19th International Congress of Speleology
38º Congresso Brasileiro de Espeleologia

UNIVERSIDADE FEDERAL DE MINAS GERAIS – UFMG
INSTITUTO DE GEOCIÊNCIAS – IGC
Laboratório de Estudo Hidrogeológico - LEHID

Syllabus – Short Course

Fluorescent Tracers in Karst Systems: Planning, Execution, and Data Interpretation

Instructor: Paulo Galvão
Email: hidropaulo@gmail.com

Instructors: Pedro Assunção[*,**,***] e Gabriel Lourenço[*,**]

Event: 19th International Congress of Speleology and 38º Congresso Brasileiro de Espeleologia

Date: July 19th, 2025

Time: 8:00 AM – 12:00 PM and 1:00 PM – 5:00 PM (8 hours total)

Venue: Room 3053, 3rd Floor, Institute of Geosciences (IGC), Federal University of Minas Gerais (UFMG)

Language: Portuguese

Target Audience: Professional and amateur speleologists, undergraduate and graduate students, professionals in hydrogeology

Capacity: 20 participants

Course Coordinators: Prof. Dr. Paulo Henrique Ferreira Galvão* and Prof. Dr. Rodrigo Sérgio de Paula*

* Institute of Geosciences, Federal University of Minas Gerais (UFMG)
** Sociedade Excursionista Espeleológica (SEE)
*** Espeleogrupo Pains (EPA)

19th International Congress of Speleology
38º Congresso Brasileiro de Espeleologia

Instructors' Backgrounds:

Pedro Assunção: Geological Engineer (2018) from the Federal University of Ouro Preto (UFOP). Master's degree in Natural Sciences (2021) from UFOP's Graduate Program in Crustal Evolution and Natural Resources. Currently a Ph.D. candidate in Geology at the Federal University of Minas Gerais (UFMG), and a member of the Hydrogeological Studies Laboratory (LEHID) at UFMG. Speleologist affiliated with the Sociedade Excursionista Espeleológica (SEE) and Espeleogrupo Pains (EPA). Areas of expertise include Hydrogeology, Karst systems, and Speleology.

Gabriel Lourenço: Geological Engineer from the Federal University of Ouro Preto (UFOP, 2023). Currently pursuing a Master's degree in Karst Hydrogeology at the Institute of Geosciences (IGC), Federal University of Minas Gerais (UFMG), where he is also part of the Hydrogeological Studies Laboratory (LEHID). His research focuses on speleology, hydrogeology, hydrochemistry, and the use of fluorescent tracers for studying cave connectivity. An experienced photographer for over 10 years, specializing in cave, geosciences, and nature photography.

Context: Determining flow directions and pathways of groundwater in highly heterogeneous and anisotropic karst systems is a complex task. The geometry of karst networks can undergo significant changes over time due to processes such as cave collapses, sediment infilling of conduits, conduits becoming unsaturated due to fluctuations in the water table, and reactivation of overflow springs under high-flow conditions. Fluorescent tracer techniques are invaluable tools in karst studies, as they enable the delineation of spring catchment areas, estimation of flow velocities, and identification of recharge and discharge zones. Fluorescent dye tracers are synthetic organic compounds with fluorescent properties; they are typically absent from natural waters, safe for human health, and highly detectable (Käss 1998; Field 2002; Ford & Williams 2007; Palmer 2007; Goldscheider et al. 2008; Goldscheider & Drew 2007; Benischke 2021).

Summary: This short course aims to introduce and demonstrate the application of fluorescent tracer techniques, with a specific focus on karst systems. The course includes a theoretical component covering general concepts, followed by a practical session using a case study. The course duration is 8 hours, and participants are required to bring their own laptops for the practical activities.

Schedule:

Part 1 – Planning and Execution of Fluorescent Tracer Tests (8:00 – 9:30 AM)

1.1 Introduction

- Types of tracers: natural and artificial

- Importance and applications of dye tracer tests in karst aquifers
- Historical overview of tracer methods

1.2 Research Planning and Preliminary Data Collection:

- Research objectives
- System approach: recharge, flow, and discharge
- Basic geological, geomorphological, climatic, and hydrological data
- Common materials and methods: fluorescent substances, activated charcoal bags (fluocaptors), field fluorimeters, portable fluorimeters, automatic samplers, hydrological monitoring networks, laboratory analysis
- Calculation of tracer mass to be injected
- Social responsibility: communication of the experiment and toxicity assessments

1.3 System Instrumentation:

- Test phases: determination of natural background levels
- Qualitative and quantitative tests
- Seasonal and spatial variability
- Selection of sampling network points based on the conceptual flow model
- Measurement of inflow and outflow rates in the system
- Conceptual model uncertainties, significance of negative qualitative tests, and identification of slow-flow zones

1.4 Fluorescent Dye Injection:

- Types of injection: instantaneous or continuous
- Precautions during injection
- Injection points: sinkholes, dolines, caves, and boreholes

Break (15 minutes)

Part 2 – Data Acquisition and Interpretation for Quantitative Tests (9:45 AM – 12:00 PM)

2.1 Field and Laboratory Data Acquisition:

- Overview
- Bench-top fluorimeter

- Fluorescence spectrophotometer
- Field fluorimeter

2.2 Breakthrough Tracer Curves:

- Curve parameters
- Recovered mass
- Average flow velocity and mean transit time

2.3 Characteristics of the Conduit Network:

- Flow patterns
- Slow-flow (stagnant) and fast-flow zones
- Geometric patterns of recovery curves
- Conduit parameters: volume, cross-sectional area, and diameter

2.4 Concepts of Mass Transport:

- Advection, dispersion, diffusion, retardation, and degradation
- Adsorption and absorption
- Advection-Dispersion Equation
- Hydrodispersive models: ADM, 2RNE, and MDP-2RNE

2.5 Software Tools for Data Interpretation:

- QTRACER2 (Field 2002)
- CXTFIT (Toride et al. 1995)
- MFIT (Bodin 2020)

Lunch Break (1 hour)

Part 3 – Practical Session (1:00 – 3:00 PM)

3.1 Introduction to Equipment and Types of Tracers:

- GGUN-FL30 field fluorimeter (Schnegg 2002)
- Activated charcoal fluocaptor
- Fluorescent tracers: Sodium Fluorescein, Rhodamine WT, and Tinopal CBS-X

3.2 Data Acquisition Using Field Fluorimeters

Break (15 minutes)

19th International Congress of Speleology
38º Congresso Brasileiro de Espeleologia

Part 4 – Practical Session (3:15 – 5:00 PM)

3.3 Case Study for Practical Data Interpretation

3.4 Application of Data Interpretation Spreadsheet and Software (QTRACER2 and CXTFIT)

Important Notes

- The short course will take place in Room 3053, 3rd Floor, Institute of Geosciences (IGC) at UFMG.
- A maximum delay of 10 minutes will be tolerated for the start of the course. Please arrive on time to ensure full participation.
- Participants must bring their own laptops for the software exercises.
- A compressed folder containing all necessary files and software for the practical session is attached.

A map of UFMG showing the location of the IGC is included below.