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THE ROLE OF EVAPORATION IN EVALUATING THE WATER RESERVE OF ROMANIAN LAKES – A CASE STUDY

Gianina Neculau[1] Florentina-Iuliana Stan[2] Mary-Jeanne Adler[3]

Abstract. Evaporation is a component of the hydrologic balance and a meteorological factor which directly influences water balance, together with rainfall. The main objectives of this paper are: the spatial and temporal analysis of lake surface evaporation in Romania and the determination of the water volume lost through evaporation. This paper is based on the use of annual data series on evaporation measured at the 21 lakes where this parameter is being monitored. In terms of methodology, our paper is based on the statistical analysis, the estimation of the water volume lost through evaporation being done by extrapolating the values measured at the level of the evaporation basin to the entire surface of the lake (according to Drobot and Şerban,1999). In order to evaluate water losses caused by evaporation in relation to the water volume of lakes, the Izvorul Muntelui, Furculeşti, Fântânele, Bezid and Dridu lakes were taken as case studies, the analysis being carried out for the years of maximum and minimum evaporation. The results of our analysis show that the volume of water lost through evaporation depends both on local climate conditions and on the morphometrical characteristics of lakes. Thus, evaporation can reduce a lake volume by up to 10%, in the case of lakes with small surface areas (below 10 km^2) and small water volumes.

Keywords: evaporation, lake, correlations, volume, water reserves

Introduction

Evaporation plays an important role in feasibility studies on water reserves and is, at the same time, a necessary parameter for creating management and water usage strategies in agriculture and fish farming. The evaporation of a lake's surface is conditioned by climatic factors, among which the most influential are: solar radiation, air temperature and humidity, atmospheric pressure and wind speed. In addition to these factors, another important role belongs to the morphometrical particularities of lakes (surface, volume, depth). Evaporation is a component of the hydrologic balance and a meteorological factor which directly influences water balance, together with rainfall. In this context, the main objectives of this paper are: the spatial and temporal analysis of lake surface evaporation in Romania and the determination of the water volume lost through evaporation.

At international level, studies on evaporation have been made by: Thornthwaite et al., 1939; Penman, 1954; Xu et al., 2001; Touchart, 2006; Dąbrowski M., 2007; Finch et al.,

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2008; Jensen, 2010 etc., and subsequently, at national level, by authors such as: Gâştescu, 1963; Bădescu et al., 1975; Breier, 1976; Drobot et al., 1999; Alexe, 2010; Croitoru et al., 2013 etc. The importance of this study stems from the fact that, in recent times, water resources have been declining (IPCC, 2013), and, in order to rationally manage these resources, we need to know the water losses caused by evaporation.

Data and methods

For the purpose of creating this scientific paper, we used data series for the interval between March and November (the period when water surface is free) and annual data series, for evaporation and the main hydrometeorological parameters (air temperature, rainfall, relative humidity), from 21 lakes in Romania (Figure 1).

