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THE LANDSCAPE STRUCTURE OF THE NATIONAL NATURE RESERVE «SIVA BRADA» DURING 1877 - 2015

National Nature Reserve Sivá Brada is located in the eastern part of Presov and belongs under administration State Protection of Nature in the National Park of Slovensky Raj. The National Nature Reserve presents fourth degree of protection and was declared in year 1979 in order to protect landforms to Quaternary travertine hill and rare halophytic and xerophyte species of vegetation and the salt-marshes. National Nature Reserve has a high natural and cultural value and is intended for scientific research. **Purpose:** is to point on the failure of protection this very significant natural locality. **Methods:** field, analytical and mathematical. **Results:** The domain of the research was the development of the classes of land cover and their changes in the three time horizons 1877, 1957, 2015 and as well at the influence disproportionate human activities in the territory. Time intervals have revealed violations of the protection of this National Nature Reserve and make appropriate recommendations for the conservation of the territory.

Key words: National Nature Reserve, classes of land, Nature protection, Siva Brada

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ЛАНДШАФТНА СТРУКТУРА НАЦІОНАЛЬНОГО ПРИРОДНОГО ЗАПОВІДНИКА СИВА БРАДА ПРОТЯГОМ 1877 - 2015 РОКІВ

Національний природний заповідник Сива Брада розташований в східній частині м Пряшева в Національному парку Словацький Рай і знаходиться у веденні державного управління з охорони природи. Національний природний заповідник був оголошений у 1979 році і має четверту ступінь захисту з метою охорони рельєфу земної поверхні з четвертинними відкладеннями та рідкісних галофітних і ксерофітних видів рослинності на солончаках. Національний природний заповідник має високу природну та культурну цінність і призначений для проведення наукових досліджень. **Мета:** показати недостатній захист цього дуже важливого природного об'єкта. **Методи:** польовий, аналітичний та математичний. **Результати:** показані класи грунтово-рослинного покриву і їх зміни в трьох часових інтервалах - 1877 р., 1957 р. і 2015 р. при впливі непропорційної діяльності людини на територію. Тимчасові інтервали дали виявити порушення захисту даного Національного природного заповідника та зробити відповідні рекомендації по збереженню території.

Ключові слова: Національний природний заповідник, класи землі, охорона природи, Сива Брада

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ЛАНДШАФТНАЯ СТРУКТУРА НАЦИОНАЛЬНОГО ПРИРОДНОГО ЗАПОВЕДНИКА СИВАЯ БРАДА НА ПРОТЯЖЕНИИ 1877 – 2015 ГОДОВ

Национальный природный заповедник Сивая Брада расположен в восточной части г. Пряшева в Национальном парке Словацкий Рай и находится в ведении государственного управления по охране природы. Национальный природный заповедник был объявлен в 1979 году и имеет четвертую степень защиты с целью охраны рельефа земной поверхности с четвертичными отложениями и редких галофитных и ксерофитных видов растительности на солончаках. Национальный природный заповедник имеет высокую природную и культурную ценность и предназначен для проведения научных исследований. **Цель:** указать на недостаточную защиту этого очень важного природного объекта.

Методы: полевой, аналитический и математический. **Результаты:** показаны классы почвенно-растительного покрова и их изменения в трех временных интервалах – 1877 г., 1957 г. и 2015 г. при воздействии непропорциональной деятельности человека на территорию. Временные интервалы дали выявить нарушения защиты данного Национального природного заповедника и сделать соответствующие рекомендации по сохранению территории.

Ключевые слова: Национальный природный заповедник, классы земли, охрана природы, Сивая Брада

