Fenomene şi procese hidrice de risc

THE WATER VOLUME-RENEWING PERIOD MODEL: LEŞU RESERVOIR ON THE IADA RIVER

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ABSTRACT. – The water volume-renewing period model: Leşu reservoir on the Iada river. The water volume-renewing period (turnover period) is in a strong relation with an other hydrological characteristic, the water volume variation. The volume variation expresses the annual renewing of the water volume and it can be computed by the help of the hydrologic balance. The intensity of this variation represents the volume-renewing period and we can define it as the time in which the whole volume of a basin is renewed. In case of natural or artificial lakes, the estimation of this intensity is very important considering the water quality and different chemical and biological water characteristics. The turnover period of water volume in lakes is mainly influenced by the volume magnitude and the input and output discharge, but there are some other elements, too.

Key words: water volume, water balance, turnover period

1. General considerations

Lake Leşu in the upper basin of Crişului Repede River is formed behind the Leşu Dam that is part of the "Drăgan-Iad" hydroenergetic scheme. The evaluation of the volume-renewing period was made by the help of the water balance, which is known to be consisted in the quantitative estimation, for a moment in time or for a time interval, and by all water balance components that contribute to the increase or decrease of the lake volume. So, the volume quantitative modification, determined by the water input and output, is reflected in the lake level variations, and also in the intensity of volume variation or the turnover period.

The lake water balance components, constitute the water balance formula

$$\mathbf{P+V_s+V_i+V_{De}-V_d-E-I=\pm\Delta W} \quad \text{(mm), (m}^3\text{)} \qquad \text{(eq. 1)}$$

where,
- P = precipitation fallen over the lake surface;
- V_s = runoff from the hydrographic basin;
- Vi = underground runoff;
- V_{De} =derivations from other hydrographic basins;
- V_d =dischargers of the dam;

– *E* = evaporation of the lake water surface;
– / = infiltrations in and/or below the dam;
– ΔW = lake water volume variation in the time period.

The lake water balance is an integral equation of all the components' values which contribute to the input and output of water in the lake volume. The values of these components exceed the simple registration and reflect the interdependences of the physical and geographical factors and their influence over the lake and its surroundings.

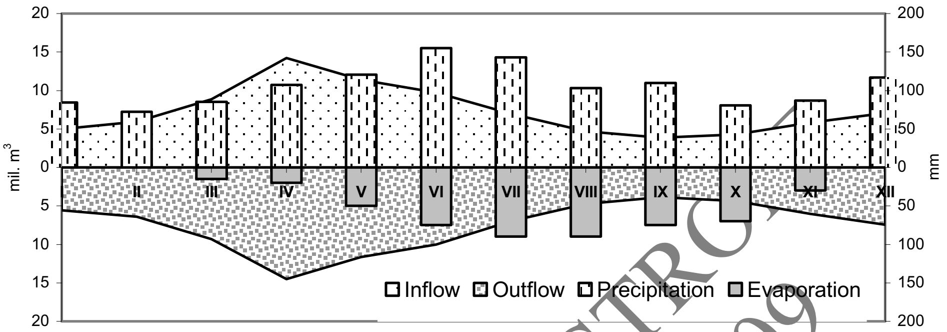

Fig. 1. Average water balance of Lake Leşu.

At Lake Leşu (Fig. 1), the water balance indicates a pluvio-nival regime. The maximal values of the water balance are reached in April-May when snow melting is correlated with the spring rainfalls. Another maximum is reached in September as a result of the June-July heavy rainfalls. The multiannual average values of precipitations are rather high in this area – 1265,6 mm. The pluviometric regime reveals a second maximum in December, because of important solid precipitations, its importance in this context being related to the explanation of the spring maximal runoff (because of snow melting).The evaporation values are greatly under the precipitation ones, the argument is based on the lake's high altitude associated with decreased temperatures, abundant precipitations and high cloud cover values. During winter months the evaporation is totally missing because of the lake water freezing.

2. Turnover period

The turnover period expresses the time in which the whole volume of a lake basin is renewed by the input part of water balance. This period changes regarding different lakes and even lake parts.

The bigger is the water exchange regarding the whole lake volume, the better is the mixture between different water characteristics, and the quicker is the turnover period and reversed: the slower is the mixture and the water exchange, the longer is the turnover period. Because the mixture of water volume is changing in time and space, the turnover period is also variable.

There is no such method which could compute exactly the turnover period for a lake or a lake part, we can only appreciate it, taking in account some simplifications and the monthly data of the water balance.

Before describing the methodology, we must assume some simplifications:

- in the studied time period the same amount of precipitation falls to the surface of the lake and the same amount of water evaporates from it
- the intensity of the precipitation, the runoff and the infiltration is the same in the time period
- the amount of infiltration input and output is the same in the studied time period, so it can be neglected
- the precipitation fallen over the lake surface and the input runoff mixture totally with the lake volume in the studied time period
- every water corpuscle has the same chance to be is exposed to the evaporation and the output off runoff

We present a mathematical computing method which says that, at the beginning of the studied time period, in the lake there is a V_o water volume, also that in the $t^{(1)}$ time period $P^{(1)}$ precipitation falls, $R_I^{(1)}$ runoff flows in, $E^{(1)}$ volume evaporates and $R^{(1)}$ runoff discharges. If we assume that the precipitation and the runoff intensity is constant, taking in to account the simplifications which says that every water corpuscle from the lake has the same chance to evaporate or discharge, in the $t^{(1)}$ time only half of the water provided by the precipitation and the runoff leaves the lake volume.

