Rainfall Returns Periods in Iraq

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Abstract

Rainfall date obtained for thirty-two meteorological stations distributed in Iraq to find the rainfall returns period, which contributes in the improvement of water management plans all over Iraq, especially during dry seasons. Mean annual summation of rainfall has a symmetrical increasing pattern from southern west towards northern east, according to the increasing ratio of rainfall in the northern region of Iraq. The northern east region of Iraq has characterized by very abnormal and abnormal events regarding rainfall (P) in term of return periods, while the northern west, middle and southern regions characterize by a normal distribution of rainfall. , Iraq has only two types of weather conditions, according to rainfall returns periods: the humid weather condition located in the northern east part and dry weather condition in the other parts of it.

Keywords: Annual and Monthly Rainfall, Meteorological Data, Returns Period, Iraq.

1. Introduction

Rainfall is one among the main components of hydrological cycle and is considered as principle source of water to the earth [1]. The changing in the seasonal rainfall has greatly effected on runoff, evapotranspiration and infiltration, although, the changing in annual total rainfall could be absent which effects on responsibility of ecosystem, stream discharge and flood forecasting [2]. Rainfall varies geographically, temporally and seasonally where the total rainfall received in a given period at a location is highly variable from one year to another [3]. The variability depends on the type of climate and the length of the considered period. The average of rainfall gives information on the normal amount of rainfall one can expect in the area. It can be used to obtain an idea of the departure of the annual rainfall from the normal, or to compare climatic regions. Because of the strong variability of rainfall in time, the design and management of irrigation water supply and flood control systems are not based on the long-term average of rainfall records, but on particular rainfall depths that can be expected for a specific probability or return period [4]. Return period (T_x) is one of the important objectives of frequency analysis to calculate the recurrence interval or return period. The return period (also called the recurrence interval) is the period expressed in a number of years in which the annual observation is expected to return. It is the reciprocal value of the probability when expressed as a fraction: $T_x=1/P_x$. The selection of the probability of exceedance (P_x) or return period (T_x) for design purposes is related to the damage the excess or the shortage of rainfall may cause, the risk one wants to accept and the lifetime of the project. Information on the rainfall depth that can be expected in a specific period under various weather conditions is required for management and planning purposes [4].

Iraq is sited between latitude (29.00°- 37.22°N) and longitude (38.45°- 48.30°E), figure (1). The climate of Iraq is generally as continental and subtropical semi-arid type whereas the mountainous regions are classified a Mediterranean climate. It is characterized by a very hot summer and a short cold winter and also by the breadth of the daily and annual temperature because of the lack of large water bodies that reduce the coldness of winter and summer heat [5].

The aim of this research is to study returns periods of rainfall in which contribute to the improvement of water management plans all over Iraq especially during dry seasons.

Earlier studies did not indicate using annual rainfall to study returns periods all over Iraq while one research has been found using this technique within the north of Iraq [6].

2. Material:

The materials used in this research were:

1- Annual and monthly rainfall records for (32) meteorological stations with their geographic coordinates from date of station operation to 2015 [7].

3- Rainfall returns periods method [8].

5- Excel, Grapher and Surfer programs demonstrating tables of results, contour maps and figures.

3. Methodology:

The annual rainfall data for (32) meteorological stations distributed in Iraq were obtained from date of stations operation to 2015. Rainfall returns periods method was used depending on to following formula [8]:

$$Tx = \frac{1}{F} \qquad \text{..... (1)}$$

$$F = \left(\frac{r}{n+1} \right) * 100 \qquad \text{..... (2)}$$

Where Tx: returns periods in years, F= Frequency of rainfall, r = rank of each rainfall observations, n= number of rainfall observations.

The first step in the frequency analysis is the ranking of the rainfall data. After the rainfall data are ranked, a serial rank number (r) ranging from 1 to n (number of observations) is assigned. Subsequently the probability have to be determined that should be assigned to each of the rainfall depths. If the data are ranked in descending order, the highest value first and the lowest value last, the probability is an estimate of the probability that the corresponding rainfall depth will be exceeded [4]. Finally Excel, Grapher and surfer programs used to present results and demonstrate contour map of rainfall in Iraq.

4. Results and discussion:

Table 1 and Fig. 1 show the geographical position of meteorological stations distributed in Iraq. Table 2 show the mean annual summation of rainfall obtained in (32) stations while Fig. 2 show the contour map of rainfall distribution all over Iraq.

