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RESERVOIR DEVELOPMENT VS. BIODIVERSITY: IS IT ALWAYS A REAL CONFLICT? A CASE STUDY – BISTRIȚA VALLEY, ROMANIA

Ioan Cărăuş, Dan Teodorescu

INTRODUCTION

An usual perception related to hydroelectric developments resulted in the hypothesis, even in the common opinion, that the construction of large dams produces – as a rule – an important, negative impact, not only on the local environment, but also, at the level of the biodiversity in the area. Of course, there are some certain and major environmental changes involved by hydroelectric developments. One of these is represented by the interruption of the river continuity and, subsequently, by some significant changes within the fish fauna of the aquatic ecosystem. Such modifications were recorded on Bistrița River, after the finishing of the hydroelectric schemes.

Based on the results of the relative numerous results of a long period of research carried out on different aspects of the environment and the biota within the upper, middle and lower sectors of Bistrița River valley, the authors try to define the real impact of the hydroelectric developments – at the level of the whole river basin and referring to a long period of time – upon the general biodiversity.

It is well known the major importance of the biodiversity as a premise for a higher ecosystem stability; it was carefully considered and analyzed at the Rio de Janeiro top meeting in 1992; as a result, a special resolution concerning the protection of biodiversity was adopted there. In the acceptance of that meeting, the concept of biodiversity refers not only to the number of species inhabiting a specific territory, but also to the various biotopes, habitats and even whole ecosystems from a certain area.

The increasing socio-economic needs for more and more energy result in a continuous expanding of hydroelectric developments, considered one of the relative clean sources of energy. So, a lot of large dams, i.e. reservoirs, were built or are to be constructed in many countries. This action determined sometimes a reaction of the local communities, mass-media or of some of ecologists' organizations to try to stop the execution of such projects. Their major arguments refers to the "damages to the genuine nature" associated with such human activities.

This paper is a result of an interdisciplinary approach of the problem: it describes some of the ecological consequences of hydroelectric developments, analyzed from both an biologist' and engineer's viewpoints.

Background

Bistrița River hydroelectric development is the first huge, complex work in this field in Romania. It was performed in early '50 and '60s of XX century.

The hydroelectric scheme consists mainly in Izvoru Muntelui dam-lake, a large water power reservoir, other seven, smaller reservoirs situated downstream on Bistrița valley, a hydroelectric canal system and the afferent power plants. The elements of the system are presented in the table below (Tab1).

In time, the date of July 1st, 1960 represented an important highlight; on this date the huge concrete dam at Izvorul Muntelui was closed and the water of Bistrița River started to accumulate behind, forming the largest inland reservoir in Romania.

Later, a new hydrotechnical development could influence the ecological situation within Bicaz water power reservoir. It consisted in a supplementary adduction of water into Bicaz reservoir, based on the catching of Bicaz River and the transferring of water, through two successive long tunnels, into the reservoir. It is to emphasize that this river has its origin in a natural dam lake – Lacul Roșu – (formed after a major landslide in a mountain region, in 1837); this ecosystem has, of course, an evolved, relative stable biocoenosis, typical to a mountain lake. A special investigation proved that at least several of the small algal plankton populations from this lake can survive after their passing through the Bicaz River and the two successive tunnels to Izvoru Muntelui reservoir.

Table 1. Bistrita hydroelectric development (Eastern Carpathians, Romania)

Structural element	Characteristics	
Dam	Type – concrete gravity dam	
	Crest length – 430 m	
	Height – 127 m	
	Volume – 1625.10^3 m^3	
Izvoru Muntelui Reservoir	Water mirror max. altitude	513 m a.s.l.
	Maximum volume of stored water	1230.10^6 m^3
	Maximal depth	90 m
	Length	37 km
	Maximal width	2 km
	Surface	3300 ha
Tunnel (headrace gallery)	Length	4745 m
	Diameter	7 m
Power plant	Installed capacity	210 MW
Downstream smaller reservoirs		7
Hydroelectric Channels		6 segments
Derivation power stations		5

Features of the environment & biocoenoses within Bistrița River basin

Bistrița River is a (second) degree left-handed tributary of the Danube: it flows in Siret River which in fact is the last but one tributary before the ending of Danube in the Black Sea.

