STUDIA UBB BIOLOGIA, LVIII, 2, 2013 (p. 85-90)

DAM RESERVOIRS – IMPACT UPON THE BIODIVERSITY

IOAN CĂRĂUŞ [1,✉]

SUMMARY. The increased number of dam reservoirs determined a special interest in order to know their ecological impact. There are generally recognized major impacts of hydrotechnical developments as the integral destruction of terrestrial and aquatic biocoenoses from the flooded area, the breakdown of the river connectivity, with a dramatic impact upon the upstream fish migration. There are also well known the alterations of natural flow pattern and of alluvial transport downstream of dams; many authors emphasize the reduction of biodiversity as a consequence of river damming. In the paper it is discussed mainly a case study – the environmental impact on biodiversity – of hydrotechnical developments on the Bistriţa valley (the Eastern Carpathians, Romania). In fact, the apparition of a new, lacustrine habitat, determined the installation in the new biotope of a lot of lentic organisms, which previously could not occur under stream conditions. The emergence of true phytoplankton and zooplankton communities determines a real increase of biodiversity at the watershed level.

Keywords: biodiversity, dam reservoirs, environmental impact.

Introduction

Today, on the Earth there are 45,000 large dam reservoirs, and about 800,000 smaller dam reservoirs; the total area flooded by all of them reaches 400,000 km^2. The reservoirs are constructed for water supply, flow regulation, water reserve for drought periods, energy production etc. (Cowie, 2002; Sikder and Elahi, 2013; WWF, 2004). In order to produce "green energy" the construction of new dams is going on.

In Romania there are 246 dams recorded in the "*World Register of Great Dams*".

Main environmental impacts of dams

The construction of more and more such hydrotechnical developments turned investigators' attention to their environmental impact, both during their construction and later, for a long term, on the duration of their existence and function (Antoniu,

[1] *Faculty of Sciences, "Vasile Alecsandri" University, 157 Mărăşeşti Str., Bacău, Romania.*
✉ ***Corresponding author: Ioan Cărăuş****, Faculty of Sciences, "Vasile Alecsandri" University, 157 Mărăşeşti Str., Bacău, Romania,*
E-mail: carausi@yahoo.com

1993; Biswas, 2012; McCartney *et al*., 2001; Railsback *et al.,* 1991; Ridley and Steel, 1975; Solacolu, 1993 etc.).

Several aspects of their environmental impact were highlighted, the most important being:

- effective destruction of terrestrial and aquatic biocoenoses, occurring previously on the flooded area;
- breakdown of the river connectivity, respectively its multiple fragmentation in the case of a concatenation of dams, with a direct impact upon the upstream migration of certain fish populations for reproduction;
- alterations of natural flow patterns and of alluvial transport;
- diminishing the quality of wildlife habitat downstream of reservoirs;
- flood control i.e. the reduction of the risk for catastrophic inundations;
- reduction of biodiversity (according to Sayadi *et al*., 2009; Sikder and Elahi, 2013; McAllister *et al*., 2001; McCartney *et al*., 2001).

The first five categories of environmental effects are beyond any doubt, they being obviously manifested for each hydrotechnical development, but the sixth one – concerning the decrease of the biodiversity – has to be analyzed carefully.

Impact on watershed biodiversity

In fact, as a consequence of succeeding from the lotic regime to the lentic one, after the damming of a river, a new biotope appears, with characteristics much different from that of the river.

The water flow regime within the hydrographic basin is modified, it appears a water mass more or less stagnant, with a thermal stratification depending of seasonal climatic changes and, also, a specific light/depth distribution.

The change of the main characteristics of aquatic environment has – as one of the effects – the impossibility of part of stream-adapted biota to survive in the new conditions.

In the new lacustrine biotope appear and are installed, gradually, new populations, able to adapt to the stagnant water conditions; they will constitute, in time, the biocoenoses of a new ecosystem, entirely different as compared to that occurring previously in the flooded area of the hydrographic basin.