So, the volume from which in the $t^{(1)}$ time the evaporation and discharge happens, can be computed with the following equation:

$$V_0^{(1)} = V_0 + \frac{P^{(1)}}{2} + \frac{R_I^{(1)}}{2} \quad \left(\mathrm{mm, m^3}\right) \qquad \text{(eq. 2)}$$

where $\boldsymbol{V_o}$ – is the lake volume at the beginning of the calculation

$\boldsymbol{P^{(1)}}$ – is the precipitation fallen over the lake surface

$\boldsymbol{R_I^{(1)}}$ – is the inflow.

If we divide the equation right components with $V_o^{(1)}$ we can calculate how much the lake volume is from the original volume $X^{(1)}$, also from the precipitation $Y^{(1)}$ and runoff $Z^{(1)}$ delivered in the $t^{(1)}$ time.

So, the equations will be:

$$X^{(1)} = V_0 / V_0^{(1)} \quad (\mathrm{mm, m^3}) \qquad \text{(eq. 3)}$$

$$Y^{(1)} = \frac{P^{(1)}}{2} * \frac{1}{V_0^{(1)}} \quad (\mathrm{mm}, \mathrm{m}^3) \qquad \text{(eq. 4)}$$

$$Z^{(1)} = \frac{R_I^{(1)}}{2} * \frac{1}{V_0^{(1)}} \quad (\mathrm{mm}, \mathrm{m}^3) \qquad \text{(eq. 5)}$$

Now, by the help of these results, we can calculate the evacuated water components, in other words how much from the original volume, the precipitation and the runoff has left the lake volume in the $t^{(1)}$ time period.

$$O^{(1)}{}_{V_0} = \left(E^{(1)} + R^{(1)}\right) * X^{(1)} \quad \left(\mathrm{mm}, \mathrm{m}^3\right) \qquad \text{(eq. 6)}$$

$$O^{(1)}{}_{P} = \left(E^{(1)} + R^{(1)}\right) * Y^{(1)} \quad \left(\mathrm{mm}, \mathrm{m}^3\right) \qquad \text{(eq. 7)}$$

$$O^{(1)}{}_{R_I} = \left(E^{(1)} + R^{(1)}\right) * Z^{(1)} \quad \left(\mathrm{mm}, \mathrm{m}^3\right) \qquad \text{(eq. 8)}$$

At the end of the $t^{(1)}$ period, which is also the beginning of the $t^{(2)}$ period, the lake volume components can be computed with the following equations:

-from the original volume:

$$V^{(1)}{}_0 = V_0 - O^{(1)}{}_{V_0} \quad (\mathrm{mm}, \mathrm{m}^3) \qquad \text{(eq. 9)}$$

-from the precipitation fallen over the water surface

$$V^{(1)}{}_P = \left(\frac{P}{2}\right) - O^{(1)}{}_{V_0} \quad (\mathrm{mm}, \mathrm{m}^3) \qquad \text{(eq. 10)}$$

-from the runoff from the watershed

$$V^{(1)}{}_{R_I} = \left(\frac{R_I}{2}\right) - O^{(1)}{}_{R_I} \quad (\mathrm{mm}, \mathrm{m}^3) \qquad \text{(eq. 11)}$$

The calculation in the $t^{(2)}$ period is the same as the $t^{(1)}$ period, only the starting point volume equation has one factor in plus, so the equation to compute the lake volume in the $t^{(2)}$ period starting point and also in the $t^{(n)}$ point can be written like:

$$V_0^{(2)} = V_0^{(1)} + \left(V_P^{(1)} + \frac{P^{(2)}}{2}\right) + \left(V_{R_I}^{(1)} + \frac{R_I^{(2)}}{2}\right) \quad \left(\mathrm{mm}, \mathrm{m}^3\right) \qquad \text{(eq. 12)}$$

Also, the X, Y, Z equations change to:

$$X^{(2)} = V^{(1)}{}_0 / V_0^{(2)} \quad (\mathrm{mm}, \mathrm{m}^3) \qquad \text{(eq. 13)}$$

$$Y^{(2)} = \left(V_P^{(1)} + \frac{P^{(2)}}{2}\right) * \frac{1}{V_0^{(2)}} \quad (\mathrm{mm}, \mathrm{m}^3) \qquad \text{(eq. 14)}$$

