ABSTRACT: This study is aimed at evaluating loss methods affecting the runoff volume and hydrograph shape produced resulting from effective hydrological methods. Here, the effective parameters in the volume of runoff and were studied in Marg wave basin and Debi and precipitation values of the basin were prepared and arranged with common basis and their units were converted into millimeters. Correlation coefficient of the runoff was calculated with precipitation height and average annual precipitation was determined using calculus mean, Tisen and precipitation curves, and the annual aquatic volume of the basin was calculated based on each of the methods. To exactly recognize flood characteristics of the basin under study (beginning, continuance, end, and amount), hydrograph of Mahidasht Marg River was prepared. Then the hydrograph characteristics calculated including runoff volume and peak time was observed in corresponding hydrographs with the same properties. And the unit hydrograph was gained using Soil Conservation Service (S.C.S) method.

Key words: runoff, precipitation, basin flow index, Marg River

INTRODUCTION

Water and the resources depending on it are considered as the factor of growth and development in human societies and achieving development in agricultural, economic and social fields will be realized with the existence of high quality water resources. Considering Iran with an area of 164195000km² and population 74 million as well as dry to semi-dry climate status with an annual average precipitation of 220-240mm, precipitation decrease in Iran and the world and finally appearance of drought as an important phenomenon require a scientific and specialized handling and continuous applied studies regarding water resources management. Marg River is emanated from south west and south east heights of Mahidasht and also Tiranz, Mirazizi, Khivar Bur Bur and Ghareh Daneh mirages as well as waters from the melting of snow from heights located at south Kermanshah such as green heights of Amoo Nesar and kouh Sefid (Enayati, 1993). Indeed, the river is considered as the drainage of Mahidasht water, its route is from east to west at the origin and connected to Gharehsu River near a place called Doaab after passing across Mahidasht (power ministry, 1999). From the distance, its route is gradually deviated toward the north and in the end totally in the east-west upon being connected to Gharehsu (Azizi, 1983). The river basin surface is calculated about 1508km² before being connected to Gharehsu (power ministry, 1997). The issue of estimating surface runoff in rivers basins is very complicated leading to a limited human information and perception of the physics rules governing it from a mathematical point of view (Sing, 1998). And achieving its qualitative and quantitative amount comprises the basis of various research designs for developing and exploiting water resources and aquatic structures. Since mid 1990s, empirical various methods and hydrologic models have been provided for estimation and calculation of the surface runoff (Sing, 1998). Since 1960s, the methods have been represented in terms of computer models (Takushi, 1999). The component of some of the models might alternatively be biased cause of the precipitation time and place distribution (Yang, 2000). Accordingly, great many researchers could anticipate the floods using linear equations and removing the errors. Some hydrologists have mentioned issues such as lack of data, absence of accuracy, and short statistical term to determine the relationship between the precipitation and runoff (Ghayur, 2000). Some have combined mathematical models and calculated the runoff (Sorushian, 1983). In this regard, simulation hypotheses of precipitation-runoff are provided as the probable, conceptual, empirical and distributional (deterministic) and consistent (bank) models by the researchers (Chaw, 1998) and different GIS capabilities are also considered by most hydrologists along with precipitation-runoff modeling. Chaw et al divided the rain loss methods into two general classes. The first are methods based on
hydrologic and morphologic characteristics of the basin; and the second are the methods gained based on basin precipitation-runoff curves CN data observed. Flood processing is defined as a set of operations through which the amplitude and time of a flood wave is determined in a point on river route using presumption or real-time information existing in one or several upstream points (Ragunat, 1997). In general, flood processing methods are divided into two hydraulic and hydrologic processing methods (Chadhuri, 2002). If the water flow is processed just in terms of a time function in a certain place, the method is called hydraulic processing or bank or centralized processing (Winman & Larson, 1979) in which consistency principle of flow and Debi-reserve relationship (given that the flow is consistent) are used. If the flow processing is a function of time and place through the system, the method is called hydraulic or distributional processing (Chaw, 1998). In the method, flow consistency equation and motion value equation are used and it is based on impermanent flows theories (Shaw, 1994). Hydraulic processing is more accurate; however, its main pitfall is the complexity and solving equations (Tsai, 2005). Hydraulic processing is simpler but the outcomes of the method are less accurate (SCS, 1985). Bari and Bachra Cahi (1995) have studied the processing method of Maxingam-Kanzhra and demonstrated that for the sake of the model sustainability Kurant number of the model must be less than 0.5 so that the estimated outcomes be of sufficient accuracy.

