitation causing streamflow, especially the flood flow in many countries and is responsible for most runoff. In addition, vertical transport of air mass is a requirement for precipitation, so far rainfall to be formed, the atmosphere must have sufficient moisture, there must be sufficient nuclei present to aid condensation, of water vapour and the product of condensation must be good for condensation must reach the earth. (3,4).

The amount, intensity and areal distribution of rainfall are essential factors in many hydrological studies (5,6). Rainfall varies geographically, temporally and seasonably (7,8). Regional and seasonal variations of rainfall are very important for water resources planning. Temporal variation in raifall intensity are extremely important in the raifall runoff process in urban areas (9).

Rainfall is also highly affected by the meteorological elements and elevation from sea level, so simple and multiple correlations were found between these variables (10,11). This research can be considered as the first study of rainfall variation over Duhok Governorate, which is located in the northern part of iraq and lies between latitude (36° - 38° N). and longitude (42° - 45° E).

The studied area contains seven weather stations, (Duhok, Zakho, Semel, Zawite, Sersing, Amedy and Akre). Fig (1) shows the studied area and the locations of the weather stations.

The latitude, longtude, altitude and years of observations for the different weather stations were presented in table (1).

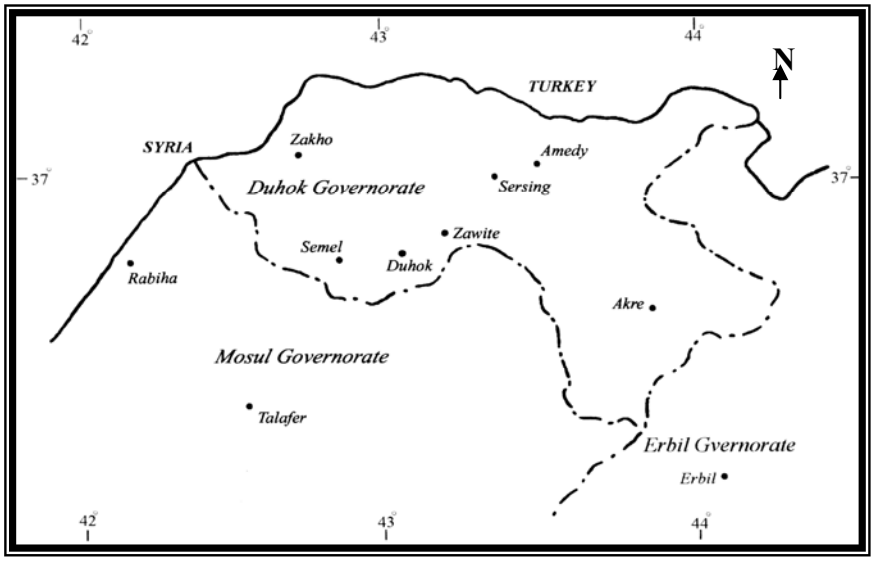


Fig. (1): the location of chosen stations for study in the study area

Table (1): The selected weather stations in Duhok Governorate and their geographical information.

Weather stations	Latitude (North)	Longitude (East)	Altitude (m)	Years of observation
Duhok	36◦ 50'	43◦ 02'	583,0	1980 - 2005
Zakho	37◦ 08'	42◦ 41'	433,8	1980 - 2005
Semel	36◦ 50'	42◦ 80'	870.0	1980 - 2005
Zawite	36◦ 54'	43◦ 09'	890.0	1992 - 2005
Sersing	37◦ 03'	43◦ 21'	1019.0	1992 - 2005
Amedy	37◦ 05'	43◦ 29'	1202.0	1980 - 2005
Akre	36◦ 43'	43◦ 51'	636.0	1993 - 2005

The climatic data and rianfall data are obtained from:

- Duhok weather station .
- Archives of the FAO coordianation office for Nothern Iraq.
- Iraqi Meteorological Organization.

