REDUCING THE EFFECTS CAUSED BY FLOODS, THROUGH HYDROLOGICAL MEASUREMENTS MADE AT THE CLUJ-NAPOCA HYDROMETRIC STATION

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Abstract: Due to the specific climate, the territory of Romania is frequently affected by floods. This work aims to highlight the way in which the main hydrological parameters of the Somesul Mic River are taken and processed, at its entrance into the Cluj-Napoca Municipality, in order to combat the phenomenon of flooding. The hydrometric station, which is a component part of the Somesul Mic hydropower complex, has the role of controlling the regime of the waters coming for the most part after the processing carried out by the upstream hydropower plants. This regime consists of determinations related to: water level and depth, flow rate, liquid and solid flows, water temperature, evaporation from the water surface, measurements on meteorological elements, collection of water samples for physical-chemical analyses. Within the automatic station there is the zonal dispatcher from the Somesul Mic hydrographic basin. Its centralized system consists of a software package implemented on a networkable IBM PC computer called "HIDROSIS" for the purpose of monitoring basin parameters (levels, temperatures, precipitation and water quality).

Keywords: flood, hydrological parameters, hydropower, flow

INTRODUCTION

Due to the specific climate, the territory of Romania is frequently affected by floods (Peptenatu et al. 2020). The need to pay more attention to this subject is given by the Water Law, which in article 34 provides the following: "In the areas where the riverbeds are arranged through defense works, consolidation, embankments or other such works, the obligation to maintain, repair or restore some such works, as well as the maintenance of the beds in the landscaped area, of the basins and the banks, are the responsibility of those who manage or operate the respective works" (LAW No. 107 of September 25, 1996). Also, the Ordinance of the Romanian Government regarding the "Legal Regime of Roads" provides in Article 1: "They are an integral part of the road: bridges, viaducts, uneven passages, tunnels, defense and consolidation constructions, sidewalks, tracks for cyclists..." (LAW no 82 of April 15, 1998).

Flooding means covering the land with a stagnant or moving layer of water, which by its size or duration causes damage and disrupts the smooth running of social and economic activities in the affected area (Ioniță and Nagavciuc, 2021). Floods are caused by random natural phenomena, accidental phenomena or human activities (Albano et al, 2020; Costache and Bui, 2017).

Watercourse overflows can be caused by:

- floods
- blocking the free flow of water by the sliding of the slopes in the bed or by the agglomeration of ice in curves or narrow sections.

River floods are the most frequent causes of flooding in Romania (Costache, 2019). They usually occur in the spring when, simultaneously with the melting of the snow, very heavy rains also fall; sometimes, due to very heavy rains, floods also occur in summer (Table 1); (Zaharia et al., 2017).

Table 1

Classification of floods according to the mode of production

Floods caused by natural phenomena	- overflows of water courses - waters from melting snow or precipitation - the rise of groundwater above the ground level due to infiltrations - sea storms
Floods caused by accidental phenomena	- breaking or damaging dams or other hydrotechnical constructions - the sudden sliding of the slopes in the basin of the reservoirs
Floods caused by human activities	- filling the tank of the reservoirs - the intentional removal of defense dykes - floods caused by earthquakes induced by accumulations

The Someșul Mic hydropower complex is a set of complex works intended for the production of electricity and the satisfaction of the water needs of the Municipality of Cluj-Napoca as well as the neighboring towns. In order to improve the hydropower parameters of the development, the collection and utilization of some flows from higher elevations and some tributaries from the Valea Ierii hydrographic basin was carried out (hidroconstructia.com).

The storage chain includes the Fântânele storage with Mărișelu underground CHP, the Tarnița storage, the Someșul Cald storage, the Gilău I and II, Florești I and II and MHE Cluj facilities. Among these accumulations, the most impressive is the Beliș-Fântânele lake, which was designed and executed in the years 1970-1974, a hydropower plant on the course of the Someșul Cald river, at the confluence of the Gilăului, Vlădeasa and Muntele Mare mountains. The lake has a surface of 9.8 Km2, a length of 13 Km and an average altitude of ~ 990m (Gheorghe, 2007).

