

Anthropogenic impact in karst environments

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Introduction

Karst habitats are extremely interesting environments **protected** at European level, unique ecosystems rich in caves and custodians of important water reserves: **groundwater** in karst aquifers constitutes about 25% of the global drinking water sources. **Caves** are one of the most important and well-known geological features in the world, an extremely interesting environments rich in specialized fauna and speleothems. Moreover, they are a cultural **heritage**, as well as an important economic resource for many countries. Thank to their relatively stable environmental conditions cave can preserve information for a long time such as paleontological/archaeological remains, however, these characteristics make caves **vulnerable** environments too, easily damaged by climate variations and pollution, causing important habitat changes. Karst surface and underground environment and aquifers monitoring becomes essential in order to **protect** and **preserve** them over time.



Aims:

- Monitoring karst surface and subterranean environments for a better knowledge, conservation, management and enhancement of environmental and cultural heritages and resources
- Understand the pollution degree in karst habitats such as microplastic contamination (sediments, water...)
- Monitoring environmental parameters in caves (natural variations, climate change, global warming and pollution)
- Monitoring anthropogenic impact in show caves
- Mitigate anthropogenic impact and promoting environmental sustainability in karst areas

Work in progress:

- Microplastics pollution in unexplored caves
- Microplastics pollution in ponor Kovači – izvor Ričina karst system, Bosnia and Herzegovina
- Microplastic pollution in springs: relations between pollution and karst aquifer typology
- Microfibres pollution in the Classical Karst aquatic environments
- Lampenflora biocorrosion in show caves with new led lamps
- Natural and anthropogenic environmental parameters variations in show caves
- Climate change in underground karst environments



Collaborations:

- DESP – University of Milan, Italy
- Biologia Sotterranea Piemonte – Gruppo di Ricerca, Italy
- Underground Karst Laboratory of Bossea Cave – S.O. Bossea CAI, Italy
- Associazione Gruppi Speleologici Piemontesi, Italy
- Speleo Club Teramo, Italy
- Speleološko Društvo Mijatovi Dvori, Bosnia and Herzegovina
- Tomislavgrad Franciscan Museum, Bosnia and Herzegovina
- Associazione Grotte Turistiche Italiane

Bibliography

- Karst ecosystems
- Anthropogenic impact in show caves:
 - Pollution
 - Lampenflora growth
 - CO₂ increase
 - Temperature increase
 - Air circulation variations
- Microplastic and textile pollution
- Environmental parameters monitoring

Microplastic pollution

- Sediments and waters of different European caves and karst areas were examined
- Microplastics in karst systems can be consumed by animals, damage ecosystems and contaminate water resources
- Surface karst areas and underground environments should be monitored and protected, especially regarding the management of water resources.

Microplastic pollution in spring and cave habitats of the Classical Karst

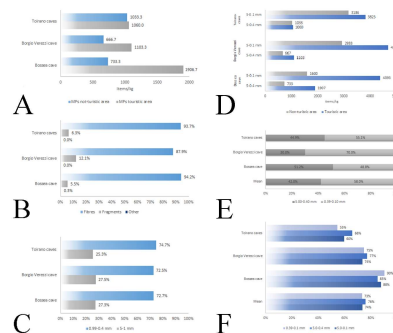
In collaboration with DESP-University of Milan and Biologia Sotterranea Piemonte - Gruppo di Ricerca Balestra et al. (under review)

- We collected and investigated water and sediment samples from aquatic environments of caves and springs in which the olms were previously reported
- Examined particles were counted and characterized by size, color and shape via visual identification under a microscope, with and without UV light, and spectroscopic analyses with μFTIR-ATR
- The concentration of microplastics in water samples varied from 47 to 96 items/L, instead, in sediments from 889 to 2178 items/kg. Most microplastics were smaller than 1 mm. Fibre-shape was the main present, followed by fragments and beads. The majority of particles was fluorescent under UV light and were mainly black, blue or brown. Samples contained especially polyesters and copolymers