Introduction

The occurrence of the rare travertine formations in the Západné Karpaty (Western Carpathians) is related with the geological and tectonic structure of territory. Travertine was formed by the chemical process of precipitation of calcium carbonate from the mineral springs in a synergy with organisms (algae, blue-green algae, higher plants). Sedimentation of the travertine is determined by two factors: chemical composition of water mineral springs and climate (temperature and humidity), which determined the relationship to the precipitation $CaCO_3$ in cycles. The travertine hills and travertine terraces represent an important group of relief forms in the basins and lowlands of Západné Karpaty (Western Carpathians). Near Spišské Podhradie a travertine hills were created from the mineral springs whose collectors are located in the block of tectonically disturbed Mesozoic rocks (the faults direction NW - SE, SE – NW and N - S) at the depth around 600 - 800 m below the sediments of Inner Carpathian Palaeogene flysch [6] in Hornadskákotlina (Basin). According to Marcin [8] the mineral springs are weakly to medium mineralised. Mineral springs have penetrated to the surface through the transverse tectonic faults and have formed hills of travertine from early Pleistocene till end of the Holocene therefore are various ages. Travertine are not stored in superposition above the other, but placed side by side. Mineral springs in oldest travertine hills gradually have disappeared (there has been to the change of the piezometric level) and have moved through the tectonic faults be further on the west or east and created new hills of the travertine in the territory. All these locations are protected. They have a high natural, archaeological and cultural value. Sivá Brada near the Spišské Podhradie is youngest travertine hill (age is 10.000 years Holocene) and creation travertine continues even today (current activity of four mineral springs and one borehole). Originally was the spring of mineral water in the apex of the conical hill. Opening of the hydrogeological borehole from year 1957 changed the state in locality. This interference was unresponsive and unprofessionally. Mineral water from geological borehole creates gradually new hill of travertine on slope of authentic hill. By opening the borehole was on a travertine hill violated original development of relief forms and habitats Halophytic plant which are exactly subject of the protection. Travertine hill Sivá Brada is very significant locality and has high natural, paleontological and cultural value and in year 1979 was declared as the National Nature Reserve in the fourth degree of protection (Regulation no. 543/2002 Coll. the Law on the Protection of Nature and Landscape NC of Slovak Republic).

The main objective of this paper is to point out on origin and development of landscape structure in National Nature Reserve as well as on current status protection of rare habitat of nature in the cultural landscape.

Material and research methods

Preparation of data was connected with the main goal of research. For the analysis of the land cover changes for the year 1877 were used topographic maps the Third Military Mapping and in the year 1957 the topographic maps from the mapping in the same year. For year 2015 we used the orthophotomaps which content was supplemented by the field research. Through the vectorisation we created the maps of the classes of land cover (map 1, 2, 3, Table 1). Results of the research landscape structure for individual time horizons were identified by the method CLC (Corine Land Cover, according scientific study Feranec and Oťaheľ [5]). In identifying land cover classes we used the legend CLC processed for needs of the landscape-ecological research the countries of PHARE [3, 4, 10]. We obtained maps of classes of land cover for individual time horizons which reflect the development the structure of the territory.

Results of researches

Landscape structure. Travertine hill Sivá Brada is located in the eastern part of Hornádskakotlina [9] on slightly undulating relief of upland at an altitude 450 m. Geographic location of locality is from the aspect of nature protection very extreme. It is located close to the road E 50 European importance and too near the highway D1. Travertine hill is the object of protection of nature, but is also a place of pilgrimage (Spišský Jerusalem) and the place of visits large numbers of the motorists, tourists and participants of school trips. On top of the hill of Sivá Brada are located sacral building, pilgrimage Chapel of Saint Cross and stone cross built end of 17th century. The place symbolizes for the believers Golgotha. On the southern slope is building of former spa (today hostel). On the east side is built car parking with toilets and here are two information boards and two promotional and advertising panels. Across the National Nature Reserve goes the tourist trail and educational trail and around cycling trail. We think that all objects and activities as well as the behaviour of the visitors in the National Nature Reserve are unsuitable.

