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ESTIMATION OF WATER BALANCE PARAMETERS IN ROGERM CATCHMENT AREA, MANGESH, DUHOK GOVERNORATE, KURDISTAN REGION OF IRAQ

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ABSTRACT

The analysis of some hydrological elements of the water balance of Rogerm catchment area which is in Mangesh subdistrict, Duhok Governorate about 45 km north-west of Duhok was conducted. The aimed area is around 179.5 km². The historical record of rainfall data in Mangesh Agricultural office stations were used to calculate the water balance parameters for the period 2012-2013 to 2020-2021. The average amount of rain is almost 783.5 mm, it falls through 56 days of eight rainfall months/year. The biggest amount of rain falls in March, it reaches 158.4 mm. In winter the rain is denser and it reaches 47.7% from the total of the rainy year. 46.1% of the total amount of rain falls during two days, which cause the surface runoff. Water surplus was between 77% - 78% and 18% ground water recharge of the total annual rainfall. The probability of return period of the water surplus each two years may be 50% from (565-907 mm/year) and 50% from (363-530 mm/year) consequently, while maximum and minimum probability of return period is (907 mm/year) and (363 mm/year) consequently of the water surplus for the coming year are 10% and 90% consequently.

***KEYWORDS*:** Water balance, Water surplus, Surface runoff, Ground water, Rainfall and Return period.

1- INTRODUCTION

The main elements of hydrological cycle are rain, snow, and sleet, …etc, storage evaporation and interception depression. Water is a necessary component to develop any area. At the present time there is a huge demand on water due to the increasing population, water is restricted for agricultural uses and other purposes (Subedi and Chavez, 2015). Analyses of water balances are necessary for calculating an area's drainable surplus, which defined is as an accounting of the inputs and out puts of water. The major input is the rainfall, while output are water losses (evaporation) and water surplus (surface runoff and ground water), so the surface runoff is defined as precipitation that reaches a surface stream without ever passing below the soil surface. While the ground water is the part of infiltrated water which composes the water resource for population and human activities. then Infiltration affects directly the amount of ground water, when the infiltration increases the surface runoff decrease and ground water increase and it all depends on the geology of the catchment area. The water balance of a place, whether it is an agricultural field, watershed, or continent, can be determined by calculating the input, out put and storage changes of the earth surface. The calculation of water balance will facilitate hydrological studies of lakes, river basins, and ground water basins out comes as well as reducing cost and time Many previous studies were used meteorological data for estimating water balance parameter, among which are Fetter (1980), Aussy (1990), Al-Sudani (2003), Hameed (2006), Al-Shamma *et al.* (2007), Ufoegbune *et al*. (2011), Al-Sudani (2018), and Al-Sudani (2019).

Technically, the study area is located in Mangesh region, Duhok Governorate around 45 km north west of the city of Duhok, and covers an area about 179.5 km^2 between Latitude (N 37º 03´0˝) and (N 36º 57´0˝) and Longitude (E 42º 57´ 0˝) and (E 43º 9´ 0˝). The catchment is bounded from the North by Zewka Abu, Milhamban and Kovli, from the East by Gondik and Majalmukht, from South by Mamani Mountain and from West by Alindki. physiographical, the topography of the Rogerm catchment is mostly steep to very steep, while in the northern part the topography is gentle which is at the bottom of the valley. The catchment area is mostly covered by limestone and marl stone these two kinds of rocks makes the summit of almost all the mountains in the area (Abdulrahman, 2019). The catchment elevation differs from 1442 m to 673 m from sea level (Fig. 2). The climate of the study area is hot and dry in summer and cold and rainy in winter which is almost the same as the Mediterranean climate condition. The wet periods as start from October to May, while the rest months of the year are considered as dry period. The catchment area consists of intermittent streams meaning that the water flows in them during the raining period apart of Zewka Abu stream are perennials stream meaning that the water flows in them through the whole year and their water is used for irrigation the crops. The Rogerm catchment drainage patterns are mainly dendritic. Recently, the water scarcity issue is becoming more serious due to several factors. By using (GIS Arc map) we calculated the catchment area and drainage pattern network of stream (Fig. 1 and Fig. 2).

The objectives of the study are estimating the parameters of the water balance of Rogerm catchment relying on the meteorological elements (rainfall as input and output are water losses, surface runoff, and ground water recharge of catchment), then to be used for agricultural needs after the water been stored in depressions or by small dams. Model the parameters of the water balance deploying meteorological data taken of the Agrometeorological offices in Mangesh for the water year 2020-2021 (Tab. 8).