Microplastic pollution in sediments of Italian show caves

Balestra & Bellopede, 2023

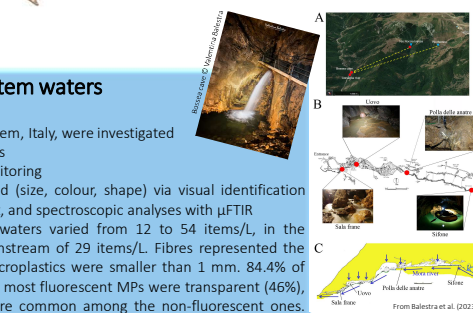
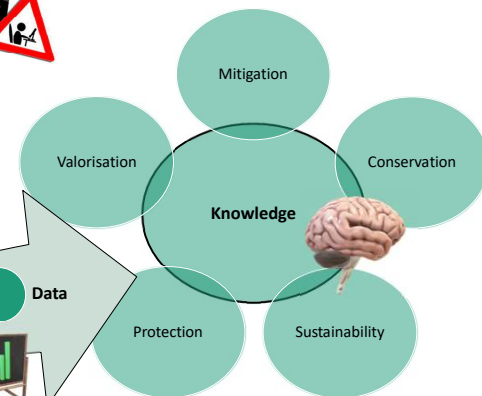
- The deposits of three Italian show caves were investigated
- We refine a methodology for cave sediment monitoring
- Microplastic were identified and characterised using MUPL automated software, observed with and without UV light under a microscope, and verified with μFTIR-ATR
- Microplastics were present in sediments of all examined caves, and were always greater along the tourist route (an average of 4300 items/kg) than the speleological areas (an average of 2570 items/kg). Microplastics less than 1 mm dominated the samples and the amount increased with the decrease in the size considered. Fibre-shaped dominated the samples. 74% particles was fluorescent under UV light. Analysed sediment samples contained especially polyesters and polyolefins



Research published:

- Balestra, V., & Bellopede, R. (2023). Microplastics in caves: A new threat in the most famous geo-heritage in the world. Analysis and comparison of Italian show caves deposits. Journal of Environmental Management, 342, 118189
- Balestra, V., Vigna, B., De Costanzo, S., Bellopede, R. (2023). Preliminary investigations of microplastic pollution in karst systems, from surface watercourses to cave waters. Journal of Contaminant Hydrology, 252, 104117
- Giardino, M., Balestra, V., Janner, D., Bellopede, R. (2023). Automated method for routine microplastic detection and quantification. Science of The Total Environment, 859, 160036
- Balestra, V., Galbiati, M., Lapadula, S., Zampieri, V., Cassarino, F., Gajdošová, M., Barzaghi, B., Manenti, R., Ficetola, G.F., Bellopede, R. (under review). Microplastic pollution in groundwater and springs: a threat to protected habitats and species. Investigations in the olm habitats

- SHOWCAVE - MIUR PRIN 2017:** A multidisciplinary research project to study, classify and mitigate the environmental impact in tourist caves
- PRIORITY Plastics Monitoring Detection Remediation Recovery - COST ACTION CA20101 :** a science and technology research network focused on developing, implementing, and consolidating strategies to tackle the global challenges of micro- and nanoplastics in the environment



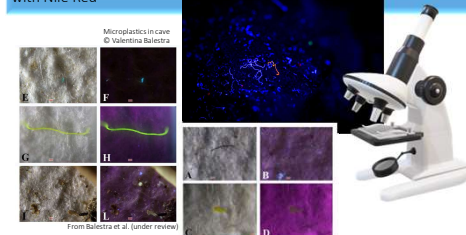
Microplastic pollution in caves and karst areas

New methodologies: MUPL software

In collaboration with DISAT – Politecnico di Torino

Giardino et al., 2023

We create MUPL Software, a semi-automatic innovative image processing method for quantifying and measuring microplastics on filters. This image analysis method is quite accurate and fast (about 10 s/image average processing time), showing an average deviation below 10%, which is further reduced to about 8% if the samples are stained with Nile Red



Congress:

- 18th INTERNATIONAL CONFERENCE ON ENVIRONMENTAL SCIENCE & TECHNOLOGY, ATHENS, 30 AUGUST-2 SEPTEMBER 2023**
 - The invisible environmental impact of tourism in show caves: microplastic pollution in three Italian show caves
- SIMP, SGI, SOGEI, AIV JOINT CONGRESS "THE GEOSCIENCE PARADIGM: RESOURCES, RISK AND FUTURE PERSPECTIVES", POTENZA, 19-21 SEPTEMBER 2023**
 - New threats in the Trieste Karst (Italy): pollution by microplastics in groundwaters and springs
- 3rd INTERNATIONAL CONGRESS OF KARST, SPELEOLOGY AND VALORISATION OF NATURAL HERITAGE "VALUATING AND PROTECTING THE KARSTIC HERITAGE BETWEEN RIGHT AND OBLIGATION, RABAT, 2-5 NOVEMBER 2023**
 - Biocorrosion of speleothems in show caves: analysis of young speleothems exposed to two years of new LED lights
 - COVID-19 pandemic: an opportunity to monitor the naturalness of show caves
 - Microplastic pollution in the Trieste Karst (Italy) protected habitats: preliminary analysis of cave and spring water sediments
 - The Underground Karst Laboratories of Bossea Cave: more than 50 years of collaborations and research
 - Environmental parameters monitoring in the oldest show cave of Italy: Bossea Cave