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Artificial lakes:Problems and solutions

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Abstract

This paper presents in the first part the climatic conditions for the past, present and future, and especially their impact on water resources. The essential part of this work presents the current problems of reservoirs, especially the existing problems in Romania. In the last part contains solutions to these problems, solutions that are the basis of future studies.

1. INTRODUCTION

While Europe is considered as having adequate water resources, water scarcity and drought is more frequent and widespread phenomenon in the European Union. Long-term imbalance resulting from water demand exceeding available water resources is not uncommon.

It was estimated that by 2007 at least 11% of Europe's population and 17% of its territory were affected by water scarcity, causing the cost of drought in Europe in the last thirty years, to reach 100 billion. Commission expects further deterioration of water resources situation in Europe if temperatures keep rising due to climate change. Water is not the problem of some regions anymore, but all 500 million Europeans.

2. CLIMATIC CONDITIONS

Current weather conditions and those in the near future are very important for thinking, developing and implementing effective measures regarding the management of water resources.

Global warming is the phenomenon of continously growing temperatures recorded in the atmosphere near the ground , water and oceans , found in the last two centuries, especially in recent decades. The average temperature of air near Earth's surface rose by 0.74 ± 0.18 C degrees in the last century.

Figure 1 shows the temperature evolution over the past 2,000 years. Temperature averages are figured on schedule one every 10 years. Since we donn't have direct temperature measurements during this period, temperatures have been reconstructed based on the measured thickness of tree growth rings and ice thickness.

As temperatures reconstructed by climatologists , the last decade of the twentieth century and the beginning of the XXI century is the warmest period of the last 2000 years (see figure 1). Our age is few tenths of a degree hotter from the medieval maximum.

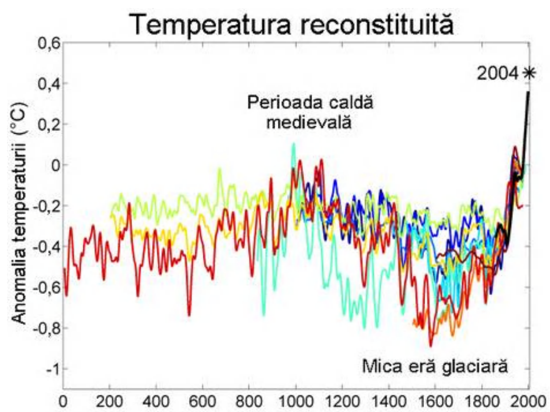

Fig.1 The temperature in the last 2000 years, reconstituted

Evolution of temperatures, as the Global Historical Climate Network (Romanian GHCN - Network monitoring global climate), in recent years is as follows:

Year	1991	1992	1993	1994	1995
Temperature increase °C	0,35	0,12	0,14	0,24	0,38
Year	1996	1997	1998	1999	2000
Temperature increase °C	0,30	0,40	0,57	0,33	0,33
Year	2001	2002	2003	2004	2005
Temperature increase °C	0,48	0, 56	0,55	0,49	0,62
Year	2006	2007	2008	2009	May 2010
Temperature increase °C	0,54	0,57	0,44	0,57	0,63

Tab.1 Annual average temperature increase over the average period from 1951 to 1980, according to GHCN

Romania is no exception, at the conference "Measures of adaptation and reduction of climate

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change impact" were reported temperature increases of 0.5 ° C in the last century.

2007 was a year of record temperatures. Winter of 2006 - 2007 was the warmest in the last 100 years, since there are weather observations in Romania. However, in the first month of 2007 the absolute maximum temperature of January was exceeded at 24 meteorological stations. Warming trend was maintained during the summer. In July a record number of 148 cases with daily maximum temperatures equal to or greater than 40 °C were recorded. In comparison, in July of 2004, the 40 ° C value was reached or exceeded only twice. In Calafat, in July the temperature reached 44 ° C . The absolute maximum summer temperature was recorded all three months: at 53 stations in June, 94 stations in July, 17 stations in August. Also has reached the maximum number of consecutive days of in which temperatures were recorded over 35 ° C and tropical consecutive nights, with temperatures exceeding 20 ° C .

Overall, 2007 is considered a year of extreme weather events.

3. CURRENT ISSUES

One effect of global warming is manifested by increased vaporization, heavy rainfalls and the increased number of storms. Increasing air temperature increases the land surface temperature thereby increasing the amount of water vapor that may be contained in the atmosphere. Although in the twentieth century the vaporization decreased, vaporization during the current century is increasing because of the oceans heating up. To achieve the balance of the water cycle in nature (Fig. 2) the rainfall level should also increase.

