MANAGEMENT OF STORAGE LAKES IN ROMANIA

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ABSTRACT. – *„Water is not any kind of trading product, but a heritage that must be maintained, protected and treated as such"* – a new European strategy and policy in the field of water management is necessary to be implemented after the sustainable development concept has reached its purpose and limits in this field. The storage lakes made along the water streams led to the increase of the water quantity used in Romania. The placement conditions and the method of using water volumes have led to the formation of storage lakes of different volumes in various physical-geographical conditions, which in time were subjected to a series of pressures which have also generated degradations of the quality thereof and of the environmental factors. In this context the aim is to prevent the deterioration, the protection and improvement of the state of aquatic ecosystems, based on the water requirements thereof, to the permanent interactions between aquatic ecosystems and adjacent terrestrial ecosystems and wet areas.

Keywords: Storage lake, exploitation regime, integrated management

1. INTRODUCTION

Romania is a county which has a theoretically estimated water resource of 134.600.000 thousand m^3, totaling the resources from internal rivers, the Danube and underground water.

The existing resource according to the degree of fitting the hydrographic tanks total 39.736.221 thousand m^3 (Source: A.N. „Apele Române"). This value is possible due to the realization of a complex range of hydro-technical buildings at the level of hydrographic tanks, of which, maybe the most spectacular are the dams behind which storage lakes are formed. Reported to the current population of the country the theoretical water resource is of approx. 1770 m^3/inhab. year. The main characteristic of this resource is the high variability in time and space.

Unfortunately this value is also restricted by the qualitative parameters of the captured water. Generally running waters fall 68% in excellent and good quality classes and only 12,0% in moderate and low quality classes.

The activity of management of storage lakes must aim at the quantitative water management (fighting floods and providing water for consumers in draught periods) as well as at the qualitative water management by maintaining bio-diversity.

The integrated management of water resources promotes the development and coordination of water, of land scape and of the resources, for the optimization,

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balanced social and economic development without compromising the sustainability of ecosystems.

The concept of integrated management of water resources presupposes, in contrast with the traditional management of water resources, an integrated approach at the physical and technical level as well as at the level of planning and management. The level of integration is the hydrographic tank, the natural unit of formation of water resources, where the artificial water storages are quartered.

2. STORAGE LAKES IN ROMANIA

The development of the number of storage lakes in Romania was theoretically favored by the water requirements for various requirements, by the energetic potential given by the forms of relief and by the water flows as well as by the needs of reducing maximum flows.

In these conditions, more than 2000 dams appeared with the afferent storage lakes of which 245 dams are classified as large dams (H>15,0 m, Volume >1,0 mil. m^3) according to the International Commission of Large Dams (ICOLD).

According to the National Dams Register in Romania (REBAR) there are 2617 dams registered, of which 2087 dams for water storage, 231 industrial waste deposits and 299 special hydrotechnical works. 372 dams of these fall in the categories of importance A and B (exceptional and special under the competence of the Ministry of Environment) and 2245 dams fall in the category C and D (normal and low, under the regulatory competence of A.N. „Apele Române") (table 1).

Table 1. ***Classification of dams in Romania per categories of importance***

No.	Type of dam acc. GEO 224/200 and NTLH-021	Share (%)	Comments
1.	Dams of exceptional importance – A	2%	Of which 30 water retentions
2.	Dams of special importance – B	12%	Of which 153 water retentions
3.	Dams of normal importance – C	49%	Of which 1040 water retentions
4.	Dams of low importance – D	37%	Of which 864 water retentions

Source: REBAR

1838 dams perform permanent water retentions (88,0% of the total), and 249 dams (12,0% of the total) are non permanent water retentions with the exclusive purpose of anti-flood protection.