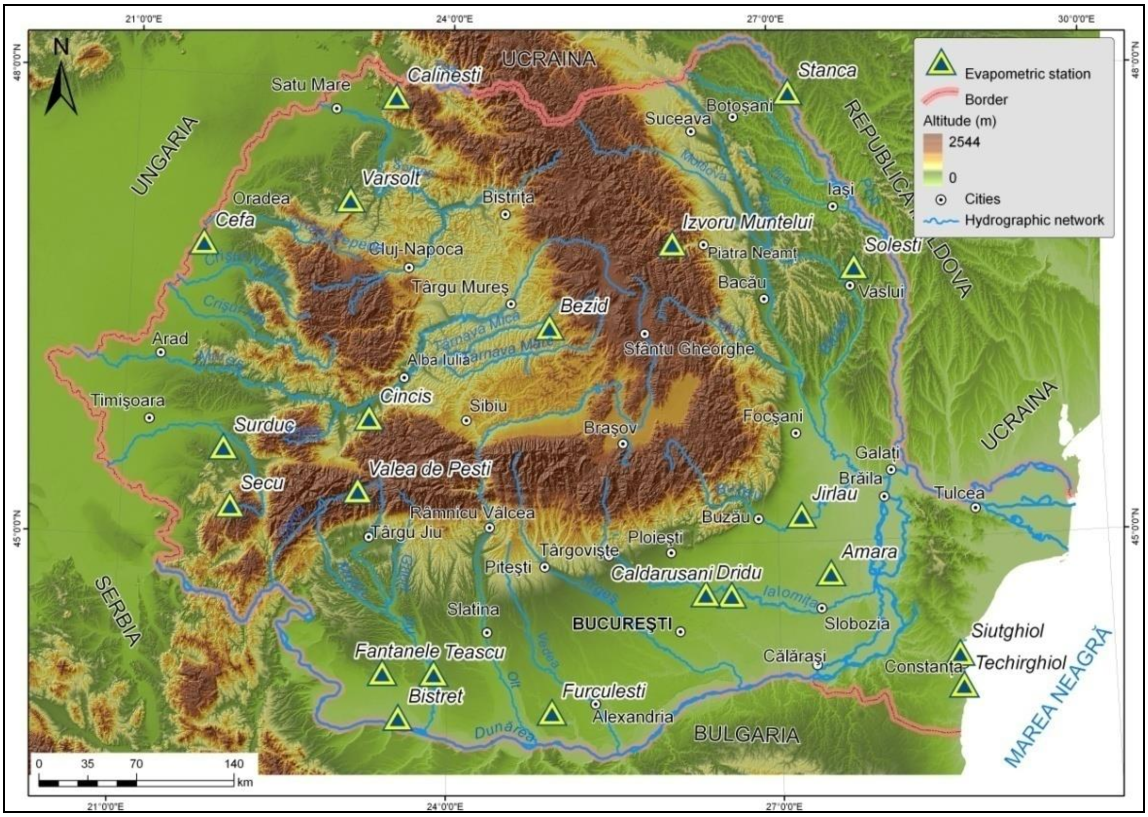

Figure 1: The network of evapometric stations located on the surface of lakes in Romania

The above-mentioned data were complemented by the morphometrical and hydrological characteristics of the lakes (such as the altitude where they are located, their volume, depth and area), taken from Romania's Atlas of Water Cadastre (1992) and from the GIS database of the National Institute of Hydrology and Water Management.

The operating intervals for the lakes evapometric stations are not the same (Table 1). Some stations began their activity in 1958 (Jirlău, Izvorul Muntelui), others in 1961 (Cefa, Căldăruşani, Amara), and after 1998 eight more stations were set up. Furthermore, 7 of the 21 lake-based evapometric stations have been closed (Siutghiol, Jirlău, Cefa, Teascu, Bistreţ, Stânca and Dridu). Nowadays, 14 evapometric stations are operational nationwide, uniformly distributed across Romania's territory.

Table 1: Evaporation values (average and maximum) and variation coefficients at the evapometric stations of Romanian lakes

Evapometric station	Water Basin Administration	Operation period	Average evaporation (mm)	Maximum evaporation (mm)	Year of E_{max}*	Coefficient of variation
Căldăruşani	Buzău-Ialomiţa	1961-2012	968,2	1203,0	1986	0,11
Amara		1961-2012	908,0	1182,0	1963	0,17
Dridu		1998-2011	732,5	993,5	1999	0,22
Jirlău		1958-2002	1042,0	1415,0	1992	0,15
Soleşti	Prut - Bârlad	2004-2012	831,7	1109,4	2011	0,27
Stânca		2004-2010	699,0	1146,8	2007	0,50
Bezid	Mureş	1998-2012	681,4	918,0	2012	0,18
Cinciş		1961-2012	740,6	917,9	1963	0,10
Secu	Banat	1998-2012	582,0	814,9	2001	0,38
Surduc		1998-2012	680,8	758,6	2000	0,09
Furculeşti	Argeş-Vedea	1961-2012	751,3	1101,0	1963	0,23
Călineşti	Someş-Tisa	1998-2012	480,8	674,0	2012	0,25
Vârşolt		1998-2012	769,4	954,4	2012	0,17
Valea de Peşti	Jiu	1998-2012	151,0	319,8	2000	0,43
Fântânele		1961-2012	717,0	947,8	1961	0,17
Bistreţ		1961-2006	1048,0	1290,6	2002	0,15
Teascu		1961-2002	1010,0	1380,0	2002	0,14
Cefa	Crişuri	1961-2002	889,1	1103,0	1963	0,10
Izvorul Muntelui	Siret	1958-2012	666,4	854.7	1961	0,14
Techirghiol	Dobrogea Litoral	1998-2012	832,0	1043,0	1963	0,17
Siutghiol		1961-2003	830,0	1044,0	2009	0,13

* Maximum evaporation

The working methodology was specifically based on the application of some statistical methods, thus creating a relation between the morphometrical characteristics of the lakes (area, depth, altitude, etc.) and evaporation, which was founded on simple and multiple correlations (Data Analysis). For identifying lake surface evaporation variability trends on a monthly and annual scale, and also for determining their statistical significance, we applied the Mann-Kendall non-parametric statistical test (Neculau, 2010). In order to more accurately describe the yearly variation of lake surface evaporation, we determined the variation coefficient of the average annual evaporation (C_v), based on the following relation:

$$Cv = \sqrt{\frac{\sum (Ki-1)^2}{n}}$$

where: Ki= module annual coefficient, calculated as a ratio between average annual evaporation, E_{an} and average multi-annual evaporation ($E_{mulatianual}$): $Ki = E_{an} / E_{mulatianual}$; n = the number of years in the analyzed interval.

