Hazardous Events on the Black Sea Rivers, Their dynamics and Regulation

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Abstract: The historical, informational and literary sources regarding flooding have been studied. Based on the statistical processing of multiyear stationary observation data the river maximal discharge parameters are specified. According tendency of their dynamics the flooding strengthening has been revealed on rivers nourished by glaciers, on the contrary in other rivers they reduced, in some regions evaporation has been increased and desertification has been detected. For mitigation negative impacts of those processes the recommendations of prevention measures are drafted.

Key words: River water discharge, flooding, climate change, forecasting method.

1. Introduction

Current climate change caused air temperature rising, disruption of climatic cycles. In connection with global climate change on the Earth the number of catastrophic floods has been enormously increased and caused great damages. This problem is especially urgent for Georgia where high waters and continuous floods are preconditioned by the landscape-climatic state. On each spring season mountainous rivers and dry gaps run in strong flows toward to the lowlands.

Except of spring floods on Georgian rivers take place high waters at any season of year that in rainy periods take catastrophic character. Also because of the growth of anthropogenic impact (elimination of lakes and growth) the high water increases, that caused irreversible destruction to the separate regions, population, industry, nature and ecological state. Especially during last 20 years in Georgia there were repeated large-scaled catastrophes in several times, that damaged economy significantly [1].

As it is known river discharge for given relief is variable. But still there doesn't exist method that

perfectly describes river discharge variation, as this variation is conditioned not only by local factors but also helio-synoptical processes which consideration is difficult. Besides that, present eustasy—uniform worldwide change in sea level caused by water thermal expansion, imbalance of fresh waters between the land and the ocean in favour of the ocean, seriously threatens Black sea coastline, where the sea level has raised by 20 cm and this is a continuous process with unfavorable forecast.

2. Study Area

In Georgia river water content has been accounted from 30th years of XX Century. For characterization of observation series deviation methods of mathematical statistics are used in hydrology. The river water maximal discharge observation line elements are random quantities and varying from arithmetical middling values. The variation line main characters of Georgian Black Sea river maximal discharges: arithmetical middling (norm), members of its variation (variation C_v and asymmetry C_s), biggest values and others are given in Table 1. Mentioned data have great practical significance in water economy calculations especially now when observation post has been sharply reduced and only river levels are

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measured.

The calculations of river discharge expected change for economical organizations is important using well-known probability curves that corresponds the issue: what is the assurance of construction or some measurement at definite values of river discharge. For construction of such curves and calculation of river maximal discharge probable values the graph-analytical method [2] is used. The obtained 1%, 2%, 5% and 10% probability (corresponding 100, 80, 20 and 10 year frequency) maximal discharges are given in table. The frequency indicates on that year number when maximal discharge happens only once in average. It is remarkable that according probability values calculated by past year data are less than present values. For example 1% probability discharges exceeds calculated discharges up to 1962 on 15%-20%, that is caused by climate global change.

From practical point of view for all type of hydrotechnical construction the identification of water maximal discharge of different probability types but also its maximal threshold values. For this the flooding activity members are used, calculated by

dividing river maximal discharge ($Q_{\max}$ m³/sec) to its mean annual discharge (Q_0 m³/sec): $Q_{\max}/Q_0$ values for Caucasus Region has been calculated firstly using 1974 year data in Ref. [3] work. Those members calculated by authors for Black Seaside River using new data are given in table.

By relevant analysis in Ref. [4] work is identified that flooding activity members reduce according increasing of river watershed basin square, their mean height, river water mean annual discharge and atmospheric precipitation. Or these members are more for little rivers than for big rivers, under wet environment conditions they are less than under dry conditions, in mountains their values decreased by height growth.

3. Results and Discussion

For assessment of further development of flooding the hydrometeorological processes variation dynamics study considering anthropogenic factors and climate global change became more urgent. For this the multiyear variation of river water maximal discharge causes great interest. In Fig. 1, the multiyear variation

Table 1 River water maximal discharge (Q , m³/sec) characteristics.

River-post	Area km ²	Height m.	Annual mean disch. Q_0	Mean max. disch. $Q_{\max}$	Cv	Cs	$Q_{\max}$	$\frac{Q_{\max}}{Q_0}$	Provision %			
									1	2	5	10
									Frequency, year			
									100	80	20	10
Bzipi-Jirkhva	1,410	1,690	98.2	502	0.37	4.4	1,890	19.2	1,315	1,100	844	669
Kodori-Lata	1,480	1,920	92.5	467	0.4	4.9	1,240	13.4	1,310	1,084	804	617
Enguri-Khaishi	2,780	2,320	118	507	0.54	4.5	1,190	10.1	1,530	1,299	984	783
Khobi-Legakhare	310	1,640	21.6	202	0.64	4.2	536	24.8	773	623	446	323
Rioni-Oni	1,060	2,260	44.8	178	0.34	0.6	382	8.93	319	300	277	255
Rioni-Alpana	2,830	1,810	103	630	0.43	4.2	1,470	14.3	1,808	1,506	1,134	880
Rioni-Sakochakidze	13,300	2,620	399	1805	0.4	1.5	5,500	13.8	4,236	3,805	3,236	2,776
Kvirila-Zestaphoni	2,490	960	60.7	513	0.34	0.5	1,100	18.1	958	896	807	732
Dzirula-Tseva	1,190	880	26	300	0.3	2.7	595	22.9	655	581	481	408
Khanistskali-Baghdati	695	1,230	15.9	118	0.48	1.2	209	13.1	294	264	226	193
Tskenishtskali-Luji	506	2,240	24.4	115	1.03	5.2	188	7.70	657	508	320	201
Tskenishtskali-Khidi	1,950	1,800	42.1	361	0.6	2.2	721	17.0	1,156	998	797	650
Supsa-Khidmaghala	1,100	970	50.8	484	0.39	3.2	692	13.6	1,219	1,043	839	702
Chorokhi-Erge	22,000	—	278	1495	0.56	4	3,840	13.8	4,803	3965	3,000	2,392
Adjaristskali-Keda	1,360	1,470	46.1	342	0.49	1.6	770	16.7	905	805	671	564