Bistrița River basin is located in the Eastern Carpathians and in the Moldavian western hill region; its catchment area is of 6974 km^2; upstream from the great dam (Izvoru Muntelui) site, the catchment area, belonging to a mountain region, is 4071 km^2. The river course has a general orientation from north-west to south-east; it passes through a mountain region, then a premountain zone, and, finally, a region characterized by low elevation hills. In its upper and middle parts, the basin is partially covered by coniferous and deciduous forests; the lower sector of river valley is characterized by predominance of fields used for agricultural activities. There are here also large areas occupied by villages, roads and other lands used by local people.

Values concerning the multiannual average water flow show, range between 32.6 m^3/sec at the upper end of Izvoru Muntelui reservoir, i.e. at the upper limit of the hydroelectric developments of Bistrița River valley, and 51,9 m^3/sec at the confluence of Bistrița with Siret River.

Chemical analyses showed that upstream Izvoru Muntelui reservoir river water may be considered as corresponding to the first class of quality, according to the Romanian official standards for surface waters. Downstream of the great dam at Bicaz, and especially after the restitution of water stored in reservoir to the river natural valley, its quality remains, generally, good; down to Piatra Neamț the water represents an environment favorable to a normal life and development of the specific biocoenoses. In the mountainous sector, dissolved oxygen values are rather high, usually over 10 mg/l; the nitrate ranges between 1-2 mg/l; chemical oxygen demand varies between 11-24 mg $KMnO_4$ mg/l. Water total hardness is about 4 – 7 ^{0}, the average calcium content in river water is 46 mg/l.

From Piatra Neamț (people 120,000) to Bacău (about 245,000 inhabitants) a gradual pollution occurs; from the middle part of this sector a heavy pollution is recorded. It is determined both by industrial wastewater spills, and by household and livestock wastes littered in Bistrița river bed. As a result, the chemical composition of water becomes less proper as compared to the ecological requirements of the common aquatic organisms. Average dissolved oxygen content decreases to 5 – 6 mg/l; the fixed residue (TDS) increases from 200 – 220 mg/l within the upper and middle sectors of Bistrița River to 300 –800 mg/l before the confluence with Siret River.

The aquatic biocoenoses of the river are the typical ones for a water course passing through mountain regions, then through low hills zones; of course, they are significantly influenced not only by hydroelectric developments in the valley, but also by pollution processes.

Under natural conditions Bistrița River presented three fish zones as follows.

The trout zone was located within the upper section of the mountain sector of the valley, namely from the springs to the village Carlibaba, i.e. the first 30 km of the river; besides the brown trout (*Salmo trutta fario*), other fish populations were the minnow (*Phoxinus phoxinus*), *Cottus poecilops*, the loach (*Noemacheilus barbatulus)*.

The second sector, considered as the grayling (*Thymallus thymallus*) zone, covered the Bistrița River between Cârlibaba and Piatra Neamț, i.e. from km.30 to km. 220. Fish fauna of this sector was characterized by the occurrence of bleak (*Alburnus alburnus*), gudgeon (*Gobio gobio*), barbel (*Barbus barbus*), *Barbus meridionalis petenyi,* chub (*Leuciscus cephalus*), *Alburnoides bipunctatus, Cobitis aurata balcanica,* brook lamprey (*Eudontomyzon danfordi*), loach (*Noemacheilus barbatulus*).

Downstream Piatra Neamț the barbel (*Barbus barbus*) zone was delimited. The fish fauna of this part of the river was dominated by barbel, dace, broad snout (*Chondrostoma nasus*), *Rhodeus sericeus amarus*, perch (*Perca fluviatilis*).

Changes produced after the hydroelectric development

Biotope modifications

The impact of the construction of the hydroelectric system on Bistrița River valley was determined not only by the construction itself (that including displacement/resettlement of localities, new roads, the apparition of a lot of new landscape elements, as dams, hydropower stations, channels, land areas covered by mineral material extracted for tunnel, channel and other constructions, power electric lines etc) but also as a result of functioning of the system.

Summarizing, the most important biotope modifications could be considered the following:

- The inundation of an important land surface and the apparition of new (lacustrine) types of biotopes, i.e. the 8 reservoirs, whose total area reaches about 4500 hectares;
- The fragmentation of the Bistrița River valley and the destruction of its "river continuum";
- The disappearance or significant mitigation of the water on a lot of sectors of the old (natural) river bed, due to its retention within reservoirs;
- The apparition of an irregular, pulsatory regime of downstream water flow, related to needs for energy production;
- The apparition of an artificial water course, represented by the channel system; this could be considered a stagnant (lentic) type of water, when the power plants do not operate, and a quick flowing water, when they do;
- Local influences on surrounding areas, as concerning air temperature regime, winds, atmospheric moisture, hydrogeological features etc.;
- Significant changes of land use within the middle and lower parts of Bistrita River basin;

- A certain intensification of forest exploitation in the upper part of the river basin, partially related to the water transport facilities offered by the water mirror of the huge Izvoru Muntelui reservoir.