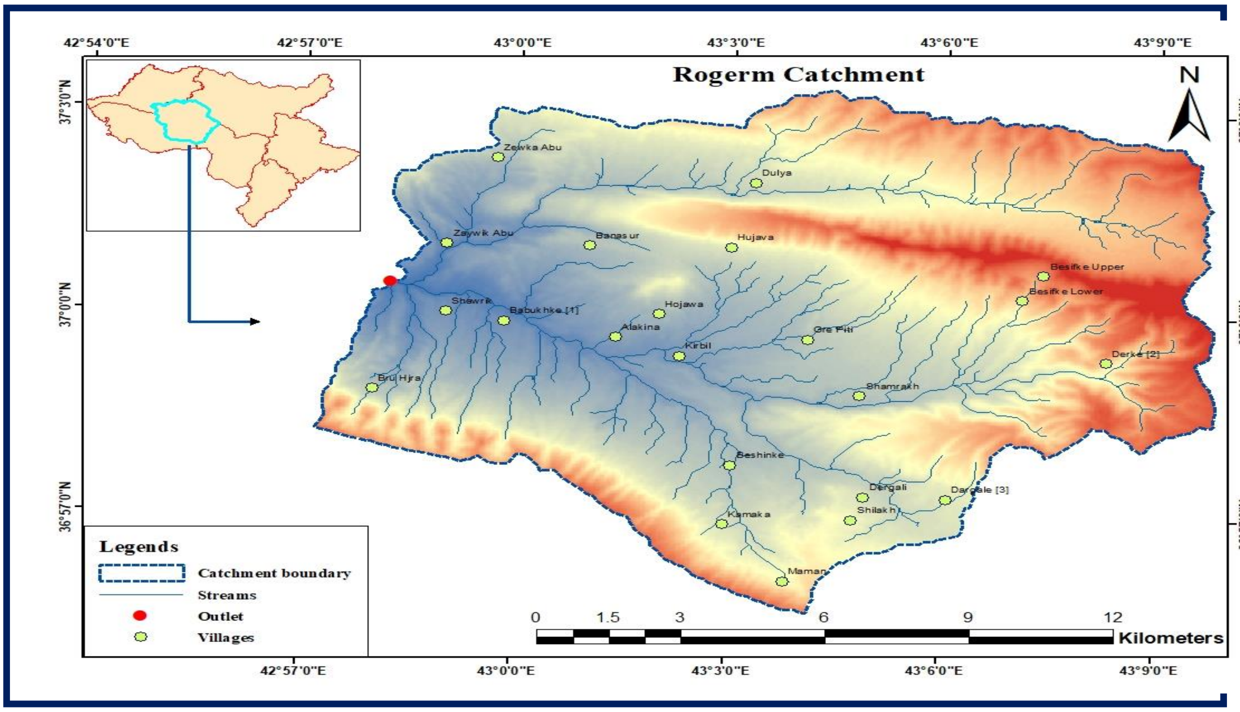

Fig. (1): Rogerm catchment map

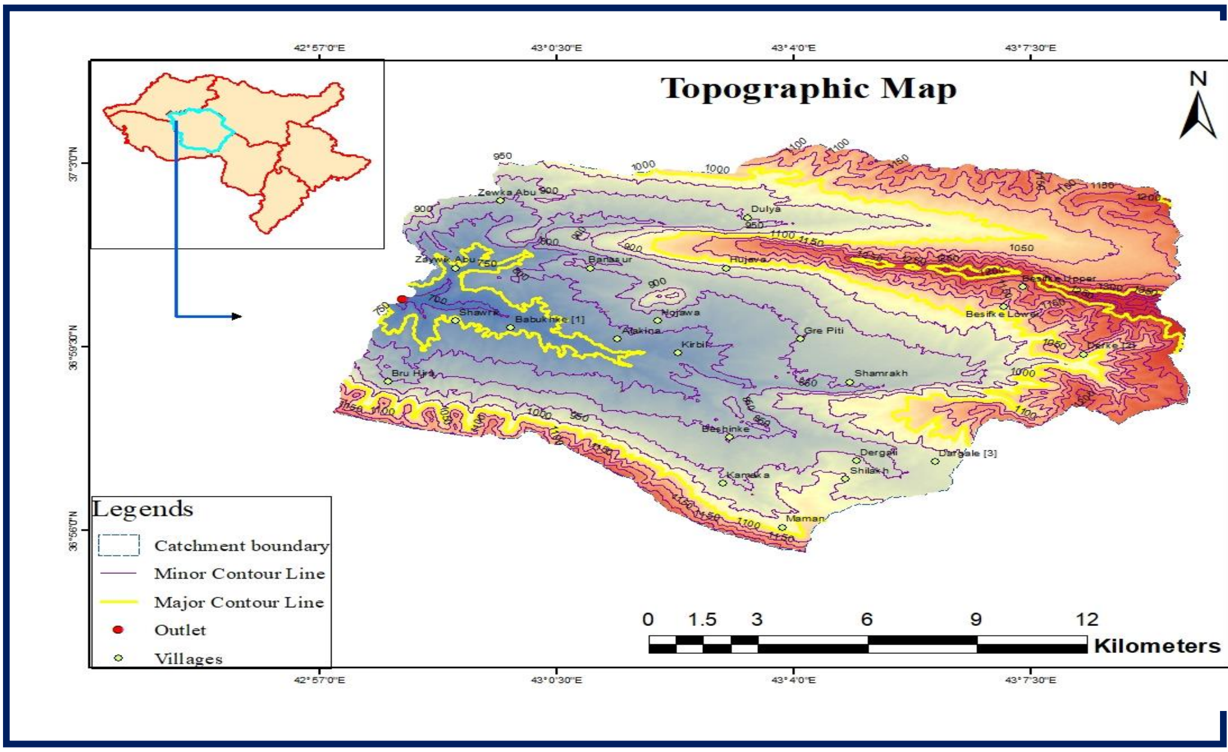

Fig. (2): Topographic map of Rogerm catchment

2- METEOROLOGICAL DATA ANALYSIS

The available rainfall data for Agrometeorological station of Mangesh Agricultural offices for the water years (2012-2013 to 2020-2021) including (annual and mean monthly rainfall, mean number of rainy days per month, mean monthly temperature, and mean monthly evaporation) were depended in this study (Tab. 1, 2 and 3).

Table 1: The mean monthly rainfall (mm) and number of rainy days/months for 2012-2013 to 2020-2021 of Mangesh offices stations (Directorate of meteorological office in Duhok).

Months	Rainfall (mm)	Number of rainy days/months
October	42.11	4
November	98.7	7
December	142.3	9
January	148.4	9
February	82.8	8
March	158.4	10
April	70.7	6
May	40.2	3
Total	**783.5**	**56**

Table 2: The mean monthly temperature (Cº) and evaporation (mm) for EPAN "A" for 2012-2013 to 2020-2021 of Mangesh offices stations (Directorate of meteorological office in Duhok).