3.1. Physical-geographical structure the landscape

Travertine of Sivá Brada is stored on the layers the sediments of sandstones and clay stone of Inner-Carpathian Palaeogene in erosion-tectonic depression of Hornádskakotlina (basin). From the geomorphological point of view it is a conical hill with a circular base and consists from the Holocene freshwater limestone (white-grey travertine) with thickness 15 m. The hill is created from the solid plates of the travertine mainly in the central part of the hill. At the edges of hill in addition to solid travertine are the limestone tuffs and crusts from limestone. The real thickness of the travertine is about 15 m. Sivá Brada has ideal shape of conical hill with a circular base (length 1 250 m) with a relative height of 25 m with a base diameter 250 m and has an area of 108 966 quadrat meters while the entire reserve has 195 472 quadrat meters, because in the National Nature Reserve is included Hradskálúka (meadow) with limestone tuffs, fens and marshes. The slopes of travertine mound have inclination 15º - 20º. According climatic regionalization of the Slovak Republic the territory belongs to the Moderately warm region into Sub region M2 which is slightly warm slightly humid with cold winter and the average temperature of January is -5 ºC and in July is 16 ° C and the number of summer days in year is less than 50 [7]. Soil cover (World reference base for soil resources 2014, International soil classification system) is represented by these types of soils: Rendzi-Lithic Leptosols and RendzicLeptosols (in the soil is high content of $MgSO_4$,magnesium sulphate). Existence of unique halophytic plant association with *Gauxmari-rima Triglochinmaritima, Plantagomaritma* from Unions *Scorzonero-Junciongerardii* and the *Halo-Trichophorionpumili* [1] so called "Carpathian travertine salty wetlands" on Sivá Brada was conditioned the occurrence of mineral waters. The total acreage of this habitat in Western Carpathians in Slovak Republic is only 10 ha and occur also in NNR [2]. Halophytic species are concentrated around mineral springs and on the slopes of travertine hill which are waterlogged a mineral water and as well as in the marshes on the foot of the travertine hill where they were mixed with the rare species of xerophyte and thermophile vegetation [13]. Hradskálúka (meadow) on the west foot of Sivá Brada is consist from biotope floristic associations that are demanding a sunlight and the nutrients of alkaline minerals and this are calcareous fens and fen-meadows. The appearance the association of plants determines *Carexda-valiana* and *Eriophorumangustifolium*. Also interesting is a fauna the Carpathian travertine salty wetlands consisting from halophytic and calcicoles species. Out of the butterflies occur here e.g. *Gynnidomorphavectisana* (tied to species *Plantagomaritima* and *Triglochinmar-itima*) and *Elachistacontaminella* [11]. From the remarkable species lives here *Javesellasalina* (*Auchenorrhyncha*) which belongs to endangered species [14]. From the important European species live here *Gastropods* of the genus *Vertigo* (*Vertigo angustior, Vertigo geyeri*) and they have tends to occupy the alkaline swamps and calcareous fens [12]. Characteristic group are here the beetles the genus *Dyschirius* (the family *Carabidae*, genera *Bledius* and *Carpelimus*) which live in the moist soils and are dependent on the presence of halophytic plants species by which they feed (*Algae* and *Diatoms*).

Insectivores are represented by species *Sorexaraneus*and *Sorexminutus* [12].

3.2. Results the research of the land cover in individual time horizons

Travertine hill is located amid of the cultural landscape of Hornádskakotlina (Basin), which has been intensively agriculturally cultivated for centuries. The structure of landscape was formed under the influence of human activities which has affected distribution of various plant and animal species and biotopes of territory. Until 1979 (Declaration NNR) was territory a part of agricultural landscape covered with natural permanent grassland (utilized as the pastures mainly for sheep). Private agriculture was terminated in 1958 and this development influenced very negatively nature of the cultural landscape. Declaration of the National Nature Reserve substantially changed the previous utilization of the landscape. Termination the grazing of and termination mowing grass has changed the composition the permanent grasslands. The varied and on species rich meadows and pastures are changed into the simple associations of monocultures grasses. Another change occurred after 1989 in the context of the economic transformation of the agriculture and of the changes ownership of the agricultural land.

Development of the structure of landscape in NNR we investigated in three time horizons 1877, 1957 and 2015. In time horizon 1877 and 1957 Sivá Brada yet not been a NNR and in year 1877 here have not been spa.

In 1877 in the studied area the (Tab. 1 Fig. 1) of the classes land cover the smallest space belonged of built-up area (1.1.2. Discontinuous urban fabric) only 0.0050 hectares, which represents the pilgrimage church and stone cross. Class of land cover of the Natural grasslands takes up in this year largest area (3.2.1. Natural grasslands with xerophyte and subalpine species), almost 11.5 hectares and a second largest extend has the class of the arable land 5.6 hectares (2.1.1 Non-irrigated arable land). Third class of the land cover, marshes and fen meadows (3.2.2. Moors and heathland, Calcareous fens and fen meadows) cover an area of almost 2 ha (1.90 ha). The class of transport networks (1.2.2. Road and rail networks and associated land) occupy acreage 0.36 ha and classes of the uncovered bedrock (3.3.2 Bare rocks and Holocene travertine) 0.063 ha and classes of salty wetlands (4.2.1 Carpathian travertine salty wetlands) 0.098 ha. A similar situation was in 1957 (Tab. 1 Fig. 2) but the construction of spa has increased share of built up area (1.1.2) on 0.080 ha and the share of class communications (1.2.2.) decreased