From all the types of environmental impact presented above, the greatest direct influences on the biodiversity, considered at the aquatic ecosystem level were exerted by the first four mentioned above.

The formation of several lacustrine basins determined, on one hand, the destruction on determined river bed areas, of preexisting, specific, animal and plant communities and, on the other hand, the apparition of completely new types of habitats, very different as compared to the former ones.

Downstream, the segmentation of Bistrița River course interrupted the "river continuum" and led to a dramatic change of living conditions for the communities occurring in the river bed previously; last, but not least, natural fish migration related to spawning was drastically cancelled.

A certain importance – as related to biodiversity – presents also the modifications within the land biotope; the installation of new localities on the slopes around Izvoru Muntelui reservoir resulted in displacing of some natural biotopes with artificial (man-dominated and oriented) areas, including rural sites, related roads, agricultural areas, fields designed for livestock pastures etc.

Biocoenose changes

The changes determined by hydroelectric developments on Bistrița River affected in a major form the structure of the biocoenoses in this area. The modifications were the result of an ecological succession in the middle and lower sectors of Bistrița valley: after the dam building, the formation of reservoirs, which implied the flooding of important land surfaces, delimited parts of the former land biocoenoses disappeared, and in the new, lacustrine-type biotopes, specific biocoenoses installed.

As concerning the *land ecosystems*, the following main modifications within the biocoenoses are to be mentioned:

- Disappearance of that section of the land biocoenoses which previously lived on the surfaces covered by water (or by different hydrotechnical and/or auxiliary works); this way, the total area occupied by these biocoenoses reduced significantly;
- Smaller land surfaces, including their vegetation & other communities were covered by deposits of minerals (mainly gritstone, marl and limestone) which were dislocated from different specific works, as the construction of dams, channels, tunnels, excavations for power stations etc.;
- Transformation of land use in relation to human communities displacement: as a result of moving of whole localities (especially from the areas designed to be flooded, other land surfaces – mainly within the surrounding territories – were occupied by the new settlements); this meant the areas for new roads, for house building, for small gardens and orchards, spaces for cemeteries etc.;
- A special importance presents the transformation of determined areas, previously occupied by forest or meadow ecosystems into grassland (pasture) fields, destined to livestock breeding;
- A certain impact on the forest ecosystems was also noticed: the construction of new localities even the needs for fire wood contributed to a reduction of forest surfaces around the reservoirs; on other hand, the construction of Izvoru Muntelui reservoir did not represent an obstacle for the continuing the upstream rafting on Bistrița River, a traditional activity in forest exploitation in this zone; the transport of wood was made on the reservoir surface toward the dam by towing with special tug boats;
- Finally, an other type of biocoenosis change is due to the controlled planting of trees on different land surfaces within the catchment area; large pine plantations appeared on the slopes near Izvorul Muntelui reservoir and in other portions of Bistrița valley.

Generally, after the finishing of the hydroelectric developments on Bistrița valley, important socio-economic changes took place here. There were constructed new localities, the existing were developed and extended, new roads appeared, new fields were fallowed and prepared for agriculture or for animal breeding, forest exploitation within Bistrița River basin increased.

All these resulted in a significant, long-term, process of anthropization of all the zone, especially within the middle and lower part of the basin of Bistrița River. It is to be mentioned that this process was much more complex, and it was not determined exclusively by hydroelectric developments. The general economic, demographic and industrial progress was accompanied by an increase of human activities in this region.

The *aquatic biocoenoses* were influenced directly by hydroelectric developments.

The appearance of completely new biotopes, represented by the reservoirs and the channels determined the conditions of installing and formation of communities typical for stagnant waters; on other hand, the disappearance of the water flow on certain segments of Bistrița river bed as a result of water retention behind the dams determined, of course, some localized losses in rheophilic species distribution. The same localized effect resulted also from the inundation of the portion of valley covered by reservoir water.

On the portions of river bed flooded after the closing of the dam(s), the greatest part of the typical flowing water communities was removed and disappeared.