Months	Temperature (Cº)	Evaporation (mm)
October	19.8	134.6
November	12.5	47.9
December	7.4	31.4
January	5.1	35.1
February	7.2	53.9
March	10.4	75.2
April	15.9	125.1
May	20.6	211.8
Jun	26.8	284.6
July	30.8	337.9
August	30.7	313.8
September	26.4	226.5
Total	**213.6**	**1877.8**

Table 3: The annual rainfall for 2012-2013 to 2020-2021 of Mangesh offices stations (Directorate of meteorological office in Duhok).

No.	Water year	Rainfall (mm)
1	2012-2013	1061.7
2	2013-2014	583.9
3	2014-2015	763.2
4	2015-2016	644.6
5	2016-2017	511.8
6	2017-2018	524.4
7	2018-2019	1660.7
8	2019-2020	848.2
9	2020-2021	453.0
	Average	**783.5**

3- RESULTS AND DISCUSSION

3-1- Mean number of rainfall days/month (n/month):

Number of rainfall days in a month was estimated for the catchment area by the average monthly rainy for the period of 2012-2013 to 2020-2021. The number of rainfall days in a month varies for the catchment area for each month relying on the pattern of rainfall (Hameed and Mohammed Ali, 2015). It is ranged from 3-10 days, with yearly average of 56 days in 8 months which stand for the average of about 783.5 mm annual rainfall (Tab. 1 and 3). The lowest amount of rain was fallen in May which represents 40.2 mm, the highest month was March and it was around 158.4 mm. It is noticed that the rainfall differs from one season to another, Autumn which include October, November, and December was 36.1%, where Winter representing January, February and March was 49.7% while spring (April and May) has been around 14.2% of the total annual rainfall. Figure (3) explained annual rainfall for water-years 2012-2013 to 2020-2021. This figure shows that the highest annual rainfall was for the water-year 2018-2019 and reached about 1660.7 mm, while in water-year 2020-2021 has the lowest annual rainfall and it reached about 453.0 mm. Also, it is noticed that the wet years are for water years 2012-2013, 2018-2019 and 2019-2020 since the annual rainfall of these years are more than the general mean of annual rainfall. While the water-year 2020-2021 is considered the less rainfall year as the total amount of this year is 453 mm and it is the lowest rainfall year among all the research period years. Other water-years are considered as semi-arid years because the annual rainfalls of these years are less than the general mean of the annual rainfall (Hameed, 2006).

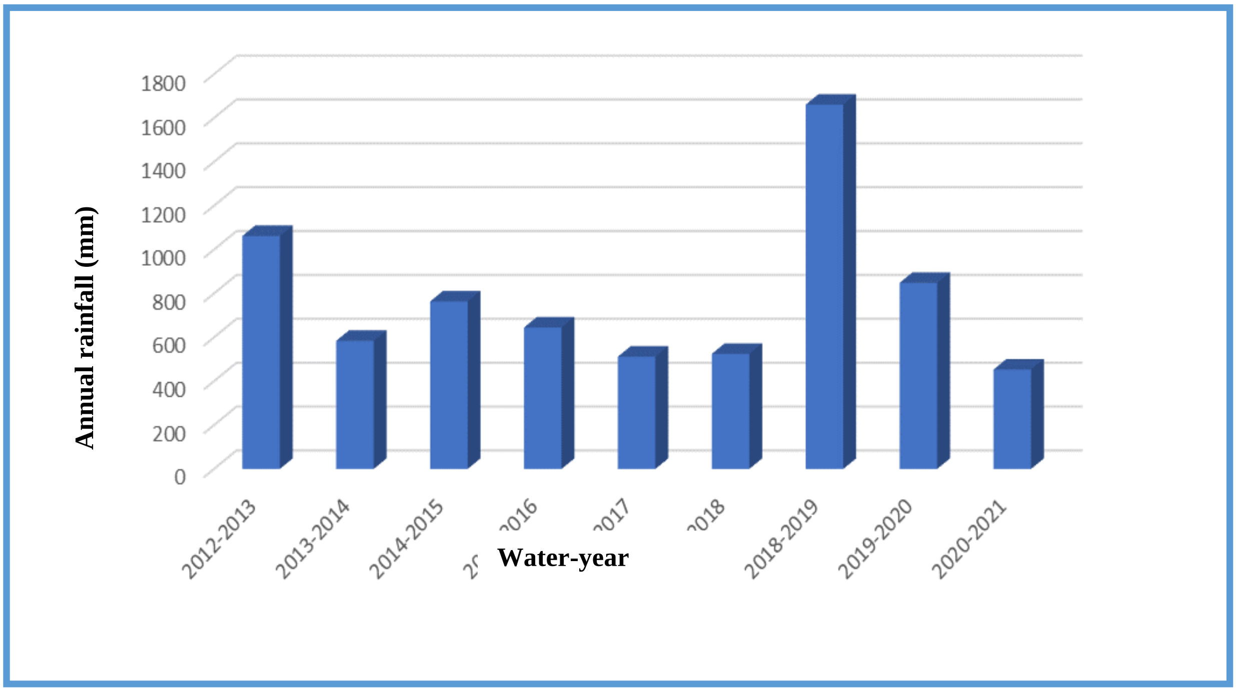

Fig. (3): Annual rainfall for the water year 2012-2013 to 2020-2021 for Mangesh offices stations ((Directorate of meteorological office in Duhok).

