University of Genova

Department of Earth, Environmental and Life Sciences

Doctorate Course in Earth and Environmental Science and Technology

Earth Science Curriculum

Università degli Studi di Genova

STAT

Dottorato in Scienze e Tecnologie per l'Ambiente e il Territorio

Research Theme n. 5

Titolo: **Modellizzazione geochimica della miscelazione di acque sotterranee con acque reflue in falde acquifere costiere**

Title: **Geochemical modelling of groundwater mixing with wastewater in coastal aquifers**

Tutor: Marino Vetuschi Zuccolini marino.zuccolini@unige.it

One of the top concerns of the circular economy regarding environmental protection is managing the pressures that arise from long periods of drought and high exploitation of water resources stored in groundwater. The direct effect of water table lowering for periods longer than the water supply emergency period pushes regulators to implement alternative solutions such as recycling wastewater in aquifers. To effectively solve a problem, a holistic and robust thermodynamic analysis is required to detect, measure, and forecast the complex schema of physical processes generated in reservoirs during and after re-injection.

The mixing of natural water and treated wastewater, both on the surface through spreading supply or directly in reservoir through well injection, can cause local changes by porosity alteration or degrading the quality of the entire groundwater body.
Potentially hazardous elements can be released or adsorbed (or exchanged) by bio-geochemical changes that overlap with a feedback effect, which is caused by physical or chemical changes due by changes in CO2 content in groundwater. In addition to this remarkable result related to water mixing, a natural barrier for the entrance of sea water in aquifers can be created by re-injection of pre-treated water, through a water recharge program.
The candidate will carry out an intensive field activity, followed by an analysis supported by significant computational effort to feature the geochemical behavior of the water reservoir of interest.
Assessment of the geochemical characteristics of water (main chemistry, stable isotopes, pharmaceutical metabolites, PHAS or nano-plastics) will be the starting point for the definition of the "ground-zero" state of the aquifer, previous whichever Managed Aquifer Recharge (MAR) solution.
A sampling period dedicated to spring and wells maintained by the institutional manager, will be developed to evaluate seasonal dynamic parameters used in the final phase.
Reconstructing a digital and high resolution, stochastically based 3D model of aquifer geological heterogeneities is the focus of the final step.
The main result will be a set of flow, transport, and reaction models that will evaluate geomechanical concerns, derived from a set of equivalent scenarios. The spatial and seasonal variability of the water system should be identified through a set of parameters provided by this approach. Based on these results, local, commercial, and political entities will be able to establish a general framework of solutions and regulations to test and monitor suggested solutions.

Financial support:
La borsa di dottorato sarà supportata (in parte o totalmente) da IRETI SpA, in qualità di Gestore unico e responsabile della rete distributiva dell'Ambiente Territoriale della Città Metropolitana di Genova

Tutor's publications (max 3)

Ricci, L., Frondini, F., Morgavi, D., Vetuschi Zuccolini, M., Boudoire, G., Laumonier, M., Caliro, S., Cardellini, C., Ionescu, A., Ariano, A. Chiodini, G. (2024) CO_2 flux from the French Massif Central groundwaters: Modelling and quantitative estimation of the degassing process. Chemical Geology, 652, 122012.

M. Miola, D. Cabiddu, S. Pittaluga et al., A computational approach for 3D modeling and integration of heterogeneous geo-data. Computers & Graphics (2022), doi: https://doi.org/10.1016/j.cag.2022.05.002.

Frondini, F., Vaselli, O., Vetuschi Zuccolini, M., (2019) Consumption of Atmospheric Carbon Dioxide through Weathering of Ultramafic Rocks in the Voltri Massif (Italy): Quantification of the Process and Global Implications. Geosciences 2019, 9, 258; doi:10.3390/geosciences9060258