For instance, within the area liable to inundation after the closing of Izvoru Muntelui dam the investigations carried up before this moment showed a relative rich diatom community within the reophillic microphytobenthos in the area. There were recognized diatom 110 species; among the most common populations are to be mentioned *Diatoma vulgare, Diatoma elongatum* var. *tenuis, Ceratoneis*

arcus var. *amphioxys, Synedra ulna, Cocconeis pediculus, Cocconeis placentula, Achnanthes minutissima, Navicula cryptocephala, Navicula gracilis, Navicula grandis, Amphora ovalis, Cymbella ventricosa, Cymbella sinuata, Cymbella affinis, Gomphonema olivaceum, Nitzschia dissipata* etc. There were also identified some relative rare species, part of them were firstly reported for the Romanian algal flora (as *Synedra amphicephala* var. *austriaca, Eunotia praerupta* var *muscicola, Diatomella balfouriana, Navicula grimmei, Caloneis pulchra* etc); one species living here (*Cymbella bistritzae*) was new for science: practically, it was discovered and firstly described here (Oltean and Zanoschi, 1963). As could be seen, all these diatom populations are specific for living under the environmental conditions offered by a mountain river, characterized by a rapid water flow, usually high transparency, relative reduced temperatures along the vegetative season, good oxygenation and, to a certain extent, low pollution.

When the high dam was closed and river bed was flooded the greatest part of these algal populations could not survive under the new conditions, i.e. on the bottom of a deep reservoir, with a very poor illumination, with no water flow etc. They really disappeared from the flooded sector of the river bed, but **they remained to live both in Bistriţa River and its tributaries upstream the Izvoru Muntelui reservoir**; these species were recognized in microphytobenthos samples from the area, during the years after the filling of the reservoir.

On the other hand, the apparition of new, lenitic (stagnant) biotopes, within a lake-like water basin, favorised the installation of a number of algal populations adapted to live within the water mass, as planktonic organisms. Before 1960 (when the great dam was closed), Bistriţa River – as a mountain, rapid flowing water – presented no typical plankton community. After the filling of the reservoir, gradually different plankton algae appeared and developed here, forming, in time, a well represented and diverse, true phytoplankton (including more than 250 species). Among the typical plankton algal populations appeared in Izvorul Muntelui – Bicaz reservoir, the following could be mentioned: *Asterionella formosa, Fragilaria crotonensis, Cyclotella comta, Cyclotella meneghiniana, Rhizosolenia longiseta, Oscillatoria rubescens, Dinobryon sociale, Bicoeca tubiformis*, *Bicoeca planktonica, Kephyrion spirale, Aulomonas purdyi, Stelexomonas dichotoma, Volvox aureus, Pandorina morum, Oocystis pelagica, Dictyosphaerium ehrenbergianum, Elakatothrix acuta, Micractinium bornhemiense, Chodatella ciliata; Coelastrum reticulatum, Peridinium cinctum, Ceratium hirundinella* etc. Some of these populations produced from time to time important quantitative developments, sometimes even "water blooms"; the most impressive was that produced by *Oscillatoria rubescens*, a typical plankton population, preferring rather cold water of mountain lakes. It represented a biological indication about the evolution of the aquatic ecosystem towards eutrophication.

Among the algal plankton species found in Izvorul Muntelui reservoir, certain are relatively rare, even representing a first record for the algae flora of Romania (as *Bicoeca tubiformis,Bicoeca crystallina, Bicoeca multiannulata, Bicoeca planktonica, Aulomonas purdyi, Stelexomonas dichotoma*).

Considering that information, we could summarize:

1. the destruction/disappearance of the previous river habitats – situation limited to several specific, precise delimited Bistriţa river sectors led to the local extinction of that populations adapted to the river conditions; their disappearance was only strictly localized, the rheophillic populations continuing to live within the upstream (and partially, downstream) in the benthic communities of the river bed;
2. part of these populations continued to live under the conditions resulted from the hydroelectric developments, included in fixed communities as the near-shore microphyto-benthos, the periphyton etc.;
3. the new habitats associated to reservoir and/or channel construction were populated by completely new types of populations, adapted to the life within water masses, mainly plankton populations. Here were identified a lot of plankton algae, constituting an abundant and diverse community.