Data Analysis

1. Raifall Data in (mm) for the different weather stations (Duhok, Zakho, Semel, Zawaite, Sersing, Amedy and Akre) were collected and analyzed.
2. Histograms and Tables were found and explained for the mean monthly, seasonal and annual values of rainfall in all the stations present in Duhok Governorate.
3. Isohyetal method was used to estimate the mean annual values and the mean monthly values of rainfall in Duhok Governorate. This method explained in detial in ref (3,5,9).
4. Correlations between Rainfall and Different Meteorological Elements in Duhok city were found.

Results & Discussion

1: Mean monthly Values of Rainfall

Fig (2-a, b, c, d, e, f, g, h) shows the variations of the mean monthly values of rainfall (mm) for the different stations present in Duhok Governorate. During Jan. Feb. and March, the mean monthly value of rainfall at the different stations were ranged between:

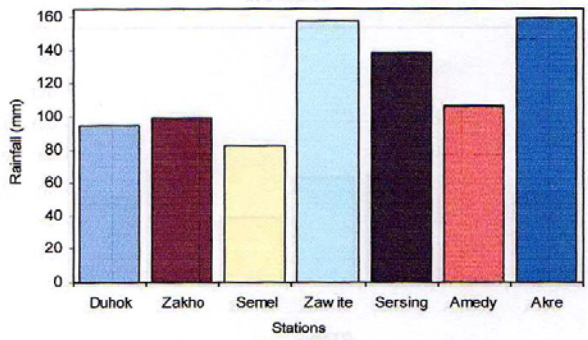
(93-97) mm for Duhok, (83-86)mm for Semel, (100-112)mm for Zakho, (119-138)mm for Sersing, (111-157)mm for Zawaite, (108-160)mm for Akre and (112-147) mm for Amedy station.

In April the highest value of rainfall was obtained in Amedy (108) mm, while the values of other stations were ranged between (42-71) mm.

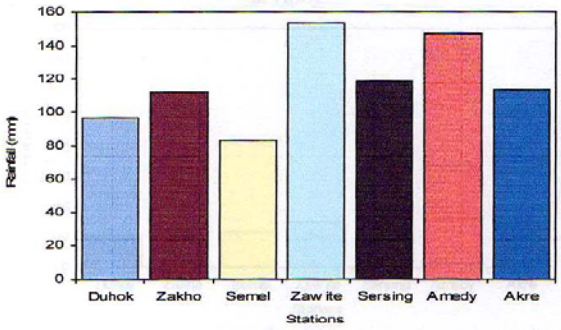
May and October showed the minimum values of rainfall which is ranged between (17-40) mm in all the stations.

November is nearly look like April. In Dec, the values of rainfall was ranged between (83-120)mm in all the stations.

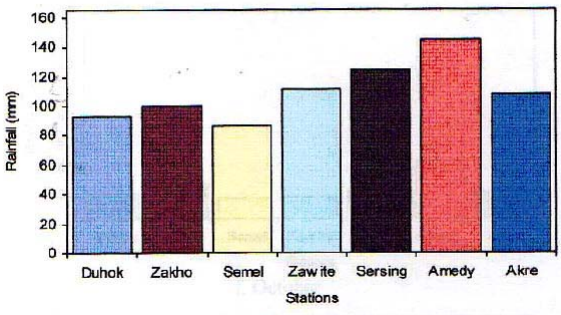
Semel station shows always the lowest value of rainfall in the region. Amedy station shows the highest values of rainfall in March, April and Nov, while Zawaite station shows the highest values in Dec., Jan. and Feb.