Table 1: Geographical position of meteorological stations in Iraq

Location of stations		Name of Station	Station No.	Location of stations		Name of Station	Station No.
Long.	Lat.			Long.	Lat.		
444300	323300	Ainaltamer	1	433600	354500	Makhmoor	17
471000	315100	Amarah	2	430900	361900	Mosul	18
415700	342800	Anah	3	441900	315900	Najaf	19
450400	325500	Azizyah	4	421500	320200	Nukhaib	20
414400	360200	Baaj	5	461400	310500	Nasiriyah	21
455700	330600	Badra	6	410100	342300	Qaim	22
441400	331400	Baghdad	7	420600	364800	Rabiah	23
432900	345600	Baiji	8	430900	332700	Ramadi	24
474700	303400	Basrah	9	401700	330200	Rutba	25

445900	315900	Diwaniyah	10	435300	341100	Samaraa	26
460300	321000	Hai	11	451600	311800	Samawah	27
442700	322700	Hilla	12	415000	361900	Sinjar	28
440100	323700	Karbalaa	13	422900	362200	Tel-Afer	29
443200	335000	Khalis	14	434200	343400	Tikrit	30
452600	341800	Khanaqin	15	443900	345300	Tuz	31
442400	352800	Kirkuk	16	360900	440000	Erbeel	32

Table 2: Mean annual rainfall (mm) in meteorological station in Iraq

St. No.	Ave. Sum of Rainfall (mm)	Duration (years)	St. No.	Ave. Sum of Rainfall (mm)	Duration (years)	St. No.	Ave. Sum of Rainfall (mm)	Duration (years)
1	92.469	20	**12**	108.981	40	**23**	367.12	38
2	178.687	45	**13**	103.4592	65	**24**	110.512	40
3	142.529	65	**14**	162.6836	30	**25**	116.65	78
4	117.814	15	**15**	308.659	70	**26**	151.5433	50
5	229.04	17	**16**	376	72	**27**	104.682	٦٥
6	204.843	15	**17**	306.914	25	**28**	389.308	63
7	136.702	68	**18**	372.995	76	**29**	322.8445	64
8	199.6981	65	**19**	94.05	55	**30**	181.878	25
9	144.805	70	**20**	72.1554	45	**31**	254.026	45
10	112.441	83	**21**	119.4807	74	**32**	449	40
11	139.17	66	**22**	140.624	30			

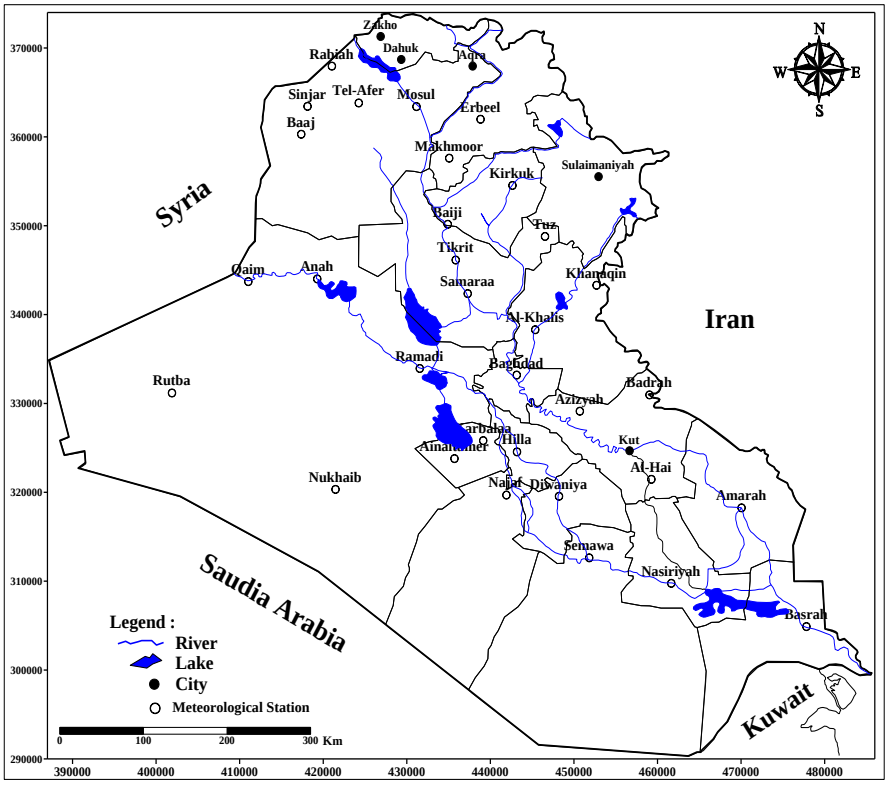

Fig. 1: Distribution map of Meteorological stations in Iraq.