In fact, the apparition of a true plankton community, which previously was impossible under the conditions offered by a quick flowing river water, is confirmed by the formation of specific zooplankton populations, consisting in typical lacustrine species, as *Brachionus calyciflorus, Keratella cochlearis, Kellicottia longispina, Asplanchna priodonta (Rotatoria), Daphnia hyalina* var. *lacustris, Daphnia longispina, Bosmina longirostris, Alona affinis, Diaphanosoma brachyurum, Leptodora kindti (Cladocera), Cyclops vicinus, Acanthocyclops vernalis, Eucyclops serrulatus, Eudiaptomus gracilis (Copepoda).*

The studies performed in the area before the closing of the great dam at Izvoru Muntelui on the benthic invertebrates (Miron, 1960) showed that in the Bistriţa River and its tributaries there were identified 198 species, belonging to Tricladida, Gastropoda (snails), Amphipoda, Hidracarina (water spiders), Ephemeroptera (mayflies), Plecoptera, Trichoptera (stone flies), Odonata (dragon flies), Heteroptera (water bugs), Coleoptera (water beetles), Chironomidae. From all these, only 18 species (i.e. 9 %) adapted and survived under new, lacustrine biotope and are present within the communities inhabiting the bottom deposits of Izvoru Muntelui reservoir. The rest of species continue to occur in the river bed of Bistriţa and its tributaries in their upstream sectors, before their inflow in the reservoir.

The changes referred too, to the fish distribution and zonation within Bistriţa River basin.

After the finishing of the hydroelectric developments some major modifications in fish fauna composition, structure and distribution were recorded.

The quantitative ratio between different species were significantly changed; in Izvoru Muntelui reservoir one of the dominating species – at least as number of individuals – become the bleak (*Alburnus alburnus*); other common species were : lake trout (*Salmo trutta lacustris*), *Salvelinus fontinalis,* rainbow trout (*Salmo irideus*), chub (*Leuciscus cephalus*), *Chondrostoma nasus,* minnow (*Phoxinus phoxinus*), barbel (*Barbus barbus*). Last ten years, an important increase of perch population (*Perca fluviatilis*) was noticed; this species became the most important predator and significant changes within ecosystem trophic structure are to be expected.

One of the rare fish species of salmonids, *Hucho hucho,* present previously in the upper part of the Bistrița River, is recorded as a stable but scarce population within the ichthyofauna of Izvoru Muntelui reservoir. An other population – that of grayling (*Thymallus thymallus*) – typical for flowing waters, was present in Bistrita River and, after the appearance of the great reservoir, it moved upstream.
Some trials to introduce new fish species have different results*:* the bream (*Abramis brama*) survived and adapted well to the conditions of the reservoir ecosystem; it became one of the most important species for fishing activities. The introduction of the sterlet (*Acipenser ruthenus)*, and *Coregonus lavaretus* was not a success.

Last, but not least, the appearance and installing of isolated, small or larger communities of aquatic macrophytes has to be mentioned. Within Izvoru Muntelui reservoir, only a weak formation of *Polygonum amphibium*, at the upper end of the basin, was recorded. A different situation was observed in downstream reservoirs. Here, the aquatic vegetation occupies many hectares in every man-made lake; the macrophytes became even a potential damage for a normal exploitation of hydroelectric plants. From an ecological point of view, it seems important to say that these abundant communities, consisting mainly in populations of *Potamogeton crispus, Potamogeton pectinatus, Potamogeton lucens, Elodea canadense, Myriophyllum spicatum,* (which, anyway, could not develop before, in quick flowing water of Bistrița River) represent a very adequate microhabitat for a lot of other vegetable (algal) and animal populations living here; this represents in fact a diversification of habitats within the ecosystem, and also a favorable condition (premise) for the installing of new species and for the increase of the biological diversity. It is also possibly that these dense plant communities to contribute to a certain extent to the biological purification of water.

The presence of these new water mirrors in Bistrița River basin, and the food resources offered by them determined also the appearance of important and diverse waterfowl populations (seagulls, wild ducks, moor hens, wild (northern) geese, divers, herons, even swans, or relative rare, nordic, species, as *Gavia arctica*). During their seasonal migration these birds find here a temporary refuge; some of the species made their nests here (Munteanu, 1968).

Systemic modifications

An interesting impact on biological diversity results from the functioning of the hydroelectric developments as a whole.