Table 1

Classes of land cover on Sivá Brada in 1877, 1957 and 2015

Classes of Land cover (CLC legend 3. Degree)	**Acreage in m^2 in 1877**	**Acreage in m^2 in 1957**	**Acreage in m^2 in 2015**
1.1.2. Discontinuous urban fabric	50.14	857.97	50.14
1.2.2. Road and rail networks and associated land	3608.59	2756.88	3959.11
2.1.1. Non-irrigated arable land	56608.52	44987.95	11838.08
3.1.3. Mixed forests – Spa park	0	36.22	36.22
3.2.1. Natural grasslands with xerophytes and subalpine species	114491.72	124863.24	129403.04
3.2.2. Moors and heathland, Calcareous fens and fen meadows	19090.23	18756.25	45887.57
3.3.2. Bare rocks, Holocene travertine	637.25	637.25	1317.77
4.2.1. Carpathian travertine salty wetlands or marshes	985.50	2576.25	2908.07
Count of mineral springs	4	4 + 1	4 + 1
Count of Information boards	0	0	2
Count of Promotional and other panels	0	0	2
Count of booths or shelters	0	0	In summer
Toilets	0	0	2

Source: In year 1877 we identified the land cover classes through the vectorisation by reambulated topographic maps of the Third Military Mapping when the territory of the Sivá Brada has not been protected; In year 1957 we identified the land cover classes through the vectorisation by topographic maps when the territory of the Sivá Brada has not been protected; In year 2015 we identified the land cover classes through the vectorization of the orthofothomaps by the legend of CLC and field research.

Fig. 1 – Structure the land cover classes on Sivá Brada in 1877

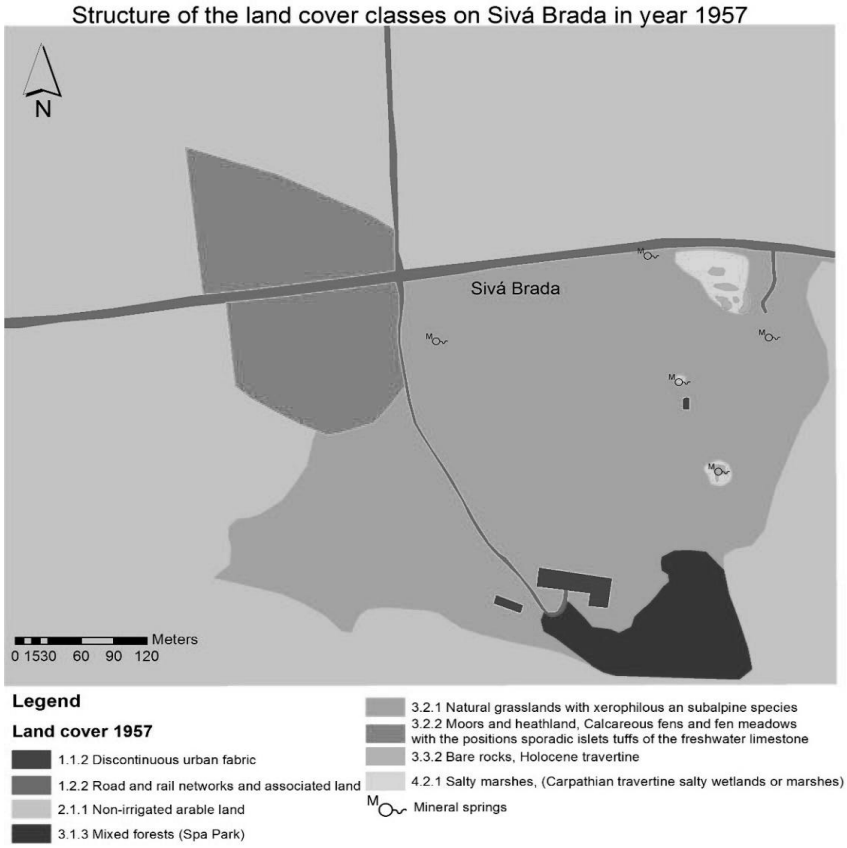

Fig. 2 – Structure the land cover classes on Sivá Brada in 1957

about 0.085 ha and share of arable land (2.1.1.) decreased by 1.16 ha. At the expense of arable land increased the share of class of natural grasslands (3.2.1.) about 1.3 ha and share of the class Carpathian travertine salty marshes and wetlands (4.2.1.) about 0.16 ha. In the classes of land cover 3.2.2. (Calcareous fens and fen meadows) has been the decline of the acreage about 0.033 ha. Class of bare rocks (3.3.2.) had the same acreage in both time horizons. In 1957 into the structure of the land cover classes shall enter new class mixed forests (3.1.3 Mixed forests, Spa Park) with an area of 0.0036 ha.