So, at the level of the whole watershed, besides of the species occurring previously in water courses, and that continue to exist in the river parts which were not included within the structure of the man-made lake, there are appearing other species of water organisms, which could not live before, in the biotope peculiar to running water. Hence, considering the diversity of living world in aquatic environment – at the scale of the whole hydrographic basin – it may be observed a certain increase of the total number of species. The increase of biodiversity determined by that ecological succession will be the greater the greater will be the difference between the characteristics of the limnic and the lotic, previous environment.

In order to examine the course of the ecologic succession from river to lake, its consequences upon the biodiversity of the watershed, it will be presented here part of some results of the studies carried on within the Bistriţa River (the Eastern Carpathians, Romania) (Cărăuş and Teodorescu, 2006; Miron *et al.*, 1983); there are also considered the investigations carried on other impoundments in Romania.

The Bistriţa River was the target of a major hydrotechnical development during the sixth decade of twentieth century. This project resulted in the construction of a great dam at Bicaz and of other seven smaller dam reservoirs downstream; later, a small dam was built upstream Bicaz impoundment.

Before the closing of great concrete dam on the Bistriţa River (July 1st, 1960), the investigations carried on the diatoms in the main river and its tributaries, within the floodable area and adjacent zone, showed 162 taxa; all were benthic species, living on the river bottom. After flooding, most of these species survived, in the same water courses, upstream their flowing into Bicaz dam reservoir. Some of them were identified, after years, in the structure of lacustrine periphytic and microphytobenthonic communities.

The apparition of the new biotope (the maximum volume of the lake is 1.23 billion cubic meters, the maximum depth 90 m) offered conditions for installing of typical plankton algae. It may be emphasized that, previously, in the Bistriţa (a fast flowing river) did not occur any true plankton algae; otherwise, even now, on upstream sectors of the main tributaries, there are no plankton algae.

The first phytoplankton species appeared early after the damming. Later, their number surpassed 200 species, the phytoplankton becoming an important component of the ecosystem, in fact the main primary producer. There were observed even "water bloom" phenomena, - massive developments of certain populations (*Planktothrix rubescens*, *Volvox aureus* etc.), which proved the tendency to reservoir eutrophication.

The other component of plankton biocoenose – the zooplankton –was also missing in the Bistriţa River and its tributaries before the apparition of Bicaz Reservoir; fast water flowing of the river, its turbulence, the presence – sometimes – of large amounts of suspensions hindered the presence of animal plankton.

During the first six years after the closing of the dam, 72 zooplankton species were identified; later, alongside the ecosystem evolution and its relative stabilization, only 51 species remained (e.g. the Rotifers *Asplancha priodonta, Keratella cochlearis, Kellicottia longispina*; Cladocerans *Daphnia longispina, Bosmina longirostris, Leptodora kindti* and Copepods *Acanthocyclops vernalis, Cyclops vicinus, Eudiaptomus gracilis* etc. – according to Rujinschi and Rujinschi, 1983).

In the zoobenthos of the Bistriţa River and its tributaries in the flooded area, 198 species were identified; from these, after the damming, only 18 species survived (Miron, 1983). It is very probably that populations of these species remained in that water courses which were not affected by flooding. In time, in the deep bottom deposits of the reservoir appeared several populations which previously were not found in the Bistriţa River, as *Tubifex tubifex*, *Limnodrilus hoffmeisteri*, *Chironomus plumosus*, *Procladius skuze* etc.

A special attention is to be paid to the situation of fish fauna after the damming.

An early, comprehensive, study on the hydrobiological state of the Bistriţa River, in its whole (Motaş and Anghelescu, 1944) recorded 23 fish species. After the construction of the great dam at Bicaz and the smaller downstream reservoirs the ichthyofauna of the new man-made lakes presented some variations, concerning its composition. 24 fish species were identified (Pricope *et al*., 2010). Eight of the species reported previously weren't identified in the reservoirs, but other nine species were caught (*Eudontomyzon danfordi*, *Esox lucius, Rutilus rutilus, Abramis brama, Gobio kessleri, Carassius carassius, Scardinius erythrophtalmus, Gymnocephalus cernua, Salvelinus namaycush*); some of them were introduced by man.