MATERIALS AND METHODS

Geographical Status in the Area under Study

The zone under study is located at south Kermanshah and in the Political-Official area of the province; the geographical coordinates of the basin is located between 5°, 31' 46" to 20°, 22' 47" eastern length and 20', 34" to 33', 34" of the northern width. Total square of Marg basin is 1438 km² allocating Mahidasht basin and an area of 839 km² to itself (Figure 1).

![Figure 1. country- and province-wise status of Mahidasht Basin (p4)](image)

Data Used and Data Analysis Procedure

To study the relationship between the runoff and annual precipitation of Marg basin the following is conducted:

Debi and precipitation values of the basin were prepared, organized and their units were converted into millimeter. Correlation coefficient of the runoff is calculated with the precipitation height ($r=\%66$) and is at a meaningful level. The status of the points on coordinates axis of plot and the line proportionate with them are drawn. Upon drawing optimum line, it was determined that the status of values and Debi of 78-79 and 79-80 and 80-81 have a great difference from it. so, regarding the probable error behind the values, data of the three
years were not included in the calculations and as a result the amount of correlation (r=88) is at a meaningful level. To calculate the runoff with the precipitation, the equation below was used (Alizadeh, 1987, p287).

Equation (1) \[ Q = \frac{1}{S} (P - P_a) \]

Q: the height of annual runoff (mm)
S: line slope
P: annual precipitation (mm)
P_a: ordinate (mm)

Upon required calculations, correlation and Debi with precipitation equations of Marg basin were changed as (p=17.2) Q= %986. As a result, the ordinate of the basin is 17.2mm, namely, if the annual precipitation is equal or less than 17.2, surface flow will equal 0. Diagram (1) shows the relationship between the runoff and annual precipitation. Based on the diagram and or using the above mentioned equation, it is possible to anticipate the amount of another variable by considering one of the two variables. For instance, if average annual precipitation of a year is 680mm, resulting runoff height of the year will be 65mm.

![Diagram](image)

Figure2. the relationship between runoff and annual precipitation

**Surface Flow Index**

The amount of surface runoff of the basin is a function of factors such as rainfall intensity and time, soil porosity, ground slope and plant cover. To determine surface flow index of the basin, two calculation and inferential methods below are used (Drawn Wiseman, 1988).

Two calculation methods of average runoff height was determined and divided by the basin average precipitation. Accordingly, resulting runoff index is 0.1 or 0.10. To determine surface flow index in inferential method, first area and slope of different cover slopes of the basin under study (farmlands, meadow and forest) were defined. Then, mean weight of the surface runoff index was determined as %34.

**Aquatic Volume of the Basin**

It is defined as the product of the square and the precipitation height; regarding the average annual precipitation estimation using calculus mean, Tisen and coprecipitation curves, and annual aquatic volume of the basin was calculated using each of the methods the amounts of which are respectively as follow: 598,927,000m³, 623,516,800m³, 677,154,200m³, and annual aquatic volume of the basin of Mahidasht station was 555,068,000m³.

**Hydrographic Area and Flood Analysis of the Basin**
Hydrograph is a diagram showing Debi changes to time; if we have a rainfall of t hours on a basin with a concentration level of tc hours and t>xc, Debi will gradually increase and reach the peak in a time less than concentration time (tc). Then, till it continues and the amount of runoff remains fixed and after it stops the Debi will gradually increase. Using the hydrograph, it is possible to determine the beginning and end points of the flood, the time Debi reaches the peak, the estate of increase and decrease of the Debi amount, flood consistence and water volume.

To accurately determine flood characteristics of the basin under study (beginning, continuing and ending), the hydrographs of Marg River, Mahidasht were provided each of which are analyzed.

