Available online at
http://journals.usamvcluj.ro/index.php/promediu

ProEnvironment

ProEnvironment 8 (2015) 629 - 636

Original Article

The use of Rapid Impact Assessment Matrix (RIAM) in Assessing the Environmental Impacts in Protected Areas. Case Study: Mountain Glacial Lakes Areas in Romania

MIHAIESCU Radu[1], Andreea Ioana POP[1], Octavian Liviu MUNTEAN[1], Tania MIHAIESCU[2], Cristian MALOS[1], Marius-George OPREA[3], Stefan DEZSI[3], Alexandru OZUNU[1], Viorel ARGHIUS[1], Nicolae BACIU[1], Gheorghe ROSIAN[1], Vlad MACICASAN[1]

[1]Babeş-Bolyai University, Faculty of Environmental Science and Engineering, Fântânele St., No 30, 400294, Cluj-Napoca, Romania
[2]Faculty of Agriculture, University of Agricultural Sciences and Veterinary Medicine, 3-5 Calea Manastur, 400372 Cluj-Napoca, Romania
[3]Babeş-Bolyai University, Faculty of Geography, Clinicilor St., No 5-7, 400006, Cluj-Napoca, Romania

Received 8 September 2015; received and revised form 30 September 2015; accepted 30 October 2015
Available online 31 December 2015

Abstract

The long-range impacts of various air pollutants attributed to industrial activities, pressures of climate changes, constitute a general threat for mountain areas. In some cases a more localized but sometimes intense cluster of impacts originate from local activities-economic exploitation and tourism. Protected mountain areas are subjected to various pressures ranging from illegal resources exploitation to pressures generated by touristic activities. Glacial mountain lakes are exposed to local and long-range originated environmental pressures and due to their high vulnerability and susceptibility to changes, and can act as environmental sensors recording and forecasting any adverse impact created by natural and/or anthropogenic factors.

Environmental impacts were comparatively assessed in three areas in the Carpathian Mountains, mountain areas characterized and influenced by the presence of mountain lakes: Rodnei Mountains (Buhăiescu and Iezerul Pietrosului lakes), Făgăraş Mountains (Bâlea and Călţun lakes) and Retezat Mountains (Bucura and Galeş lakes). Identified impacts were aggregated by using the Rapid Impact Assessment Matrix (RIAM) (adapted version) structured on 4 components: physical/chemical, biological/ecological, social/cultural, and economic/operational. An in-depth comparative analysis was performed on these glacial lakes areas located in Romanian Carpathian Mountains. The results allowed a common base impact assessment in the purpose of improving the management measures.

Keywords: mountain glacial lakes, environmental impact assessment, RIAM method, Romanian Carpathians.

1. Introduction

Mountain ecosystems offer a large array of goods and services to human kind, for people living in the mountains as well as around its area. For example, more than half of population globe depends on fresh water, captured, deposited and purified in the mountain regions. From an ecological point of view, mountain regions are a biodiversity hotspot, while from a social point of view they are of paramount importance as key destinations for tourism and recreational activities [1]. Environmental impacts are defined as a direct or indirect effect of human activities causing a change of the direction of development of the quality status of ecosystems, change that can affect human health, environmental

Corresponding author.
Fax: +40-264-593792
Tel: +40-264-596384
e-mail: tania.mihaiescu@usamvcluj.ro

integrity, cultural heritage or socio-economic conditions' [2]. The environmental impact assessment is mainly instrumental in assessing the impacts caused by human activities [3]. The first methodology for environmental impact assessment was first proposed in the United States in 1970 in the National Environmental Policy Act. Canada and France followed in 1973 and respectively in 1975. In the EU policy was implemented as a method of assessment on pollution prevention in Directive 85/337 as amended set of terms and conditions for the implementation of Directive 99/11. For a more objective assessment of the environmental impact there are many methods, techniques and matrices that specialists are using and trying to adapt the study to have a more relevant. Anthropogenic impact assessment using matrices and methods can help early identification of existing impacts and help the environment and improving public awareness on the importance of these areas and their protection.