Similar ecosystem changes were recorded after investigation of ecological situation of other dam reservoirs in Romania. True plankton communities appeared after flooding in dam reservoirs as Vidraru (on the Argeş River), Vidra (on the Lotru River), Tarniţa (on the Someşul Cald River), the reservoirs on the Siret River, partially the dams on the Olt River and others.

In all these cases, the apparition and development of plankton communities resulted in a significant increase of biodiversity at the level of the whole hydrographic basin.

It is to be emphasized that the formation of plankton biocoenose (especially phytoplankton) depends directly on the retention time of the water in a impoundment: short retention times will restrict algal proliferation and, on the contrary, long retention times favor the lacustrine algae. Hence, large, deep reservoirs will have an important phytoplankton community, but smaller impoundments, characterized by fast passage of water, usually have a rather scarce plankton (or no true plankton at all !).

After the construction of the two large dams on the Danube River (Iron Gates 1 and Iron Gates 2), no significant changes of biodiversity due to plankton development were recorded; before damming, the river had complex plankton communities. Most of them are still present now in the two reservoirs. The only increase of biodiversity is determined by mass development of huge macrophyte communities, especially in the downstream impoundment; such large communities of rooted or floating plants were not a common presence before the damming. On the surface of leaves, branches or stalks of water plants, a very abundant periphyton was installed, consisting in fixed algae, various invertebrates (protozoans, worms, crustaceans, mollusks etc.).

A special situation referred to some smaller dam reservoirs. On the Bistriţa valley, downstream of the main power station at Stejaru, there are seven dam reservoirs. They were populated by massive communities of aquatic macrophytes, covering – in several cases – even tens of hectares of water mirror. Dominant species belong to genus *Potamogeton* (*P. crispus, P. pectinatus, P. lucens*); *Elodea nuttallii*, *Myriophyllum spicatum, Ceratophyllum demersum* etc. were also identified.

All these species weren't observed in the middle and lower sectors of the Bistriţa River, before its hydrotechnical development.

The apparition and growth of these communities represent not only an effective increase of biodiversity, but a source of microhabitats constituting supports for periphytic organisms, refuges and food resources for fish fry, for a lot of invertebrates and even for some waterfowl (especially ducks from the genus *Anas*).

The same small reservoirs were/are location for a lot of waterfowl populations, especially in late autumn and winter; there are constantly observed (year by year) hundreds and hundreds of mute swans (*Cygnus olor*), wild ducks (*Anas platyrhynchos*, *Anas crecca, Anas querquedula* etc.). All these birds were not previously an usual presence on the Bistriţa waters; they appeared only after the construction of these reservoirs. It is important that the presence of waterfowl contributed to the introduction into the new habitats of some algae, transported from other water bodies (Munteanu, 2000).

Conclusions

The hydrotechnical developments on inland rivers determine important environmental changes, as effective destruction of flooded terrestrial and aquatic biocoenoses, the interruption of the river connectivity, with direct impact upon upstream migration of fish populations, change of water flow regime.

Some authors consider that one of the negative consequences of dam construction consists in the reduction of biodiversity.

Examining the results of a lot of comprehensive investigations on Romanian dam reservoirs, especially the case study of the Bistriţa River valley, there was stated that, as a result of apparition of a new aquatic habitat, very different from previous river conditions, a lot of new populations are installed. It was impossible for them to occur previously, under running water conditions.

It is obvious that in the new limnic environments, a true phytoplankton appears, also a typical zooplankton and other communities adapted to lacustrine conditions.

The increase of general biodiversity at the level of the whole hydrographic basin is more pronounced in mountain areas, where the environmental differences between river and man-made lake are greater.

Finally, it may be concluded that, the damming of a river determines major environmental impacts, as the ceasing of river connectivity, the breaking of fish migration, associated destruction of riparian biocoenoses, alterations of natural flow patterns on the river downstream the impoundment, modifying the physics, chemistry and biota of the water.

However, in many cases, the new filled impoundment constitutes a new, stagnant habitat, populated, in time, by a lot of new organisms (especially plankton biota) which previously could not live under running water conditions; this represents a contribution to increased biodiversity at the level of the whole watershed.