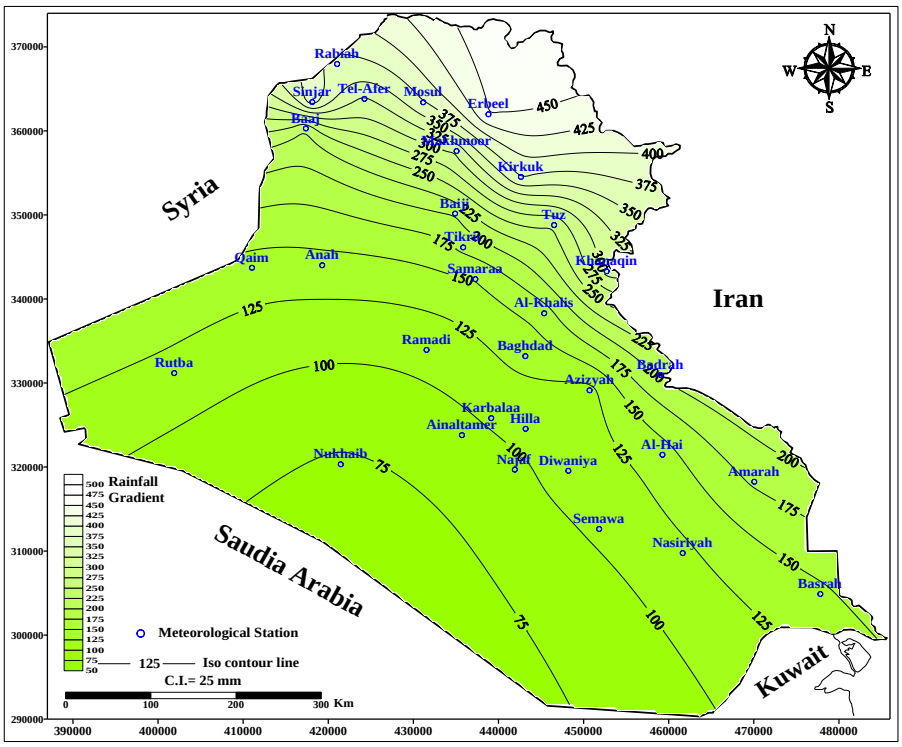

Fig. 2: Contour map of annual summation of Rainfall in Iraq.

It seems that mean annual summation of rainfall has a symmetrical increasing pattern from south-west towards north-east according to increasing ratio of rainfall in northern region of Iraq. The topography, atmospheric depression and the nature of air masses blowing from the surrounding areas play an important role in the variation of annual values of rainfall in these locations. As mentioned before the climate of Iraq is continental and subtropical semi-arid type whereas the mountainous regions in the north-eastern and north parts are classified a Mediterranean climate.

Using equations (1 and 2) mentioned above, the return periods of rainfall in (26) stations shown in Table 3 and Fig. 3. We used only stations that have at least thirty years observations in order to insure that return periods did not affected by low observations of rainfall. The estimated equation of returns periods versus mean annual rainfall was (P = 130.595 * log (T) + 76.4755) with correlation of determination reached (93.07%).

Depending on Table 4 which indicates the classification of meteorological events based on return periods, Table 5 show the normal distribution of rainfall all over Iraq according to the locations of meteorological stations.

Table 3: Returns periods obtained in (32) meteorological station in Iraq

r	F	T x (Years)	P (Rainfall mm)	Station no.	Duration
1	0.037037	27	449	32	40
2	0.074074	13.5	389.308	28	63
3	0.111111	9	376	16	72
4	0.148148	6.75	372.995	18	76
5	0.185185	5.4	367.12	23	38
6	0.222222	4.5	322.8445	29	64
7	0.259259	3.857	308.659	15	70
8	0.296296	3.375	254.026	31	45

9	0.333333	3	199.6981	8	65
10	0.37037	2.7	178.687	2	45
11	0.407407	2.454545	162.6836	14	30
12	0.444444	2.25	151.5433	26	50
13	0.481481	2.077	144.805	9	70
14	0.518519	1.928	142.529	3	65
15	0.555556	1.8	140.624	22	30
16	0.592593	1.687	139.17	11	66
17	0.62963	1.588	136.702	7	68
18	0.666667	1.5	119.4807	21	74
19	0.703704	1.421	116.65	25	78
20	0.740741	1.35	112.441	10	83
21	0.777778	1.286	110.512	24	40
22	0.814815	1.227	108.981	12	40
23	0.851852	1.174	104.682	27	65
24	0.888889	1.125	103.4592	13	65
25	0.925926	1.08	94.05	19	55
26	0.962963	1.038	72.1554	20	45
N+1= 27					

