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Comparative studies of the global ecological state variation of the aquatic environment in the Crişuri Hydrographic Space between 2007 and 2009

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Abstract. The paper presents a comparative study regarding the evolution across time of the quality of aquatic eco-systems in the Crişuri Hydrographic Space (CHS), between 2007 and 2009. Having as a goal a real and complete image of the quality of the environment in the CHS, the ecological monitoring conducted was meant to observe the structure of the aquatic communities (macrozoobenthos, microphytobenthos, phytoplankton) and the biotope characteristics (physical and chemical parameters of water: pH, conductivity, dissolved oxygen, CBO5, CCO-Mn, CCO-Cr, nitrites, nitrates, phosphates, amonium, chlorophyll "a", chlorides, sulphates, fix residues, As, Hg, Cu, Zn, Mn, phenols, detergents etc). The choosing of the monitoring sections, their identification and geographical position were accomplished in 2006. The basic criterion in the choice of the monitoring sections was the identification of all aspects that can influence the quality state of the waters. The monitoring of the quality state of the waters in the CHS was conducted in 40 sections, both on the main courses and their affluents, over a 3-year period. After the results of the analyses of physico-chemical and biological samples were obtained, the categorization of the prelevation sections in quality classes followed; depending on these classes, the modelation of the global ecological states of the watercourses in the CHS was realized by means of mapping techniques (GIS). Most of the monitoring sections were in the good ecological state category. The very good ecological state was determined only for those sections upstream all polluting sources. Nevertheless, some of the prelevation points exceeded both physico-chemically and biologically the limits of the good quality state, entering the category of moderate quality state. No watercourse in the CHS was determined for poor or bad quality state. Generally, a "preservation" of the quality state of the waters from one year to the following was noticed, although some monitoring points registered an improvement of the global ecological state, whereas others, a degradation. The improvement (eg. prelevation sections Râbiţa on Crişul Alb, Pădurea Neagră on Barcău or upstream Huedin on Crişul Repede) is mainly due to the lower quantity of mis-/untreated residual water upstream the monitoring sections. The modernization of waste-water purifying stations as well the connection of the urban areas to these stations finally contributed to the improvement of the water quality upstream these polluting sources.
Key words: bioindicators, monitoring, ecological state, sources of pollution.

Rezumat. In lucrare este prezentat un studiu comparativ privind evoluţia în timp a stării calităţii ecosistemelor acvatice din Spaţiul Hidrografic Crişuri, în perioada 2007-2009. Pentru a obţine o imagine reală, de ansamblu, asupra starii calităţii mediului din Spaţiul Hidrografic Crişuri, monitoringul ecologic s-a realizat prin urmărirea în timp a structurii comunităţilor acvatice (macrozoobentos, microfitobentos, fitoplancton) şi a caracteristicilor de biotop (parametrii fizici şi chimici ai apei ca: pH, conductivitate, oxigen dizolvat, CBO5, CCO-Mn, CCO-Cr, azotiţi, azotaţi, fosfaţi, amoniu, clorofila "a", cloruri, sulfaţi, rezidiu fix, As, Hg, Cu, Zn, Mn, fenoli, detergenţi etc). Alegerea secţiunilor de monitorizare, identificarea si respectiv localizarea lor geografică, s-au realizat în anul 2006. Ideea de bază a alegerii punctelor de monitorizare a fost aceea de a identifica toate aspectele care pot să influenţeze starea calităţii apelor. Monitoringul stării calităţii apelor din Spaţiul Hidrografic Crişuri s-a realizat în 40 de secţiuni de monitorizare, atât pe cursurile principale cât şi pe afluenţi, pe un interval de trei ani de zile. După obţinerea rezultatelor analizelor probelor fizico-chimice şi biologice, s-au făcut încadrările secţiunilor de prelevare în clasele de calitate, iar în funcţie de clasele de calitate obţinute s-au realizat cu ajutorul tehnicilor de cartografiere (GIS), modelarea stărilor ecologice globale a cursurilor de apă din Spaţiul Hidrografic Crişuri. Majoritatea secţiunilor de supraveghere s-au încadrat în starea ecologică bună. Starea ecologică foarte bună s-a determinat doar la acele secţiuni care au fost localizate în amonte de toate

sursele de poluare. Câteva puncte de prelevare, însă, au depăşit atât din punct de vedere fizico-chimic cât şi din punct de vedere biologic limitele maxime stării bune de calitate, încadrându-se doar în stările ecologice moderate de calitate. Starea ecologică proastă şi rea nu s-a determinat la nici un curs de apă din Spaţiului Hidrografic Crişuri. În general s-a observat o "conservare" a stării calităţii apelor din bazin de la un an de cercetare la celălalt an. Însă, la unele puncte de monitorizare am constatat o îmbunătăţire a stării ecologice globale, iar la altele un anumit grad de degradare a stării ecologice. Îmbunătăţirea stării calităţii apelor la unele secţiuni (de exemplu în bazinul Crişului Alb la secţiunea de prelevare Râbiţa, în bazinul Barcăului la Pădurea Neagră, sau pe Crişul Repede în aval de localitatea Huedin) se datorează în cea mai mare măsură scăderii cantităţii de ape reziduale netratate corespunzător în amonte de secţiunile de monitorizare. Modernizarea staţiilor de epurare şi totodată racordarea zonelor urbane la staţiile de epurare, au contribuit în final la îmbunătăţirea calităţii apelor în aval de aceste surse de poluare.
Cuvinte cheie: bioindicatori, monitoring ecologic, stare ecologică, sursa de poluare.

