

POTAMOLOGICAL MONITORING IN MANAGMENT AND SPATIAL PLANNING OF BOSNIA AND HERZEGOVINA'S RIVERS

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Potamological monitoring includes hydrological stations distributed in river systems, which continuously record water levels, according to which water level and flows, are determined used in a variety of water management purposes. In addition, potamological monitoring data serve to define the area of indirect riverbed, and refers to the alluvial plain who at the time of the highest water levels is flooded and functions as a riverbed.

Alluvial plain during low and mid-water levels are very favorable pre-riverbed surfaces for various purposes of occasional or temporary use, especially in agriculture, when during the vegetation period, as a rule, average and average low, and often lowest water levels are achieved. Using these areas for other purposes is very risky and according to spatial planning rules unacceptable, particularly at the time of environmentally neglected watercourses in whose river beds bed load of anthropogenic origin are deposited. Upstream river gauge should harmonize, where the river bed gets shallow, and even during the average high water river water flows in the alluvial plain.

In order to prevent and reduce damage from floods it is necessary to introduce new automated system of potamological monitoring, which automatically supplies hydrological center with water levels data from all hydrological dispensaries of the same river system. At the same time potamological monitoring would be used to alert in the case of sudden increase in water levels, when taking measures and activities for flood protection.

Keywords: *potamological monitoring, alluvial plain, water level, spatial planning, automated potamological monitoring, protection.*

INTRODUCTION

Potamological monitoring followed by water level measurement gauge and limnigraph, established on thalweg of the major river system in Bosnia and Herzegovina does not meet water management and spatial planning purposes. The measured water levels with water level measurement gauge requires surveillance service, which detects water levels every day at 7:30, and changes waterlevel recorder tape from limnigraph every 7 days. Measured water levels in this way requires their analysis and when needed, disclosure of information in the central hydrological institutes.

Existing potamological monitoring does not satisfy needs of water resources of Bosnia and Herzegovina. In addition to this, river regime monitoring does not provide completely accurate and relevant data and is not adequate nor densely distributed in river systems and river network of Bosnia and Herzegovina. Thus, there is a multitude of streams, second,

third and nth rank that are not covered by potamological monitoring system, and therefore are not covered by hydrological analysis, especially when it comes to determining the water balance of the river flows of lower taxonomic rank which, most often, mountain streams . This need is imperative, especially when one takes into account the rational management of clean water resources.

Water levels in the major flows are influenced by the tributaries, where, apart from rare exceptions in Bosnia and Herzegovina, there is no network of potamological systems, though high water levels in major rivers are the consequence of the same effects on tributaries. High water levels on the tributaries cause changes in the river regime and at the same time are the key for forecasting high waters or flood waves in the middle and lower sections of major watercourses in Bosnia and Herzegovina.

All this directs the economic activities in a new phase of design, planning and mapping the network of potamological systems, as well as the substitution of existing, outdated, water level measurement gauge with modern automatic monitoring, in order to prevent the negative consequences related to river regimes. Modern automatic hydrological monitoring is in function of time alerting in case of the high water level danger in the river systems and river network by which time it can be able to take measures to protect people and property from flood waves.

WATER LEVELS

Potamological science defines water levels as the current water level in the river bed, and as the average water levels for a certain period of time. Water levels are determined by well-known and accepted methodology of water level measurement gauges, for daily visual readings of water levels and limnigraph for weekly analysis of continuous water level registered on the tape. Both water levels registering methods define current numerical state, without predicting the tendency of further development, such as stagnation, decline and rise in water levels. All these procedures and actions that determine the water levels are insufficient for understanding complex networking of physical-geographical phenomena and processes that determine the tendencies of future development. One of them can be continuous growth of the water level to the highest levels, causing enormous damage floods in river alluvial plain.

Hidrological monitoring and planning immediate measures for flood protection

Direct protection measures against flood waves and extremely high water levels includes registration of their height on each measuring system on the river system thalweg, including tributaries of the first rank. Networked data system of water levels, when taking measures for the protection of the floods, should be arranged by informing automatic hydrological monitoring, which alerts about the coming flood.

Prior to submission of the alarming water levels, it is necessary to analyze the current and future state meteorological of the and categories of water flow, given the morphography of the river basins, in order to understand the future trend of water level. If the results of the hydrological and meteorological monitoring show growth tendency in regard to currently registered, then the distribution center alerts the population to protect from flooding.

To comply protection measures against flood waves it is necessary to modernize the hydrological monitoring and substitute visual current numerical monitoring with automatic measuring instrument associated with telecommunications systems towards hydrological centers equipped for tracking and analyzing complex meteorological-hydrological trend of water level. In addition, hydrological centers are obliged to alarm the institutions about the acquired elevation of water levels, when taking direct measures of flood control.

On the basis of the alarming water levels height on the river system mapping is performed and based on the development of the meteorological situation trend of further development of the water level is estimated. Mapping monitorin current water level and the tendency of future development is with isolynes plotted on a topographic map of large scale or regional planning basis. Based on maps and plans we calculate the area affected by floods. In this way, define objects that need protection of the embankments, as well as their height regarding meteorological conditions.