**Hydrograph of the Unit**

Based on hydrograph definition: Th of runoff volume flow with a height of unit mm/cm on the basin is called the hydrograph. By precipitation runoff, we mean upon saturation, the soil is transformed into surface flow. Providing unit hydrograph of the basin requires the basin precipitation statistics and the Debi of hour to hour. (Hydrologs recommend that for drawing the unit hydrograph of the basin with an area of 250 to 2500km², downfalls of s6 and 8 or 12h are used). Since the amount of precipitation and Debi of Marg River basin is not measured in terms of hour to hour and the unit hydrograph of the basin under study was prepared using Soil Conservation Service (S.C.S) of the U.S. various steps of calculating the unit hydrograph of Marg River using S.C.S are as follow:

Delay time which is the distance between precipitation center and Debi peak point calculated through the following formula:

\[ t_1 = \frac{L^{0.64} (S + 1)^{0.7}}{781/64 \times 0.65} \]

\( t_1 \): delay time (h)
\( L \): river length (m)
\( G \): average basin slope (%)
\( S \): maintenance index depending on the curve number and calculated through the following formula …

Based on the above formula and the calculations conducted, delay time of the basin was gained as \( t_1 = 10.8 \) (Alizadeh, 1997).

**Concentration Time**

Concentration time of the basin under study was determined through the following equation:

\[ t_c = \frac{5}{3} t_1 \]

\( t_c \): concentration time (h)
\( t_1 \): delay time

Using the formula, the basin concentration time was calculated (\( T_c = 18h \)).

**Precipitation Time**

In S.C.S, we can alternatively select the hydrograph unit time and at the same time it is recommended that the precipitation time to be considered %133D of the concentration duration. Accordingly, the duration of precipitation of the basin under study equals 2.39h.

**The Time of reaching Peak Debi**

The time of reaching peak Debi of the basin under study was determined using the following equation:

\[ T_p = \frac{D}{2} + t_1 \]

\( T_p \): the time of reaching peak Debi (h)
\( D \): precipitation duration
\( t_1 \): delay time

Using the formula, the span of reaching peak Debi was determined as 12h for Marg River.

**Peak Debi**

Peak Debi of the basin was calculated via the following formula.

\[ QP = \frac{\Delta Y \Delta A}{T P} \]

\( QP \): peak Debi amount is in l/s equal an inch precipitation
\( A \): basin area
\( T \): peak Debi time
Peak Debi quantity (PQ) was calculated as 24.9 m³/s for one millimeter of rain using Marg River hydrograph. Upon the latter calculations, the quantity of 12 (TP) in column (t/TP) and the quantity of OP (24.9) in column was multiplied into q/qp of the hydrograph table of the next unit (S.C.S). As a result, the quantities of the hydrograph point's status were gained.

12h after the beginning of the rain, the quantity of Debi reached its maximum amount (24.9 m³). Flood duration was 60h. The upstream arm of the hydrograph had a more severe slope than the downstream one. The flood will end in 24h after the peak Debi duration.

**Hydrograph Design**

To calculate the hydrograph, a precipitation design is considered as calculation basis called precipitation design, because estimating maximum quantitative capacity of meteorological capacity (precipitation design) of an area is with a vital capacity to the estate of constructing infrastructure establishments such as bridge, drainage network route, dam, town and the like.

Because destruction of these structures create enormous financial damages and sometimes life harms. Regarding the necessity of the issue, design precipitation parameter is studied before the design hydrograph analysis. Based on the definition, probable maximum precipitation (PMP) is the greatest precipitation probable in a certain time and considering atmospheric, climate, and topographic conditions of the zone, and there would be no greater rain than that. Probable maximum precipitation of the basin under study was calculated using the statistical method below (Alizadeh, 1997, 608).

Formula $P.M.P = \bar{R} + KM \times S$

- **PMP**: probable maximum precipitation
- **R**: mean maximum precipitations in a certain time (usually 24h)
- **KM**: constant 15
- **S**: standard deviation

Based on the formula, probable maximum precipitation of Marg River is 2.9mm in 24h. Design hydrograph of the basin under study is provided based on S.C.S. the method is based on direct calculation of the runoff and use of the curves provided by soil conservation service of the US. The service introduces two types of designs for constructing small dams (with a capacity less than 30Mm³) regarding the amount of precipitation. That the emergency overhead of dams has the capacity required for flood discharge. Free height over the crown is enough.