Introduction. Lying in Western Romania, the Crişuri Hydrographic Space borders the Someş Hydrographic Space in the North and the North-East, the Mureş Hydrographic Space in the East and South, and the Republic of Hungary in the West (Figure 1).

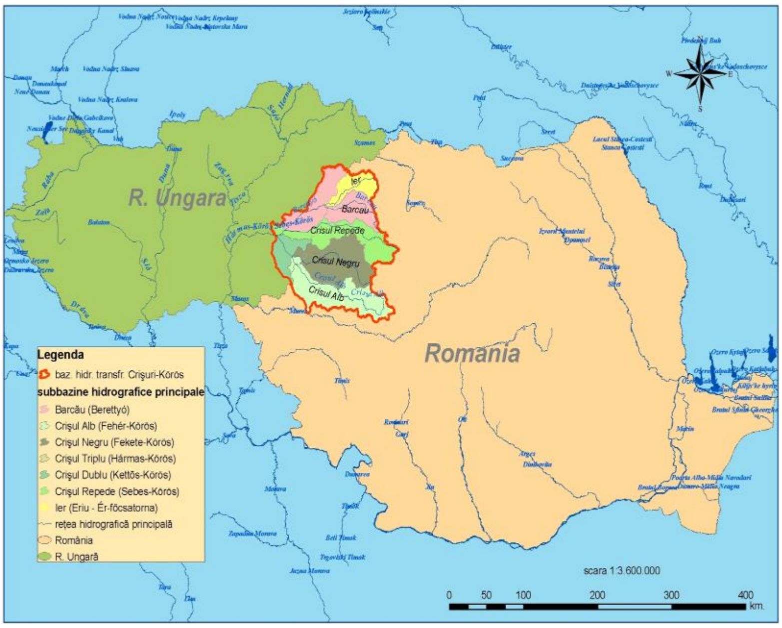

Figure 1. The Crişuri Hydrographic Space.

The Crişuri Hydrographic Space drains an over 27500 km^2 area and comprises 5 main rivers converging like the branches of a tree: Crişul Alb (the White Criş), Crişul Negru (the Black Criş), Crişul Repede (the Quick Criş), Barcău and Ier, all collecting their waters from the Western slopes of the Apuseni Mountains. Together with their affluents, the total length of the rivers is 5785 km: Barcău 196 km, Ierul 107 km, Crişul Repede 207 km, Crişul Negru 168 km, and Crişul Alb 248 km. These rivers join by twos on the territory of the Republic of Hungary, forming one single course that flows into the Tisa river.

Water monitoring is defined as an integrated activity of assessment of physical, chemical and biological characteristics of the water in relation with human health and ecological conditions reported to water use (Varduca 1999; but see also Turcan et al 2008 and Dudaş & Tentiş 2002).

Environmental monitoring, on the other hand, is a system of monitorization, prognosis, prevention and intervention, targeted at systematic assessment of the dynamics of the qualitative characteristics of environmental factors, with a view to knowing their quality state and ecological significance, the evolution and the social implications of the changes, followed by measures to be taken (Popa & Bud 2010; Petrescu-Mag & Petrescu-Mag 2010). Usually, in Romania, we talk mainly about integrated monitoring and less about ecological monitoring (Godeanu 1997).

This integrated monitoring of the CHS between 2007 and 2009 was based on preliminary field research and was meant to identify all the polluting sources in this hydrographic basin. The preliminary study was conducted over 2006, when we identified in the six counties belonging to the Crişuri Space (Satu Mare, Bihor, Arad, Cluj, Hunedoara, Sălaj) 125 units evacuating waste-water in the main watercourses, collecting canals etc.