Fig. 1 The multiyear variation dynamics of river water maximal discharges in River Rioni (a) and Adjaristskali (b).

dynamics of river water maximal discharge is shown on river Rioni (a) on its lower part vil. Saqochakidze which sources are located in Caucasus and according Ref. [4] are 124 glaciers total square 63 km². On figure is also presented river Adjaaristskali (b) maximal discharge dynamics at vil. Keda in its basin glaciers are absent. River Rioni chart shows maximal discharge growth trend, and on River Adjaaristskali vice versa- maximal discharges reduce.

Averaged values of above said variations-trends are qualitatively assessed with linear regression. The analytical expressions with corresponding dispersion criteria are given at the chart. The river water maximal discharge mutually exclusive trends are caused by the fact that because of global climate warming the glaciers located in river Rioni basin and eternal snow cover have been intensively melted resulted in river discharge growth. Such process is excluded in river Adjaristskali basin where temperature rising causes evaporation growth from basin surface and river water discharges correspondingly reduced.

As the global warming still presents the air temperature growth is expected. These will undoubtedly caused intensification of eternal snow cover and glacier melting and river flooding increasing and in places where glaciers absent the evaporation increases and flooding reduce. Thus in river Rioni the flooding and river water maximal

discharge increasing is expected till on its outlet in Caucasus there exist glaciers and in river Adjaristskali flooding and their maximums reduces. According investigations conducted by Prof. Tsomaia "The Caucasus Ridge will became glacier free in 2150-2160 years" [1]. This process in region would cause water resources sharp reduction, spring drying, crop yield and water supply reduction and other negative events that would have harmful effect on environment, society and country development.

4. Recommendations

For present time against the background of current climate change the dangerous hydrometeorological events are intensified. The flooding frequency and damages increase and at the same time in some regions the desertification and water scarcity increase. For the mitigation of negative impacts of those processes the definite adaptation measures have to be conducted, included woodland restoration and enlargement, which is needed for moisture also for moisture deficit eradication and is flooding regulation measure, as wood canopy conserves for long time winter snow cover. Besides forest protects soil and reduces its erosion and desertification.

For river water regulation the most effective are reservoirs, because they can retain high water flows and mitigate catastrophic processes, and during low

waters they are the basic sources of water resources, which may simultaneously be used for various purposes: water supply, irrigation, power generation, fishing recreation-touristic zone and etc.. Thus for mountainous rivers the construction of small reservoirs would be useful. The construction in mountain regions is possible by the deepening of river basins or may be used intermountain depressions. Also natural lakes may be used as reservoirs; the most of them are nonfunctional.

The correct planning of water resources is essential for reservoir to use according to its intended purpose. For this the preliminary definition of the resources is needed. The forecasting of water discharge of Reservoir Rivers for different periods has been performed for this reason. Besides for efficient use of reservoirs as in west as in east Georgia the identification of river flooding and their maximal discharge is necessary, because they threaten not only reservoirs but also environment.

The formation of Georgian river discharge has been realized in different hydrometeorological and physical-geographical conditions. The water regime of each one is characterized by individuality and thus they aren't identical. For this reasons for each river the different forecasting methodic is needed. The flooding discharge is especially important when in rivers passed 60%-70% of all water annual discharges. According flooding discharge prognosis the planning of reservoir rational application has been drawn up. For this purpose the authors elaborated long-range forecasts of western Georgia river (Jvari and Vartsikhe) flooding discharges [5] and their maximal runoffs [6].

The forecasting methods are based on the multifactor statistical model, considering precipitation, snow water content and air temperature data. By using their timely and correct information in March it is possible to calculate 3-5 month beforehand forecasts.

Because in Georgia damages caused by flooding

and storm water still increase so for safety reasons the conducted of following measures are necessary: regularly clean and deepen river basins, extracted stones may be used in bank seat constructions. The river ravine lope must be terraced and mountain basement water channels have to be passed.

The most easily safety measure from water element is the flooding margin identification and declaration of this zone as dangerous, where all kind of industrial or living activity would be prohibited.

If according March prognosis the expected maximal discharges exceed its mean annual values (norm) and approach to their biggest values then the inhabitants must be informed and their and tangible property have to be evacuated and also environment ecological safety must be provided. For this reason the reservoir gradually timely emptying is essential to obtain further water big flow.

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