3-2- The Parameters of Water Balance:

The parameters of water balance are the calculation of the inputs and outputs of the water predicted for various time scales and spaces, i.e. river basin, a given amount of time or yearly and seasonal. The parameter of water balance for the catchment may be determined from calculating the inputs and outputs of the water at the surface of the catchment area. Rainfall (Ri) is considered to be the only input element in the water balance where set of outputs as water surplus (WSi) and water loss (WLi). In which the water surplus (WSi) includes surface runoff (SRi) and ground water (GWi) (Hussain, 1994). hydrologically, a water balance formula is used to prescribe the flow of water in and out of system. According to (Subedi and Chavez, 2015) A general water balance equation is:

$\Delta S = \text{Input} - \text{Output}$ (1)

$\Delta S = Ri - WLi + WSi$

$Ri = WLi + WSi + \Delta S$

The water losses (WLi) are pondered as a kind of EPAN ″A″ evaporation as maximum losses that might take place (Jameel *et al*., 1999) that covers the moisture in the soil as well as a part of evaporation (Hassan and Zeki, 1982). That why, the EPAN ″A″ and precipitation were taken in to a count for the catchment area. The most important element influencing the level of evaporation is the temperature that why, it is given the priority while estimating the EPAN ″A″ (Hassan *et al*., 1987).

3-3- Water Surplus Parameters (WSi):

Water surplus is a positive difference between rainfall and evaporation type of EPAN ″A″ during a certain period. More than one way is used to estimate water surplus parameter by comparing among average yearly rainfall (Ri) and water loss (WLi). Three ways were applied to determine the water surplus, the first way is using the average yearly parameter, while the second way is using the average monthly parameters, and in the third way is using the average daily parameters.

3-3-a- Estimating average yearly parameter for water surplus (WSi):

It can be estimated by comparing the average yearly rainfall and the total of the average monthly temperature in the rainfall months (Hassan *et al*., 1999) at equation (2).

$WSi\% = Ri \times \sum Ti / u$ (2)

Where:

WSi% = Water surplus in percentage.

Ri = Average yearly rainfall (mm)

$\sum$ Ti = Sum of temperature in rainfall month (C°) (October - May).

u = 1000

$WSi\% = 783.5 \times 98.9/1000$

$WSi\% = 77.5\%$

3-3-b- Estimating average monthly parameter for water surplus (WSi):

It is calculated from the average monthly temperature (Ti) refers to average monthly rainfall (Ri) for estimating mean monthly water surplus (WSi). This way can be obtained by two methods (Hassan *et al*., 1999).

First method where Ti ≥ Ri; WLi = Ri

Second method where Ti < Ri; WLi has two possibilities:

1- Where 2Ti < Ri ≤ 4Ti; WLi = 2Ti

2- Where Ti < Ri ≤ 2Ti; WLi = Ti

The average monthly water surplus (WSi) was obtained for the study area by applying methods as follow (Tab. 4).

$$WSi = Ri - WLi \quad (3)$$

$$WSi\% = (\sum WSi/\sum Ri) * 100 \quad (4)$$

$$WSi\% = (606.4/783.5) * 100 = 77.4\%$$

Table (4): Average monthly temperature approach for estimating average monthly water surplus (WSi) for Rogerm catchment area.

Month	Ri (mm)	Ti (C°)	WLi	WSi
Oct.	42.11	19.8	39.6	2.5
Nov.	98.7	12.5	25.0	73.7
Dec.	142.3	7.4	14.8	127.5
Jan.	148.4	5.1	10.2	138.2
Feb.	82.8	7.2	14.4	68.4
Mar.	158.4	10.4	20.8	137.6
Apr.	70.7	15.9	31.8	38.9
May	40.2	20.6	20.6	19.6
Sum	**783.5**	**98.9**	**177.2**	**606.4**

3-3-c- Estimating mean daily parameter of water surplus:

By using number of rainfall days three status were applied to calculate the water surplus (Hassan *et al*., 1999).

First status: even possibility of water losses (WLi) (n/year) event:

Even possibility of water losses realizes on a number of rainfall days (n/year) with the total of EPAN ″A‶ evaporation that is referring to them days as shown in (Tab. 5).

$$En = n \times \sum EPAN \text{″A‶} / \sum di \quad (5)$$

While:

En= The sum of evaporation (mm) happens in number of rainfall days in a year.

N= The sum of rainfall days in a year = 56

∑EPAN ″A‶= The of sum of evaporation during rainy month = 715

∑di= The sum of days in rainfall month is equal 243 days

$$En = 56 \times 715/243 = 164.8 \text{ mm}$$

$$WSi\% = (\sum EPAN \text{″A‶} - En) / (\sum EPAN \text{″A‶}) \times 100 = (715 - 164.8) /715 \times 100 = 77\ \%$$

Second status: changeable possibility of water loss (WLi) (n/year) event:

Changeable possibility based upon the mean rainfall days in a month where the evaporation of EPAN (″A‶) is differ from one month to another. Calculating the daily average evaporation in a given month is done by dividing the evaporation (mm) in a month by the total number of days in that month. The total evaporation amount for rainfall days in a month is done by multiplying the sum of rainy days by the daily average evaporation in a certain month. In (Tab. 5) the water surplus is extracted by subtracting the rainfall (mm) in a month from the sum of evaporation for rainy day during a month (Hameed, 2006) as it shows below:

$$Edi = EPAN (\text{″A‶}) \div di \quad (6)$$

$$Ei = Ni \times Edi$$

$$WSi = Ri - Ei$$

While:

Edi: The average daily evaporation in a month (mm).

EPAN (″A‶): The evaporation (mm) in a month.

di: The number of days in a month.

Ei: The sum of evaporation for rainfall days in a month (mm).
Ni: The sum of rainfall days.
WSi: The monthly water surplus (mm).
Ri: The monthly rainfall (mm).

Thus,

$$WSi\% = (\sum WSi / \sum Ri) \times 100$$
$$= 651.5 / 783.5 \times 100$$
$$= 83.1\%$$

Table (5): Average monthly water surplus (WSi) for changeability n/months of Rogerm catchment area.