Starting from field observation, we decided that 40 monitoring sections were needed to characterize the CHS from an ecological point of view:

Crişul Alb, 12 prelevation sections: Dragu-Brad(A1), Crişcior(A2), Râbiţa(A3), Baia de Criş(A4), Hălmăgel-Sârbi(A5), Tăcăşele - Avram Iancu(A6), Gurahonţ(A7), Sebiş-Sebiş(A8), Ineu(A9), Cigher-Zărand(A10), Canalul Morilor-Vărşand(A11), Vărşand(A12);

Crişul Negru, 10 prelevation sections: Crişul Băiţa-Băiţa Plai(N1), Şuşti(N2), Crişul Băiţa-Ştei(N3), Valea Neagră-Molhaş-Valea Izbucelor(N4), Crişul Pietros-Upstream Confluence Boga(N5), Amonte Beiuş(N6), Valea Nimăeşti-Beiuş(N7), Uileacu de Beiuş(N8), Tinca(N9), Zerind(N10);

Crişul Repede, 8 prelevation sections: Şaula(R1), Downstream Huedin(R2), Iad-Bulz(R3), Downstream Şuncuiuş(R4), Upstream Aleşd(R5), Upstream Oradea(R6), Peţea-Peţea-Downstream Oradea(R7), Cheresig(R8);

Barcău, 5 prelevation sections: Valea Răchitelor-Tusa(B1), Boghiş(B2), Bistra- Upstream Pădurea Neagră(B3), Downstream Marghita-Sânlazăr(B4), Parhida(B5);

Ier, 5 prelevation sections: Checheţ-Săcăşeni(I1), Andrid(I2), Tarcea(I3), Salcia-Confluence Ier(I4), Diosig(I5).

The geographical localization of the prelevation sections (Fig. 2) is presented by means of the GIS programme, using an identification code for each monitoring section (e.g. for Crişul Alb from station A1 to A12, for Crişul Repede from station R1 to R8, for Crişul Negru from station N1 to N10, for Barcău station from station B1 to B5, for Ier river from station I1 to I5)

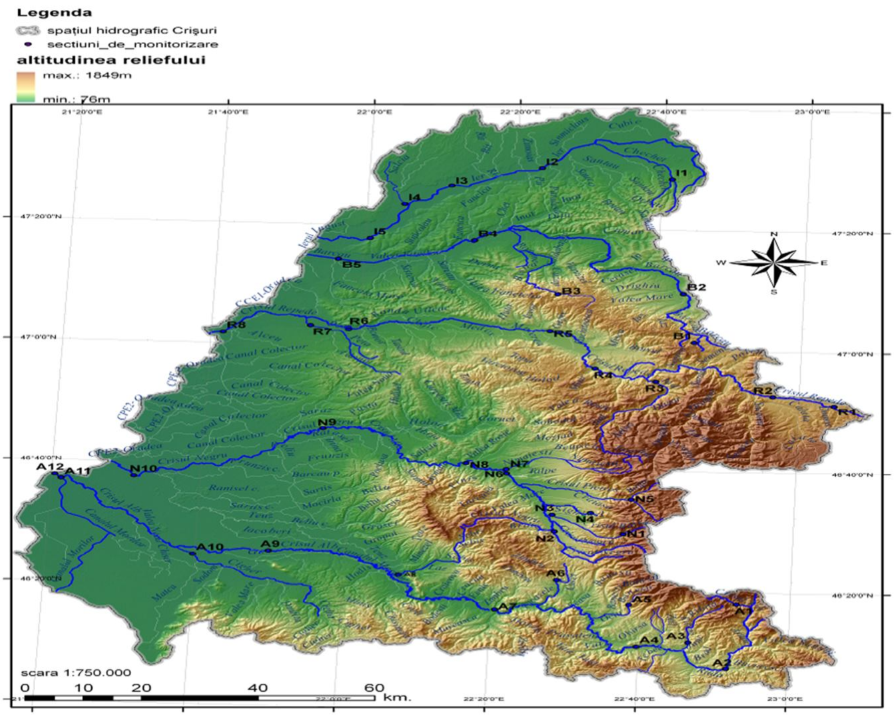

Figure 2. Localization of the prelevation sections in the CHS.

Material and Method. The classification of the surface water quality with a view to establishing the ecological state was realized in accordance with Order 161/2006.

During the research period, the categorization of the monitoring sections according to quality was realized by means of automatic calculating machines; synthesis values were obtained from the average concentrations determined in periodical campaigns, for each indicator, in each monitoring section. Then, the values obtained applying investigation methods and data processing were compared with admissible limit values stipulated in Order 161/2006. The interpretation of biocenotic characteristics was based on the saprob index, according to the Pantle-Buck method (Godeanu 2002).

The final assessment of the monitoring sections was based on the results of the biological indicators (phytoplankton, benthic macroinvertebrates, periphyton), but also taking into account the results of the physico-chemical analyses.

The final quality state was established by the value (concentration) of an indicator pointing to higher concentration in comparison with the other indicators monitored. In other words, the global quality of the water in a monitoring section was assessed starting from the quality indicators of each analysis, and the final quality state was established with reference to the lowest group of indicators.

The values (limits) of the saprob index, the ecological states with reference to the saprob index, respectively, are presented in Table 1 (Order 161/2006).