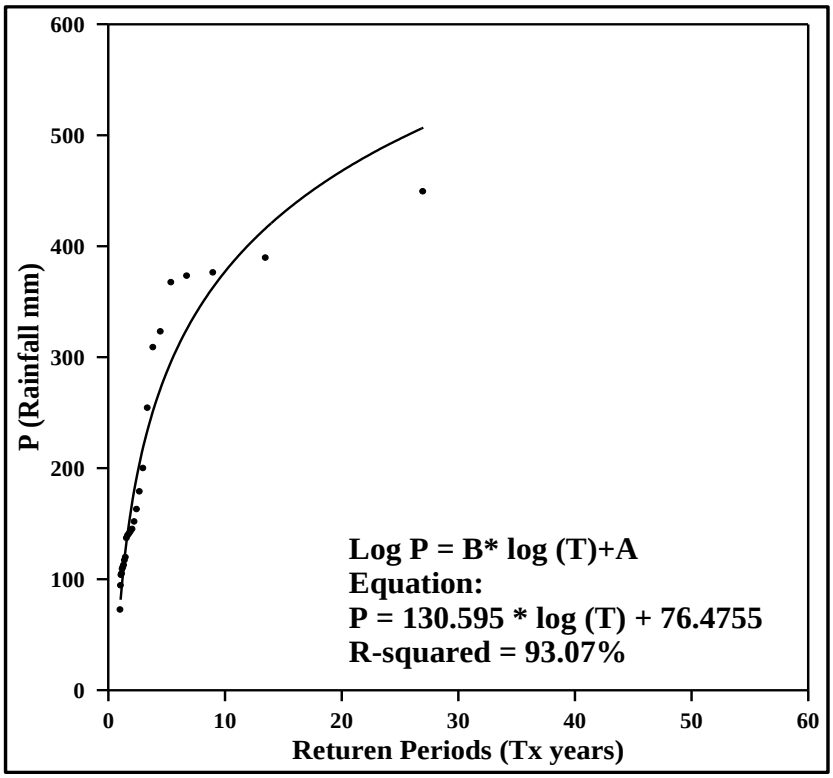

Fig. 3: the relationship of returns periods and rainfall in Iraq

Table 4: Meteorological events classification based on rainfall returns periods [9].

Classification	Returns periods (Years)
Normal	< 6
Abnormal	6 - 10
Very abnormal	10 - 30
Exceptional	30 -100
Very exceptional	> 100

Table 5: Normality distribution of rainfall according to returns periods in Iraq.

No.	Classification of meteorological events (P mm)	rainfall returns periods (years)	Sum of Stations	Area
1	Very abnormal	13.5- 27	2	Erbeel and Sinjar
2	Abnormal	6.75 - 9	2	Kirkuk and Mosul
3	Normal	1.038 - 5.4	22	All other stations

Fig. 4 show the distribution of rainfall returns periods in Iraq, where north-east region has characterized by very abnormal and abnormal events regarding rainfall (P) in term of returns periods. The north-west, middle and southern regions of Iraq characterize by a normal distribution of rainfall. Food and Agriculture Organization (FAO) uses the following rules to determine dry, normal and humid weather conditions depending on returns periods:

- The weather condition in a period is called dry if the rainfall received during that period will be exceeded 4 out of 5 years, i.e. having returns periods of 80%;

- The rainfall during a period is normal, if the rainfall received during that period will be exceeded in 1 out of 2 years. The returns period is equal to 50%;

- The weather condition during a period is called humid if the rainfall received during that period has exceeded 1 out of 5 years, i.e. having returns periods of 20% [5].

Depending on this classification, Iraq has only two types of weather conditions, according to rainfall returns periods: the humid weather condition located in the northern east part and dry weather condition in the other parts of it. It seems that this classification is highly similar to the general classification of Iraqi climate as it is characterized by a very hot summer and a short cold winter of continental and subtropical semi-arid type.

