EQUILIBRIA IN AQUATIC ENVIRONMENTS

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Throughout history, the development of human civilisation has been closely associated with the quantity and quality of available water resources. Furthermore, human interaction with nature and the environment has severely compromised water resources, primarily through pollution and hydro-construction projects. In this paper, we are going to try to analyse the two perspectives from which one can look at water: the environmental and the socio-economic. This analysis will be carried out with a view to the future.

Through the mastering of science and technology, we have become the dominant species of the ecosphere, capable of transforming the environment and adapting it to our own needs. This domination has resulted in a severe crisis in our relationship with the ecosphere. The general tendency in all ecosystems is to increase energy production within the system, through biological diversification, and to maintain equilibrium even in the face of disturbing influences. One of the most important goals of the natural strategies of ecosystems, is to attain a level of production equal to the level of consumption. Net productivity in a balanced ecosystem is close to zero.

In contrast to nature's strategy, that of human civilisation lies in its efforts to maximise the productivity of ecosystems, increasingly and intensively exploiting biological and non-biological resources. Human disturbance of the fragile balance of nature will, not only disturb the normal lifecycles of many species and lessen their chances of survival through the reduction of biodiversity, but also the very economy and existence of humanity itself. This contradiction between the two strategies brings to light the problem of finding an intelligent way to make use of natural resources that will allow for socio-economic development in such a way that one will be able to make use of nature for a long time while protecting it from destruction. In this light, the establishment of limits as to the degree to which humans can impact the ecosystem without irreversibly affecting its integrity becomes the essential goal of modern ecology. Heading into the third millennium, the viable development of the economy requires a co-ordination of the use of resources necessary to society, with a plan to protect all elements of the environment, among which water plays a major role. In many parts of the world, water can become a factor which limits economic growth. Romania, a country which is presently in transition to a market economy, has very limited water resources:

- Water resources from rivers and (from exclusively) Romanian lakes is estimated, theoretically, to be in the region of forty billion cubic metres per year, of which five billion is used in natural water flow and thirteen billion in water management. Taking only interior lakes into account, water resources can be measured at 1,700 cubic metres per inhabitant, which, when compared to the water resources of other countries in Europe, is a relatively small figure.
- Theoretically, the water resources of the Danube amount to eighty-five billion cubic metres per year. The amount of usable water is reduced to thirty billion cubic metres per year because of the navigability of the river.
- The Black Sea is not taken into consideration as a source of drinking water because of industrial pollution and because of the high costs of desalination.
- Subterranean water resources are estimated to have a usable capacity in the region of nine billion cubic metres per year, of which, because of present technology and finances, is reduced to three billion cubic metres per year.

Water resources, from the point of view of what is technically usable, will not be available in the coming millennium without achieving results from greater investments in the complex area of water management, without proper purification installations, and without taking into account that:

- The Danube, Romania's most important water resource, can only be used in small measure because of its geographical position in the southern limits of Romanian territory.
- Internal rivers are not evenly spread out and leave a lot of the country with insufficient water resources. There are also some significant differences in the volume and size of their estuaries.
- A significant degree of pollution in these rivers renders their use difficult if not at times, prohibitive.

From what has heretofore been presented, and with an eye to the future, it is obvious that Romania must use its technically available water resources through greater investments in hydro-technology. In order to maintain the ecological balance and acquire water of a high quality, people must respect certain criteria which will assure sustainable development. The construction, in anticipation of the coming millennium, of new reservoirs, will relieve some of the worries water specialists presently have with regard to the quantity and quality of water resources. The major factor which reduces the quality of water in reservoirs, particularly those consigned for human consumption, is the accelerated rhythm of eutrophication. Eutrophication is the natural or artificial introduction of nutritive substances into water, either detrimental or beneficial,

which then, eliciting reactions in the ecosystem similar to the primary link of the food chain, produce live substances.

Table 1

Average Annual Water Resources	Resource Categories		
	Available	Usable	
		Potentially	Actually
Rivers and Lakes	40	24-25	13
The Danube	85	20-30	10
Underground Waters	9	5-6	3
Total	134	49-61	26

In recent decades, pollution induced changes to the nutrients of the food chain of the lakes (principally to nitrogen and phosphorus) have altered eutrophication from a phenomenon that was evolving at nature's pace, to one that is evolving at the pace of human development, something which will come to a crisis in several years. The eutrophication of water reservoirs could become a major socio-economic problem in the third millennium both for Romania and for the rest of the world. In this context, the establishment and maintenance of a certain degree of ecological balance in these artificial ecosystems can become one way to guarantee an ongoing and harmonious socio-economic development by ensuring the continuing availability of high-quality water resources. The rate of reservoir eutrophication could be reduced by choosing reservoir locations correctly, and by constructive use and exploitation. The majority of existing reservoirs in Romania have multiple uses, and draw their water from the hypolimnion. By ensuring that reservoirs beds are properly cleaned, especially during the summer months of stagnation, one can, through a positive intervention, effect a reduction in eutrophication. The following are characteristics unique to reservoirs:

- A uniform distribution of oxygen, as shown by orthograde analysis, can be obtained by assuring a vertical circulation of water, which contributes to a uniform vertical distribution of oxygen within the water mass.
- Oxygenation of the deep water layers, impedes the re-circulation of nutrients, especially nitrogen, at the point where water interacts with the sediment at the bottom.
- The possibility of the removal and exportation of a large quantity of nutrients from bottom sediments through evacuations and cleaning, in order to slow down the turn-over rate of these nutrients.
- The possibility of eliminating toxic substances, such as hydrogen sulphur, ammonia and organic pollutants.