The Gilău reservoir was formed following the construction of the dam in 1971, it being located within the radius of the commune of Gilău Jud. Cluj at an altitude of 422.25 m. The dimensions of the dam, 25 m high and 285 m wide, create the conditions for an accumulation of ~ 4.2 million m3 of water on a water surface of 70 Ha. The formed lake is the main source of drinking water for the Municipality of Cluj-Napoca, and upstream water pollution creates serious problems for the Gilău water plant, where the water captured from the lake is made potable.

The Mărișelu Hydrotechnical Development is the first step in the cascade of 8 hydropower plants of the Someșul Mic hydrographic basin, this being the most important in terms of its contribution to the national energy system. The Fântânele dam is made of rock with a concrete mask on the upstream face. 2,315,000 m3 of stone brought from a neighboring quarry were used to build the dam, 92 m high and 410 m long at the crest.

Fântânele Lake (Figure 1), impressive both in terms of its surface, 815 Ha, and its length, 22 Km, provides a total volume at the normal retention level of ~ 213 million m3 of which ~ 202 million is useful volume, allows the multi-year regularization of a average flow of approx. 12 m3/s and a flood mitigation volume of ~ 31 million m^3.

Figure 1. Lake Beliș-Fântânele

The Mărișelu Hydroelectric Power Plant (Figure 2) is of the underground type, being equipped with three Romanian-made Francis turbine hydro aggregates, with a unitary power of 75 MW which ensures the production of an annual energy of 390 GWh and allows the operation of system services in optimal parameters (Hidroelectrica.ro).

Figure 2. Marișelu Hydroelectric Power Plant

MATERIAL AND METHOD

In this paper we will refer to how the water level in the river is determined at the CLUJ-NAPOCA HYDROMETRIC STATION, as well as the link between level and flow through the tabular limnimetric key (Table 1; Figure 3); (Apostol and Aldea, 2016).

Table 1

Tabular limnimetric key

H	Q (m^3/s)									
cm	0	1	2	3	4	5	6	7	8	9
10	2	2,16	2,32	2,48	2,64	2,8	0,96	3,12	3,28	3,44
20	3,6	3,76	3,92	4,08	4,08	4,4	4,56	4,72	4,88	5,04
30	5,2	5,43	5,66	5,89	5,89	6,35	6,58	6,81	7,04	7,27
40	7,5	7,9	8,3	8,7	8,7	9,5	9,9	10,3	10,7	11,1
50	11,5									

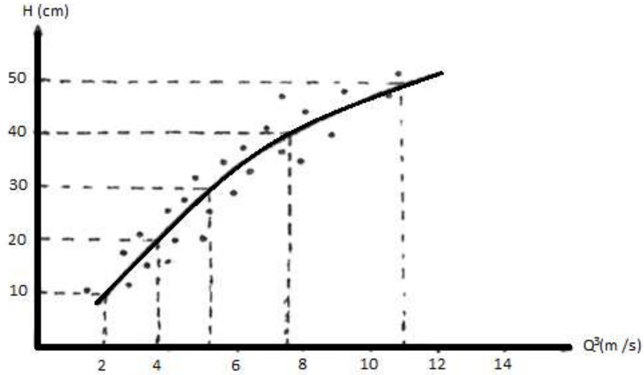
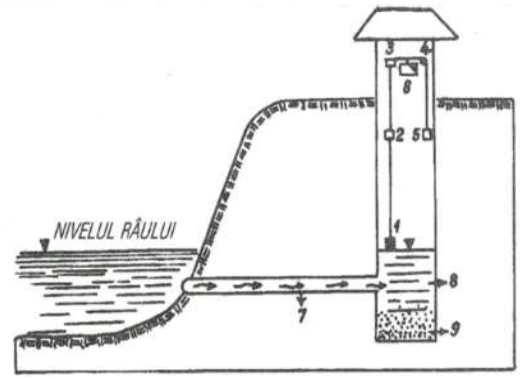


Figure 3. The graph of the tabular limnimetric key

To measure the water level, the following are used: the hydrometric gauges, the limnigraph (Figure 4) and the automatic taking over of the levels by means of a float sensor installed in the well of the limnigraph which allows us to continuously establish the water level in the Cluj-Napoca hydrometric station section..