This may establish measures to minimize the negative effects before they become irreversible. In this study were approached six mountain lakes and were studied the human impact and other pressures exercised on lakes and their adjacent region.

2. Studied Areas

In Romania, due to approximately even distribution of the major relief forms and the influence of the other components of the geographical landscape, numerous mountain lakes can be found which differ from each other in terms of morphology, morphometric and especially on their genesis.

Glacial and periglacial lakes are the best category represented in the alpine level, sculpted and shaped by the action of the quaternary glaciers. The traces left by these glaciers in the Oriental Carpathians, especially in the Rodnei Mountains and in the Meridional Carpathians, are well kept at altitudes beyond 1,800 meters [4, 5]. The studied protected areas are located in 3 different protected mountain regions in Romanian Carpathians: Rodnei Mountains (Buhăiescu and Iezerul Pietrosului lakes), Făgăraș Mountains (Bâlea and Călțun lakes) and Retezat Mountains (Bucura and Galeș lakes) (Fig. 1) [6, 7, 8]. The main morphometric characteristics of the studied lakes are presented in Table 1.

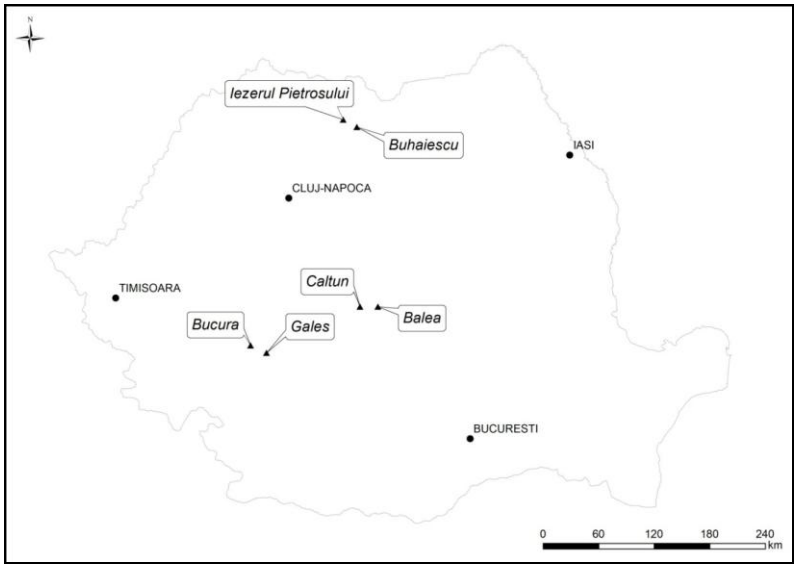

Figure 1. Studied lakes

According to preliminary studies [6, 7, 8], it appears that in the studied mountain areas, located in protected areas, the main environmental pressures are attributable to tourism activities and their associated environmental impacts and pressures.

Tourist flow is closely related to the accessibility in these regions, such as the accessibility is higher, the number of tourists will grow [11]. In Romania, the mountain tourism activities are practiced especially in summer, from May to September, due to difficult

accessibility and the need for special equipment and training in winter time.

For example, Bâlea Lake, located in the close vicinity of the national road DN 7C present important touristic flows in summer period but also in winter due to the presence of cable transport. Intense touristic activity led to development of the area, and also along the road at lesser altitudes.

Although the impact of massive presence of people and cars is usually well managed, the impact on local fauna is undeniable.