The extrapolation of the evaporation measured at the evaporation basin level to the entire lake surface, and also the estimation of the water volume lost due to evaporation, were achieved by applying the equation proposed by Drobot and Şerban, 1999:

$$P_E=10^3*E*A$$

where: P_E = annual water losses through evaporation; E_l = monthly evaporation in mm; A = surface of the water surface in km^2.

Results

Analyzing the spatial and temporal variability of evaporation

Lake surface evaporation varies significantly, from 150 mm/year at altitudes above 1000 meters (Valea de Peşti), 600 mm/year at stations located in the Banat region (Secu, Surduc) and the Transylvanian Plateau (Bezid), all the way to 1000 mm/year for the lakes situated in plain regions (Căldăruşani, Amara, Bistreţ, Fântânele). The vertical distribution of evaporation (Figure 2) is mostly conditioned by climatic factors (solar radiation, air temperature and humidity, wind speed), which are, in turn, influenced by the geographic location of the lake, and particularly by altitude. Thus, evaporation increases from North to South and from West to East, due to an increase in average temperature and a decrease in rainfall and relative humidity.

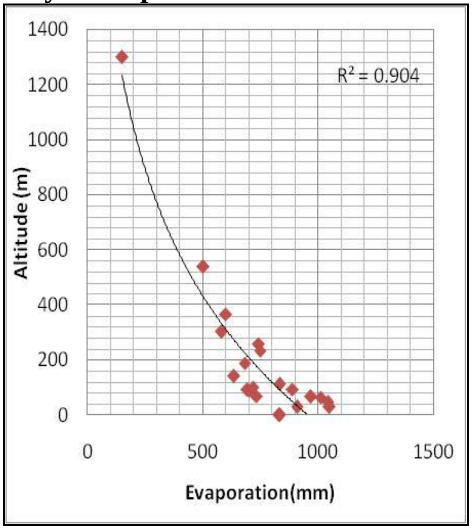

Figure 2: Correlation between evaporation at lake surface and altitude; the E – f (H) relation

Consequently, the highest values for evaporation are recorded in the Romanian Plain (as a result of the temperate climate, with an arid character and Mediterranean influences) and the lowest values are registered for the lakes located in the mountains and in the contact region between mountains and hills or plateaus. In addition to climatic factors, lake surface evaporation is conditioned by the morphometrical particularities of lakes: area, volume and depth (Table 2).

Table 2: Morphometrical data for the analyzed lakes

Lakes	Altitude (m)	Area (km sq)	Total volume (mil mc)	Average depth (m)
Căldăruşani	68	2.24	4.48	2.00
Amara	30	1.32	2.64	2.00
Dridu	70	9.96	60	6.02
Jirlău	48	8.9	5.6	0.63
Soleşti	113	4.52	47	10.40
Stânca	90	59	1400	23.73
Bezid	367	1.7	31	18.24
Cinciş	260	4.5	43.3	9.62
Secu	302	0.73	15.1	20.68
Surduc	190	5.38	66.27	12.32
Furculeşti	92	0.42	-	-
Călineşti	143	3.8	30.3	7.97
Vârsolt	235	5	40.7	8.14
Valea de Peşti	1300	0.22	5	22.73
Fântânele	102	3.25	31.7	9.75
Bistreţ	30	18.67	28	1.50
Teascu	65	0.48	-	-
Cefa	95	6.59	9.88	1.50
Izvorul Muntelui	540	31	1230	39.68
Techirghiol	0	11.61	41.8	3.60
Siutghiol	1	19	88.7	4.67

* *Altitude of the location of the water body, area and lake volume are taken from Romania's Atlas of Water Cadastre (1992), except for the Furculeşti and Teascu lakes, where data was obtained from the INHGA GIS database.*

Therefore, there is a direct relation between a lake's volume and its water losses due to evaporation (Figure 3), with a larger volume leading to a greater amount of evaporated water (depending on the climatic conditions of the lake's location); evaporation can reduce the volume of a lake by up to 30% (for lakes with an area of less than 10 km^2).