Table 1

Ecological state with reference to the saprob index

Value Saprob index	Impurification	Ecological state
1.0 - <1.8	Absent impurification	Very good
1.8 - <2.3	Moderate impurification	Good
2.3 - <2.7	Moderate to critical impurification	Moderate (Satisfactory)
2.7 – 3.2	High impurification	Poor (Unsatisfactory)
>3.2	High to very high impurification	Bad (Degraded)

The ecological states determined by this study were presented in graphic form using the state-of-the-art techniques of graphic (ArcMap).

The graphic presentation of the ecological states in the CHS needed the introduction of a colour codification of the different ecological states (Table 2).

Table 2

Colours specific to the ecological states

VERY GOOD ECOLOGICAL STATE (blue)
GOOD ECOLOGICAL STATE (green)
MODERATE ECOLOGICAL STATE (satisfactory) (yellow)
POOR ECOLOGICAL STATE (unsatisfactory) (brown)
BAD ECOLOGICAL STATE (degraded) (red)

Results and Discussion. Table 3 presents the variations of the global ecological states of the monitoring sections on Crişul Alb, between 2007 and 2009.

The results of the 3-year research showed that the prelevation sections Crişcior, Baia de Criş, Sârbi, Avram Iancu and Sebiş maintained the "Good" quality state category; Dragu Brad and Râbiţa improved qualitatively, from "Good" in 2007-2008 to "Very good" in 2009; some sections, such as Gurahonţ, had small fluctuations of the ecological state, from "Good" in 2007 to "Moderate" in 2008, whereas in 2009 they improved to a "Good" ecological state; the "Moderate" ecological state characterizes the monitoring section Canalul Morilor at Vărşand over the 3-year period, while the prelevation sections at Ineu and Vărşand degraded from a "Good" ecological state in 2007 to a "Moderate" one in

2008 and 2009. This degradation is mainly due to anthropic influences which contributed to a growing content of nitrites, nitrates, phosphates etc in the water.

The results of the determinations of the ecological states in the Crişul Negru basin are presented in Table 4.

The ecological states determined on the Crişul Negru watercourse over the research period did not show significant fluctuations. Of the 10 monitoring sections, 7 registered a "Good" ecological state from 2007 to 2009, 1 section (Crişul Pietros-Upstream Confluenţă Boga) - a "Very good" one, and 1 section (Nimăieşti-Beiuş) degraded from "Very good" in 2007 to "Good" in 2008 and 2009. The degradation to a moderate ecological state at the prelevation section Zerind was mainly due to the reconditioning works on the bridge over Crişul Negru, upstream the prelevation section. Because of bank reinforcement with stone and concrete, most of the benthic species disappeared, leaving only a small surface of the former habitats on both of the river banks. Consequently, biological sample prelevation was possible only mid-river, which is not very reelvant since benthic macroinvertebrates communities do not agree with high water speed and lack of organic matter, their main food. The reconstruction of the former habitats of the organisms in 2010 leads to a significant growing of the density of the benthic fauna.

The results regarding the evolution of the water quality state in the Crişul Repede hydrographic basin are presented in Table 5.

Over the 3-year period of monitorization, prelevation sections R4, R5, R6, R7 and R8 did not show fluctuations of global ecological state. At the prelevation section Downstream Huedin, an improvement of water quality could be noticed, due to the modernization of the purifying station at Huedin town. The prelevation section Şaula registered an oscillation between "Good" (2007, 2009) and "Moderate" state (2008).

Due to the relocation of the prelevation section at Bulz (R3) upstream, for reasons of flow fluctuations (resulted from water machining at the Remeţi Hydroelectric Power Plant), the ecological state of the water improved from "Good" (2007, 2008) to "Very good" (2008). Revising the prelevation section at Bulz at the end of 2008 was necessary because of the lack of representativity of the biological samples, strongly influenced by these flow variations.

Table 3

Global ecological states on Crişul Alb, 2007- 2009

Section code	Watercourse	Monitoring section	Ecological state in 2007	Ecological state in 2008	Ecological state in 2009
	Crişul Alb (the White Criş)		↓	↓	↓
A1	C.Alb	Dragu- Brad	Good	Good	Very good
A2	C.Alb	Crişcior	Good	Good	Good
A3	Râbiţa	Up.Râbiţa	Good	Good	Very good
A4	C.Alb	Baia de Criş	Good	Good	Good
A5	Hălmăgel	Sârbi	Good	Good	Good
A6	Tăcăşele	A.Iancu	Good	Good	Good
A7	C.Alb	Gurahonţ	Good	Moderate	Good
A8	Sebiş	Sebiş	Good	Good	Good
A9	C.Alb	Ineu	Good	Moderate	Moderate
A10	Cigher	Zărand	Good	Good	Moderate
A11	C.Morilor	Vărşand	Moderate	Moderate	Moderate
A12	C.Alb	Vărşand	Good	Moderate	Moderate

The Barcău watercourse presented in Table 6 is quite uniform over the research period. None of the 5 prelevation sections registered any degradation of the water quality in comparison with previous years. At the prelevation section at Pădurea Neagră (B3), the good ecological state characteristoc of 2007 and 2008 turns into very good in 2009.
The water quality in the Ier hydrographic basin is presented in Table 7. A certain improvement of the global ecological state could be noticed at the level of the prelevation stations Andrid (I2), Tarcea (I3) and Diosig (I5). The moderate ecological state characterized the 2007-2009 period at the prelevation station Salcia (I4), while at Săcăşeni (I1) only in 2007 the good quality state degraded to a moderate one in the following years.