Table 1. Main morphometric characteristics of the studied lakes [8]

Location /Lake	Altitude (m)	Coordinates	Catchment area (ha)	Lake area (ha)	Catchment: Lake ratio	Max depth (m)
Rodnei Mountains						
Iezerul Pietrosul	1,825	47°35'54" N 24°38'52" E	54.4	0.41	132.7	2.3 [9]
Buhăiescu II	1,890	47°35'14" N 24°38'48" E	62.9	0.2	314.5	5.2 [9]
Făgăraş Mountains						
Bâlea	2,034	45°36'13" N 24°37'07" E	45.5	4.78	9.5	11.35 [9] 16.9 [10]
Călţun	2,135	45°34'55" N 24°34'26" E	18.6	0.8	23.3	11.8 [9]
Retezat Mountains						
Galeş	2,040	45°38'70" N 22°91'11" E	167.206	4.04	41.4	20.1 [9] 20.5 [10]
Bucura	2,041	45°36'24" N 22°87'65" E	202.08	8.92	22.7	15.7[9] 17.5 [10]

Another important impact factor leading to degradation of these areas is represented by the presence of numerous herds that graze intensively during summer, in about the same perimeter, concentrated due to the presence of easily accessible water sources. The results are visible in the form of soil erosion processes, landscape and biodiversity degradation. The continuous presence of livestock can contribute also to a chemical change composition of lakes, in terms of pollution with nitrates and nitrites [7]. In some localized areas, endemic species are being replaced by invasive species, specific to intensive grazed areas.

The differences in water chemistry between the studied glacial lakes can be attributed to several factors such as geology, climate and relief (different input from the weathering, different size of the watersheds, different retention times) and in some cases (Bâlea Lake) human influence [7, 8, 12, 13].

3. Material and Method

There are many tools and techniques that have been developed for use in impact assessment processes, including scoping, checklists, matrices and qualitative and quantitative models [14]. While impact assessment processes have become more technically complicated, it is recognized that approaches including simpler applications of available tools and techniques are also appropriate [15].

The Rapid Impact Assessment Matrix (RIAM) is a tool for organizing, analysing and presenting the results of a holistic environmental impact assessment [16]. The matrix method was developed specifically to transform subjective decisions in a transparent manner in the assessment of human impact [17, 18]. RIAM was originally developed to compare the impact of alternative procedures in a single project. The basic principle of RIAM is that characteristics of impact form the basis for scoring [16, 17].

The RIAM matrix was applied to all three areas of interest and for all six mountain lakes. Environmental components were stated for each location separately and were classified into four categories:

a. Physical and geographical components (PGC), referring at aspects like physical and chemical processes and phenomena (were selected and analysed 15 components);
b. Biological and ecological components (BEC) referring at biotic environment (were selected and analysed 15 components);

c. Social and cultural components (SCC), that include human aspects in the environment (were selected and analysed 14 components);
d. Economic and operational components (EOC), identifying qualitative economic and social effects (temporary and permanent) on the environment (were selected and analysed 15 components).

However, with the aim of repetitive assessment, we specified the evaluation order for each criterion to match our test. According to these orders, the assessment and usage of that method is also a hopeful possibility in future studies. The basic formula for the RIAM is (according to Pastakia & Jensen, 1998 [16]):

(A1) x (A2) = (At) *(1)*
(B1) + (B2) + (B3) = (Bt) *(2)*
(At) x (Bt) = (SE) *(3)*

Within this context, the evaluation criteria are of two types:

(A) criteria that can change individual environmental score obtained;
(B) criteria that individual cannot change the environmental assessment score (Table 2).