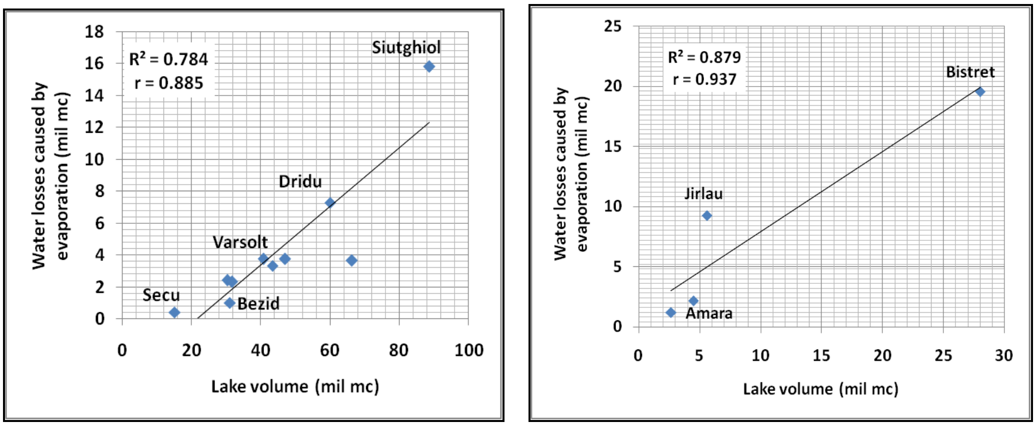

Figure 3: Correlation between lake volume and average multi-annual volume of evaporated water: E – f (W); Lakes with a large volume of water (left) and lakes with a small volume of water (right)

Regarding the correlation between evaporation and the area of the lake (Figure 4), we noticed that, in the case of the lakes with a surface below 10 km^2 (Lake Dridu, Lake Bezid), evaporation can reduce their water volume by up to 10%. With regard to mountain lakes (such as Izvorul Muntelui), with large surfaces (31 km^2) and significant water volumes, the evaporation is negligible in the reduction of their water reserves.

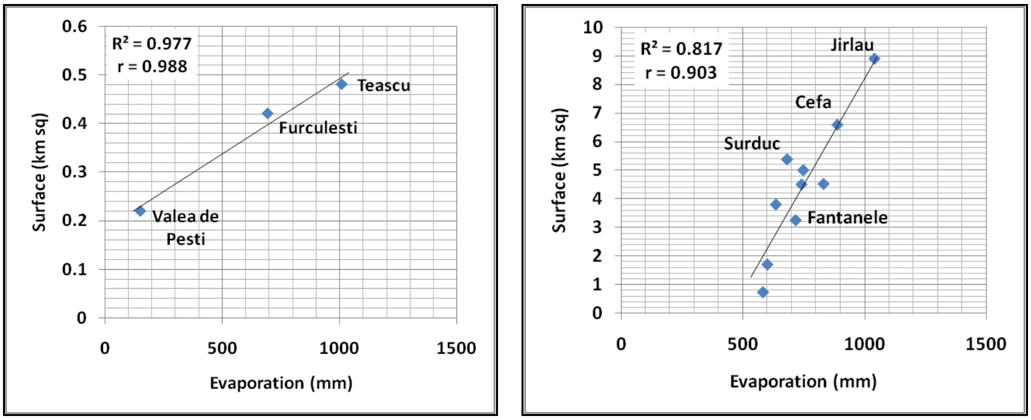

Figure 4: Correlation between average multi-annual evaporation and lake area: E – f (F); Lakes with areas below 1 km^2 (left) and with average areas up to 10 km^2 (right)

Between evaporation and the depth of a lake there is an inverse relationship – an increased depth leads to a decrease in evaporation. Thus, at depths of less than 10 meters, evaporation varies between 600 and 1000 mm (Figure 5). For lakes with large areas and shallow depths (Bistreţ), evaporation is greater than for lakes with similar areas but greater depths (Izvorul Muntelui).

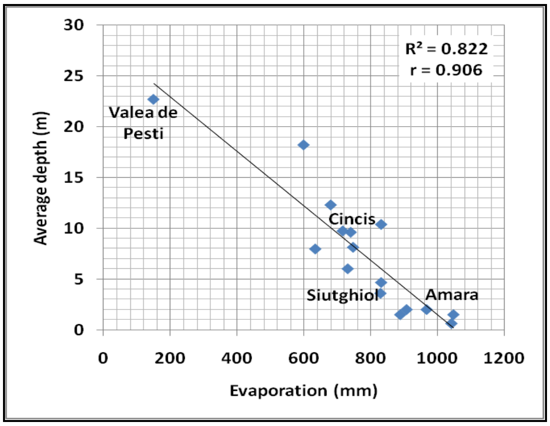

Figure 5: Correlation between average multi-annual evaporation and the average depth of lakes: E – f (h)

For the studied lakes, evaporation has varied from one year to another, as a consequence of the changes in the climatic conditions, and this fact is highlighted by the average annual values and also by the values of the evaporation variation coefficients (Cv). Average annual evaporation has oscillated from one year to another and thus, in the 1999-2002 and 2007-2012 intervals, and also in 1963, 1986 and 1992 (Table 1), the highest evaporation was recorded. Elevated values have been conditioned by climatic circumstances (higher temperatures, increased humidity deficits during summer and decreased rainfall). For the studied lakes, the evaporation variation coefficients ranged between 0.09 and 0.50, which indicate a rather homogenous data series, without significant differences from one year to another. In terms of inter-annual variations of evaporation at lake surface, the highest values were registered in July and August (Figure 6), when average monthly temperatures exceed 20˚C, relative humidity experiences average monthly values below 60% and the duration of sunshine is at its maximum (over 300 hours/month).