1. Float
2, 4, 5. Counterweight
3. Clockwork mechanism
6. The limnigraph
7. Connecting tube
8. The fountain
9. Alluvium settling site

Figure 4. Riverside limnigraph installation

The fragmentary hydrometric gauges (Figure 5) existing at the Cluj hydrometric station are placed in the main profile of the station in such a way that the water level in the river never drops below the zero plane of the gauge, which will be chosen in such a way that it is located by 0,5...1,5 m below the historical minimum level recorded at the station.


Figure 5. Hydrometric brides

The station's fragmented baseboards are made of plastic, 2cm thick and 15cm wide. The graduations are made every 2 cm, being grouped in 5 divisions in the form of the letter E, placed normally or inverted. For the direct reading of the maximum and minimum levels in the river, special installations are used, such as toothed gauges (Figure 6) or floats.

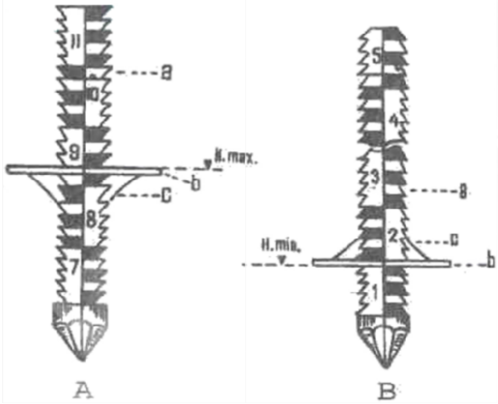


Figure 6. Serrated hydrometric brides

RESULTS AND DISCUSSIONS

The hydrometric station (Figure 7) is located at the base of the Someșul Mic hydropower complex, with the aim of taking over and processing the main hydrological parameters of the river at its entrance into the Cluj-Napoca Municipality.

Figure 7. Hydrometric station Cluj-Napoca

The data regarding the levels collected at the hydrometric station Cluj-Napoca are particularly important for the defense of some objectives against floods, as well as for the calculation of flows with the help of the tabular limnimetric key.

The design of hydrological damming or bank protection works is carried out on the basis of hydrological data that must cover as long periods of time as possible.

For the dimensioning of different categories of works, we will need to know the frequency of occurrence of the hydrological phenomenon of a certain value (maximum, minimum or average flows), the duration of the phenomenon in question as well as its repetition interval (Figure 8).

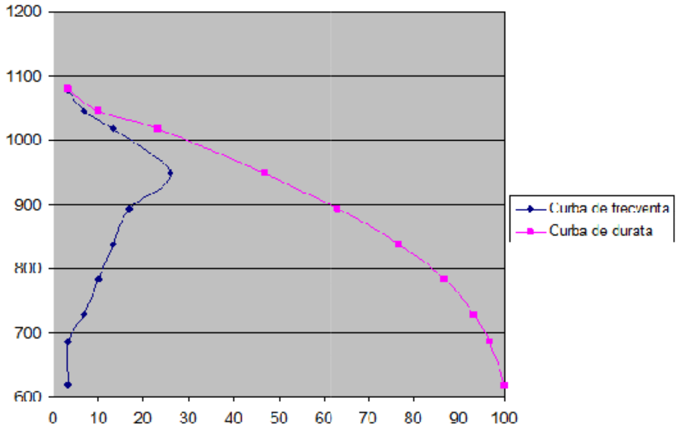


Figure 8. Frequency and duration graph

At the hydrometric station Cluj-Napoca there is an ACTION PLAN regarding the production of exceptional high waters. The defense quotas included in this plan are:

- CA (attention quota) – when this quota is exceeded, a yellow code is issued, which refers to the risk of floods or rapid increases in the water level;
- CI (inundation rate) – when this rate is exceeded, an ORANGE CODE is issued, which refers to the risk of major floods generating significant overflows that may lead to the flooding of some households or some social-economic objectives.
- CP (danger quota) – when exceeding this quota requires the issuance of a CODE RED, which refers to the imposition of special measures to evacuate people and goods, restrictions on the use of bridges and roads, as well as taking special measures in the operation of constructions hydrotechnical.

The quantitative monitoring of the water resource in the section within the Cluj hydrometric station is carried out by means of an automated data acquisition station (Figure 9), at the level of the Someșul Mic river and a meteorological station managed by the Cluj Regional Meteorological Center.

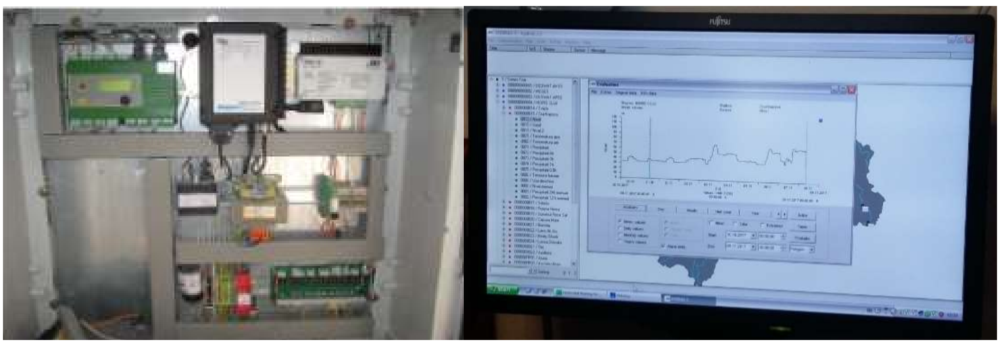


Fig. 9. Automatic data processing station

Floods are accompanied by negative economic, social and ecological effects. As a result of the floods, the following are affected, registering damages:

- localities, by destroying or damaging homes and household annexes, household goods, water sources.
- industrial objectives

- agricultural objectives

The damages caused by floods are grouped into direct damages and indirect damages. Direct damages represent the value of the destruction and damage caused by floods to the affected objects, to which is added the value of the expenses made with the defense operations during the floods. Indirect damages represent the value of the goods not realized by stopping the production processes, the economic losses caused by the delay in the delivery of some products compared to the contractual terms, the expenses for restoring the affected objectives.

Negative social effects include:

- the production of human victims
- the need to evacuate the population
- the danger of epidemics

The ecological effects of floods are related to the negative influence on the environment, through:

- water and land pollution affected
- persistence of excess moisture
- deposition of alluvial material on the affected lands
- occurrence of landslides
- modification of the biotope of the flooded areas

CONCLUSIONS

Through the determination of levels and flows in a river section, the characteristic values necessary for the design, execution and operation of various hydrotechnical constructions, as well as the data necessary for hydrological data forecasting, can be highlighted.

The graph regarding the frequency and duration of the levels, makes possible a more judicious characterization of the water flow regime reflected by the variation of the levels. Frequency indicates how many times a considered interval was repeated, and duration shows how long those levels were maintained.

The tabular limnimetric key from the Someșul Mic section is especially used to determine daily flows, based on average daily levels and measured flows, thus obtaining daily flows without measuring them every day.

All surfaces and objectives located in the major riverbeds, at elevations below the maximum levels that can form due to natural or accidental phenomena, are considered potentially floodable.

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