Table 4

Global ecological states on Crişul Negru, 2007-2009

Section code	Watercourse	Monitoring section	Ecological state in 2007	Ecological state in 2008	Ecological state in 2009
Crişul Negru (the Black Criş)			↓	↓	↓
N1	C.Băiţa	Băiţa- Plai	Good	Good	Good
N2	C.Negru	Şuşti	Good	Good	Good
N3	C.Băiţa	C.Băiţa- Ştei	Good	Good	Good
N4	V.Neagră	Molhaş	Good	Good	Good
N5	C.Pietros	Up.C.Boga	Very good	Very good	Very good
N6	C.Negru	Up.Beiuş	Good	Good	Good
N7	Nimăieşti	Beiuş	Very good	Good	Good
N8	C.Negru	U.de Beiuş	Good	Good	Good
N9	C.Negru	Tinca	Good	Good	Good
N10	C.Negru	Zerind	Good	Good	Moderate

Table 5

Global ecological states on Crişul Repede, 2007-2009

Section code	Watercourse	Monitoring section	Ecological state in 2007	Ecological state in 2008	Ecological state in 2009
Crişul Repede (the Quick Criş)			↓	↓	↓
R1	C.Repede	Şaula	Good	Moderate	Good
R2	C.Repede	Dn. Huedin	Moderate	Moderate	Good
R3	Iad	Bulz	Good	Good	Very good
R4	C.Repede	Şuncuiuş	Good	Good	Good
R5	C.Repede	Up.Aleşd	Good	Good	Good
R6	C.Repede	Up.Oradea	Good	Good	Good
R7	Peţea	Peţea	Moderate	Moderate	Moderate
R8	C.Repede	Cheresig	Good	Good	Good

Table 6

Global ecological states on Barcău, 2007-2009

Section code	Watercourse	Monitoring section	Ecological state in 2007	Ecological state in 2008	Ecological state in 2009
	Barcău		↓	↓	↓
B1	V.Răchitelor	Tusa	Good	Good	Good
B2	Barcău	Boghiş	Good	Good	Good
B3	Bistra	Pd. Neagră	Good	Good	Very good
B4	Barcău	Sânlazăr	Moderate	Moderate	Moderate
B5	Barcău	Parhida	Moderate	Moderate	Moderate

Table 7

Global ecological states on Ier, 2007- 2009

Section code	Watercourse	Monitoring section	Ecological state in 2007	Ecological state in 2008	Ecological state in 2009
	Ier		↓	↓	↓
I1	Chechet	Săcăşeni	Good	Moderate	Moderate
I2	Ier	Andrid	Moderate	Moderate	Good
I3	Ier	Tarcea	Moderate	Good	Good
I4	Salcia	Salcia	Moderate	Moderate	Moderate
I5	Ier	Diosig	Moderate	Good	Good

Of the 40 monitored sections in 2007, 29 registered a good ecological state, 9 – a moderate ecological state, and 2 – a very good one (see Figure 4).

Consequently, 72% of the sections enter the good ecological state category, 23% - the moderate one, and 5% - the very good ecological state (see Figure 3).

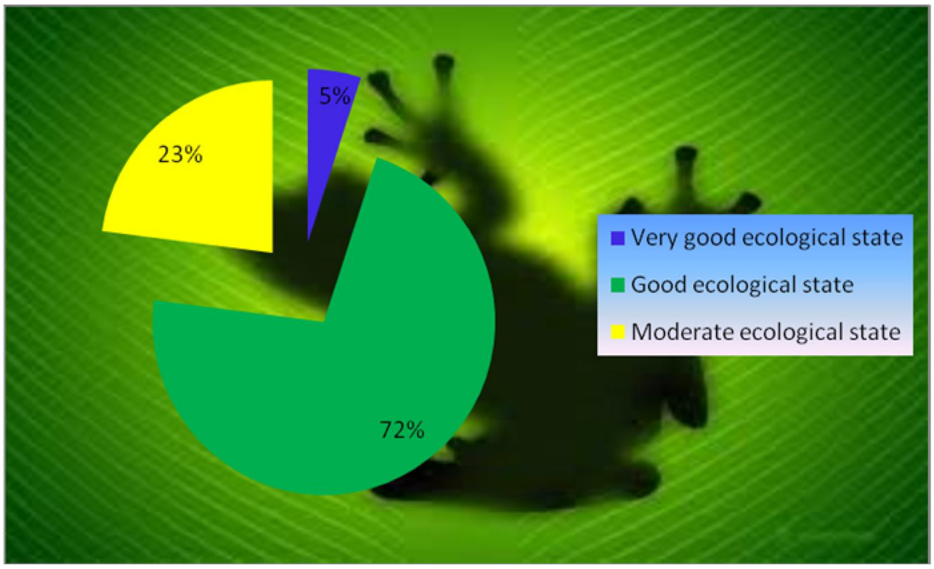

Figure 3. Percentages for the ecological states at the 40 monitorizing stations in 2007.