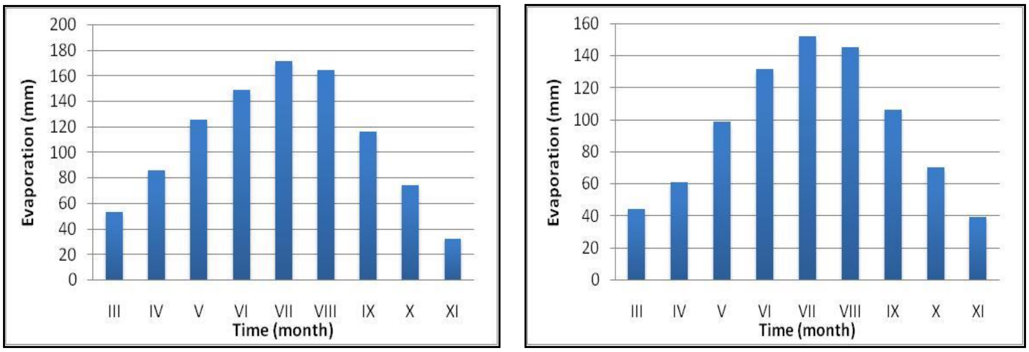

Figure 6: Inter-annual variation of average monthly multi-annual evaporation at Căldăruşani (left) and at Siutghiol (right)

Applying the Mann-Kendall test to the monthly and annual values of evaporation has shown increasing trends with a high degree of significance, between 0.001 and 0.05, for lakes in southwestern Romania (Cinciş, Vârşolt), and decreasing trends for evaporation, with a higher degree of confidence at the Furculeşti and Amara stations, and with an insignificant degree of confidence for Dridu and Siutghiol Lakes. In the case of the Surduc, Secu, Bezid, Soleşti, Cefa and Techirghiol lakes (lakes with a short observation period and measurement of evaporation covering less than 15 years), the Mann-Kendall test could not identify trends for increasing or decreasing evaporation (Table 3).

Table 3: Monthly and annual trends in the evolution of evaporation at the lakes surface, resulting from the application of the Mann-Kendall test (***: α = 0,001; **: α = 0,01; *: α = 0,05; +: α = 0,1 ; red highlights decreasing trends and black shows increasing trends)

Evapometric station	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	***X***	***XI***	***Annually***
Cinciş	**	***		**	***	***	**			*
Bezid										
Amara		**	*	***			**	*		***
Căldăruşani	*	**	**	**	***	**	*	+	+	**
Jirlău	*	+	**	*	*					*
Dridu			*	+	*			***		+
Soleşti										
Stânca							*			
Secu										
Surduc										
Furculeşti		**	***	***	***	***	***	*	***	***
Călineşti			+			+		+		+
Vârşolt		+	+	*	**	***				**
Fântânele				+	*	**	+	*		***
Valea de Peşti			**				+			
Bistreţ		***				*				
Teascu	+									+
Cefa										
Izvorul Muntelui							+			*
Siutghiol		*					*			**
Techirghiol										

Determining the volume of water lost through evaporation and the impact on the water reserve – a case study

Evaporation plays an important role in the hydrological balance equation. In order to determine the amount of water lost through evaporation at the lakes' surface, we used the method elaborated by Drobot and Şerban, 1999. It was applied for the Izvorul Muntelui, Furculeşti, Fântânele, Bezid and Dridu lakes, for the years of maximum and minimum evaporation. The studied lakes are all reservoirs and have major hydroenergetic significance (Izvorul Muntelui), fishery significance (Furculesti), and a role in irrigation and mitigating flood waves (Fantanele, Dridu).

For the Izvorul Muntelui Lake, the highest evaporation values (over 800 mm/year) were identified in the 1961-1962 and 1998-1999 periods, and the lowest ones were recorded in 1969 and 2009 (below 500 mm/year). The determination of the volume lost at the lake's surface was done for 1999 (a year with evaporation above the multi-annual average values) and 2009 (a year with low evaporation). In 1999, high air temperatures (above 20°C during summer months) and significant evaporation (more than 798 mm) led to the loss of 23.72 million m^3 of water between April and November, with a maximum monthly loss of 4.12 million m^3 recorded in July. In 2009, due to greatly reduced values for evaporation (418.5 mm), the water volume lost to evaporation was reduced in half compared to 1999, and amounted to 10.33 million m3, with a maximum monthly loss of 1.72 million m3 in July (Figure 7). In conclusion, for the Izvorul Muntelui Lake, water losses caused by evaporation are insignificant, representing around 1% of the lake's average volume.