Table 2. Description of the evaluation criteria

Evaluation criteria	Scores	Description
A1 Importance of impact & effect	4	Important to national/international interests
	3	Important regionally
	2	Important to areas immediately outside the local context
	1	Important only in the local context
	0	No geographical or other recognized importance
A2. Magnitude of change and effect	+3	Major positive benefit
	+2	Significant improvement in status quo
	+1	Improvement in status quo
	0	No change in status quo
	-1	Negative change to status quo
	-2	Significant negative disadvantage or change
	-3	Major disadvantage or change
B1. Permanence of the impact-causing activity	3	Permanent: The project or activity causing impact is meant to be a permanent one. Some examples from our data: Nature trails, snowmobile routes, roads, building etc.
	2	Temporary: The project or activity causing impact is temporal. Some examples from our data: rehabilitation of watersheds, villages, residential areas or environmental restoration, completion of construction.
	1	No change/not applicable
B2. Reversibility of impact	3	Irreversible impact: The impact is irreversible, if the original state is not restored after the activity is finished. Such activity has changed the environment permanently or for a long period of time. Some examples from our data: roads, buildings
	2	Reversible impact: The impact is reversible, if the original state will be restored after the activity is finished. Some examples from our data: nature trails, camping, restoration activity, repair building.
	1	Not applicable: Targeting the impact is impossible, e.g. the impact of educational activity is difficult to determine as reversible or irreversible.
B3. Accumulation of impact	3	Impact is cumulative or synergistic. The project or activity probable has combined impact with other projects or activities in the same area. Examples from our data: noise pollution, air pollution and wastewater emissions, e.g. to the watershed of soil. In the context of social issues, impact in general is often cumulative.
	2	Impact is non-cumulative
	1	No change/not applicable

The environmental scores (ES) were classified as follows (Table 3). Environmental components (59 components) are detailed in the assessment matrix example in Table 4.

Most components were selected from the environmental matrix [19] and adapted to the evaluation methodology and analysed territorial context.

Table 3. Description of range bands (according to Pastakia & Jensen, 1998 [16])

Environmental Score	Impact Class	Description
+72 to +108	+E	Major positive change/impact
+36 to +71	+D	Significant positive change/impact
+19 to +35	+C	Moderately positive change/impact
+10 to +18	+B	Positive change/impact
+1 to +9	+A	Slightly positive change/impact
0	N	No change/status quo/not applicable
−1 to −9	−A	Slightly negative change/impact
−10 to −18	−B	Negative change/impact
−19 to −35	−C	Moderately negative change/impact
−36 to −71	−D	Significant negative change/impact
−72 to −108	−E	Major negative change/impact

4. Results and Discussions

Various types of impacts and pressure, both natural and human, occur on these sensitive ecosystems. Impacts may be originated from local, regional and global pressures. The modified RIAM method was applied to all studied lakes, an example being presented in Fig. 2 and Table 4. The evaluation scores were assigned, by the study team, taking into consideration the available data, in scientific literature combined with field observations.