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$$Z^{(2)} = \left(V_{RI}^{(1)} + \frac{R_I^{(2)}}{2} \right) * \frac{1}{V_0^{(2)}} \quad (\mathrm{mm}, \mathrm{m}^3) \qquad \text{(eq. 15)}$$

$$V_0^{(n)} = V_0^{(n-1)} + \left(V_P^{(n-1)} + \frac{P^{(n)}}{2} \right) + \left(V_{R_I}^{(n-1)} + \frac{R_H^{(n)}}{2} \right) \ (\mathrm{mm}, \mathrm{m}^3) \qquad \text{(eq. 16)}$$

From this point on the calculation is the same as the $t^{(1)}$ period methodology, we must calculate first the components of the lost volume and after that the components of the lake volume. The calculation must be repeated till the original volume V_o is consumed or it reaches 1 %. The time period from the study starting point to the moment when the entire starting volume is consumed is called the lake water turnover period. If we use real data we can compute the concrete time in which the lake volume is renewed. In case of lakes that have long period of observed data, we can compute the turnover period for any moment in time, but because of the variation of water balance components the period will also change. If we use multiannual monthly values (Fig. 2.) we can compute the lakes average turnover period.

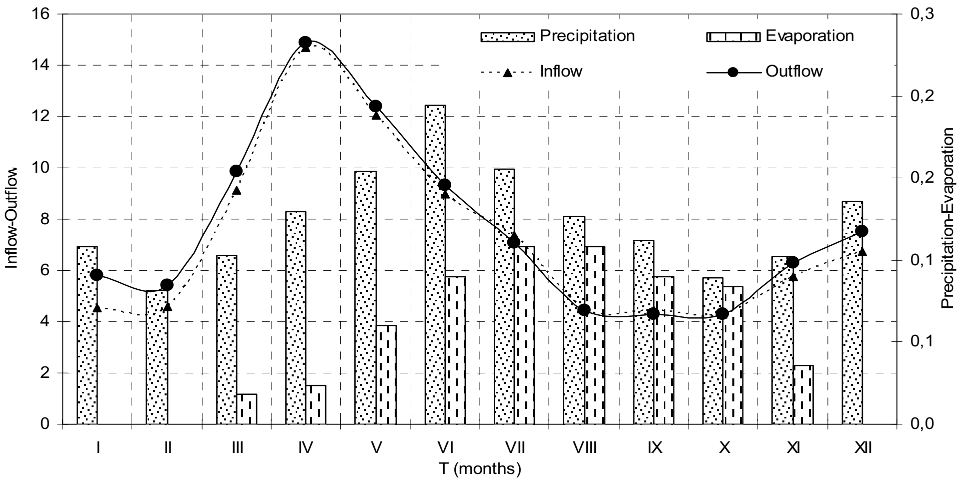

Fig. 2. Used monthly average (1975-1995) water balance values (mill. m^3).

3. Conclusions

We implemented the calculation in several scenarios, using average multiannual data and the data of two years' characteristic: the rainiest (1995) and the driest (1990) from the studied time period. The results are different for every starting point in time and also for different volumes, but they give a more comprehensive image about de characteristics of the water volume renewing period of the lake (Fig. 3.).

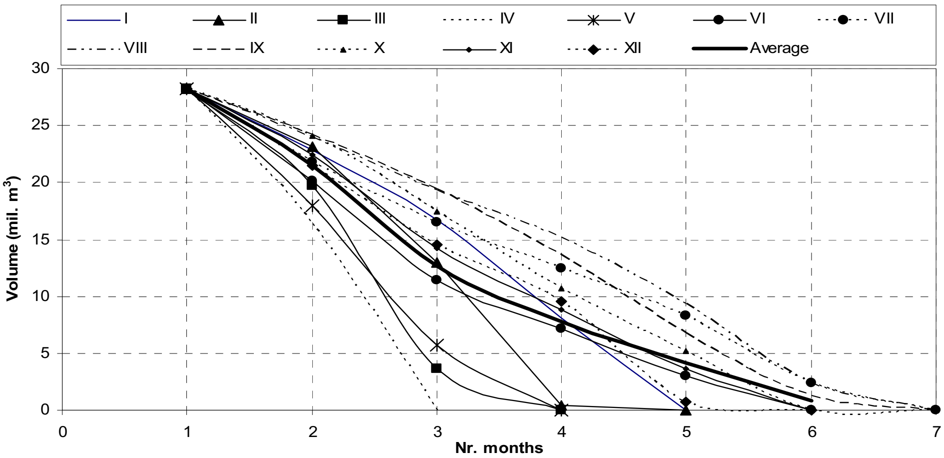

Fig. 2. Lake Leşu water renewing period.

In concordance with the precipitation volumes and the runoff, the turnover period varies between three and seven months according to the volume exchanges between the input and the output of the lake volume. In rainy years it's quicker (2-3 mounts) and in drier years it is slower (7-8 mounts), the average renewing period of the lake remains at 6 mounts. Even if in our case the lake volume is influenced by the dam human regulated discharge, so we can not exactly predict the discharge volumes, the turnover period and the equation give a fairly good estimation to the volume exchange intensity.

The knowledge of this exchange intensity or turnover period is very important, considering the water quality and different chemical and biological characteristics of the lake water; also it could help in forecasting the lakes ecosystem capability of self-sustenance regarding an accidental pollution.

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