REFERENCES

Antoniu, R. (1993) Impactul lacului de acumulare asupra mediului înconjurător, In: *Lacurile de acumulare din România*, 1, Ed. Univ. "Al. I. Cuza" Iaşi; pp 9-17

Biswas, A.K. (2012) Impacts of large dams: Issues, opportunities and constraints, In: *Impacts of Large Dams – A Global Assessment*, Springer-Verlag, Berlin, pp 18

Cărăuş, I., Teodorescu, D. (2006) *Reservoir development vs. biodiversity : it is always a real conflict ? A case study – Bistriţa Valley, Romania*, *Studii şi Cercetări Stiinţifice – Biologie, Univ. Bacău*, **XI**, 9-15

Cowie, G. (ed.) (2002) *Reservoirs in Georgia: Meeting water supply needs while minimizing impacts*, River Basin Science and Policy Center, University of Georgia, Athens, USA, pp 42

McAllister, D.E., Craig, J.F., Davidson, N., Delany, S., Seddon, M. (2001) *Biodiversity impacts of large dams*, Background Paper no.1, IUCN/UNEP/WCD, pp 63

McCartney, M.P., Sullivan, C., Acreman, M.C. (2001) *Ecosystem impacts of large dams*, Background Publication no.2; IUCN/UNEP/WCD, pp 76

Miron, I. (1983) Zoobentosul, In: *Lacul de acumulare Izvoru Muntelui-Bicaz. Monografie limnologică*, Ed. Acad., Bucureşti, pp 166-172

Miron, I., Cărăuş, I., Măzăreanu, C., Apopei, V., Battes, K.W., Grasu, C., Ichim, I., Mihăilescu, F., Rujinschi, R.I., Rujinschi, C., Simalcsik, F., Misăilă, C., Tăruş, T., Apetroaei, N. (1983) *Lacul de baraj Izvorul Muntelui-Bicaz. Monografie limnologică*, Ed. Acad. R.S.R., Bucureşti

Motaş, C., Anghelescu, V. (1944) *Cercetări hidrobiologice in bazinul râului Bistriţa*. Monografia Inst. Cercet. Piscicole, Bucureşti, 2, pp 320

Munteanu, D. (2000) *Avifauna bazinului montan al Bistriţei Moldoveneşti*. Ed. Alma Mater, Cluj-Napoca, pp 250

Pricope, F., Stoica, I., Battes, K.W. (2010) The effects of anthropic activity on ichthyofauna diversity in some reservoirs of the Bistrița River *Studii şi Cercetări Stiinţifice – Biologie, Univ. Bacău*, **XV**, 28-32

Railsback, S.F., Cada, G.F., Petrich, C.H., Sale, M.J., Shaakir-Ali, J.A., Watts, J.A., Webb, J.W. (1991) *Environmental impacts of increased hydroelectric development at existing dams*, Environmental Sciences Division, Publ. no. 3585, pp 60

Ridley, J.E., Steel, J.A. (1975) Ecological aspects of river impoundments, In: *River Ecology*, Blackwell Scientific Publications, Oxford, pp 565-587

Rujinschi, R.I., Rujinschi, C. (1983) Zooplanctonul, In: *Lacul de acumulare Izvoru Muntelui-Bicaz. Monografie limnologică*. Ed. Acad., Bucureşti, pp 129-155

Sayadi, A., Khodadadi, A., Partani, S. (2009) Environmental impact assessment of Gotvand hydro-electric dam on the Karoon River using ICOLD technique, *World Academy of Science, Engineering and Technology*, **30**, 1-8

Sikder, M.T., Elahi, K.M. (2013) Environmental degradation and global warming – consequences of Himalayan mega dams: a review, *American Journal of Environmental Protection*, **2(1)**, 1-9

Solacolu, P. (1993) Impactul lacului de acumulare asupra mediului exterior, In: *Lacurile de acumulare din România*, 1, Ed. Univ."Al. I. Cuza" Iaşi; pp 26-37

*** (2004) WWF – *Dams and freshwater ecosystems – repairing the damage*, Dam Right, WWF's Dams Initiative, pp 4