Months	di	EPAN (mm)	Edi (mm)	Ni	Ei (mm)	Ri (mm)	WSi (mm)
October	31	134.6	4.3	4	17.2	42.11	24.9
November	30	47.9	1.6	7	11.2	98.7	87.5
December	31	31.4	1.0	9	9.0	142.3	133.3
January	31	35.1	1.1	9	9.9	148.4	138.5
February	28	53.9	1.9	8	15.2	82.8	67.6
March	31	75.2	2.4	10	24.0	158.4	134.4
April	30	125.1	4.2	6	25.2	70.7	45.5
May	31	211.8	6.8	3	20.4	40.2	19.8
Sum	**243**	**715**	**23.3**	**56**	**128.4**	**783.5**	**651.5**

Third status: Maximum daily rainfall:

According to (Hassan *et al*., 1999) water surplus given from the total of maximum rainfall in one day in a month by equipollent parameter, where the surface runoff is extracted from the total of maximum rainfall of two days in a month (mm) as following:

$$WSi = m \times \sum R1d \qquad (7)$$
$$SRi = \sum R2d$$

When:
WS: Water surplus (mm) in a month.
m: Equipollent parameter equal two.
R1d: Maximum rainfall in one day in a month (mm).
SRi: Surface runoff (mm) in a month.
R2d: Maximum rainfall in two days in a month (mm).

Surface runoff (R2d) can be obtained by the last stated equation conforming to United States Geographic Services (USGS) (2014) method of (n).

$$2\sum R1d > \sum R1d$$

That why, ground water is:

$$GW = 2\sum R1d - \sum R1d \qquad (8)$$

Selected individuals' annual rainfall for Agrometeorological station of Mangesh office station from 2012-2013 to 2020-2021, (Tab.6) explained the ratio of water surplus WSi% which is 79.2% of the total yearly rainfall and the ratio of surface runoff SRi% is 61.2% of the total yearly rainfall [As stated by the United States Geographic Services].

Table (6): The maximum sum of daily rainfall in 2012-2013 to 2020-2021 of Rogerm catchment area.

Water-year	Ri (mm)	2∑R1d=WSi	WSi%	∑R2d= SRi	SRi%	GW	GW%
2012-2013	1061.7	565.0	53.2	477.5	45.0	87.5	8.2
2013-2014	583.9	715.0	122.5	511.4	87.6	203.6	34.9
2014-2015	763.2	586.0	76.8	496.0	65.0	90.0	11.8
2015-2016	644.6	591.0	91.7	458.5	71.1	132.5	20.6
2016-2017	511.8	513.0	100.2	364.1	71.1	148.9	29.1
2017-2018	524.4	372.0	70.9	296.0	56.4	76.0	14.5
2018-2019	1660.7	907.0	54.6	714.5	43.0	192.5	11.6
2019-2020	848.2	531.0	62.6	444.5	52.4	86.5	10.2
2020-2021	453.0	363.0	80.1	268.0	59.2	95.0	20.9
Mean	**783.5**	**571.4**	**79.2**	**447.8**	**61.2**	**123.6**	**18.0**

3-3-d- Gained results of water surplus parameters (WSi):

As a results of estimating water surplus (WSi) different method were applied that is related to rainfall parameters with response to its evaporation. And so, there are various values for water surplus (WSi) depending on specific period of similarity.

According to the annual method the water surplus is 78% of the yearly rainfall, while it is 77% in monthly method. In the two stated methods for rectifying the sensible evaporation the temperature were used.

The rainy-day method values are relied on equipollent evaporation from maximum evaporation type (″A‶) from equal possibility for (n/year) event appears that 77% is the percentage of the water surplus from yearly rainfall. changeable possibility of evaporation for mean (n/month) event is 83% water surplus. In one day, rainfall in a month method, water surplus is 79.2% from the yearly rainfall.

3-4- The surface runoff parameter (SRi):

Surface runoff is any water that flows over the top of the earth and into river, lake and bodies of water. From the obtained results, surface runoff parameter (SRi) is around 61.2% of the yearly rainfall or 78.4% from the water surplus of the catchment area, in consideration to ∑R2d maximum of one/two days or surface runoff (SRi) is 0.78 WSi (Tab. 6).

3-5-The ground water recharge parameter (GWi):

The ground water recharge is around 18.0% of the yearly rainfall or 23% from water surplus or GWi= 0.23 as shows in (Tab. 7).

According to (Fetter, 1980) (Tab. 7):

WSi = SRi% + GWi% (9)

In (Tab.7) explains the average monthly ranking of water surplus into surface runoff and ground water recharge that is from October to May.

Table (7): Water surplus (WSi) partitioning in to surface runoff (SRi) and ground water (GWi) for Rogerm catchment for the period 2012-2013 to 2020-2021.

Month	WSi	SRi	GWi
Oct.	24.9	19.4	5.7
Nov.	87.5	68.3	20.1
Dec.	133.3	104.0	30.7
Jan.	138.5	108.0	31.9
Feb.	67.6	52.7	15.5
Mar.	134.4	104.8	30.9
Apr.	45.5	35.5	10.5
May	19.8	15.4	4.6
Sum	**651.5**	**508.1**	**149.9**