Fig. 1. Geographical distribution of meteorological radar service in European Union member states

If the mapping system of one river system would get expanded and covered the river network of Bosnia and Herzegovina networked hydrological monitoring mapped system would be created. On the basis of this system form one or more centers measures for flood protection could be taken. In this way, proper insight of the vulnerability of the population and their material goods, according to which could predict the actual damage would be gained.

In order to get a clear idea of the meteorological conditions development complex analysis of the weather situation in the prior action centers of the atmosphere and tendencies of the weather immediate and future development is required. For this purpose, analyzed satellite images, are the most important and represent the initial synoptic indicator of weather development. All these steps and measures belong to the operational program for flood protection.

Modernization and development of hydrological monitoring, especially its automation, is of particular importance for smaller watercourses where, because of the fast creation of flood waves, remains a short period of time to undertake other activities on flood prevention. Automatic meteorological and hydrological monitoring allows forecasting of water level and river bottomland flooding.

Indirect measures for flood protection

In addition to direct measures and procedures that are applied in the protection of flood waves indirect measures and activities, which often include the non-investment measures for flood protection are also applied. They impact on reducing the damage and are related to the elimination of harmful consequences of the alarming flood waves.

Of the numerous indirect (previous) measures and activities undertaken in the river basins in order to reduce the consequences of high water on this occasion spatial planning

activities will be treated. They take into account high and extremely high water levels as a reality or segment of the natural basis of any spatial plan. Spatial planning involves analysis of mutual links and relations of natural geographical and social geographical phenomena and processes that determine the reality of the environment state, and in this case the river water against the river bed and its flood plain. Alluvial plains are key morphoforms for creating spatial basis, because floods manifest in them.

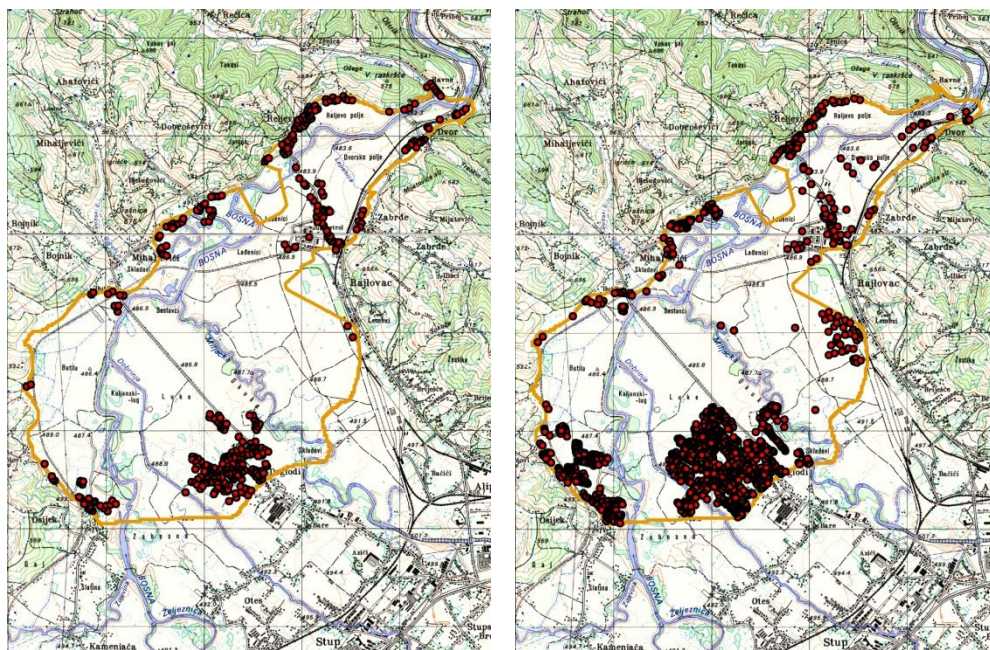


Fig. 2. Comparable topographical maps 1: 25 000 that represent the position of objects from 1975. year map to the left, and 2015. year map to the right in the alluvium of Bosnia and its tributaries. Yellow line marked the boundaries of the alluvial plain, which is flooded to extremely high water levels. Instead of relocation and rehabilitation of existing facilities, their numbers have increased, whether it be on legal or illegal construction with the 380, as it was in 1975. year on 1136 as registered in 2015. year.

Spatial base includes zoning, from lowest to highest, flood zones in river bottomlands, which exclude any construction. This potamological procedure is based on the analysis of cosmic images, which provide the recent basis, large scale topographic maps and hydrologic basis and calculations. In this way maps on which isobaths present areas that are occasionally flooded, and thus are not suitable for construction are produced. These risk maps define areas along the river that are lined with isobaths of high water levels on the basis of which they differentiate the valley bottom to the favorable or unfavorable for use. Risk maps are an integral part of spatial planning documents for institutions that issue permits for the usage of the area. Potentially flooded alluvial plains exclude any new construction, and if it is necessary, additional construction water protection actions need to be carried out. In the additional activities for the protection of high waters waves construction of reservoirs, which stop high water waves, and may be multi-purpose are included.