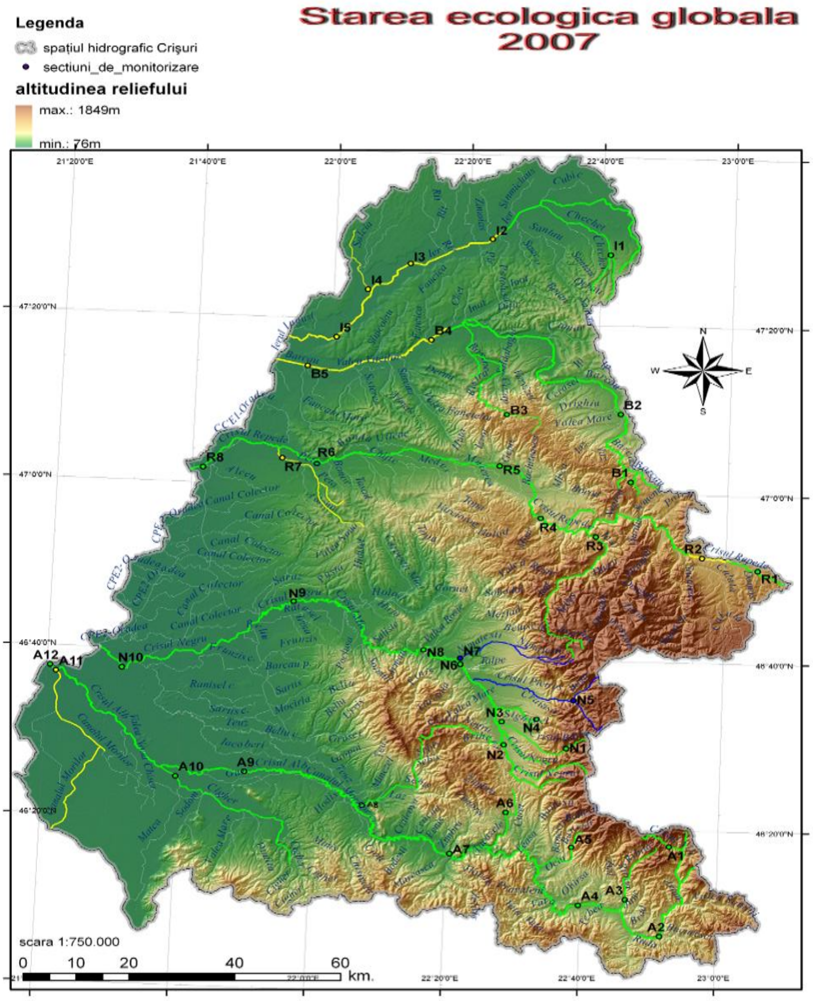

Figure 4. Global ecological state in 2007.

Of the 40 monitored sections in 2008, 27 registered a good ecological state, 12 – a moderate ecological state, and 1 – a very good one (Figure 6).

Consequently, 67% of the sections enter the good ecological state category, 30% - the moderate one, and 3% - the very good ecological state (Figure 5).

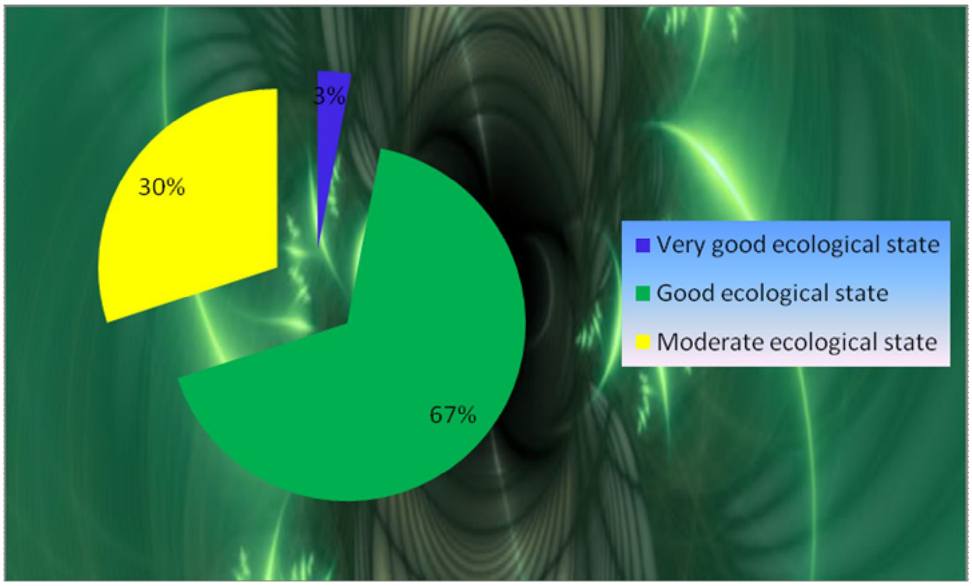

Figure 5. Percentages for the ecological states at the 40 monitorizing stations in 2008.