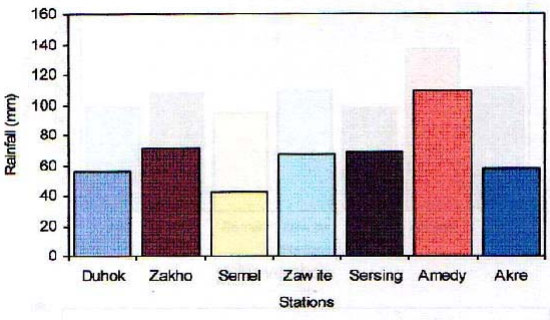
a. January



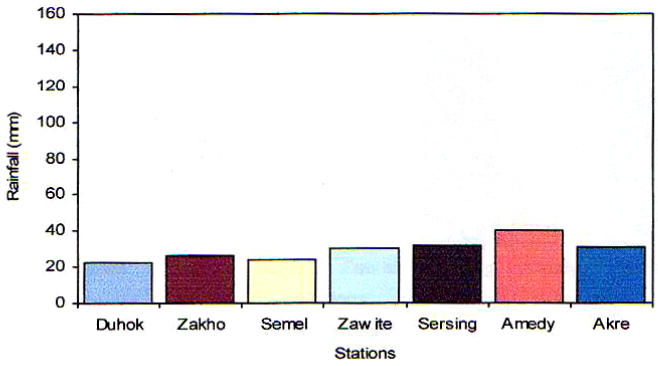
b. February



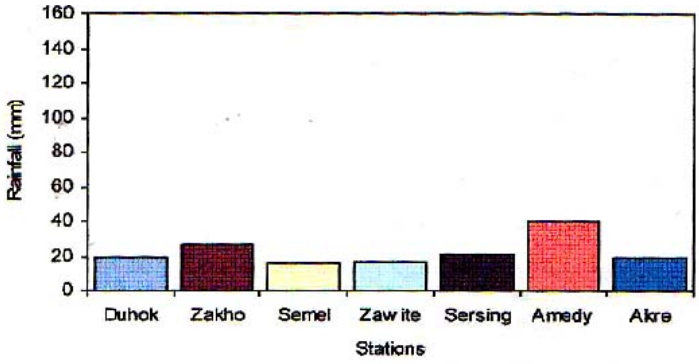
c. March



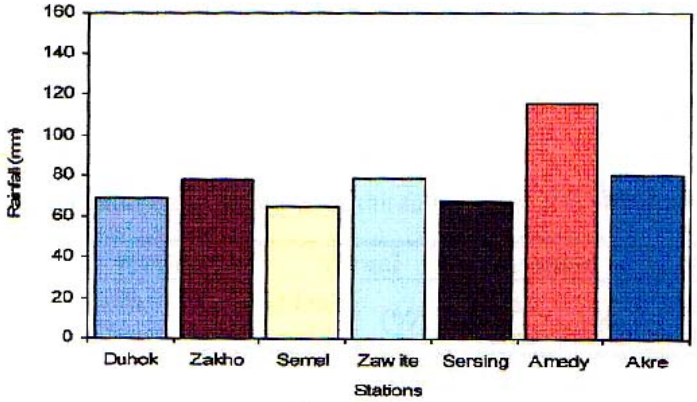
d. April



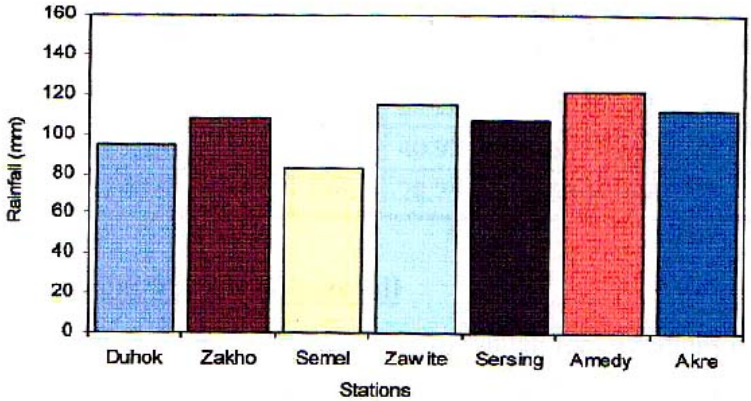
e. May



f. October



g. November



h. December

Fig (3-1, a, b, c, d, e, f, g, h) Variations of the mean monthly values of rainfall (mm) for all stations in Duhok Governorate

2-

2: Mean Seasonal Values of Rainfall

Table (2) shows the mean seasonal values of rainfall in all the stations present in Duhok Governorate.

