Science of the Total Environment 631–632 (2018) 1268–1278

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Highlighting the importance of transitional ventilation regimes in the management of Mediterranean show caves (Nerja-Pintada system, southern Spain)

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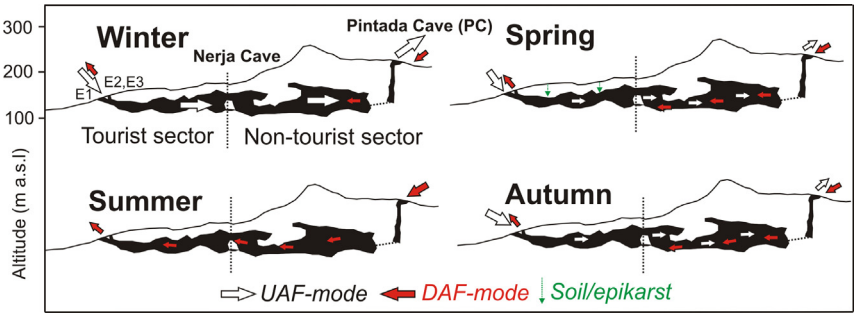
HIGHLIGHTS

- It has been described transitional ventilation patterns in the underground environment.
- The transitional ventilation regimes are the most complex of the annual cycle.
- These regimes could be considered in the management of Mediterranean show caves.
- The anthropogenic CO_2 is a good tool to trace the subterranean air flows.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 22 December 2017
Received in revised form 19 February 2018
Accepted 26 February 2018
Available online xxxx

Editor: SCOTT SHERIDAN

Keywords:
Anthropogenic impact
Carbon dioxide
Cave management
Cave ventilation
Environmental tracer
Microorganisms

ABSTRACT

This study shows the utilization of the air CO_2 exhaled by a very high number of visitors in the Nerja Cave as both a tracer and an additional tool to precisely evaluate the air circulation through the entire karst system, which includes non-touristic passages, originally free of anthropogenic CO_2. The analysis of the temporal - spatial evolution of the CO_2 content and other monitoring data measured from January 2015 to December 2016 in the Nerja-Pintada system, including air microbiological controls, has allowed us to define a new general ventilation model, of great interest for the conservation of the subterranean environment. During the annual cycle four different ventilation regimes and two ventilation modes (*UAF-mode* and *DAF-mode*) exist which determine the significance of the anthropogenic impact within the caves. During the *winter* regime, the strong ventilation regime and the airflow directions from the lowest to the highest entrance (*UAF-mode*) contribute to the rapid elimination of anthropogenic CO_2, and this affects the whole karstic system. During the *summer* regime the *DAF-mode* ventilation (with airflows from the highest to the lowest entrances) is activated. Although the number of visitors is maximum and the natural ventilation of the karstic system is the lowest of the annual cycle, the anthropogenic impact only affects the *Tourist Galleries*. The transitional ventilation regimes -*spring* and *autumn*- are the most complex of the annual cycle, with changing air-flow directions (from *UAF-mode* to *DAF-mode* and *vice versa*) at diurnal and poly diurnal scale, which conditions the range of the anthropogenic impact in each sector of the karst system. The activation of the *DAF-mode* has been observed when the temperature difference between the external and air cave is higher than 5 °C.

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https://doi.org/10.1016/j.scitotenv.2018.02.304
0048-9697/