From the point of view of the purpose for which they were performed, storage lakes have the following destinations:

- 59 dams have storage dams with a complex role which provide raw water to the population and to the industry, the production of electricity, reduction of flood waves, pisciculture and recreation;
- 56 dams are used for the water supply of localities and reducing floods;
- 119 dams and afferent lakes are used for irrigation, pisciculture, reduction of flood waves and recreation; 1398 dams make small local storage lakes

for pisciculture and recreation, bearing the highest risk of incidents, accidents and/or damages, most of the times for reasons of sizing and exploitation;
- 121 dams have lakes for recreation and for other destinations.

Most storage lakes are quartered in the hydrographic space Argeş – Vedea (532 storage lakes), followed by Prut-Bârlad (412 storage lakes) and Ialomița – Buzău (348 storage lakes), although these hydrographic tanks have no significant water resources (table 2).

Table 2 .*The existing dams in Romania in 2007 on the hydrographic tanks*

No.	Hydrographic space	Total dams		Categories of importance			
		Nr.	%	A+B	%	C+D	%
1	Tisa- Someş	146	6	31	7	115	6
2	Crişuri	181	7	20	4	161	8
3	Mureş	138	5	48	8	90	5
4	Banat	87	3	14	2	73	4
5	Jiu-Dunăre	108	4	40	7	68	3
6	Olt-Dunăre	169	6	51	15	118	3
7	Argeş-Vedea	545	21	39	23	506	19
8	Ialomița-Buzău	428	16	34	15	394	15
9	Siret	288	11	57	11	231	11
10	Prut-Bârlad	436	17	26	6	410	22
11	Dobrogea-Litoral	91	4	12	2	79	4
Total		2617	100	372	100	2245	100
Percentage			100		14		86

Data source: CONSIB, Ministry of Environment

The management of storage lakes is of great interest both economically speaking and concerning the environmental impact and of the evolution of retention volumes and of the physical-chemical parameters of water. Most storage lakes are administered by A. N. „Apele Române" and S.C. „Hidroelectrica" S.A. to which A.N. „Îmbunătățiri funciare" S.A. is added as well as fishing companies, economic agents, local administration and natural persons as well.

The difference between these structures of administration of storage lakes is given by the method of exploitation thereof. The allotment of water resources for each hydrographical dam for satisfying the water requirements of the integrated destinations in centralized systems is made using monthly reports of central exploitation of the main exploitations.

The exploitation reports establish the stocks, estimated affluent and effluent flows that must on one hand continuously supply with water the beneficiaries and authe hand other to avoid the settlement of all transported drifts, the alteration of the water quality, the deterioration of environmental elements and of hydro technical buildings.

A delicate issue is the degree of silting of lakes which generally ranges between 0 and 25%, which in average does not seriously affects the useful volume and the flood reduction volume (Giurma, 1997).

The quantities of slits transported by the water flow varies according to the rivers and to the form of relief traveled, which makes the slitting process bear differentiations, with respect to the river sector where the storage lake is located.

However, there are storage lakes with a high degree of slitting which generates an economic inefficiency. Among the most affected lakes by this phenomenon are: the Voila lake – 70,0%, Pucioasa lake – 67,0% (D.A. Buzău-Ialomița); Ogrezeni lake – 100,0%, Curtea de Argeş lake – 88,0%, Piteşti lake – 68,0%, Vîlcele lake – 62,0%, Zăvoiu Orbului lake – 50,0%, Buftea lake – 60,0% (D.A. Argeş-Vedea); storage lake Puşcaşi – 62,3%, Bucecea – 50,0%, Solca – 62,0% (D.A. Siret); Işalnița – 92,0% (D.A Jiu) etc.

The hydrographic space Argeş-Vedea has the highest number of storage lakes (532) but also the most lakes with a high degree of slitting due to the lithologic conditions, the vegetation coverage, the way the lands are used and the regime of exploitation of the lakes. The extension of the period of exploitation thereof by reducing the quantity of slits, which would deposit in pits, can be directly achieved through the method of exploitation and maintenance of the slits and indirectly by using measures of reducing the erosion of the hydrographic basin controlled by the lake.