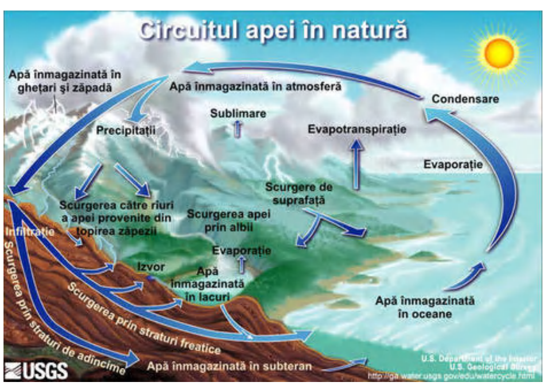

Fig.2 Water cycle in nature

This causes alternating periods of drought and heavy rainfall creating floods.

This brings us to the subject of this paper, artificial lakes, that protect the population while storing flood water to be used for different purposes in dry periods.

Ideally operation of these accumulations would be not to allow flash flooding downstream and also to store a maximum volume of water to be used in power generation, water supply, irrigation, etc..

Unfortunately this does not happen all the time because of issues that will be presented below.

3.1 Hydrological forecasting discrepancy with reality

In this case we are faced with two situations. The first is the situation in which actual output is higher than forecast, in which case it is possible that the measures taken (lake predischarge) is not sufficient, which can have serious consequences such as increased water levels sufficiently to overflow resulting damage to the dam, or even dam breaking.

Another case is where the actual flow is lower than forecast, in which is lost a lot of water because the water volume resulting from the flood will be insufficient to replace the water volume discharged. It may even reach the situation when the lake's water level decrease below the minimum operating level or under the water intake level if in this hypothesis is introduced the possibility that this flood will be followed by a period of drought.

3.2 Accidents

Another very important problem with disastrous consequences is the dam accidents that can occur for various reasons and are influenced by many factors.

One of them is the human factor, namely the lack of automatic operation of the dischargers that does require human intervention only in extreme cases.

Below are some examples of such accidents.

Belci dam and accumulation, on the river Tazlău were designed and executed to ensure a flow rate of 6 m³ / s water for supllying with water the Borzesti thermoelectric power plant and industry in Onesti. Lake volume when it was put into service was 12, 5 million cubic meters. Then in 1983 it was made a small hydroelectric power plant at the foot of the dam with 1.1 MW of power and an annual output of 3.5 MWh / year.

Belci Dam is the first dam of earth in Romania, built between 1958-1962.

Belci dam, closes Tazlău valley over a length of 415 m and having in the minor riverbed the surge of high waters and two sides of earth dams, one to the left side 234 meters long and one to the right side 126 meters long. On the right terrace slope the lake is limited in extension to the earth dam by a dike of earth four meters high, over a length of 580 m.

In the night of 28 to 29 July 1991, after a clear day without rain, the river basin Tazlău experienced torrential rain falls with exceptional character.

Torrential rains which have fallen 28 to 29 July 1991 in the Eastern Carpathians in Moldavia and the Curvature Carpathians caused a river flood wave on Tazlău (Bacau), about 7 meters high. In only 1 ½ hours, at Lucăceşti hydrometric station, from 30 km upstream were recorded rainfall of 95.6 l / m^2, and at the Livezi station, from 16 km upstream, 148.8 l / m². Small Hydroelectric power station downstream was halted due to technical failure, so that interrupted power supply to dam mechanisms.

Lake water level rose very quickly, so that water reached 2.15 a.m. at the crown and began dumping ground over the dam. At about 4.50 a.m. there was an increase in the flow downstream at about 1.800 m³ / sec, implying the collapse of the dam. The lake was nearly empty at 7.15 a.m. and at 7.50 a.m. Tazlău river flowed through a hole formed in the dam's left bank. Maximum flow of the river flood Tazlău from 28 to 29 July 1991 was 3100 m / s.

Earth dam failure mechanism was erosion of the downstream prism surface, while its saturation and then slipping downstream slope followed by a rapid and profound erosion.

Causes of the accident were: in the design stage, the dam has been classified in the first class of importance for wich the flow calculation insurance 0.1% and 0.01% verification were considerably lower than values determined on the basis by observations over 25 years of operation and hydrological observations, of 1515 m³ / sec and 2450 m³ / sec.