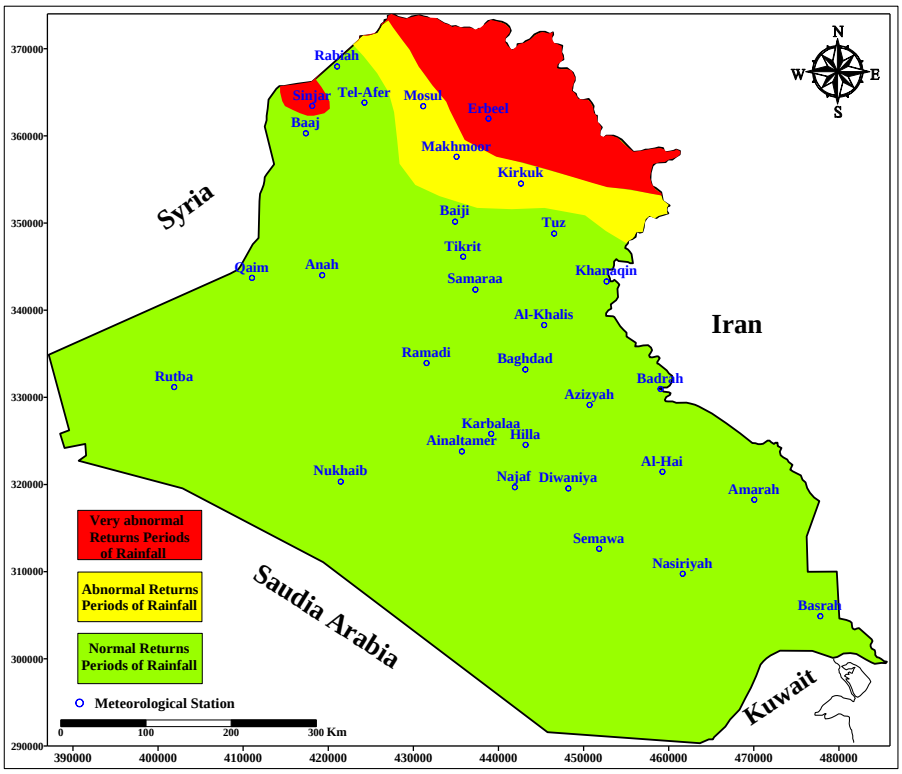

Fig. 4: Distribution of rainfall returns periods in Iraq

5. Conclusion:

1- Mean annual summation of rainfall has a symmetrical increasing pattern from southern west towards northern east, according to the increasing ratio of rainfall in northern region of Iraq.

2- The estimated equation of return periods versus mean annual rainfall was ($P = 130.595 * \log (T) + 76.4755$).

3- The northern east region of Iraq has characterized by very abnormal and abnormal events regarding rainfall (P) in term of returns periods, while the northern west, middle and south regions characterize by normal distribution of rainfall.

4- Depending on (FAO) classification, Iraq has only two types of weather conditions according to rainfall returns periods: the humid weather condition located in the northern east part and dry weather condition in the other parts of it.

6. Recommendations:

Water harvesting and dam constructions are highly recommended in north and northern east of Iraq due to highly mean annual rainfall as well as the very abnormal and abnormal meteorological events obtained by returns periods calculation related to rainfall observations. These two regions contribute in highly water surplus which increase surface water storage in dams and lakes as well as groundwater natural recharge.

Conflicts of Interest

The author declares that they have no conflicts of interest.

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العودة الزمنية للامطار في العراق

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خلاصة

بيانات الساقط المطري في اثنين وثلاثين محطة مناخية موزعة غلى العراق تم الاستعانة بها لايجاد العودة الزمنية للامطار والتي تساهم في تحسين خطط إدارة المياه في جميع أنحاء العراق خاصة خلال المواسم الجافة. بينت النتائج بان متوسط المجموع السنوي للامطار بان هناك نمطاً متناظر من تزايد الساقط المطري من المنطقة الجنوبية الغربية في العراق باتجاه مناطقه الشمالية الشرقية حيث اتسمت الاخيرة بكون الحدث المناخي بالاستناد للعودة الزمنية للامطار بكونه فوق طبيعي جدا الى فوق طبيعي بينما امتازت باقي مناطق العراق بحدث مناخي متمثل بتوزيع طبيعي للامطار بدلالة العودة الزمنية لها. اوضحت النتائج بان العراق يتميز بنوعين فقط من الظروف الجوية حسب فترات سقوط الأمطار متمثلة بحالة الطقس الرطب الموجودة في الجزء الشمالي الشرقي والظروف الجوية الجافة في الأجزاء الأخرى منه.

الكلمات الداله: العودة الزمنية للامطار، العراق.