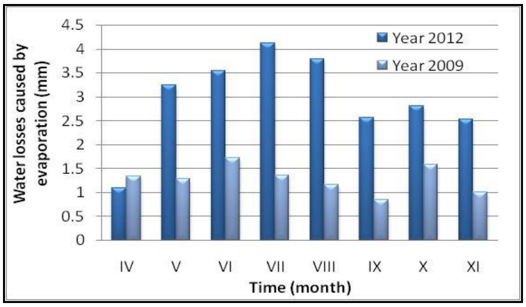

Figure 7: Monthly variation of water losses caused by evaporation (million m^3) in 2009 and 2012 at the Izvorul Muntelui Lake

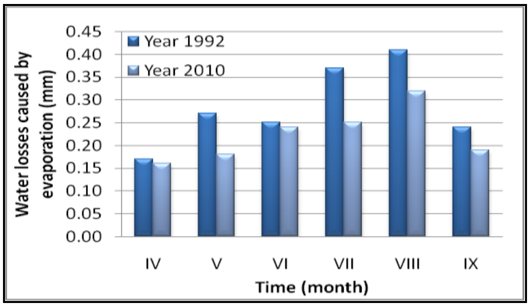

Figure 8: Monthly variation of water losses caused by evaporation (million m3) in 1992 and 2010 at the Fântânele Reservoir

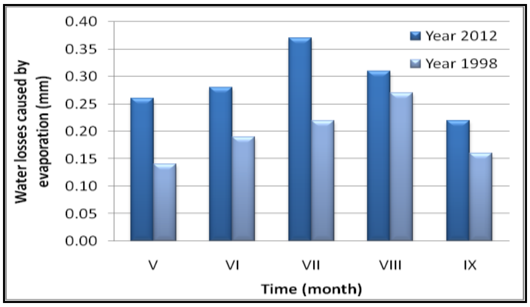

Figure 9: Monthly variation in evaporation-caused water losses (millions of m^3) in 1998 and 2012 at the Bezid Reservoir

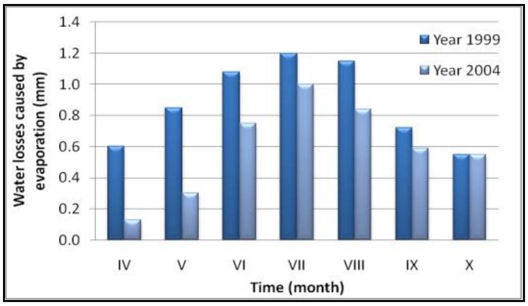

Figure 10: Monthly variation in evaporation-caused water losses (millions of m^3) in 1999 and 2004 at the Dridu Reservoir

In the case of Furculeşti Lake, despite it having a significantly smaller area than Izvorul Muntelui, we were able to establish, based on the analysis that we undertook, that evaporation-caused losses do not play a major role in the variation of its volume, because evaporation only caused negligible losses. For highlighting this aspect, we analyzed the data for 2005 (with an evaporation of 374.4 mm, below the multi-annual average) and 2012 (with a value of 844.1 mm). In 2012, the monthly values for evaporation were clearly greater than those registered in 2005 (Table 4), thus leading to a loss of 0.2 million m^3 of water, twice the amount lost through evaporation in 2005 (0.087 million m^3).

The Fântânele Reservoir was built to serve multiple purposes: irrigation, fish farming and protection against flood waves and its evaporation has been monitored since 1961. During its operating interval, we identified periods with evaporation greater than 800 mm (1961-1968; 1983-1987; 1992-1993), but also lower than 600 mm (1998-1999; 2003-2006; 2009-2010). The determination of water losses due to evaporation was done for 1992, with a total evaporation between March and November totaling 824.2 mm, and for 2010, when evaporation between April and September amounted to 529.5 mm. Thus, the volume lost to evaporation is 2 million m^3 for years with maximum evaporation and 1.3 million m^3 for years with decreased evaporation. At a monthly level (Figure 8), the volume lost because of evaporation can reach 0.41 million m^3 (in August 1992), and a monthly evaporation greater than 100 mm can cause a loss of 5-7% of the lake’s volume (Table 4).

For Bezid Lake, we identified periods with evaporation higher than 800 mm in 2002, 2003 and 2013, and intervals of evaporation lower than 600 mm between 1998 and 2000 and in 2006, 2007. By analyzing the data recorded in 1998 (538.0 mm) and 2012 (918.0 mm), we determined that water losses for Bezid Lake vary between 0.14 million m^3 in spring and late autumn months and 0.37 million m^3 mid-summer (Figure 9). For this particular lake, considering climate conditions, water losses through evaporation can affect its volume by up 12%.