In year 2015 we have identified on Sivá Brada eight classes of land cover (Table 1, Fig. 3). In the reserve there are also objects that are marked on a map as point and as line (Table 1, Fig. 3). Point objects are shown as the map marker (namely the springs of mineral water and the hydrological borehole). From the other objects are information boards, promotional and advertising panels and toilets. The smallest area in the reserve occupies Discontinuous urban fabric (1.1.2.) which presents the pilgrimage church and cross (50.14 m^2 or 0.0050 ha). Share of the class 1.2.2. (Road and rail networks and associated land) has increased due to the construction of car parking 0.12 ha (1202.23 m^2).

The share of arable land (Arable land 2.1.1.) decreased about 3.31 ha change in favour the two classes 0.45 ha on 3.2.1 Natural grassland and 2.70 ha on 3.2.2 Calcareous fens and fen meadows. Extent the class of mixed forests - Spa Park (3.1.3.) has same acreage as in 1957. Share of class 3.3.2 (Bare rocks, travertine) increased by 0.064 ha and share of the class 4.2.1 (Carpathian travertine salty wetlands or marshes) 0.040 ha in relation to opening of the sealed borehole of mineral water at the expense of Natural grassland (3.2.1.).

The changes of land cover in year 2015 are related with the Nature protection of the territory. It can be observed that in 2015 originated some new elements (points elements, linear and areal elements) which have a negative impact on protected territory and are not in accordance with the law on Protection of nature and landscape of the Slovak Republic (Tab. 1, Fig. 3).

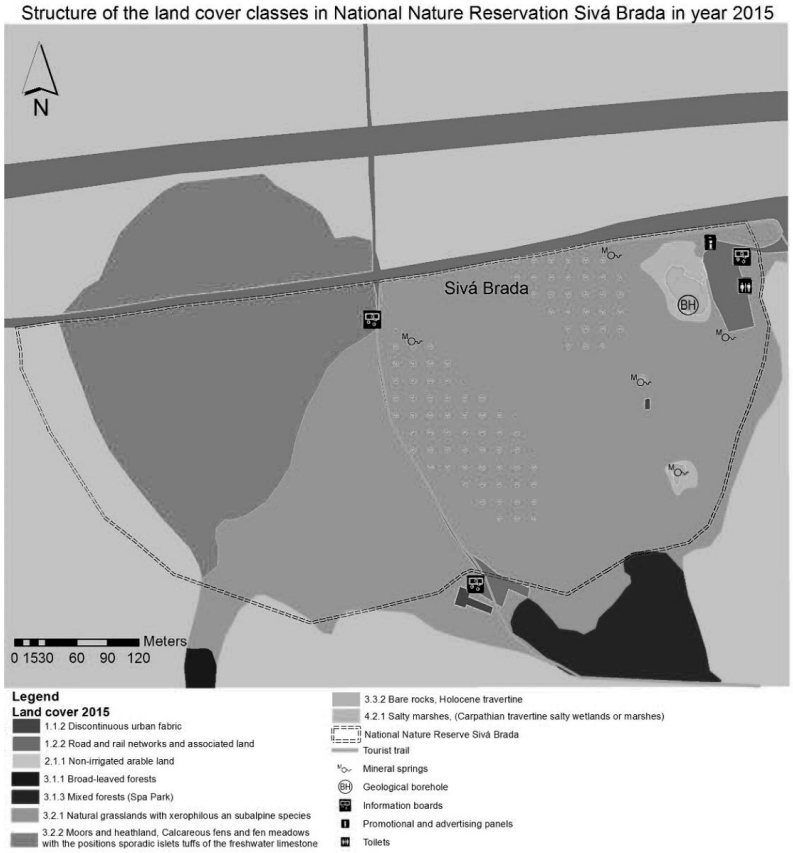

Fig. 3 – Structure the land cover classes in National Nature Reserve Sivá Brada in 2015