To prepare and draw design hydrograph of Marg River basin, its quantities were calculated based on respective formulae which are as follow:

- Design precipitation quantity (probable maximum precipitation) (in) $PMP=8.62\text{in}$
- Reformed precipitation amount regarding the area and climate of the basin $\text{revp}=5.603\text{in}$
- Modifying precipitation based on concentration time index $7.62\text{in}$
- Runoff height based on CN number and precipitation $Q=51\text{in}$
- Hydrograph set number based on CN and modified precipitation equal 2
- Extra precipitation duration $T_0=15.37\text{hr}$
- Peak time of hydrograph $TP=12.6\text{hr}$
- Ratio $T_p/T=1.2$
- Modified TP quantity is $15.37\text{hr}$
- Debi quantity for one mm/s precipitation
- Peak Debi for basin maximum precipitation $2525.5\text{m}^3/\text{s}$

Now, to determine the status of the points on hydrograph coordinates axis, Rev (TP) was multiplied to $T/TP$ quantities of respective table and as a result the quantity of it was gained in hour. Also, the quantity of Q (QP) was multiplied to $qC/Qp$ column figures and the q quantities were gained for each t numbers in m³/s. The result will beusing the calculated amounts for hydrograph Debi quantity. Resulting flood continues for 90.4h. The river Debi reaches the peak after 21.5h. Debi quantity at peak time is $88\text{m}^3/\text{s}$. peak Debi quantity for probable maximum precipitation of 24h is $2528.8\text{m}^3/\text{s}$. Regarding the latter calculations, it is concluded that if infrastructures like dam, bridge, communication route, drainage network are to be constructed in the basin, they must be designed in a way that they can resist a flood with peak Debi of $2525.8\text{m}^3/\text{s}$, on the other hand, considering current climate and physiographic conditions, the basin will not face a flood over $2525.8\text{m}^3/\text{s}$.

S quantities are calculated using Berlton method as $2*10^{-2}$ and $5*10^{-2}$ for open water table of the plain and reserve index gained for testing surrounded water tables are about $10^{-5}$ and $10^{-2}$.

**CONCLUSION**

General study of the relationship between runoff, precipitation and basin flow index of Marg River basin in Mahidasht resulted in the followings:
Upon necessary calculations, correlation and Debi with precipitation equations of Marg basin was
gained as \( p=17.2 \) Q= 986. As a result, the ordinate for basin is 17.2mm, namely, if annual precipitation
quantity is equal or less than 17.2, surface flow will be 0.

Peak Debi duration calculated for Marg River is determined 12h.

peak Debi quantity for probable maximum precipitation of 24h is 2528.8m\(^3\)/s. Regarding the latter
calculations, it is concluded that if infrastructures like dam, bridge, communication route, drainage network are
to be constructed in the basin, they must be designed in a way that they can resist a flood with peak Debi of
2525.8m\(^3\)/s, on the other hand, considering current climate and physiographic conditions, the basin will not face
a flood over 2525.8m\(^3\)/s.

S quantities are calculated using Berlton method as 2*10\(^{-2}\) and 5*10\(^{-2}\) for open water table of the plain
and reserve index gained for testing surrounded water tables are about 10\(^{-5}\) and 10\(^{-6}\).

REFERENCES

Alizadeh A. 1997. principles of applied hydrology, Ferdowsi University of Mashhad, 8th print
Azizi J. 1983. studying Mahidasht underground water tables, Kermanshah Water Affairs
Enayati V. 1993. Studying climatology of surface waters of Marg River, University of Tehran
Kahrizi MT, Kamal BA. 2010. Collection of articles for 1st conference of regional water organization of water, Iran water resources
(hydrology, hydraulic and various aspects)
Kakavand R. 2000. Studying the relationship between precipitation and flood hydrograph using synoptic
Kermanshah Province consulting engineers of water and soil, spring 1997, Kermanshah
Ministry of Power.1999.statistical yearbooks of precipitation-metric stations ofJajrud basin, MS thesis, Tarbiat Moalem University,
Tehran
Ministry of Power.1999. studying and recognizing Mahidasht underground waters
Ministry of Power.1999.statistical yearbooks of precipitation-metric stations ofLalehvan-Mohabatabad, Khosroabad, Gharebaghestan
Tamab consulting engineers. 2003, assessing ecological power of Mahidasht basin from agriculture perspective
West Region Water Organization.1999. water and soil affairs of Kermanshah Province