Pietro de Anna **November 16, 2025**

Personal Information	Associate Professor at ISTE, (UNIL) - Born in Florence (IT), February 1981	
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Education

Ph.D., **University of Rennes 1** Rennes, France - July 2012
- Thesis Topic: *Reactive transport in heterogeneous porous media*
- Advisors: Philippe Davy and Tanguy Le Borgne
- Area of Study: Fluid Mechanics and Hydrology

M.S., **University of Florence**, Italy, February 2009
- Thesis Topic: *Collective dynamics in a protocell: analytical and numerical study*
- Advisor: Duccio Fanelli
- Area of Study: Statistical Mechanics

Employment history

Post-doc, Civil and Environmental engineering of MIT Cambridge, USA. September 2012 - June 2015
- Research Topic: *Chemotaxis and bacterial dispersal in porous media*
- Supervisor: prof. Ruben Juanes

Assistant Professor (tenure Track), **University of Lausanne**, Institute of Earth Sciences (August 2015 - July 2021)

Associate Professor (tenured), **University of Lausanne**, Institute of Earth Sciences (August 2021 - present)

Institutional responsibilities

Head of the Environmental Science Master degree 2021 - present, University of Lausanne

Research project as leading investigator

Swiss National Science Foundation (division II) project no. 200021_219863, title *Reactive-Transport in confined micro-structures: unraveling the link between structure, flow, filtration and colonization*, 2024 - on going.

Horizon 2020 - Future and Emerging Technologies project no. 828890, title *NAtuRal instability of semiConductors thIn SOlid films for sensing and photonic applications (NARCISO)*, 2019-2022.

Swiss National Science Foundation (division II) project no. 200021_172587, title *Flows in confined micro-structures: coupling physical heterogeneity and bio-chemical processes*, 2017 - 2021.

Contributions to the career of young scientists

Supervised 4 PhD theses (Dr. Filippo Miele, Dr. Mayumi Hamada, Dr. Chiara Recalcati and Dr. Wenqiao Jiao) at UNIL
Supervising 3 PhD students (Nadine Harmsen, Fateme Sajedi and Michele Caola).

Supervising two post-doctoral researcher, at University of Lausanne (Dr. Isaac Pincus and Dr. Wenqiao Jiao).
Supervised a visiting post-doctoral researcher (Dr. Takuya Sugimoto), at University of Lausanne (2020), working on filtration by un-saturated porous media. Funded by the Leading House of Asia.
Supervised 6 post-doctoral researchers (Dr. David Scheidweiler, Dr. Ankur D. Bordoloi, Dr. Giulia Ceriotti, Dr. Nolwenn Delouche, Dr. Stephane Mahe and Dr. Isaac Pincus), at University of Lausanne (2016-present).

Supervised 15 Master students.
Supervised 12 Bachelor students.

Teaching Activities

University of Lausanne - UNIL, Switzerland

- Spring 2025-present, Environmental Science Master degree program at UNIL, course on *Laboratory methods: experiments, measurements and uncertainties.*
- Spring 2022-present, Environmental Science Master degree program at UNIL, course on *Master Project Preparation.*
- Spring 2022-present, Environmental Geoscience Bachelor degree program at UNIL, course on *Vectorial Analysis.*
- Fall 2015 - 2024 Environmental Science Master degree program at UNIL, course on *Flow and Transport in the Subsurface.*
- Fall 2015 - 2023 Environmental Geoscience Bachelor degree program at UNIL, course on *Introduction to Environmental Sciences.*
- Fall 2019 - 2025 Environmental Geoscience Bachelor degree program at UNIL, course on *Subsurface Hydrology.*
- Spring 2016 - 2018 Environmental Geoscience Bachelor degree program at UNIL, course on *Hydrology.*

PhD committees

Member of 16 PhD Juries (internationally) and chair of 8 PhD Juries (at UNIL)

Meetings organization

Director of summer school *Flow and Transport in Porous and Fractured Media, Development, Protection, Management and Sequestration of Subsurface Fluids*, 3rd edition at the I.E.S.C. in Cargese, France (2015), 120 participants and **Member of the organizing committee** of the 4th edition of the same school (2018), 100 participants.