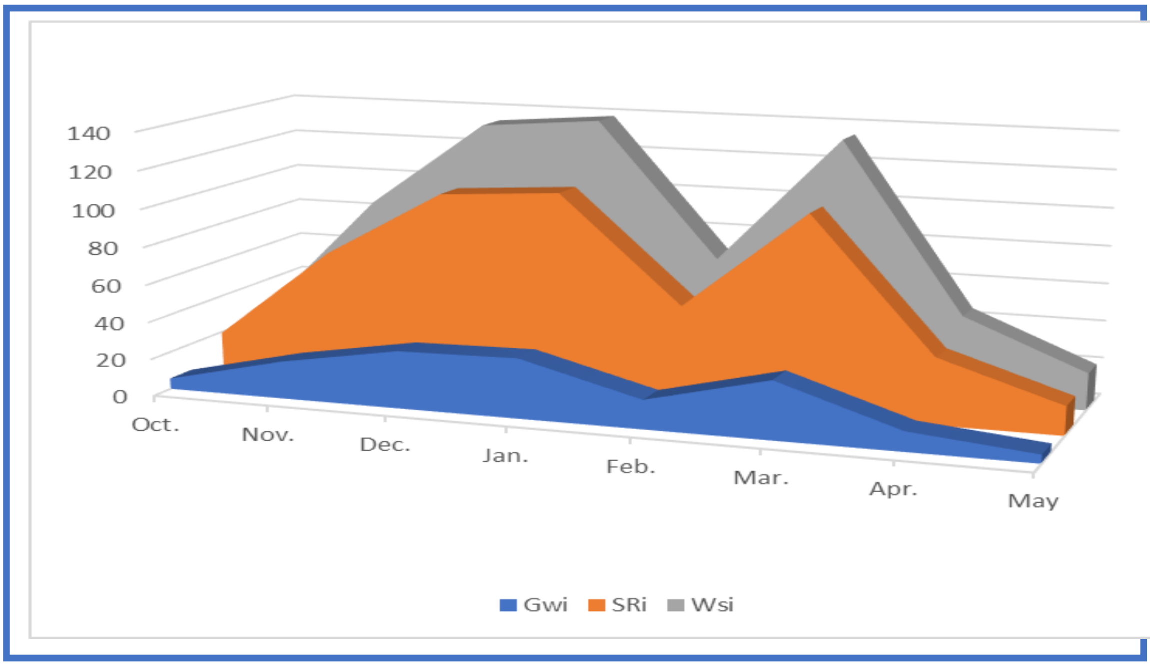

Fig. (4): WSi partitioning in to (SRi) and (GWi) for the water year 2012-2013 to 2020-2021 for Rogerm catchment.

3-5- The Water Balance Model:

The model different between the average rainfall (Ri) in a month and the water losses (WLi) in a form of evaporation. The last parameter (WLi) can be calculated by two methods, the first one is using the mean monthly temperature (Ti) while the second one is using the available possibility (n/month) event of rainfall in a day in a specific month (Hassan *et al*., 1999). In my research I used the first method which is the mean monthly temperature. The water balance model was confirmed by the rainfall for the 2020-2021 for the proposed Mangesh office stations.

Model affirmation starts of the theoretical model for the water surplus (WSi) like below:

WSi = Ri - WLi, the next act estimating the values of the surface runoff (SRi) and the ground water recharge (GWi) in a month at equation (9) (Hassan *et al*., 1999) as given bellows:

SRi = 0.78 WSi (10)

GWi = 0.23 WSi (11)

The relationship among the parameters of water balance in Rogerm catchment is clarified in (Tab. 8), also the same table shows that the (Ri), (WLi), (WSi), (SRi) and (GWi) are 453 mm, 94.7 mm, 358.3 mm, 279.4 mm, and 82.3 mm consequently from the beginning of November to the end of March, while in October, April and May the water surplus value are nil (Fig. 5) as the rainfall in these months is less than the evaporation. Water surplus (WSi) occurs when the rainfall value is more than evaporation value.

Depending on the previously stated parameter in the water balance model for Mangesh office station, mean annual rainfall was 453.0 mm. In order to calculate this portion of rain that was fallen in the study area as volume in (m^3) the following formula was used: Volume (m^3) = Rainfall (mm) × Area (Km^2). So, volume (m^3) = (453×10^{-3}) * (179.5×10^6) that is equal to 81.31 × 10^6 m^3. Around 358.3 mm of rainfall begin to be water surplus that is equal to 79 % of the yearly rainfall that is about (358.3×10^{-3}) * (179.5×10^6) equal to 64.314 × 10^6 m^3, whereas around 61.7 % of the yearly rainfall that is almost 279.4 mm convert in to surface runoff (279.4×10^{-3}) × (179.5×10^6) equal to (50.152 × 10^6 m^3). This amount of water is usually taken advantage of for agricultural needs that is actually aggregated behind small dams or it can be used for ground water recharge. The ground water is 82.3 mm or 18.2 % of the yearly rainfall and its volume is (82.3×10^{-3}) × (179.5×10^6) equal to (14.772 mm × 10^6 m^3) of the yearly rainfall which supply the ground water through infiltration and percolation in to the soil. whiles, the water loss from EPAN ″A‷ is 94.7 mm that is 20.9 % of the yearly rainfall and volume that is (94.7 mm × 10^{-3}) × (179.5×10^6) that is (16.998 × 10^6 m^3).

Table (8): Water balance modelling of Rogerm catchment for water year 2020-2021.

Months	Ri	WLi	WSi	SRi	GWi
Oct.	4.5	4.5	0.0	0.0	0.0
Nov.	90.5	24.2	66.3	51.7	15.2
Dec.	75.5	15.4	60.1	46.9	13.8
Jan.	149.5	12.4	137.1	106.9	31.5
Feb.	38.0	16.2	21.8	17.0	5.0
Mar.	92.0	19.0	73.0	56.9	16.8
Apr.	0.0	0.0	0.0	0.0	0.0
May	3.0	3.0	0.0	0.0	0.0
Sum	**453.0**	**94.7**	**358.3**	**279.4**	**82.3**