Lake Dridu, situated close to Ialomiţa River, has been monitored in terms of evaporation since 1998. The years with evaporations higher than 900 mm are 1998 and 1999, whereas years with evaporation below 600 mm are 2003, 2004, 2010 and 2011. The water volume lost due to evaporation was determined for 1999, and it amounted to a total of 6 million m^3, and in 2004, the lake’s volume was clearly greater than in 1999. Evaporation values for 2004 were below the multi-annual monthly averages, generating a water loss of 4 million m^3 (Figure 10). At a monthly level, the volume lost through evaporation exceeds 1 million m^3 during the summer (Table 4), whereas in spring and autumn, losses can be as low as 0.13 million m^3.

*Table 4: Water volume lost due to evaporation (million m^3) at the surface of the following lakes: Izvorul Muntelui, Furculesti, Fantanele, Bezid and Dridu**

Lakes	Year	Months / Parameters	III	IV	V	VI	VII	VIII	IX	X	XI
Izvorul Muntelui	1999	W (mil mc)	-	840.8	1068.87	1064.42	1062.64	1066.29	1040.24	947.6	812.2
		E (mm)	-	40.1	106	116	135	124	84.7	97.8	94.6
		P_E(mil mc)	-	1.09	3.25	3.55	4.12	3.80	2.56	2.82	2.53
		%	-	0.13	0.30	0.33	0.39	0.36	0.25	0.30	0.31
	2009	W (mil mc)	-	685.225	741.105	756.685	817.415	784.3	686.44	597.78	546.05
		E (mm)	-	55.1	50.7	66.7	50.8	44.6	35	69	46.6
		P_E(mil mc)	-	1.35	1.29	1.72	1.36	1.17	0.85	1.58	1.01
		%	-	0.20	0.17	0.23	0.17	0.15	0.12	0.26	0.18
Furculeşti	2005	W (mil mc)	-	194	207	203	203	212	205	205	-
		E (mm)	-	49.5	51.3	53.1	65.3	52.2	52.2	50.8	49.5
		P_E(mil mc)	-	0.011	0.012	0.012	0.015	0.013	0.012	0.012	-
		%	-	0.009	0.006	0.006	0.007	0.006	0.006	0.006	
	2012	W (mil mc)	-	204	204	204	204	198	179	175	186
		E (mm)	-	73.04	97.9	142.7	198.6	153.5	78.9	82.3	17.2
		P_E(mil mc)	-	0.018	0.024	0.035	0.049	0.037	0.018	0.018	0.004
		%	-	0.009	0.012	0.017	0.024	0.019	0.010	0.010	0.002
Fântânele	1992	W (mil mc)	4.07	5.04	5.67	5.96	6.15	5.60	3.99	2.56	2.44
		E (mm)	46.5	70.8	106.9	98	142.6	162.5	107.1	55.8	34
		P_E(mil mc)	0.13	0.17	0.27	0.25	0.37	0.41	0.24	0.11	0.06
		%	3.19	3.37	4.77	4.19	6.02	7.32	6.02	4.30	2.46

Lakes	Year	Months / Parameters	III	IV	V	VI	VII	VIII	IX	X	XI
	2010	W (mil mc)	-	4.91	5.6	6.28	6.55	6.39	6.02	-	-
		E (mm)	-	66.5	73	95	95	123	77	-	-
		P_E(mil mc)	-	0.16	0.18	0.24	0.25	0.32	0.19	-	-
		%	-	3.26	3.21	3.82	3.82	5.00	3.16	-	-
Bezid	1998	W (mil mc)	-	-	14.80	17.33	16.66	14.13	14.30	14.74	-
		E (mm)	-	-	76.7	100.0	114.4	155.3	91.8	-	-
		P_E(mil mc)	-	-	0.14	0.19	0.22	0.27	0.16	-	-
		%	-	-	0.95	1.10	1.32	1.91	1.12	-	-
	2012	W (mil mc)	-	-	14.52	15.08	14.22	13.38	12.6	11.93	-
		E (mm)	-	-	144.2	155.5	209.3	184.2	132.1	93.1	-
		P_E(mil mc)	-	-	0.26	0.28	0.37	0.31	0.22	0.14	-
		%	-	-	1.79	1.86	2.60	2.32	1.75	1.17	-
Dridu	1999	W (mil mc)	-	12.27	17.85	21.18	21.31	22.08	21.60	16.68	-
		E (mm)	-	125.7	141.4	163.9	182.8	175.5	108.3	95.9	-
		P_E(mil mc)	-	0.60	0.85	1.08	1.20	1.15	0.72	0.55	-
		%	-	4.9	4.8	5.1	5.6	5.2	3.3	3.3	-
	2004	W (mil mc)	-	17.03	26.70	26.72	26.61	25.31	20.65	24.11	-
		E (mm)	-	25.0	40.0	97.8	131.7	112.3	99.2	76.6	-
		P_E(mil mc)	-	0.13	0.30	0.75	1.00	0.84	0.59	0.55	-
		%	-	0.80	1.1	2.8	3.8	3.3	2.9	2.3	-

* W – lake volume (million m^3); E – lake surface evaporation (mm/month); P_E – water losses through evaporation (million m^3); % – monthly percentage of water losses caused by evaporation as a percentage of the lake's volume.