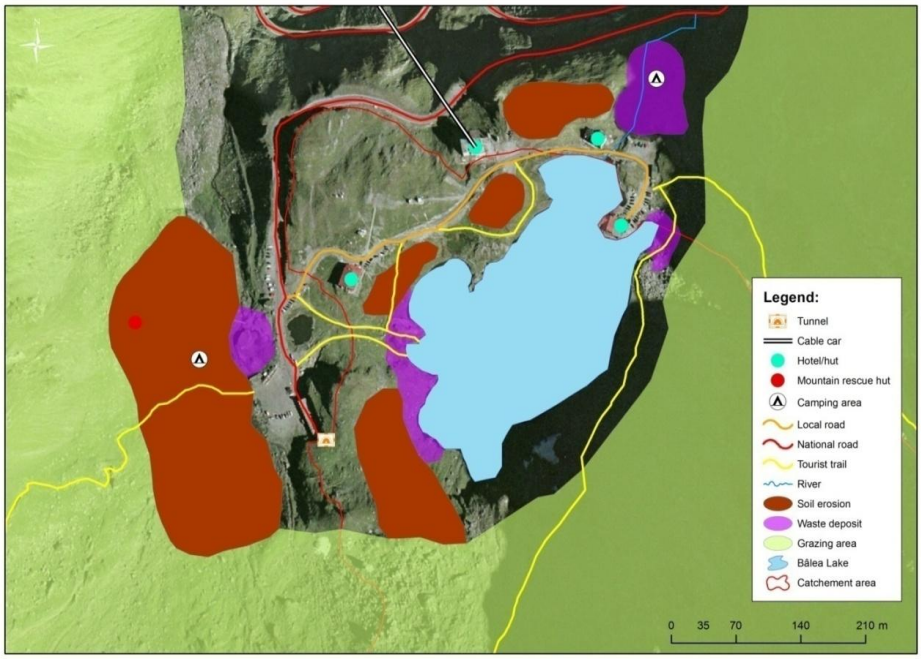

Figure 2. Identified environmental pressures in the Bâlea Lake area

The applied matrix on impact assessment on Romanian Carpathians glacial lakes, taking into account the human factor, the availability and the distribution of lakes in different mountain protected areas, resulted in a negative total score of evaluation, in most areas (exception Buhăiescu Lake), which allows the classification in the general category of impact –A corresponding to slightly negative impacts (Călţun, Bucura, Galeş and Iezerul Pietrosului lakes), the general category of impact +A corresponding to positive impacts (Buhăiescu Lake) and only in the case of Bâlea Lake the corresponding impact category is –B (negative impacts) (Table 5). Despite the fact that thousands of tourist are present yearly in the mountain lake catchments the water quality is still maintaining in good quality as shown by the obtained results in previous studies [8].

Table 4. Matrix of human impact assessment in the Bâlea Lake area

Environmental components	A1	A2	1.1	B1	B2	B3	ES	IC
Physical and geographical components (PGC)								
Geological substratum / mineral resources	1	1		1	1	1	3	+ A
Building materials	0	0		1	1	1	0	N
Soils	0	0		1	2	2	0	N
Field morphology	0	0		1	1	2	0	N
Groundwater	0	0		1	1	1	0	N
Water quality	1	-2		2	2	3	-7	-A
Surface water	2	-2		2	2	2	0	N
Air quality	1	1		1	1	1	3	+A
Air temperature	2	0		1	1	1	0	N
Flooding	2	0		1	1	1	0	N
Erosion torrential / linear	2	-2		1	1	1	0	N
Sedimentation / siltation	2	-1		1	1	1	3	+A
Compaction / subsidence	2	-3		1	1	1	-3	-A
Land stability (landslides)	2	-1		1	1	1	3	+A
Areal erosion	2	-3		1	2	2	-5	-A
1.1.1.1.1.1.1.1 Evaluation Score							**-3**	**-A**
Biological and ecological components (BEC)								
Trees	1	1		1	1	1	+3	+A
Bushes	1	-2		1	1	1	-3	-A
Grass	2	-2		2	1	1	0	N
Crops	0	0		1	1	1	0	N
Microflora	1	-2		1	1	1	-3	-A
Aquatic plants	1	-2		2	1	1	-4	-A
Endangered plant species	0	0		1	1	1	0	N
Birds	1	0		1	1	1	0	N
Terrestrial animals and reptiles	1	0		1	1	1	0	N
Fish and crustaceans	1	-1		1	1	1	0	N
Benthos	1	-2		1	1	1	-3	-A
Insects	1	0		1	1	1	0	N
Microfauna	1	0		1	1	1	0	N
Endangered Animal Species	2	-3		1	1	1	-3	-A
Ecological corridors	0	0		1	1	1	0	N
1.1.1.1.1.1.1.2 Evaluation Score							**-13**	**-A**
Socio-cultural components and land use (SCC)								
Land use	0	0		1	1	1	0	N
Open spaces and wilderness	2	-3		1	1	1	-3	-A
Swamps	0	0		1	1	1	0	N
Wooded areas	1	-2		1	1	1	-3	-A
Grassland	1	-2		1	1	1	-3	-A
Agricultural lands	0	0		1	1	1	0	N
National parks /Protected reservations	3	-3		1	1	1	0	N
Monuments of nature	1	0		1	1	1	0	N
Rare and unique species and ecosystems	3	-2		1	1	1	3	-A
Cultural models / lifestyle	0	0		1	1	1	0	N
Objectives / historical and archaeological sites	0	0		1	1	1	0	N
Interests aesthetic and human	1	-2		1	1	1	-3	-A
Landscape quality	1	-2		1	1	1	-3	-A
Green spaces	2	-1		1	1	1	3	+A
1.1.1.1.1.1.1.3 Evaluation Score							-9	-A
Economic and operational components (EOC)								
Human health and safety	1	+1		1	1	1	+3	+A
Hunting and Fishing	1	-1		1	1	1	0	N
Camping	1	-3		1	1	1	-6	-A
Unemployment rate	0	0		1	1	1	0	N
Tourism and attractions	4	-3		4	3	1	8	+A
Population density	0	0		1	1	1	0	N
Landfilling / waste management	1	-3		2	2	1	-10	-A
Anthropogenic structures	1	-2		1	1	1	-3	-A