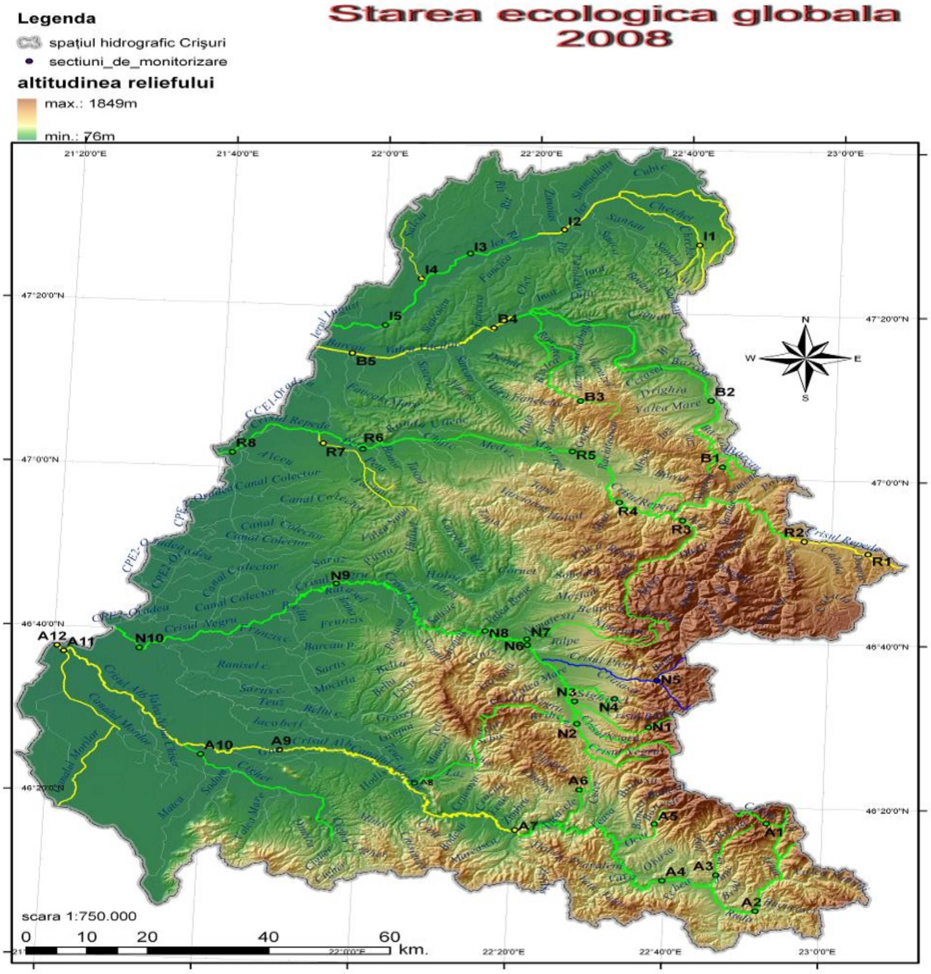

Figure 6. Global ecological state in 2008

Of the 40 monitored sections in 2009, 25 registered a good ecological state, 10 – a moderate ecological state, and 5 – a very good one (Figure 8).

Consequently, 62% of the sections enter the good ecological state category, 25% - the moderate one, and 13% - the very good ecological state (Figure 7).

