EXPLORATION OF THE RELATION BETWEEN THE MAXIMUM RUNOFF AND THE AVERAGE RIVER RUNOFF IN SOME BULGARIAN RIVERS

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Abstract

The data on the maximum river runoff are extremely important because they help determine a number of dimensional characteristics of the hydrotechnical facilities, the magnitude of the high wave for the purpose of flood protection and others. Frequently, in hydrological practice, there is no data from its immediate observation. We investigate the possibility of recovering the maximum outflow data on the average runoff data. Some Bulgarian river catchments were investigated. Several correlation coefficients have been calculated. The closest is the relationship between the maximum monthly water runoff and the average monthly water runoff.

Keywords: *data recovering, maximum annual water runoff, average annual water runoff*

INTRODUCTION

Extreme natural phenomena (floods and droughts) have increased in recent years. Under these conditions, the management of the built dams and water systems is of paramount importance, both for taking the expected inflow and flood prevention, and for securing the water consumption during periods of drought.

The possibility of receiving an extreme inflow (in high wave and high water) is determined in each case by the ratio between the available free volume in the dam and the maximum expected inflow (maximum water quantity and maximum water volume), by the capacity of the relief facilities and of the downstream reservoir zone, and others. An approach for estimation of the maximum monthly inflow to the reservoirs and the necessary free volumes for their management in situation of high levels have been developed in NIMH and it has been applied in practice [6]. The estimation of the retention volumes, the expected inflow volumes (dispatching schedules for management of the dams by high water levels), the technical safety of the HTF (Hydro-technical Facilities) are directly related to the adequate and correct estimation of the extreme inflow and reduce the damages [4,5]. On the other hand, the justification of an approach for assessing the extreme inflows to the dams depends on the correct formulation and solution of the relevant hydrological, hydraulic, hydrotechnical and water economic tasks.

MATERIALS AND METHODS

The research presents a new approach for Bulgaria to determine the maximum inflow in the absence of data. It is based on the statistical relationship between the maximum monthly water discharge and the average monthly water discharge. According to the genetic theory of flow formation, a whole set of factors influences the high wave peak. The most important of these are precipitation intensity, snowfall intensity, snow cover thickness and density and much more. Since the process of deciphering is extremely complex, the access to daily or hourly observations data is limited and for most of the dams there is no such data, the idea of estimating the statistical relationship between the maximum runoff and the average monthly runoff, for which in most cases data exist, occurs. Such a relationship has already been investigated in the territory of Russia [1].

A total of 13 water catchments were studied. They are divided into 3 river basins:

- Water catchment area of Mesta River - 7 catchments
- Water catchment area of Struma River - 3 catchments
- Water catchment area of Arda River - 3 catchments

The water catchment area recommendations for which the method can be applied are followed. The requirements for at least a 20-year observation period are also met. In this study, estimates were made for a 26-year period.

Table 1. Hydrological characteristics of the catchments [2]

RESULTS AND DISCUSSION

The values of the correlation coefficient k1 between the maximum annual water discharge Q_{max} and the average annual water discharge $Q_{ave\ ann}$ are presented. (Table 2).
Depending on its values, catchments are divided into the following groups:

- 0.2 - 0.4 – weak correlation - 4 catchments
- 0.4 - 0.6 - moderate correlation - 3 catchments
- 0.6 - 0.8 - significant correlation - 6 catchments

Table 2. Correlation coefficients between the maximum annual water discharge Q_{max} and the average annual water discharge $Q_{ave\ ann}$

In attempting to increase the correlation coefficients the relationship between the maximum annual water discharge Q_{max} and the maximum average monthly runoff $maxQ_{avemonth}$ was investigated. The results did not improve.
Depending on the values of the new correlation coefficient k2, the catchments are divided into the following groups:

- 0.0 - 0.4 - weak correlation - 6 catchments
- 0.4 - 0.6 - moderate correlation - 2 catchments
- 0.6 - 0.8 - significant correlation - 5 catchments

Compared with the previous coefficient, there are also catchments where the correlation is weak at the expense of reducing the number of catchments with significant and high correlation. It is found that it is better to apply the $Q_{max}/Q_{aveann.}$ coefficient.

Table 3. Correlation coefficients between the maximum annual water discharge Q_{max} and the maximum average monthly water discharge $maxQ_{avemonth}$.

The correlation connection, examined by months, shows higher values. The table 3 shows the correlation coefficients between the maximum monthly water quantity $Q_{max\ month}$. and the average monthly water quantity $Q_{ave\ month}$. for each month.
Monthly values of the correlation often are very high, with correlation coefficients above 0.6-0.8. They are more typical for the periods of high water (from November to February or in the spring months) in the respective catchment. The highest values of the coefficient are observed in the months of February and December at HMS Zlataritsa-Eleshnitsa, in March at HMS Mesta-Momina Kula and others. They are the lowest in September and October at HMS Mesta-Yakoruda and others.

Table 4. Correlation coefficients between the maximum monthly water discharge $Q_{max\ month}$ and the average monthly water discharge $Q_{ave\ month}$.