The remaining eight classes of land cover have a natural and semi-natural character. With them is linked protection of NNR. Sivá Brada is one of living travertine hills and the land cover classes are affected by water of mineral springs which create conditions for the presence of halophytic vegetation. Land cover in NNP has a remarkable development and composition. On solid travertine are Natural meadows with an admixture of xerophytes, thermophiles, calcareous and subalpine plants species. Around mineral springs and mineral water are created a unique halophytic association "Carpathian travertine salty wetlands" having rare species *Glauxmaritima*, *Plantagomaritima*, *Triglochinmaritima* (in the Carpathians are rare and occur mainly on sea coast). On the meadows where water from mineral springs flows down is the vegetation of the marshes and wetlands with mixed vegetation a halophyte and calcareous species. So on several dozen of square meters are located large amount of valuable habitats of small dimensions. Protection exceptional landscape structure on Sivá Brada is currently insufficient.

3.3. Current status of protection

NNR was declared in year 1979 by Act no. 543/2002 Coll. NC of Slovak Republic for purpose to protect the travertine hill of Holocene age and rare species of plants. Reserve was created for scientific research halophytic vegetation (fourth degree nature protection). Carpathian travertine salty wetlands are one of the significant authentic biotopes in Západné Karpaty (Mts. Western Carpathians). Wide range of human activities and ignoring Act on Protection caused that Sivá Brada is from all NNR in the Slovak Republic most endangered. On the natural structure of NNR Sivá Brada have affects the following factors and processes: automobile transport, agriculture, encroachment in the water regime of mineral springs, uncontrolled visits (vandalism of some groups of tourists' e. g. by firing of objects, destruction of rare species vegetation, littering waste etc.).The pollutant in air from automobile transport from adjacent communications (D1, E 50) threaten the mainly rare association of plants notably of herbal floor (all plant species, here is only herbal floor). Frequency of the transport is a high. It is of more than 28 560 unit cars per 24 hours. NNR is located in the middle of the agricultural landscape. Chemical substances used in farming mainly affect the plant associations. Besides that the absence the original agricultural activities (mowing and grazing) occurred to the unification of plant associations (the transformation of composition and a colourful flower meadows are changed on the monocultures grasses). Every encroachment to the regime of mineral springs is for NNR the essence of existence this structure. The most serious problem from the aspect of nature protection is the geological borehole (B2 deep 132 m, drilled in 1956). Geological borehole was closed longer period (what was right) and then was open (probably of visitors). In this way was disturbed the natural structure of the reserve as well as its evolution. The opening of the borehole damaged the morphological form of authentic travertine hill. Caused a reduction in activity of the mineral spring at the apex of the hill which created the originally hill of travertine. Around the borehole creates a new hill on the slope of authentic hill. This fact is not consistent with the protection of National Nature Reserve. The Act on Nature Protection prohibits conduct geological work in the National Nature Reserve on the fourth degree of protection. Hydrogeological borehole should remain straight sealed after drilling. Devastation of the locality takes place mainly under impact of unchecked visits and vandalism of some groups of tourists (by firing of objects, destruction of rare species vegetation, littering etc.) The visitors are very serious problem of reserve. Into NNR will come more than 200 visitors in summer a daily and in Saturday and Sunday is it more (to accede pilgrims and school trips). Some visitors are coming with their dogs and other animals what is prohibited according the Act of the Nature Protection. The second fact as pollution of biotopes with various wastes (e. g. PET bottles, paper and other wastes). For the wealthy and vital population of *Glauxmaritima* (halophyte) which mainly located around the mineral springs is the biggest threat unchecked movement of visitors. The walking in the National Nature Reserve destroys the species of halophytic flora and the young crust of travertine which are formed near the mineral springs. All of the above activities are in essence is in the contrary with the original idea of protecting the territory thus with the part of State Act Protection of nature and landscape which says: National Nature Reserve Sivá

Brada (fourth degree of protection) was declared to protect the unique travertine hill of Holocene age with a rare halophyte, xerophyte and vegetation of wetlands and marshes for scientific purposes. Act on Nature and Landscape Protection was in this case breached in all points.

Conclusion

Postulates and principles of nature conservation on the territory within the fourth degree of protection are very strict. In the Act no. 543/2002 Coll. on the Protection of Nature and Landscape National Council of Slovak Republic are listed the files of activities that are prohibited in NNR. Ministry of Environment of Slovak Republic do not check violations of protection of this rare territory and ignores their obligations. Underestimated the importance of the NNR and its preserved for scientific research for and for future generations and as well did not ensure its sustainable development.

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