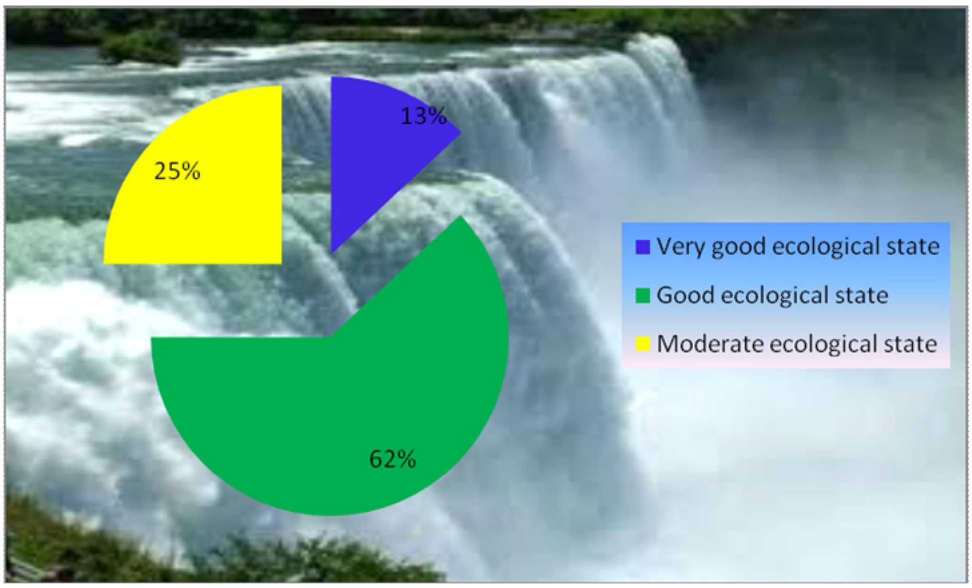

Figure 7. Percentages for the ecological states at the 40 monitorizing stations in 2009.

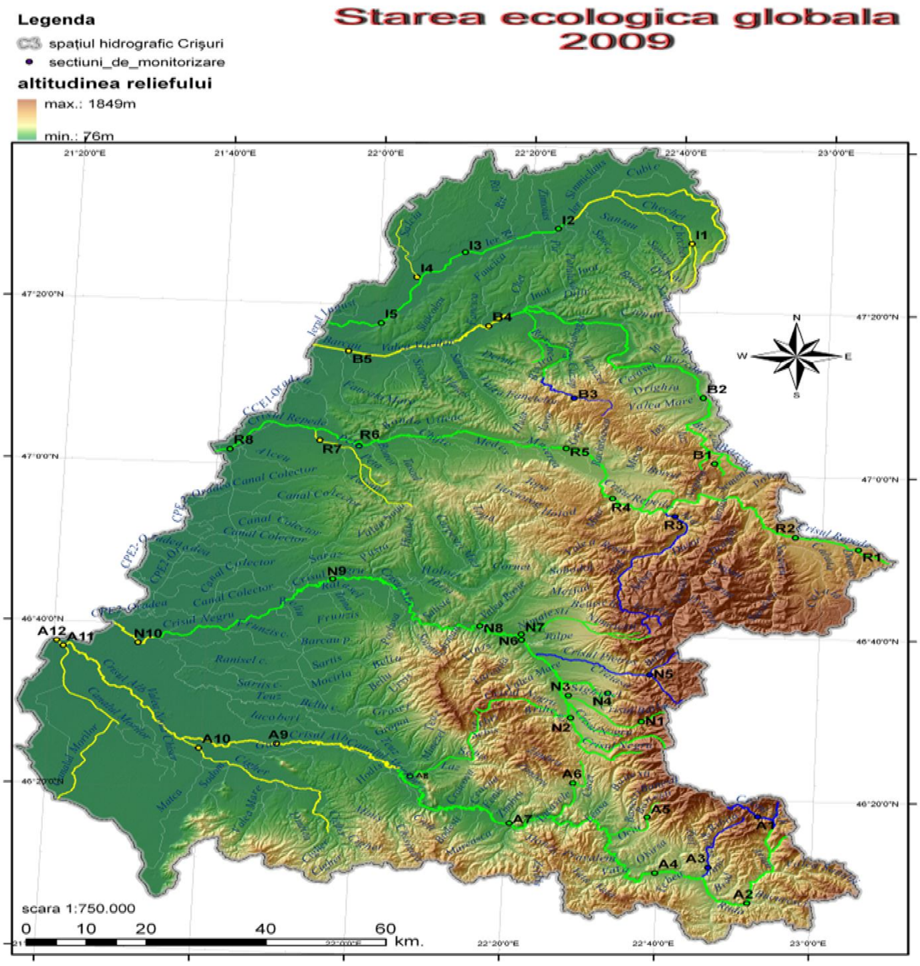

Figure 8. Global ecological state in 2009.

Conclusions. Regarding the global ecological state of the rivers in the CHS, the 2007-2009 research period showed that the influence of the 125 units evacuating waste-water into surface waters is not always negative on the water quality state.

Some sections, such as Şaula, Aval Huedin, Andrid, Tarcea, Diosig, registered a degree of improvement from moderate ecological state to a good one.

Others, such as Ineu, Zărand, Vărşand, Zerind, Săcăşeni, registered a degree of degradation from good ecological state to a moderate one.

Nevertheless, most of the sections presented a uniform character of the water quality state; no fluctuations were registered for sections such as Crişcior, Baia de Criş, Sârbi, Şuşti, Upstream Beiuş, Amonte Aleşd etc.

The present study identified 3 ecological states in CHS: "VERY GOOD", "GOOD"and "MODERATE". The water quality state did not degrade under the moderate ecological state limit in none of the hydrographic basins, and the "POOR" and "BAD" ecological states were not registered in any of the monitored watercourses.

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