Winter season recieves about (45–55%) of the annual rainfall and thus it represents the wettest season of the year.

The Vernal season recieves a valuable amount of rainfall and contributes 28-35% of the annual rainfall. The Autumn season contibutes 13 – 21 % of the annual rainfall. Summer season receive less than 0.5% of the total annual rainfall and for most of the times can be neglected.

Table (2): Mean season Value of Rainfall in (mm) for all the stations.

Season / Station	Winter		Vernal		Autumn		Summer	
	Mean Value	(%)	Mean Value	(%)	Mean Value	(%)	Mean Value	(%)
Duhok	285.9	52.18	172.4	31.46	88.8	16.21	0.8	0.15
Zakho	319.4	51	198.6	31.71	105.4	16.83	2.9	0.46
Semel	248.7	51.63	152.3	31.62	80.4	16.69	0.3	0.06
Zawite	425.6	56.81	207.9	27.75	113.9	15.21	1.7	0.23
Sersink	364.5	53.73	224.4	33.08	89.2	13.15	0.3	0.04
Amedy	380	45.5	292	35	159.3	19	4.1	0.5
Akre	384.6	56.38	196.1	28.75	101.2	14.83	0.3	0.04

3: Mean Annual Values of Rainfall

Fig (3) shows mean annual values of rainfall for all stations in Duhok Governorate, which can be arragned from the heighest values to the lowest values as: Amedy 835mm, Zawaite: 749 mm, Akre: 682 mm, Sersing: 678 mm, Zakho: 626 mm, Duhok: 547 mm and Semel: 481 mm.

The topography, atmospheric depression and the nature of air masses blowing from the surrounding areas play an important role in the variation of the annual rainfall in these locations.

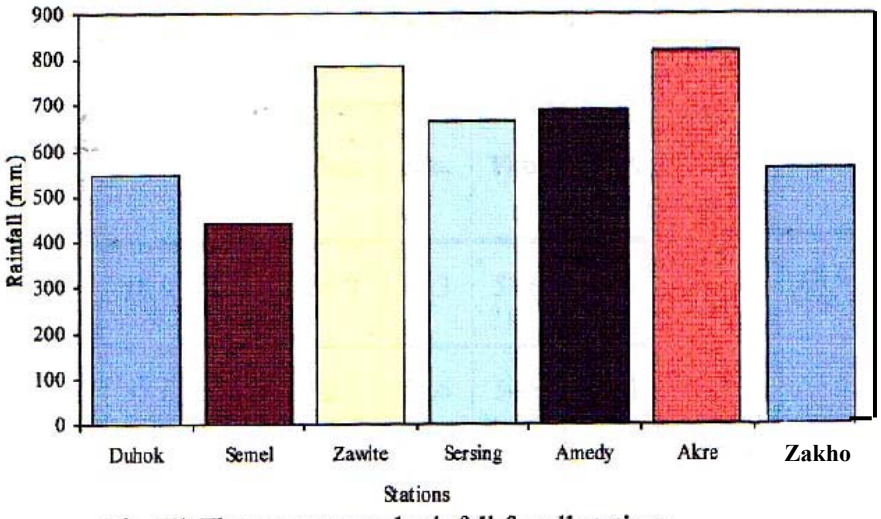


Fig. (3) The mean annual rainfall for all stations

Table (3) shows the mean, maximum and minimum values of the annual rainfall during the period of the records.

Standard Deviation (SD) and coefficient of variation (CV) of the annual values of rainfall were also shown in this table.

Table (3): Information about the annual values of rainfall for the selected station.