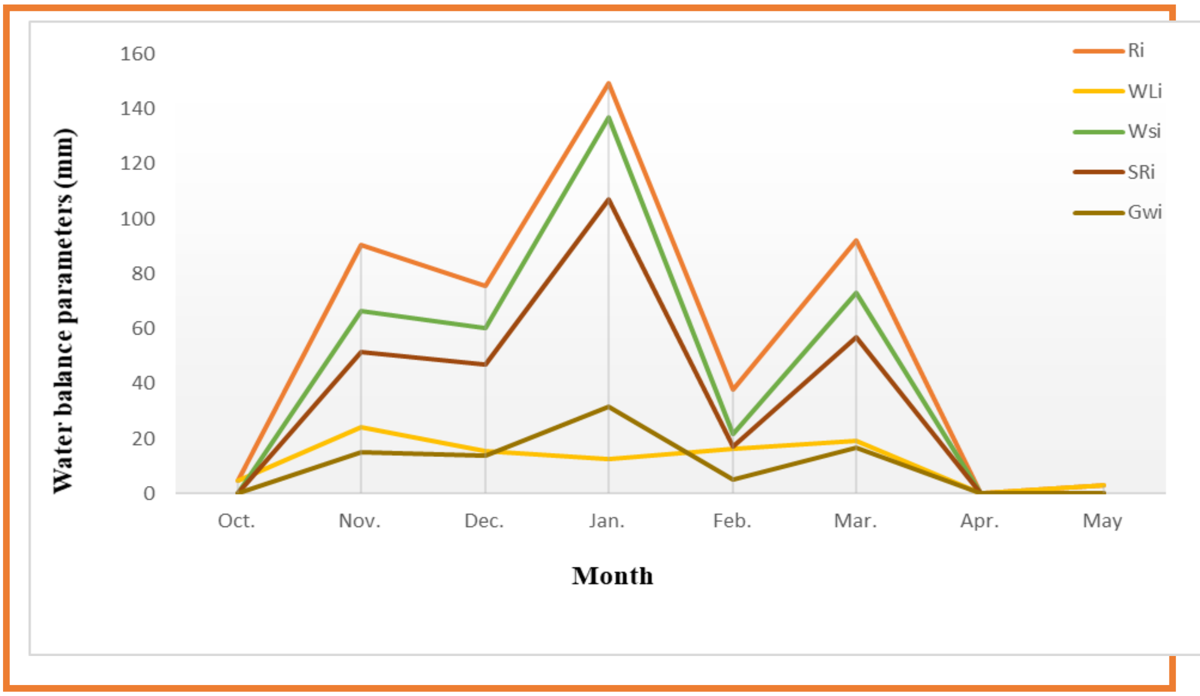

Fig. (5): Mean monthly water balance modeling of Rogerm catchment.

3-6- Return period (recurrence interval) of water surplus (Tr):

Return period, known as well as a repeat interval or recurrence interval, is an average time or a predict average time among events such as floods, earthquakes, landslides, or river discharge flows to happen. Therefore, the return period among the events that are equal or more than a specific event. Return period may be estimated the following equation (Jabbouri, 1988):

$$Tr = (n+1) \div m \quad \text{or} \quad Tr = 1 \div p \qquad (12)$$

while:

Tr: The Return Period in years.

n: Number of Recording years.

m: Storm number in the rank.

p: Possibility of Occurrence (%).

The possibility of happening (p) of the event in the next year is ($P = 1\div Tr$) and possibility of non-happening (q) of the event in the next year is ($q = 1-p$) or mainly ($pn = 1-q^n$).

The yearly water surplus of Rogerm catchment area for the water year 2012-2013 to 2020-2021 has been used to calculate the value of return period. According to (Kosslar and Read, 1974) appears the return period for the water surplus can be determined by sorting of the yearly water surplus in descending order as it shows in (Tab. 9).

(Tab. 9) clarify that the return period of the water surplus each two years is 50% from 565-907 mm/year and 50% among 363-530 mm/year, the maximum and minimum of the water surplus in the coming year are 10% (907 mm/year) and 90% (363 mm/year) consequently.

Table (9): Recurrence interval of water surplus for Rogerm catchment area.

Water-year	WSi	Tr	P	Q
2018-2019	907.0	10.0	0.1	0.9
2013-2014	715.0	5.0	0.2	0.8
2015-2016	591.0	3.3	0.3	0.7
2014-2015	586.0	2.5	0.4	0.6
2012-2013	565.0	2.0	0.5	0.5
2019-2020	531.0	1.7	0.6	0.4
2016-2017	513.0	1.4	0.7	0.3
2017-2018	372.0	1.3	0.8	0.2
2020-2021	363.0	1.1	0.9	0.1

R = Rank.
Tr = Return period (year).
P = Probability of occurrence.
Q = Probability of un occurrence.

4- CONCLUSION

Based on the study of water balance parameters for Rogerm catchment results, the following point can be concluded:

1- The average number of rainy days in a month (n per month) were estimated in the study area from the monthly average rainfall and it was ranged from 3-10 days, with yearly average of 56 days from eight months which makes the average of around 783.5 mm yearly rainfall. The total number of rainfall days differ for 31-94 days within a year. The lowest amount of rain was fallen in May which represents 40.2 mm; therefore, the highest month was March and it was around 158.4 mm. It is noticed that the rainfall differs from one season to another, the Winter has more rainfall than Autumnal and Spring season which gained about 49.7 % from the yearly rainfall.

2- The heaviest rainfall in two days event through eight months which represent 46% of the yearly rainfall, that cause surface runoff (SRi). So, more than two weeks of eight rainfall months supplies 46% of the yearly rainfall, when the other 30 days from 56 rainy days will supply 54% of the yearly rainfall.

3- The water balance term in this research refers to the two hydrological elements (surface runoff and ground water recharge) that why the input parameter (rainfall) of the catchment can be separated to water surplus and water losses. According to comparison method there are different values of water surplus, annual parameter of water surplus which equal 77.5% of the annual rainfall, while 77.4% with monthly water surplus. On the basis of number of really rainy day with respect to evaporation Pan ″A‟. Equal probability of water surplus (n/year) event appears that the water surplus is around 77% of the yearly rainfall. The variable possibility of water losses event is almost 83 % of water surplus. While the water surplus for the maximum daily rainfall is about 79%.

4- The surface runoff which is about 61% of the yearly rainfall or 78% from water surplus of the catchment area, which referred to ∑R2d maximum of one/two days.