The presence of one huge reservoir and of other 7 smaller downstream reservoirs, as well as the artificial water course, represented by the successive channels from Stejaru power plant to Bacău-II electric station realize a sum of individualized elements which constitute a large functional system.
Each aquatic basin with its direct tributaries, each segment of hydroelectric channel, represent in fact a specific, unique biotope, able to offer optimum living conditions to one or other species. But, besides the local, microhabitat differences, the system as a whole has a certain "unifying factor": it is the continuum represented by the flowing of a $\pm$ same water from one section to another. This flow has not a regular character; in fact, it depends on economic demands and, partially, on the characteristics of the inflow regime. This situation determines important opportunities for a real and significant increase of the biological diversity at the level of the entire Bistrița River basin. It may be mentioned the possibility that upstream reservoirs to contribute to the populating of downstream basins; the presence of some plankton species originating from Izvorul Muntelui reservoir was reported in small reservoirs, downstream to Bacău.

On the other hand, the economic reasons led, for long periods of time, to reduce the servitude water flow downstream the dams under the level of minimum security for old river bed biocoenoses. This fact produced, year by year, important modifications within these sectors of Bistrita River.

A complementary feature as related to the biodiversity situation was a relative heavy water pollution, produced especially downstream Piatra Neamt city, due to household and industrial wastewater. Of course, this is an other problem, not related to hydroelectric developments.

Biodiversity – in danger?

Summarizing, from the information presented above, it may be observed that, in fact, the construction and the operation of Bistrita River hydroelectric development did not determine a real or significant decreasing of biological diversity **at the level of the whole hydrographic basin**.

On contrary, the appearance of new types of aquatic habitats and microhabitats made possible the installation and extension of some completely new populations, belonging to species adapted or typical to lacustrine ecosystems.

Conservation measures

In present it isn't in usage to think (or to act !) about the nature conservancy when speaking of a man-made lake.

In spite of this fact, taking into consideration the natural process of a graduate installation of new and new populations within the new biotope

represented by the reservoir, one has to understand this is a very fragile and sensitive process. It is a long lasting evolution, with both ascending and descending slopes. Human intervention, either from the lack of knowledge, or from some negligence, could determine major interruption of a relative natural evolution of the biocoenoses.

The main possible ways to endanger the process of biodiversification within the new formed aquatic ecosystem are:

- Total subordination of the operation regime within the hydroelectric system to the economic needs;
- A regime of very high water level oscillations from one season to another; this makes not possible the installation of littoral vegetation belts and determines an important shore abrasion;
- The same water level oscillations could determine the remaining on a drying ground (previously the bottom of the reservoir) of the fish eggs placed in shallow littoral zones of the basin; this leads to the reduction of several fish populations in the ecosystem;
- Major variations of the volume of the stored water implies significant changes of the duration of the water retention period in the reservoir; at low levels (i.e. smaller volumes of water), this results in a reduced effective eutrophication, in lesser conditions for a normal development of planktonic primary producers;
- A too reduced water flow regime downstream of the dam to the restitution section; this results in the disappearing of most of the aquatic biocoenoses present previously in the river bed;
- Certain pollution processes, determined by human activities upstream in the catchment area (as mining industry, forestry exploitation, timber production, other industrial activities, livestock breeding etc.) , within the surrounding area (esp. due to household wastes, some tourist activities) or even just within the reservoir itself, especially as a result of navigation;
- Overfishing (or uncontrolled fishing), as well as the empirical introduction of new fish populations (or other aquatic organisms) could cause significant disequilibria within the biocoenosis;

It has to be considered that a reservoir – including the upstream and downstream river sectors – represents an entirely new habitat, resulted by a human action; this habitat is to become, gradually, based on natural laws, a new, different ecosystem. The process lasts usually many years and it results in a certain diversification of biotopes at the scale of the whole hydrographic basin and, finally, in an increase of general biodiversity.

So the sources of ecological impact mentioned above must be considered with maximum responsibility and professionalism.

To protect the "new" biodiversity it is necessary a specific environment-friendly management of the hydroelectric system.

CONCLUSIONS

1. Bistrita River basin (Romania) was investigated for years, before and after the hydroelectric development; an important amount of scientific information was achieved;
2. The appearance of new habitats and microbiotopes related to hydroelectric developments determined the installing of completely different populations and biocoenoses, typical for stagnant waters (phytoplankton, zooplankton, macrophyte communities etc);
3. The partial (local) destruction of populations within the flooded areas, or on the sectors occupied by constructions, waste mineral deposits etc. doesn't mean a reduction of biodiversity at the whole hydrographic basin scale; other parts of the populations usually remain upstream (or within the tributaries), sometimes downstream the hydroelectric works;
4. In fact, a certain increase in the biodiversity of the whole hydrographic basin occurred in the case of Bistrita River basin;
5. The problem of conservation of this "secondary" biodiversity may be considered.