Although it was known the maximum flow modification, this hasn't resulted in increased exhaust capacity. Under these conditions the discharge over the dam, and then failure, occurred the night of the accident due to exceptional flood, estimated at 2800 - 3000 m³ / s and the handling impossibility of the hydraulic equipment.

There were 25 dead and none of the 250 houses were not left standing.

The dam has not been reconstructed.

Vidraru Lake is a reservoir created in 1965 by Vidraru dam in Arges, on the Arges River for power production.

Situated between the Fruntii mountains and Ghitu Mountain , the lake gathers the waters of rivers Capra , Buda and several direct tributaries (Doamnei River, Cernatul and Valsanul , Topologul, Valea lui Stan and Limpedea), with a total flow of about 5.5 m^3 / s .

The total area of the lake is 893 ha , length of 10.3 km , maximum width of 2.2 km in the Valea Lupului – Calugarita area and a circumference of 28 km. Maximum water depth is 155 m high next to the curved dam of 166 m high with a length of 307 meters crown. Water volume is 465 million m^3. The normal retention level is 830.00 meters above sea level (mdM).

The construction took five years and a half since the year 1960 . For this achievement, it took 42 km of underground tunnels were excavated from 1.768 million m^3 of rock, of which about 1 million underground bands have 930 000 m^3 of concrete of which 400,000 m^3 underground and also were installed 6300 tonnes of electromechanical equipment.

On completion it was located, measured in height, approximately the 8th place in Europe and ranked 20th in the world .

In an average hydrological year, Vidraru hydroelectric power plant located underground, can produce approximately 400 GWh of electricity. It has an installed capacity of 220 MW .

In 1974 an accident occurred due to handling errors. It gave the area between two electrically operated valve which closes one of the galleries through which the lake emptyed. Which allowed that through the dam to pass a water slide at a rate of 800 m^3 /s and a force of about 10 to 12 atmospheres, said Simon Gheata foreman then to Hidroconstructia, Vidraru dam builder. In turn, representatives of Hidroconstructia appreciate that, because of handling errors through the drainage gallery was then poured 400 cubic meters of water per second.

The external valve - a gate about 10 tons, which must retain water and 16 millimeters thick armor, which lined a gallery of 80 meters long, were shattered by water hammer. Were found at about 500 meters away, said Florica Braileanu, head of the productive sectors of Hidroconstructia Arges. Burst water destroyed everything to find in its way, including the source to power the valves closing.

Result: inner valve, though whole could not be used. It lasted four hours before its closeing. Solution was found by Mengher engineer, former head of the dam site, which brought a generating set from the tunnel construction site Transfagarasan. He came back just in time to Vidraru to save the hydroelectric power station. If Mengher came an hour late, water wells would have been flooded, ventilation and wiring of the plant it would'we been destroyed.

The proportions of the disaster:

If power plant made it, not the same thing happened with bridges, viaducts and houses that have stayed in water's way. Then, downstream, at Arefu, four-five houses were destroyed. Poienari was based an auto fuel depot of troops working in Transfagarasan. Over 200 cars were dragged by the flood and the fuel drums were took by the water.

When the water has sprung from the dam, the seismic station Vidraru indicated that an grade I earthquake occurs , the accident at the dam did no victim. However, there are witnesses who say otherwise. "The troops working on Transfagarasan were housed at Capataneni. When the flood came, many soldiers were taking lunch in canteen. It was tooked by the water and nobody knows how many of them died, but in the following days many coffins came from downstream, "says Simon Gheata. After the accident, both galleries needed repair Vidraru, enormous sums were spent for this, especially as it had to rebuild the massive support of the slope in the destroyed valve area. In addition, the left side and all the galleries of the dam body were injected to stabilize the rock.

Banqiao Dam (Fig. 3) was built in the early 1950s on the Ru River as part of a project to control flooding and generate electricity and as a response to severe flooding in the Huai River basin in 1949 and 1950. The dam was 118 meters tall and had a storage capacity of 492 million m3, 375 million m³ reserved for storing water from floods. After completion the building had cracks in the dam due to mistakes of execution and design. They were repaired with tips from Soviet engineers and the new design, called the barrage of iron, was considered indistructible.