Stations	Mean (mm)	Max. Raifull (mm)	Year	Min. Raifull (mm)	Year	SD (mm)	Cv %
Duhok	546.5	909.70	1994	284.30	1999	166.7	30.7
Zakho	579.3	943.90	1988	352.00	1999	205.9	35.5
Semel	437.1	732.50	1988	189.40	1999	174.7	40.0
Zawite	785.6	1266.50	1992	387.50	1999	761.6	91.5
Sersink	663.7	1109.30	2004	234.30	1995	347.8	52.4
Amedy	835	1086.60	1994	367.00	1999	196.8	28.3
Akre	680.4	1105.80	1994	329.80	1999	203.3	29.9

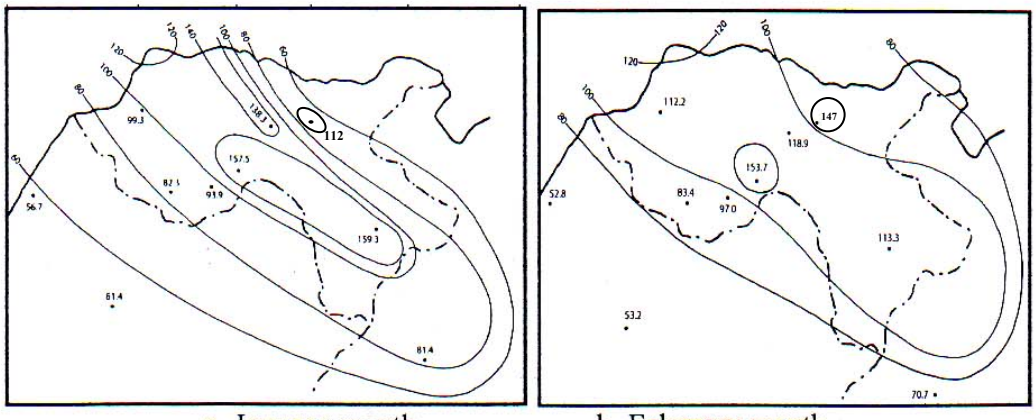
4: Study of the Mean Areal Rainfall over Duhok Governorate

The main hydromteorological problem related to the areal variation of rainfall is the estimation of rainfall over a given period of time. Isohyetal method was used to estimate the mean areal rainfall over Duhok Governorate.

Fig (4, a, b, c, d, e, f, g, h) show the mean monthly values of rainfall over Duhok Governorate during the months (Jan, Feb, Mar. Apr. may. Oct. Nov and December).

From the figure we obtain the mean monthly value of rainfall over Duhok Governorate which are (100, 104, 104, 66, 31, 26, 82, 103)mm for the months Jan., Feb., March, April, May, Oct., Nov. and Dec. respectively.

Fig (5) shows that the mean annual rainfall over Duhok Governorate was 621 mm.