A recent study in three large Romanian reservoirs showed that in comparison to a natural lake, which hypothetically has the same water properties but whose principal evacuation takes place on the surface, artificial reservoirs, through bottom evacuation, removed 25% of their nitrogen and phosphorus. The above mentioned characteristics, unique to artificial reservoirs, result in the removal of the generally accepted limit of nutrients. The disturbance to the balance of nature, the acceleration of the phenomenon of eutrophication, as well as water evaporation, can be slowed down by maintaining a vertical circulation of water in the lake and by evacuating the bottoms of reservoirs.

Studies in applied ecology, carried out over the last fifteen years, have led to the establishment of specific indicators of trophic evolution in reservoirs in Romania. The phenomena were approached through their causes, bearing in mind the indices which reflected cause and those which reflected the manner in which the phenomena appeared. The concentration of nutrients, as well as their use and distribution, are the principle causes of lake eutrophication. If certain elements of the structure of living cells such as carbon, oxygen and hydrogen are abundant in the water, then our attention is directed toward nitrogen and phosphorus, which condition and limit trophic evolution by regulating the development of vegetation. Simple nitrogen and phosphorus salts are fundamental compounds used in the process of photosynthesis. Since these elements have a high turn-over rate, the total, long-range concentration of nitrogen and phosphorus has to be taken into account when characterising a particular lake. This is especially true of phosphorus, as it is recycled more rapidly in these ecosystems. In the framework of this presentation we have taken into account the total concentration of both phosphorus and nitrogen.

Besides looking at trophic evolution indicators in order to understand the nature of a lake, we can also look at biological productivity and oxygen consumption. By analysing biological productivity, one can determine that a reduction in biodiversity correlates with an increase in plankton vegetable biomass, which is characteristic of a certain degree of eutrophication. In the case of reservoirs, one can observe a more accentuated reduction in biodiversity which, in the most part, can be explained by increased entropy in comparison to natural lakes. At the same time, overall productivity is also seen to be notably higher, because of a weak presence of consumers from the food chain. Ecosystems created by reservoirs have a greater degree of vulnerability and a more fragile ecological balance than natural aquatic ecosystems, as they are more sensitive to the modifications effected by pollution. A measurement of the increase of the planktonic vegetable biomass in the light zones, performed simultaneously in numerous reservoirs, has led to the establishment of certain characteristic values for the trophic evolution of reservoirs in Romania. Variations in oxygen concentration also reflect the results of eutrophication. The exchanges that take place in the decreased oxygen thermal layers of deep reservoirs as well as the capacity for aerobic metabolism in these zones, reflect, in quite an expressive manner, the effects of bottom evacuations and are specific indicators of eutrophication in reservoirs. The continual removal of

oxygen-poor water and oxygen-consuming material, as a result of these evacuations, is responsible for increased oxygen concentration levels, even during the summer months. One of the essential criteria in the evaluation of trophic levels is the capacity for aerobic metabolism of organic substances in the lakes.

This effect is depicted by the relationship between oxygen consumption, as expressed by DCO - mgO2/l, and the concentration of oxygen. Numerous studies undertaken have demonstrated that relationships of 30-40% show a balanced metabolic activity, and that increases to the region of 50-60% show an aggravated situation. While an increase in this relationship demonstrates that metabolic activity is effected, at relationships that go beyond 100% it is evident that there is an accumulation of non-metabolised organic substances, a specific phenomenon of eutrophication. With regard to oxygen saturation, phosphorus and nitrogen concentration, maximum phytoplankton biomass and eutrophication levels, a trophic picture of Romanian reservoirs is shown in Table 2.

Table 2

	Oligotrophic	Mesotrophic	Eutrophic
Total P (mg/l)	< 0.03	0.03 - 0.15	> 0.15
Total N (mg/l)	< 0.3	0.3 - 1.5	> 1.5
Max Phytoplankton (mg/l)	< 10	< 10	> 20
Oxygen Saturation	70%	10-70%	10%
Eutrophication	0-30%	30-100%	> 100%

In analysing factors related to the cause and manifestation of eutrophication in reservoirs, where bottom evacuations functioned normally, it was found that nutrient concentration could not be proportionally translated into evidence of eutrophication. Large quantities of water, removed through evacuation processes, inadvertently carry an increased number of nutrients. At the same time, the high concentration of oxygen, at increased reservoir depths, ensures the aerobic metabolism of organic substances. It is thus that a balance between the added and subtracted material is maintained, in a state proportional to the concentration of nutrients in the water of the lake and not in relation to the exchange of nutrients.

Studies carried out on many Romanian reservoirs, with the purpose of assuring a high quality of reservoir water through decreasing the risks of a disturbance in the balance of the ecosystem, have led to the establishment of certain regulations for projects and uses of reservoirs. These efforts amount to tenants of environmental criteria, and play an important part in the overall environmental development of society, the only path to sustainable development in the third millennium.

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