Spatial planning which defines the purpose of the space represents the most appropriate form of protection from floods. With this program, goes educational training program, which is realized through the educational system and continuous awareness development on rivers protection from anthropopressing. The set of training include those concerning the functional competence and expanding knowledge of professional services of the administrative apparatus, to its oversight and implementation of legislation.

DISCUSSION AND CONCLUSION

Water levels are not only numerical indicators in the system of hydrological services or published in hydrological bulletins. These data are very important in order to take measures for protection against extremely high water levels in the river valleys where the majority of the population of Bosnia and Herzegovina lives. Due to the lack of building space in urban areas, the population has more recently transformed to the suburban areas, usually lower, often in floodplain soil, to the extent that even the mid-water threaten them. These urban dislocation of private buildings in the alluvial plains, in the period of high and extremely high water levels are flooded.

In order to stop the process of alluvial plain settlement it is necessary to create a series of direct and indirect measures and activities that are most important. Indirect measures are related to the development of hydrological monitoring, and direct measures belong to the spatial and regional planning. These activities are based on a networked or complex analysis of natural geographical and social geographical phenomena and processes, which are closely related to hydrological processes.

Direct potamological complex analysis are related to the automation of hydrological monitoring, including their digitization, which directly to the hydrological center alerts the on water level when taking reasonable measures to protect against floods. Correspondent to modern hydrological monitoring, it is necessary to improve synoptic monitoring on the basis of which the anticipated future water level is predicted. Previous direct measure of establishing modern monitoring should include analysis for expanding network which are subject to permanent hydrometeorological measurements, on which extensive analysis of future conditions in a given basin could be undertaken.

In the immediate measures of protection against high water levels in existing urban areas are the construction of upstream dams, behind which water reservoirs that eliminate flood waves are formed. Water levels in the reservoirs must be brought into full correlation with the development of future meteorological conditions. For this purpose excess of water through the dam at the time of low water levels or just before the coming of high water levels is released.

Since these accumulation are multi-purpose, and usually for recreational purposes, need for long-term synoptic forecasts is exclusively required. If it is incorrect the consequences are evident. Wrong forecast of dry season leaves more water in the reservoir for recreation in the warmer periods of the year, which can be fatal, and in the humid period with a large amount of precipitation water will overflow over the dam and cause even greater damage. Also wrong humid forecast directs the release of water from the reservoir. If it is wrong and replaced with the dry season then accumulation, due to evaporation is converted into a marshy swamp complex that eliminates the possibility of recreation.

Indirect measures on reducing the causes of the high river water consequences are those resulting from the spatial planning. Spatial complex analytical procedures is

determined by water-bearing belt, and refers to the direct and indirect alluvial plain part of the river bed. The direct part of the river bed covers hydraulic radius, which includes river bottom and river sides with the banks, while indirect alluvial plain part of the river bed covers pre-river bed alluvium and alluvial plains. Hydraulic radius is actually river profile through which river water flows and the upper level varies depending on the category of precipitation water from the basin. Intermediate part of the river bed covers pre-river bed alluvium that is flooded by medium high water level, while alluvial plains occasionally flooded by extremely high water levels.

Alluvial plain represent productive agricultural land, and recently settlement area as well. Transformations of the city in the new suburbs on the alluvial plains is evident. Settlement of alluvial plains is contrary to the requirements of spatial planning, which is based on respect of defined water-protective zones and zones for the rehabilitation of the flood.

The indirect measures and activities for the protection of flood waves include population education about the proper zoning measures of water protection zones. Thus once the owner - builder realizes useless investment in construction of buildings, to which he must be indicated by the institutions that issue building permits, they will soon give up the original idea.



Fig. 4. Wrong forecast of isohyets regimes during the cold period of the year when large amounts of water were released from the lake Modrac, so (in the same period), winter rainfall brought by tributaries Spreča and Turija could be accumulated, which prolonged dry season in summer which caused a decrease in the area lake for 1/3. This had negative impact on summer-tourism season.

To ensure an adequate legal framework for the implementation of the proposed measures and activities in the field of flood protection, it is necessary as soon as possible to regulate and adapt the legislation requirements of modern potamological science, practices and principles of sustainable development. In the implementation framework is necessary to begin the substitution of the existing automatic monitoring. This program involves phased implementation of measures and activities on the reduction and elimination of flood waves and include: program, diagnostic and prognostic studies.

Initial or program research include analysis of the current hydrological monitoring. In the second diagnostic phase, recommendations for interpolation of new systems as well as proposals for their automation. In the third prognostic phase all river systems should be mapped and automatically connected to one or more hydrological centers, where competent institutions would be alerted in order to take measures and actions to rescue people and property from flood waves.

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