5- the ground water recharge is around 18% from yearly rainfall or 23% from water surplus.

6- The model of water balance is contingent on the water surplus which is transform Pan evaporation, temperature and rainfall. Surface runoff may be extracted directly from rain or from water surplus. The ground water recharge, may be obtained. The ground water began at the beginning of November to the end of March, and depletions takes place in October, April and May. The model is depending on actual output runoff for study area within in the water-year 2020-2021. It was observed that there is around 279 mm of surface runoff water and ground water recharge is almost 82 mm happening through that period of time (2020-2021).

7- The probability of return period of the water surplus each two years is 50% when the rainfall is from 565-907 mm in a year, while it is 50% when the rainfall is from to 363-530 mm in a year, the maximum and minimum of the water surplus in the coming year are 10% (907 mm/year) and 90% (363 mm/year) consequently.

5- RECOMMENDATION

1- Water surplus is about 50 × 10^6 cubic meter that is gathered by mud dams taken advantage of to irrigate crops and farms in the surrounding area especially in the years when the rainfall is not so sufficient.

2- Providing means in the catchment area to maintain vegetation cover and preserving the soil from erosion and this will provide a pleasant appearance and view for the area which might help to attract tourist to the area.

3- In order to obtain accurate data and measurement regarding the water discharge of the watershed. We recommend to have automatic measuring system in the outlet of the catchment.

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خەملاندنا پارامیتەرێن هەڤسەنگیائاڤێ ل ڤەرێژگرا روکەرم ,مانگیش پارێزگەها دهوکێ- هەرێما کوردستانا عیراقێ

پوختە

شلوڤەکرنا هندەك کانزاییت زانستێن ئاڤێ و بتایبەتی هەڤسەنگیا ئاڤێ ل ڤەرێژگرا روگەرم دکەڤیتە دەڤەرا مانگێشکێ ل باژێرێ دهوکێ ئەوژی کو دیراتیا وێ 45 کیلومەتران ژ باکورێ-روژهەلاتا دهوکێ. رویبەرێ دەفەرا کارێ دگەهیتە 179.5 کیلومەترێن دووجار. ب کارئینانا داتایین بارینا بارانا ژ بنگەهێ رێڤەریا چاندنێ ل مانگیشێ هاتنە وەرگرتن و ب کارئینان ژ بو دەرێخستنا پارامیتەرێن هەفسەنگیا ئاڤێ ژ ماوێ 2012-2013 تا 2020-2021 . و تێکرایا بارانێن سالانە 783.5 ملیمەتران ئەوا کو هاتیە کومگرن بو ماوێ 56 روژان د 8 مەهێن بارانێ د سالێ دا. ل مەها ئادارێ پترین رێژا بارانێ باریە کو دگەهیتە 158.4 ملیمتران. زفستانا دەفەرێ ژ هە می وەرزێن دی یین سالێ تێر باران ترە ب رێژەیا 47.7 % ژ کوژمێ بارانێن د بارن سالانە. دوو پترین رێژینێن روژانە دگهیتە 46.1 % ژ بارانا سالانە، کو دبیتە ئەگەرێ ئاف رابونێ. زێدەهیا ئاڤێ دنافبەرا 78%-77% دگەل 18% ژ ئافا ژێر زەڤی ژ بارانێن سالانە پێکدهات. ئەگەرا زڤرینێ بو زێدە ئاڤیێ هەر دوو سالا جارەکێ هەیە ب رێژا 50% د ناڤبەرا (565-907 ملیمەتر/سالانە) و 50% د ناڤبەرا (363-530 ملیمەتر/سالانە) ل دیف ئێك. بەلێ ئەگەرێ زڤرینا ئاڤێ بو پترین (907 ملیمەتر/سالانە) و کێمترین (363 ملیمەتر/سالانە) یا زێدە ئافیێ بو سالا بهێتن دگهیتە 10% و 90% سالانە ل دیف ئێك

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تـقدير معاملات الموازنـة المائيـــة لحوض روكرم منطقـــة مانكيـــش محافظة دهوك - أقليـم كوردســـتان العـراق

الخلاصـــة/

تحليل بعض العناصر الهيدرولوجية الخاصة بالموازنة المائية لحوض روكرم و الذي يقع في منطقة مانكيش في محافظة دهوك اقليم كوردستان العراق والذي يبعد حوالي 45 كيلومتر شمال شرق مدينة دهوك. الدراسة تغطي حوالي 179.5 كم^2، استخدمت البيانات المتوفرة لسقوط الامطار من محطة دائرة زراعة مانكيش لحساب معاملات الموازنة المائية للفترة من 2012-2013 الى 2020-2021. وان معدل سقوط الامطار السنوية هو حوالي 783.5مليمتر والتي سقطت خلال 56 يوماً من ثمانية اشهر ممطرة من كل سنة. علماً ان شهر اذار هو الاكثر مطراً والتي تصل فيها الامطار الي حوالي 158.4 مليمتر. ويعد فصل الشتاء من اكثر فصول السنة مطرا حيث تبلغ حوالي 47.7% من مجموع الامطار السنوية. كما ان اعلى سقطتي مطر يومية خلال الاشهر الثمانية تمثل حوالي 46.1% من الامطار الساقطة سنوياً والتي تسبب الجريان السطحي. الزيادة المائية شكلت مابين 78%-77% مع حوالي 18% تغذية مياه الجوفية، احتمال العودة الزمنية للزيادة المائية لكل سنتين قد تكون 50% مابين(565-905 مليمتر/السنة) و 50% مابين(363-530 مليمتر/سنة) على التوالي، بينما احتمال العودة الزمنية لاعلى (907مليمتر/سنة) و ادنى (363 مليمتر/سنة) زيادة مائية خلال السنة القادمة هي 10% و 90% على التوالي.