Member of organizing committee of *Flow and Transport in Porous and Fractured Media, Development, Protection, Management and Sequestration of Subsurface Fluids*, at the I.E.S.C. in Cargese, France 2018, 2021 and 2024. More than 100 participants.

Chair of the mentoring session, *Gordon Research Seminar* Flow & Transport in Permeable Media, Newry, USA. July 2018.

Session convener of the European Geophysical Union meeting in Vienna (AU). April 2017, April 2018, April 2019 and April 2020-1-2 (online).

Session convener of the InterPore 2016, 2017, 2018, 2019 and 2026 International Conference on Porous Media & Annual Meeting.

Fellowships

Marie Curie PhD fellowship, International Training network *IMVUL* 2009-2012.

International **mobility fellowship** - European University of Brittany, 2010.

Post-doc Earth Resource Laboratory **ERL-fellowship of the Massachusetts Institute of Technology** 2012-2014.

Reviewer duties

Journals: about 20 reviews per year (including Science Advances, Nature Physics, PNAS, J. of Contam. Hydrol., Geophys. Res. Lett., Water Resour. Res., J. of Fluid Mech., Environ. Sci. & Technol., Adv. in Water Resour., Transp. in Porous Media)

Funding agencies: German Research Foundation (DFG), National Science Foundation (USA), Isreal Science Foundation (ISF), American Chemical Society (ACS) and Horizon 2020 (EU).

SCIENTIFIC ACHIEVEMENTS

I worked on flow, mixing, reactive transport and microbial dispersal and growth in confined and heterogeneous porous systems. I developed a theoretical framework for the understanding of coupled heterogeneous flows and mixing-driven processes in porous media that can be summarized in the following main research achievements.

Diffusion-limited reactions

When considering reaction kinetics in poorly mixed systems, the transport mechanisms become very important and the resulting overall kinetics are different from the ones observed in well-mixed reactors. I showed that spatial concentration fluctuations of reactants in conjunction with diffusion alone can have a dramatic impact on their global reaction kinetics. Using a stochastic population dynamics approach, I investigated anomalous reaction kinetics related to segregation in the one-dimensional reaction-diffusion system $A + B \to C$.

Medium structure and flow heterogeneity

The solid structure of natural porous systems is characterized by their heterogeneity, or spatial variability. This property can be related to the wide distribution of pore sizes (λ), or their shape. By means numerical simulations and stochastic modeling, I showed that porous media Lagrangian velocities display intermittency, that controls anomalous dispersion. Moreover, while I showed, with theoretical analysis and numerical simulations, that the overall fluid velocity distribution can be linked to the one of λ in terms of flow profile within single pores, I recently demonstrated, by means of microfluidics experiments and numerical simulations, that within cavity-like, dead-end, pores laminar vortices emerge, controlling late time Lagrangian transport.

Transport and mixing of solutes

I have shown (with numerical simulations, experiments and theoretical modeling) that mixing at a displacing fronts develops a lamellar structure for stable, unstable and un-saturated cases, controlling the overall reaction kinetics. I also showed the fundamental difference of mixing dynamics of porous systems when the discrete nature of the medium is resolved, compared to classical description that simplify a porous medium with a continuous permeability field, since under confinement molecular diffusion has a fundamentally different solution and also fluid stretching undergoes a different kinematics.

Transport and filtration of colloidal/bacterial suspensions

I used a microfluidic model to directly image and rigorously quantify the role of bacteria motility and chemotaxis on their dispersal and residence time in porous media flows. I, then, used this methodology to investigate the transport and filtration of bacteria and colloids: these data inspired the derivation of a novel framework to model filtration by heterogeneous media.

Resources availability and microbial growth

Combining novel experiments with microfluidic devices, sequencing and modeling, I showed that architectural plasticity enhances space exploitation by multi-species biofilms in porous environments: biofilms differentiate into two architectures, one coating the grains and another one protruding from the grains into the pore space, the streamers. Moreover, I showed that within biofilms exposed to constant well-oxygenated flow of nutrients, oxygen can be depleted due to metabolic activity of bacteria. Thus, I developed a novel technology to directly visualize with optical methods the oxygen availability with optodes sensors embedded within microfluidic devices (one article under review). These novel tools allowed me to show how chemotaxis and quorum sensing, triggered by nutrients limitation, control the overall biomass accumulation in porous systems.