a. January month b. February month

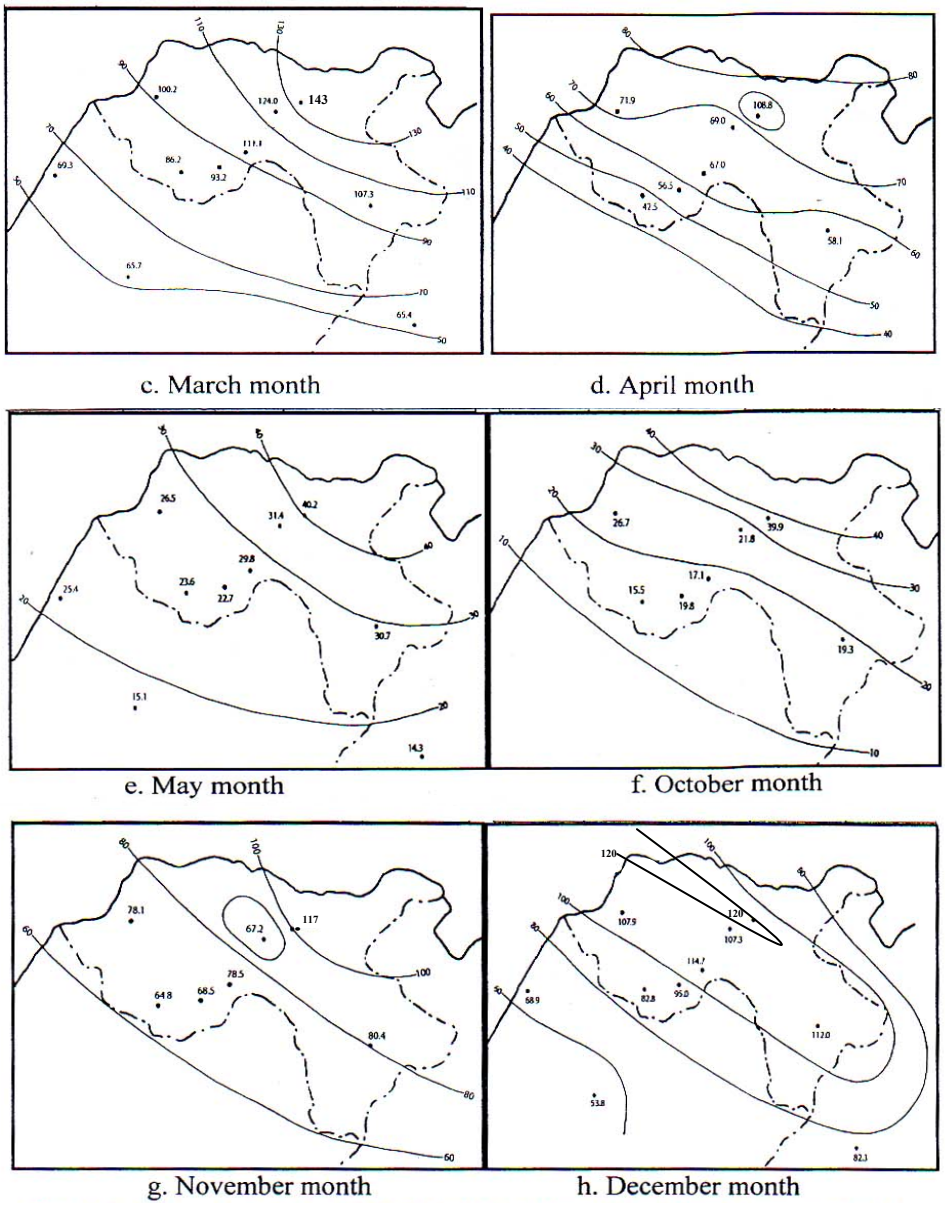


Fig (4- a, b, c, d, e, f, g, h) : The Isohyetal method for estimating mean monthly Valus of rainfall over Duhok Governorate.

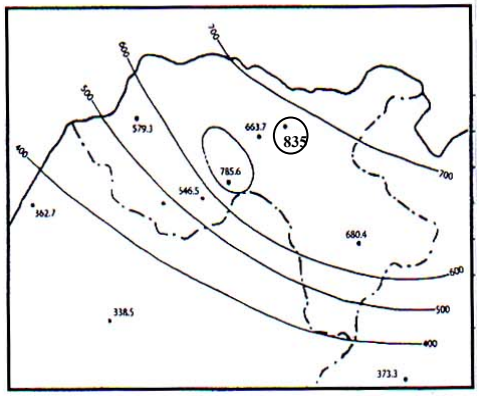


Fig (**5**) The Isohyetals method for estimating mean annual value of rainfall over Duhok governorate

5. Correlations between Rainfall and Different Meteorological Elements in Duhok City.

Fig. (6) shows a highly negative correlation between Rainfall and Temperature in Duhok city. The value of (R^2) was (0.95).

This correlation is normal because high temperature lead to evaporation and low temperature lead to condensation.

Fig. (7) shows a highly positive correlation between Rainfall and Relative Humidity in Duhok city. (R^2) was equal to (0.94). it is clear that the atmospheric humidity is one of the principal factors for condensation and formation of water droplets and hence rainfall.

Fig. (8) shows clearly a highly negative correlation between rainfall and evaporation in Duhok city, where (R^2) was (0.89).

Fig. (9) shows a week negative correlation between rainfall and wind speed in Duhok city. The value or (R^2) was (0.51).

Fig. (10) shows a week positive correlation between rainfall and Atmospheric pressure in Duhok city. The value of (R^2) obtained was (0.59).