Table 4. Matrix of human impact assessment in the Bâlea Lake area - continued

Environmental components	A1	A2	1.2	B1	B2	B3	ES	IC
Transport networks	1	-2	1	1	1	-3	-A	
Utilities networks	1	-2	3	3	1	-7	-A	
Plant cultivation	0	0	1	1	1	0	N	
Livestock / Animal breeding	0	0	1	1	1	0	N	
Residential Areas	0	0	1	1	1	0	N	
Commercial areas	2	-1	1	1	1	+3	+A	
Industrial areas	0	0	1	1	1	0	N	
Evaluation Score (ES)							**-14**	**-A**
Evaluation Score of environmental assessment							**-14**	**-B**
Evaluation Score of social component							**-25**	**-C**
Total Evaluation Score (TES)							**-39**	**-B**

Table 5. The synthesis of the total evaluation score (TES) and the impact class (IC)

Lake	TES	IC	Description
Bâlea	-39	-B	Negative change/impact
Călțun	-4	-A	Slightly negative change/impact
Iezer	-18	-A	Slightly negative change/impact
Buhăiescu	18	+A	Slightly positive change/impact
Bucura	-24	-A	Slightly negative change/impact
Galeș	-26	-A	Slightly negative change/impact

4. Conclusions

The presence of unique and valorous mountain ecosystems, highly valued by general public, should justify even greater protection and conservation efforts, in the conditions of constantly increasing tourist traffic.

Mountain areas represent a domanin were, perhaps, more than in other places, measures that are needed to be taken in order to preserve and protect ecosystems, as required by EU Directives, need to be constantly adapted to a possible future climate change.

Main environmental pressures are attributable to tourism activities and their associated environmental impacts.

Due to their high vulnerability mountain lakes are not only sensible to environmental changes but also to changes of any kind, making them excellent environmental sensors. Their high quality recording system, the sediment substrate, can be used to estimate the speed, direction and biological impact of the changes in air quality and climate.

Because of their sensitivity to small changes in environmental factors, mountain lakes can act as laboratories of study for evidence of early human impact phenomena.

Applying the RIAM matrix allowed to take a snapshot of the current situation, on comparatively bases, which can constitute valuable information for decision makers in designing the strategies for development and protection of the analysed areas.

Nevertheless, the evaluation criteria, as in all numeric methods can be subjective, especially in aspects that regard comparison of social impacts versus impacts on natural environment.

Indeed, the criteria used may suffer adjustments, influenced by factors such as development of environmental awareness that can bias the attributed scores for individual criteria, even by the same team of evaluators.

Once again, it appears that in current situation, characterized by global pressures, such as climate change, local and regional environmental pressures, social pressures, the conservation and development of protected areas should take into a balanced account all the objective conditions as well as social actors and general public opinion.