A faster slitting of the bowls of energetic lakes is observed, because the owners seek to maintain the lake at high quotas and at high water volumes, which are used for short periods of time, during the peaks of energetic demand of the national energetic system. Furthermore these owners do not afford to discharge water on the bottom drains, to wash the bowl, because these volumes of water cause a direct waste of money. There are methods of de-slitting which consist of opening the gates or the bottom drains during floods, at a certain time interval, for driving and discharging the quantities of slits which have been deposited in time on the lake bowl.

The Spanish method is seldom used, consisting of a full drainage of the lake and the transport of sediments by fluvial erosion exercised naturally by the river. This happens because it takes a long time to re-fill the lake, a time in which the water demands cannot be satisfied.

Dragging is the method which can be applied without affecting the water stocks during accumulation, but which according to the costs can be profitable or not. A measure that must be taken into account would be to grant permits for the exploitation of slits deposited on the lake tail, by primarily extracting slits which are more difficult to drive during floods or by simply opening the bottom gates. To sum up, the state of slitting of storage lakes in Romania is the following:

- An advanced degree of slitting for 15 storage lakes, with average sizes of 8 mil. mc and which are all placed in the area of large production of slits (more than 25 t/ha/an); the time $T_{50\%}$ of slitting of these lakes is between 2 and 10 years;
- A high degree of slitting for 30 storage lakes, with average capacities of 35 mil. mc, and the time $T_{50\%}$ of slitting ranges from 10 to 50 years. In this case lakes are located in the large production area of slits between

10–25 t/ha/an, cascade lakes from the rivers Olt, Argeş, Buzău and Bistrița, but also lakes from the basin of Bârlad;

- An average degree of slitting for 13 storage lakes, those which have a slitting time under 100 years and which are usually located in the area of under 5 t/ha/year (for example Rogojeşti on Siret, Izbiceni on Olt, Bacău on Bistrița, Văliug on Bârzava) (Ichim, 1992).

From a biological and qualitative point of view storage lakes, and primarily the lakes with small volumes where changes of water are total in a short period of time, do not meet the conditions of a lake ecosystems, because most of the times they fall between the characteristics of the lake and river systems, or most of the times they are in a permanent ecosystem imbalance.

The majority of lakes on the river Olt (Turnu, Dăieşti, Călimăneşti, Rm. Vâlcea, Govora, Slatina) undergo complete changes of the water volumes every 0,8 and 4,5 days. In these circumstances, lakes are closer to the particularities of fluvial ecosystems, with permanent modification of the abiotic and biotic factors.

Where total water changes take place every 6,5 to 7,5 days (Drăgoeşti, Zăvideni, Arceşti) there are transitory conditions between the lake and river ecosystem.

The differences appear in terms of the parameters of thermal water stratification, the distribution of the concentration of dissolved oxygen, the penetration of light, the deposit of slits and consequently he degree of troficity of the water and the development of hydro-biocenoses.

The analysis of physical-chemical parameters of water from storage lakes is made at a low number, predominantly where the water is used for the supply of the population. After analyzing approximately 100 monitored lakes, the result is that 47,1% fall in the **1st quality class** (excellent), 22,2% in the **2nd class** (good), 17,6% in the **3rd class** (moderate) and 2,0% in the **4th class** (satisfactory).

The quality of the main lakes in Romania in terms of the degree of troficity reveals the following aspects from the point of view of nutrients (the total mineral nitrogen and the total phosphorus): out of 102 monitored lakes, 4 lakes (3,9%) corresponded to the ***ultra-oligotroph category***, 1 lake (1.0%) to the category of ***oligotroph***, 1 lake (1,0%) to the category of ***oligo-mezotroph***, 13 (12,7%) to the ***mezotroph category***, 14 (13,7%) to the category of ***mezo-eutrophes***, 35 (34,4%) to the category of ***eutrophs*** 16 (15,7%) to the category of ***eutroph-hipertroph*** and 18 (17,6%) to the category of ***hipertrophs.***