Multiple correlation between rainfall and all the other meteorological elements was found in Duhok city. This correlation was:

R = 3305.699 – 5.179 T + 0.329 RH – 2.634E – 3.326 Pa – 19.700 WS

Where:

R = rainfall (mm), T = temperature (C°), RH=relative humidity (%)
E = evaporation (mm) Pa=atm. Pressure (mb) WS=wind speed (m/s)

The (R^2) of this multiple correlation was (0.99).

These correlation was very important for some climatological and hydrological estimation.

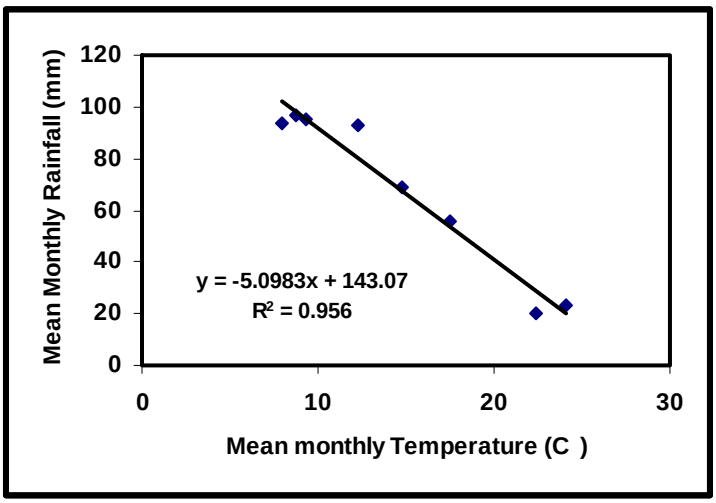


Fig (6): Correlation between Rainfall and Temperature in Duhok City

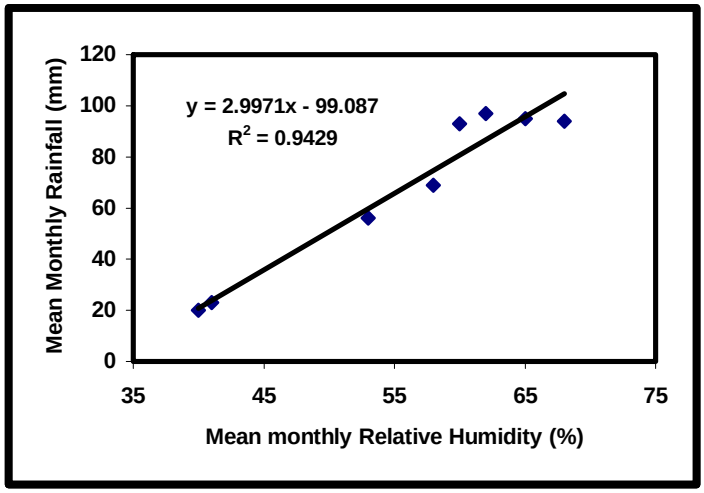


Fig (7): Correlation between Rainfall and Relative Humidity in Duhok City

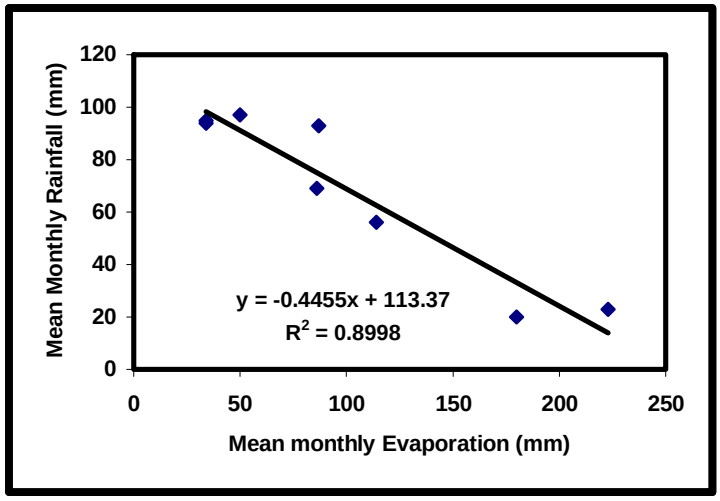


Fig (8): Correlation between Rainfall and Evaporation in Duhok City

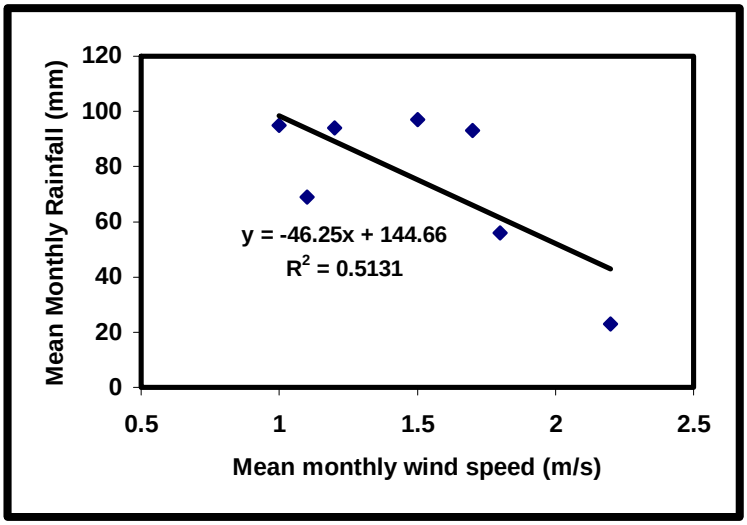


Fig (9): Correlation between Rainfall and wind speed in Duhok City

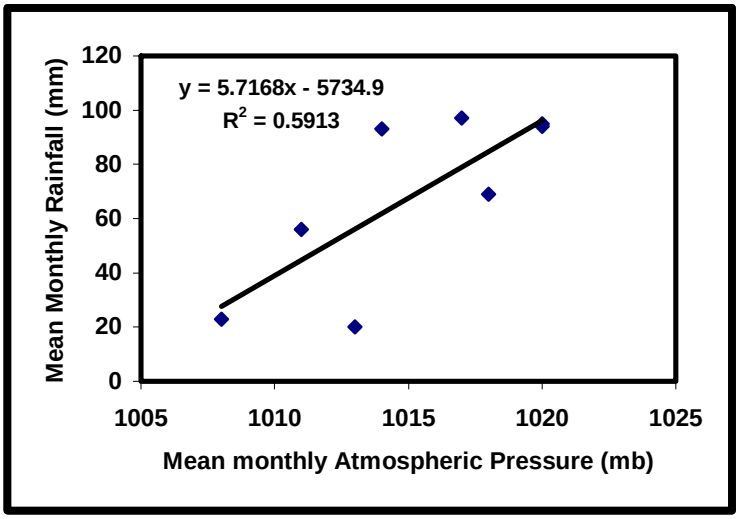


Fig (10): Correlation between Rainfall and Atmospheric Pressure in Duhok City

Conclusions

1. The maximum monthly values of rainfall was found in Amedy and in Semel station.
2. Winter months recieves about 45-55% of the annual rainfall and thus it represents the wettest season of the year.
3. The mean annual rainfall of the different stations can be arranged as: Zawaite:749mm, Amedy:688mm, Akre:682mm, Sersing:678mm, Zakho: 626 mm, Duhok: 547 mm and Semel 481mm.
4. The mean monthly values of rainfall over Duhok Government aculated by Isohyetal method gives the values: 100, 105, 105, 66, 31, 26, 82 and 103 mm for the months Jan. Feb. mar. Apr. May. Oct. Nov. and Dec.
5. Simple linear regression equations between rainfall and other meteorological elements in Duhok city were found. (R^2) obtained between Rainfall and Temperature, Relative Humidity, Evaporation, Wind Speed and Atmospheric Pressure were (0.95, 0.94, 0.89, 0.51, 0.59)
6. Multiple Correlation between Rainfall and all other Meteorological Elements for Duhok city was

R = 3305.699 – 5.179 T + 0.329 RH – 2.634E – 3.326 Pa – 19.700 WS

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