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RESEARCH ARTICLE

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Condensation water in heritage touristic caves: Isotopic and hydrochemical data and a new approach for its quantification through image analysis

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Abstract

Condensation water is a major factor in the conservation of heritage caves. It can cause dissolution of the rock substrate (and the pigments of rock art drawn on it) or covering thereof with mineral components, depending on the chemical saturation degree of the condensation water. In show caves, visitors act as a source of CO_2 and thus modify the microclimate, favouring negative processes that affect the conservation of the caves. In spite of their interest, studies of the chemical composition of this type of water are scarce and not very detailed. In this work we present research on the condensation water in the Nerja Cave, one of the main heritage and tourist caves in Europe. The joint analysis of isotopic, hydrochemical, mineralogical and microbiological data and the use of image analysis have allowed us to advance in the knowledge of this risk factor for the conservation of heritage caves, and to demonstrate the usefulness of image analysis to quantify the scope of the possible corrosion condensation process that the condensation water could be producing on the bedrock, speleothem and rock art. To our knowledge, this application of image analysis (relative to the condensation water in caves) is the first one of this type that has been documented.

KEYWORDS

cave conservation, corrosion condensation, hydrochemistry, image analysis, isotope, microbial community, Nerja Cave, nitrate contents

1 | INTRODUCTION

In caves, the air water vapour content influences the air density and, consequently, the airflows and the gas exchange between the exterior and interior atmospheres. It also influences phase-change processes between the vapour and liquid phases. Under natural conditions, an equilibrium exists between water vapour evaporation and condensation, which is determined by the vapour pressure that is in turn dependent on the temperature. The assumption is that, at the surface of cave walls and speleothems there is a boundary layer of saturated air that has the same temperature as the surface. This boundary layer interacts with the surrounding air, causing condensation or evaporation of condensate in a dynamic relationship that is driven largely by the vapour gradient (De Freitas & Schmekal, 2003). Condensation per se is a dynamic process of moisture flux that might vary from hour to hour and for any given time period. The process can involve both condensation and evaporation of the condensate, depending on the direction of the vapour gradient between the air and the moist surface. When the amount of condensation over a given period exceeds the evaporation of condensate over that same period, condensation is observed to have occurred. Condensation water will accumulate if this condition re-occurs; otherwise it will dissipate (De Freitas &