From the point of view of the fitoplanctonic biomass: from the 102 of the monitored lakes, 15 lakes (14,7%) have fallen in the category of ***ultraoligotrophs*****,** 33 lakes (32,4%) in the category of ***oligotrophs,*** 17 lakes (16,7%) in the category of ***mezotrophs*****,** 8 lakes (7,8%) to the category of *mezo-**eutrophs,*** 12 lakes (11,8%) to the category of ***eutrophs***, 4 lakes (3,9%) to the category ***eutroph-hipertroph and*** 13 (12,7%) to the category of ***hipertrophs*****.**

For the safe exploitation of dams and storage lakes, several norms were issued in time, which regulate the certification of the abilities of the staff to monitor the behavior in time of dams, the issuing of operating permits thereof as well as procedures of conservation, post-use and abandonment.

Reports concerning the physical state of dams and of the equipment used as well as regarding the bowl of the storage lakes (erosions, slitting, slope drifts, etc.) are issued annually for each water direction.

Hydrotechnical constructions have a well-structured exploitation system, to follow the behavior in time and for the periodical execution of maintenance and repairing works, with safety of exploitation. For some dams, such as Poiana Uzului, Siriu, Vârşolt, Dridu and Gura Apelor, works of maintaining the projected safety level are under execution. For other dams, such as Leşu, Stânca – Costeşti and Poiana Mărului, the exploitation is made under certain restrictions (low Normal Level of Retention) and aggradations are carried out for increasing the retention capacity at Sacele dam. Moreover, dams administered by the National Administration „Îmbunătățiri Funciare", are subject to a new organized exploitation system.

Small local dams which are more than 25 years old, are not built according to technical projects which correspond to the performance requirements from the field of operating safety of dams, as they are not adequately maintained. They need significant words of rehabilitation and observance of the degree of safety in a normal exploitation or must be transferred in the post-usage, conservation and abandonment procedure.

Most dams and storage lakes, from the C and D categories, proposed for decommissioning are located in D.A. Prut (36 dams), Argeş-Vedea (17 dams) and Buzău-Ialomița (12 dams). In directions such as Someş-Tisa, Mureş, Jiu, Siret, Dobrogea-Litoral there are no such situations.

3. CONCLUSIONS

The integrated management of water resources presupposes:

1) The integration of the system of natural water resources, represented by the natural hydrological cycle and its components: precipitations, evaporation, surface drainage and underground drainage. The preservation of the hydrological balance and of the ratios between its components, is based on the bio-physical connections between forests, soil and water resources from a hydrographic basin and is essential for the sustainable use of the natural water resource system and the exploitation of the storage lakes created.

2) The integration of the water resource infrastructure in the natural capital. By building an environmentally friendly water management infrastructure which ensures the optimal water supply of the uses as well as the reduction of the risk of floods, draughts, but also the conservation and growth of the biodiversity of aquatic ecosystems.

3) Integration of water uses. The supply with water of the population, the industry and the agriculture and the conservation of aquatic ecosystems are sectorially approached in a traditional manner. The majority of water uses require increasingly larger quantities of water and of a higher quality. The processes of solving the water resource-requirements equation and of protecting the water resources require the analysis of the uses at the level of the hydrographic basin and of the method of exploitation of volumes of stored water.

4) Upstream-downstream integration. The qualitative degradation and the reduction of water resources by the uses upstream and mainly the transit regime of slits, generate problems for the exploitation of water resources and implicitly the territorial development downstream.

5) The integration of water resources in the policies of planning. Water is one of the fundamental vital elements and a factor which conditions the social and economic development, being often a limitative factor. The company and the economy can be developed only provided that the water management is also developed, this condition marking the role and importance of the activity in the context of the sustainable development.

The integrated management of water resources is based, according to the provisions of the Framework Directive 2000/60 of the European Union, on the Management Plan of the hydrographic basin.

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