CAVEMONITOR – Monitoring Show Caves of Romainia

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Romania hosts spectacular karst areas with many caves holding the potential to become touristic attractions. While the number of caves opened for tourism is still low, in the last years there is a trend of opening new caves for tourism or re-fitting old show caves by using new lighting technologies and construction materials. In the last 4 years only, 5 new caves were opened for tourism and a couple of others are currently being under consideration for development. However, at a national level there are no management protocols enforced to monitoring changes in show caves and none of the caves opened to tourists have any such monitoring.

The CAVEMONITOR project started in the summer of 2014 and aims at establishing a robust protocol of monitoring the impact of tourist traffic upon the biotic and abiotic elements in show caves and to apply it as a pilot-study. The protocol includes monitoring of physical and chemical parameters of the caves (from air, water, speleothems, sediments) as well as the biological ones (population densities, the evolution of biodiversity hot-spots, air microbiology) in relation to the touristic traffic. The study should establish: (a) the extent to which the frequency and volume of the tourist traffic affects the monitored parameters; (b) required measures to ensure a physico-chemical equilibrium of the cave air and water and preserve cave's attractions; (c) limitations required in order to preserve cave biodiversity and to avoid the input of allochtonous elements such as lampenflora; (d) identify potential health risks to both cave personnel and tourists related to radon levels.

The project includes 5 show caves from the Southern and Western Carpathians and and one laboratory cave used as a reference site. The project includes the monitoring of the number of visitors and groups frequency, paralleled by the monitoring of the main physico-chemical parameters of the air (CO^2, temperature, RH) and drip and condensation waters (drip rate, temperature, conductivity, pH, water chemistry). Meteorological parameters are monitored using automated weather stations located in the close vicinity of all caves. We also monitor the vertebrate (Chiroptera) and invertebrate populations from caves, as well as the microbiological composition of the air, water and sediments. To assess speleothem vulnerability to the changes in chemistry of condensation or percolating waters calcite precipitation stations are installed and periodical measurements of stable isotopes ($d^{18}O$, $d^{13}C$) are carried out on both precipitated calcite and dripwaters. Radon concentrations are measured using both active and passive instruments.

The project will: (i) establish a robust monitoring protocol to be applied to all show and protected caves; (ii) establish threshold values for the tourist carrying capacity such as to allow for the preservation of the subterranean environment; (iii) create reliable technical solutions for monitoring the cave environment, including remote monitoring and online data transfer; (iv) establish a set of basic principles to be en-

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Fig.ure 1: Location of the monitored caves in Romania.

forced by the management plans of show caves pending on their morphology or the type of touristic traffic; (v) issue a set of preventive measures and instructions to be followed by the personnel and stakeholders of the show caves.

A total number of 35 monitoring stations have been installed in the 6 caves under observation (Figure 1). We are using both automated fixed stations, where sensors are connected to a central datalogger and mobile stations consisting of a combination of low-cost dataloggers that are functioning independently to each other.

A variety of sensors and dataloogers available on the market have been tested for their performance and robustness. In this report we discuss the performance and difficulties related to different sensors and cave conditions as seen after 6 months of measurements. We also present preliminary data showing the influence of lighting regimes and human traffic on the environment of the caves in different settings.