

Managing visitor impacts on World Heritage Site Škocjan Caves, Slovenia

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Managing visitor impacts on destination communities

Škocjan Caves is an exceptional natural site on a global scale, which is also used for tourism purposes. A balance between the two can only be provided by good knowledge of the natural characteristics of the cave and by specifying the permissible level of anthropogenic load. On karst, interdisciplinary methods must be the basis of research, as this is a complex system that entails events from the geological past as well as present-day events, i.e. flowstone growth, flowstone deposits in rimstone pools, active floods, and, last but not least, the impact of climate change on the microclimate of the cave's interior.

Our original interdisciplinary problem-solving approach can potentially influence the addressing of similar issues on a global scale. With the analysis of meteorological conditions in the atmosphere above the cave, we will identify parallels with the cave microclimate and evaluate the potential impact of external climate and future climate change on the cave. For this proposes the ongoing (2017-2020) interdisciplinary applicative project “Karst research for sustainable use of Škocjan Caves as world heritage” is being implemented.

The research aims to determine the actual state of the karst in the Škocjan Caves and surface, perform system measurements (meteorology and hydrology), identify the current tourism impact, and determine the best methodology and measures for sustainable use of the tourist cave. Interdisciplinary methods should be karst-based studies since this is a complex system involving both past geological and current events, e.g. flowstone growth, flowstone deposition in rimstone pools, active flooding. The innovative interdisciplinary approach for solving the karst problem should impact the solving of similar cases worldwide. We shall analyse meteorological atmospheric conditions above the cave, compare them against the cave's microclimate, and evaluate the potential effect of climate changes on the cave. The monitoring of the cave's climate and of hydrological conditions of the Reka River shall enable long-term monitoring of various parameters, analysis, and data collection. The monitoring shall include the DTN internet technology for data collection as it is also suitable for karst caves. It is an innovative technology that should impact the development of new research branches in terms of automatically collected data measurements in extreme and remote cave environments. Measurements of CO₂ (both as a natural and anthropogenic source) in the cave shall be carried out which should help understand the sources and sinks of CO₂ in the karst in relation to the global climate changes. The project goal is to use modern karst research methods (determination of geological structure and development of the karst phenomena, speleo- (micro)biology, cave climate monitoring (on-line systems connected wirelessly/via optical fibres for monitoring micrometeorological parameters), geochemical modelling of percolated water, numerical hydraulic modelling (the Reka River flooding model), and the method of data display (e.g. spatial presentation of geological structures). The latter shall visually emphasize the connection between the initial geological structures (fault structures and tectonised bedding) and the initial development of cave channels or preferential scope of the water basin of percolated water inflow, and serve as an interactive and innovative teaching tool. Flooding probability model, built using the perceptron neural

network is also a global innovation. For the difficult parts of automated monitoring, the DTN technology of data transfer shall be used, a global novelty first tested in Slovenia. Example will be used from study in Postojna Cave, where MEIS and IZRK researchers, together with other European partners, have proven on the case of Postojna karst cave that DTN type of internet (delay and disruption tolerant networking) is suitable for collection of meteorological and other automatic measurements in huge karst caves. According to published reviewer's comments, the article presents »ingenious solution to the problem of data communication in a cave system« and »extremely interesting« and »excellent work«. DTN internet is otherwise used for the most demanding environments (from interplanetary communications at NASA to remote Lapland areas). The first news about successful experiment in Postojna cave was commented: »THIS IS JUST GREAT!!! WHAT A STORY TO TELL!« by dr. Vinton Cerf, widely recognized as one of the "Fathers of the Internet" for his work on the design of the TCP/IP protocols and the architecture of the Internet, and also one of the authors of DTN. Just after the article publication dr. Cerf also forwarded this news to the DTN interest group of researchers. This proves that we are the first in the world in using DTN technology for the data collection in karst caves. Because caves take millions of years to develop and due to significant suppression of external factors, they are extremely sensitive areas that require a sustainable use. This is particularly true of the caves protected by UNESCO that are subject to intensive tourist use. Assessing the existing negative impacts on the Škocjan Caves and determining the measures for reducing these impacts shall contribute to a sustainable economic use of the caves in the future. The measuring network allows the manager better monitoring and management even after the project concludes. Project partners have implemented a similar technology development approach in a project in the Postojna Cave (MEIS d.o.o., IZRK ZRC SAZU). The results shall help increase the competitiveness and innovation of Slovenia in the field of sustainable use of tourist caves. Around 150,000 visitors who annually visit the Škocjan Caves shall benefit from the project's improved and nature conservation-oriented experience. The flooding forecast information system shall provide a safer use of the beautiful water passage of the Reka River.

We wish to obtain a complete image of the dynamics of the Škocjan Caves. This image will include the speleological, geological, biological, microbiological, meteorological and hydrological events in the cave. Based on a comprehensive understanding of the system we will be able to provide guidelines for further sustainable tourism use of the UNESCO World Heritage Site – the Škocjan Caves.

Managing a show cave that is also a World Heritage Property requires the assurance that the impact on the cave is minimised, that the cave is properly presented to the visitors, and that the safety of visitors and staff is well taken care for. The agency tries to minimize the tourist impact on the cave environment by establishing different visitation protocols and especially by promoting off-season visits.