Conclusions

Ultimately, the amount of water that evaporates from the surface of a lake differs from one unit to another and also for the same unit, depending on local climatic characteristics and on the lake's morphometrical parameters. The relations between evaporation and the morphometrical characteristic of the lakes (area, depth, volume and its altitude) are close.

On the basis of our study, we have established that evaporation can reduce the volume of a lake by up to 10% for lakes with small surface areas (below 10 km^2) and small volumes. Therefore, a lower lake volume means less water loss through evaporation, considering the altitude where the water body is situated and local climate conditions. The opposite is also true. Additionally, for lakes with significant water volumes and elongated shapes (such as Izvorul Muntelui) evaporation is insignificant in the reduction of their water reserves.

References

1. Al Domany M., Touchart L., Bartout P., Nedjai R. 2013. The Evaporation from ponds in the French Midwest, lakes, reservoirs and ponds, p. 75-78.
2. Alexe, M. 2010. Studiul lacurilor sărate din Depresiunea Transilvaniei, Cluj University Press, Cluj-Napoca..
3. Atlasul Cadastrului Apelor din România 1992. AQUAPROIECT, I, Bucharest.

4. Bădescu V., Tibacu L. 1975. Determinarea evaporaţiei reale de la suprafaţa lacurilor de dimensiuni medii, Studii şi Cercetări partea a II-a Hidrologie XLIV, Bucureşti.
5. Breier A. 1976. Lacurile de pe litoralul românesc al Mării Negre. Studiu hidrogeografic, Ed. Academiei, p. 173.
6. Croitoru A. E., Piticar A., Dragota C. S., Burda D. C. 2013. Recent changes in reference Evapotranspiration in Romania, Global and Planetary Change, nr. 111, p. 127-132.
7. Dąbrowski M. 2007. Evaporation from surface of lakes, Limnological Review 7, p. 133-138.
8. Drobot R., Şerban P. 1999. Aplicaţii de Hidrologie şi Gospodarirea Apelor, Editura H.G.A.
9. Finch, J., Calver, A. 2008. Methods for the quantification of evaporation from lakes - prepared for the World Meteorological Organization's Commission for Hydrology, Centre for Ecology & Hydrology, United Kingdom.
10. Gâştescu P. 1963. Lacurile din România- geneză şi regim hidrologic, Edit. Academiei, p. 293.
11. IPCC, 2013. Climate Change 2013: The Physical Science Basis. GIEC, http://www.ipcc.ch/report/ar5/wg1/.
12. Jensen M. E. 2010. Estimating evaporation from water surfaces, Presented at the CSU/ARS Evapotranspiration Workshop, Fort Collins, CO.
13. Jhajharia D., Kithan S. B., Fancon A. K. 2006. Correlation between pan evaporation and meteorlogical parameters under the climatic conditions of Jorhat (ASSAM), Journal of India Water Resources Society Vol. 26 No. 1-2, p. 39-42.
14. Neculau, G., Stan F.I. 2014. Indrumar pentru activitatea statiilor evaporimetrice, Institutul National de Hidrologie si Gospodarire a Apelor, ISBN 978 – 606-93776-2-8, Bucuresti.
15. Penman H.L. 1954. Evaporation over Parts of Europe, Proceedings of the General Assembly of Rome, 3, p. 168-176.
16. Preoteasa V. 1984. Variabilitatea de la an la an a evaporaţiei de la suprafaţa ape pe teritoriul României, Studii si Cercetări Hidrologice 52, Bucureşti.
17. Thornthwaite C.W. şi Holzman, B. 1939. The Determination of Evaporation from Land and Water Surfaces, Soil Coservation Service, Washington, D.C, p. 4-1.
18. Touchart L. 2006. Lacs et risques: un essai de typologie, Riscuri şi catastrofe., Cluj-Napoca, p. 13-20;
19. World Meteorological Organization - WMO 2008, Guide to Meteorological Instruments and Methods of Observation, No.8, Chapter 10, p. 227-237.
20. Xu C-Y. 2002. Hydrologic Models, Uppsala University Department of Earth Sciences Hydrology.