CONCLUSION

Recovery of the maximum runoff data by this method is more reliable in catchment areas where there are no intruders significantly altering the natural river runoff. To recover missing data of maximum outflow, it is better to use the relationship between the maximum annual water runoff Q_{max} and the average annual water runoff $Q_{ave\ ann}$ than the relationship with the maximum average monthly runoff $maxQ_{ave\ month}$.

It is even more reliable if the maximum outflow is recovered on a monthly basis. Then, especially during the period of high water, the relationship with the average monthly outflow is even narrower.

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Table 1. Hydrological characteristics of catchments

	River-HMS	Area (F), km2	AveElevation Watershed, m
Water catchment area of Mesta River	Mesta-Yakoruda	262.00	1712
	Mesta-Momina kula	1510.00	1422
	Mesta-Hadzhidimovo	2260.00	1310
	Votrachka-Belitsa	33.48	1826
	Zlataritsa-Eleshnitsa	91.20	1300
	Breznishka-Breznitsa	39.48	1597
	Kanina-Beslet	49.90	1550
Water catchment area of Struma River	Dragovishtitsa-Goranovtsi	819.00	1188
	Novoselska-Slokoshtitsa	63.50	1240
	Eleshnitsa-Vaksevo	315.20	1058
Water catchment area of Arda River	Varbitsa-Varli dol	471.20	647
	Varbitsa-Dzhebel	1149.00	584
	Krumovitsa-Krumovgrad	497.60	494

Table 2. Correlation coefficients between the maximum annual water discharge Qmax and the average annual water discharge Qaveann.

Qmax/Qaveann.	River - HMS	k1
Water catchment area of Mesta River	Mesta-Yakoruda	0.45
	Mesta-Momina kula	0.51
	Mesta-Hadzhidimovo	0.61
	Votrachka-Belitsa	0.66
	Zlataritsa-Eleshnitsa	0.39
	Breznishka-Breznitsa	0.62
	Kanina-Beslet	0.58
Water catchment area of Struma River	Dragovishtitsa-Goranovtsi	0.71
	Novoselska-Slokoshtitsa	0.30
	Eleshnitsa-Vaksevo	0.32
Water catchment area of Arda River	Varbitsa-Varli dol	0.60
	Varbitsa-Dzhebel	0.37
	Krumovitsa-Krumovgrad	0.71

Table 3. Correlation coefficients between the maximum annual water discharge Qmax and the maximum average monthly water discharge $maxQ_{avemonth}$.

Qmax/maxQavemonth.	River - HMS	k2
Water catchment area of Mesta River	Mesta-Yakoruda	0.05
	Mesta-Momina kula	0.59
	Mesta-Hadzhidimovo	0.62
	Votrachka-Belitsa	0.65
	Zlataritsa-Eleshnitsa	0.39
	Breznishka-Breznitsa	0.57
	Kanina-Beslet	0.64
Water catchment area of Struma River	Dragovishtitsa-Goranovtsi	0.65
	Novoselska-Slokoshtitsa	0.14
	Eleshnitsa-Vaksevo	0.34
Water catchment area of Arda River	Varbitsa-Varli dol	0.25
	Varbitsa-Dzhebel	0.30
	Krumovitsa-Krumovgrad	0.66

Table 4. Correlation coefficients between the maximum monthly water discharge $Q_{maxmonth}$ and the average monthly water discharge $Q_{avemonth}$

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Mesta-Yakoruda	0.61	0.62	0.74	0.87	0.69	0.56	0.74	0.41	0.04	0.10	0.74	0.59
Mesta-Momina kula	0.85	0.86	0.93	0.30	0.54	0.51	0.62	0.57	0.71	0.86	0.82	0.87
Mesta-Hadzhidimovo	0.70	0.88	0.88	0.39	0.43	0.58	0.72	0.87	0.65	0.84	0.73	0.82
Votrachka-Belitsa	0.62	0.51	0.77	0.83	0.81	0.62	0.92	0.60	0.57	0.73	0.85	0.85
Zlataritsa-Eleshnitsa	0.83	0.94	0.81	0.76	0.39	0.30	0.77	0.24	0.29	0.89	0.61	0.92
Breznishka-Breznitsa	0.69	0.82	0.82	0.68	0.69	0.54	0.31	0.42	0.68	0.86	0.28	0.83
Kanina-Beslet	0.86	0.64	0.72	0.51	0.84	0.84	0.51	0.20	0.63	0.74	0.91	0.71
Dragovishtitsa-Goranovtsi	0.87	0.89	0.78	0.90	0.78	0.90	0.71	0.25	0.56	0.84	0.70	0.67
Novoselska-Slokoshtitsa	0.73	0.84	0.86	0.69	0.56	0.75	0.74	0.43	0.50	0.48	0.60	0.80
Eleshnitsa-Vaksevo	0.88	0.78	0.75	0.54	0.43	0.39	0.70	0.11	0.25	0.65	0.83	0.68
Varbitsa-Varli dol	0.73	0.02	0.85	0.83	0.80	0.85	0.87	0.84	0.85	0.74	0.84	0.68
Varbitsa-Dzhebel	0.90	0.80	0.87	0.70	0.83	0.90	0.94	0.71	0.80	0.85	0.72	0.68
Krumovitsa-Krumovgrad	0.84	0.77	0.67	0.75	0.85	0.74	0.71	0.49	0.51	0.70	0.72	0.81