References

[1] Grêt-Regamey A**.**, **S**.H. Brunner, F. Kienast, 2012, Mountain ecosystem services-who cares? Mountain Research and Development**,** 32, 23-34, http://www.irl.ethz.ch/plus/people/agrtrega/2012_MRD

[2] Rojanschi V., Florina Bran, 2002, Politici şi strategii de mediu, Ed. Economică, Bucureşti

[3] Cartalis C., H. Feidas, M. Glezakou, M. Proedrou, N. Chrysoulakis, 2000, Use of Earth Observation in support of Environmental Impact Assessments: Prospects and Trends, *Environmental Science & Policy*, 3, 287-294

[4] Gâştescu P., 1960, Caracteristicele hidrochimice ale lacurilor din R.P.R., Meteorologia, hidrologia şi gospodărirea apelor, V(1), 22-25

[5] Gâştescu P., 1971, Lacurile din România. Limnologie Regională, Ed. Academică Bucureşti

[6] Pop Andreea Ioana, R. Mihăiescu, Al. Ozunu, Tania Mihăiescu, M.G. Oprea, I.V. Ardelean, I. Lehaci, 2011, Human impact on remote mountain lakes from Romanian Carphatians. Case Study: Avrig Lake, Făgăraş Mountains, ProEnvironment, 4, 319–323

[7] Pop Andreea Ioana, R. Mihăiescu, Tania Mihăiescu, E. Muntean, C. Tănăselia, C. Maloş, M.G. Oprea, Al. Ozunu, 2012, Study on Bâlea and Călţun Glaciar Lakes, from Făgăraş Mountains, ProEnvironment, 5, 260–265

[8] Pop Andreea Ioana, R. Mihăiescu, Tania Mihăiescu, M.G. Oprea, C. Tănăselia, Al. Ozunu, 2013, Physico-chemical properties of some glacial lakes in the Romanian Carpathians, Carpathian Journal of Earth and Environmental Science, 8(4), 5–11

[9] Pişota I., 1971, Lacurile glaciare din Carpaţii Meridionali. Studiu hidrologic, Ed. Academiei RSR, Bucureşti

[10] Vespremeanu-Stroe A., P. Urdea, F. Tătui, Şt. Constantinescu, L. Preoteasa, M. Vasile, R. Popescu, 2008, Date noi privind morfologia lacurilor glaciare din Carpații Meridionali, Revista de geomorfologie, 10, 73-87

[11] Ciangă N., Șt. Dezsi, 2003, Riscuri și impact în amenajarea turistică a spațiului montan. Riscuri și Catastrofe (ed. V. Sorocovschi), Ed. Casa Cărții de Știință, Cluj Napoca, II, 236-243

[12] Mihăiescu R., Andreea Ioana Pop, Tania Mihăiescu, E. Muntean, S. Beldean, Nicoleta Muntean, Livia Alhafez, Al. Ozunu, 2012, Physico-Chemical characteristics of the karst Lake Ighiu (Romania), Environmental Engineering and Management Journal, 11(3), 623-626

[13] Mîndrescu M., D. Mihăilă, D. Ţolca, 2005, Lacul Lala Mare. Studiu hidrobiochimic, Seminarul Geografic "Dimitrie Cantemir", 25, 149-158

[14] Morris P., R. Therivel, 2001, Methods of Environmental Impact Assessment, 2nd Edition, Spon Press, London and New York

[15] Kuitunen M., K. Jalava, K. Hirvonen, 2008, Testing the usability of the rapid impact assessment matrix (RIAM) method for comparison of EIA and SEA results, Environmental Impact Assessment Review, 28, 312-320

[16] Pastakia C.M.R., A. Jensen, 1998, The Rapid Impact Assessment Matrix (RIAM) for EIA, Environmental Impact Assessment Review, 18, 461–82

[17] Ijäs A., M.T. Kuitunen, K. Jalava, 2010, Developing the RIAM method in the context of impact significance assessment, Environmental Impact Assessment Review, 30, 82-89

[18] Muntean O.L., L. Buzila, R. Mihaiescu, C. Malos, N. Baciu, 2013, Assessment of Environmental Vulnerabilities and Constraints in the Vascau Plateau (Natura 2000 Protected Area, Romania), Journal of Environmental Protection and Ecology, 14(4), 1860-1871

[19] Leopold L.B., F.E. Clarke, B.B. Hanshaw, J.E. Balsley, 1971, A procedure for evaluating environmental impact, U.S. Geological Survey Circular 645, Washington, D.C.