Chen Xing was one of the most prominent hydrologists from China and was involved in dam design. He was also a critic of government policy to build more dams in the basin. He recommended Banqiao 12 gates for the dam, but this was reduced to 5 and Chen Xing was criticized as too conservative. And other dams in the project, including dam Shimantan, has had a similar reduction of safety features and Chen has been removed from the project. In 1961, after the emergence of problems he was brought in to help. Chen continued to be a critic of the system and was again removed from the project.

The dam was designed to survive a flood of 0.1% (once every 1,000 years) insurance. However, in August 1975 has been a flood of 0.05% (once every 2,000 years) insurance, the water of rainfall in 24 hours exceeded rainfall for a whole year (new records were set, to 189.5 mm / h and 1060 mm / day) so that weather forecasts failed to predict it.

Communication to the dam has been largely lost due to destruction of buildings and telecommunication lines due to Nina taifun. On August 6, an opening of the dam surge request was rejected because of existing flooding in downstream areas. On August 7, although this request was accepted, telegrams were unable to reach the dam.

On August 7 at 21:30, 34450 unit of the People's Liberation Army, who were at the Banqiao dam, sent the first warning of a dam failure by telegraph. On August 8, 0:30, the smaller Shimantan dam upstream, which was designed to withstand a flood with 0.2% (once every 500 years) insurance, had to take a quantity of water twice as that and breaked, just 10 minutes after the 34450 unit sent a request that would open the dam Banqiao by air attack. A half hour later, the water discharged over the dam and Banqiuo breaked at 1:00. This led to failure of 62 dams in total.

Fig.3 Banqiao Dam after the break.

According to the Hydrology Department of Henan Province, in the province, about 26,000 people died from floods and other 145 000 subsequently died due to epidemics and starvation. In addition, about 5.96 million buildings were destroyed and 11 million people were affected.

Death toll of this disaster was declassified in 2005.

4. PROPOSED SOLUTIONS

Given the above it is clear that developing a medium and long term strategies for effective management of water resources is imperative.

One proposed solution is to upgrade the existing dams and especially water surge systems. More specifically creating a system that would allow automatic operation of the water dischargers without the need for human intervention, except in exceptional cases.

Such a system that includes technologies (sensors for finding the water level in real time, specific software, etc.) will be based on an optimization study conducted with modeling programs through repeated trys with different scenarios.

One of these programs and most widely used internationally is HEC-RAS (Hydrologic Engineering Centers River Analysis System).

HEC-RAS (Fig. 4) numerical modeling one-dimensional movement of water surface in a cross-sectional profile gradually varied flow in natural river beds or artificial channels, under uniform and uniform regime. Can calculate the surface within the transverse profile under subcritical, supercritical regime or mixed regime, considering: the distribution of variable cross-section of the Manning coefficient, contraction or sudden enlargement of section, change of the current thread unevenness (α).

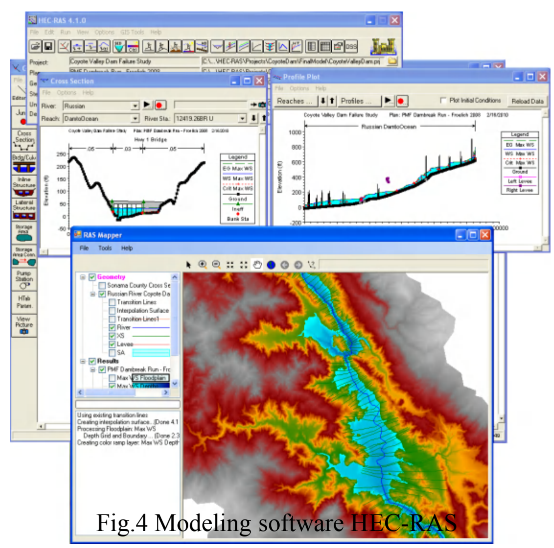

Fig.4 Modeling software HEC-RAS

This program is very complex, but to be used in an optimization calculation results obtained from simulation of a scenario must be as close to what happens in reality. This is more difficult if the dams have special spillways (funnel spillway, daisy spillway, etc.), whose modeling can't be achieved in this program.

For this reason among the solutions to problems of the artificial lakes include thinking and develop a software that allows use in a simulation of several types of special spilways common in the existing hydrotechnical arangements.

5. CONCLUSIONS

Considering the evolution of climate and especially the uptrend of the annual average temperatures, water resources problem is very important.

Elaboration of strategies and studies leading to an efficient management of water resources is imperative.

Upgrade of the existing equipments of the dams is a first measure that can be taken to improve water resources management and reduce the risk of accidents.

6. ACKNOWLEDGMENT

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