REFERENCES

1. BATTES K., CĂRĂUŞ I., MĂZĂREANU C., MIRON I., RUJINSCHI R., RUJINSCHI C., SIMALCSIK FL., SIMALCSIK FR., 1971 – Hydrobiological charac-teristics of Bicaz water power reservoir (in Romanian*). Trav. Station Recherches Biol*., *Géol. et Géograph. "Stejarul*", Biologie, 3, 577-596.
2. BUŞNIŢĂ TH., 1971 – The ichthyofauna of the reservoirs; its evolving and utilization (in Romanian). *Trav.Station Recherches Biol*., *Géol. et Géograph. "Stejarul"*, Biologie, 3:572-576.
3. CĂRĂUŞ I., 1968 – The ways of populating the new reservoirs. I. The role of waterfowl. *Trav.Station Recherches Biol., Géol. et Géograph. "Stejarul*", 1: 143-149.
4. CĂRĂUŞ I., 1971 – The ways of populating the new reservoirs. II. Neighboring limnetic ecosystems. *Trav.Station Recherches Biol., Géol. et Géorgaph. "Stejarul",* Biologie, 3: 323-330.
5. CĂRĂUŞ I., 1971 – The phytoplankton of Bicaz dam reservoir. III. Investigations on the qualitative composition (in Romanian). *Trav. Station Recherches Biol., Géol. et Géograph*. "*Stejarul*", Biologie, 3, 313-322.
6. MIRON I., 1960 – Contributions to the study of aquatic invertebrates in Bistriţa River and its tributaries in the zone of Bicaz reservoir (in Romanian). *An.Univ. "Al.I.Cuza*", Iasi, Biol., VI, 3: 719-728.
7. MIRON I., CĂRĂUŞ I., MĂZĂREANU C., APOPEI V., GRASU C., ICHIM I., MIHĂILESCU FL., RUJINSCHI R.I.,

RUJINSCHI C., SIMALCSIK FL., MISĂILĂ C., ȚĂRUȘ T., APETROAEI N., 1983 – Izvorul Muntelui – Bicaz Reservoir. Limnological Monograph (in Romanian). *Ed.Academiei*, Bucharest.
8. MUNTEANU D., 1968 – Ornithological observations on Bicaz reservoir (III) (in Romanian). *Trav.Station Rech. „Stejarul“,* 1, 345-350.
9. OLTEAN M., ZANOSCHI V., 1963 – Diatomological observations in Bistrița River and its tributaries in the zone of Bicaz reservoir (in Romanian). *Lucr.Grăd.Botan.Bucureşti*, 1, 175-185.
10. POPESCU E., OLTEAN M., 1963 – The dynamics of the planktonic trophic resources in Bicaz reservoir during the first two years after flooding (in Romanian). *Buletinul Inst.Cerc.Proiect.Piscicole*, 20, 2: 32-51.
11. RUJINSCHI C., RUJINSCHI R.I., 1981 – Aspects of the realization of biocoenotic integrity within Bicaz reservoir (in Romanian). *Stud.Cercet.Biol., ser. Biol.Anim*., 33, 1:45-50.
12. TEODORESCU D. et al., 1995 – The analysis of environmental impact of Izvoru Muntelui hydroelectric development (in Romanian). *Research Project ISPH* 4473/3965.
13. TEODORESCU D., CĂRĂUȘ I., 1996 – The impact of the Izvoru Muntelui hydroelectric development on the environment, especially on the aquatic fauna and flora of Bistrița River. *Proc. Internat. Conference on Aspects of Conflicts in Reservoir Development and Management*. City University, London, UK : 3-5 September 1996; p: 263-268.

Note. In the literature list presented above, part of the papers refers to Izvoru Muntelui reservoir as “Bicaz reservoir”; in fact, is one and the same dam reservoir.

AUTHORS’ ADDRESS

IOAN CĂRĂUȘ – University of Bacău, Faculty of Sciences, Calea Mărăşeşti, No 157, 600115 Bacău, Romania.

DAN TEODORESCU – THEO CONSULTING, Aleea Sănduleşti, No. 2, 061786 Bucharest, Romania.