WORKSHOP Geopolymer for Environmental Remediation
Faenza 14th of February 2025

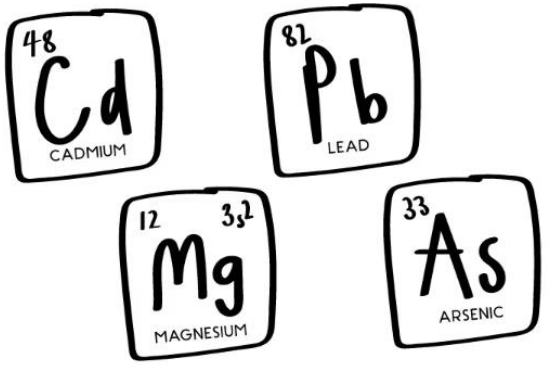
ZEOREMEDIA project

DESIGN MULTIFUNCTIONAL FOAMS FOR WATER REMEDIATION

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
DIPARTIMENTO DI ECCELLENZA 2023-2027
DICMaPI
Applied Chemistry Labs Laboratori di Chimica Applicata

Water Quality

Water quality is nowadays suffering from the pollution caused by the release of a wide variety of **contaminants** from different sources



Heavy Metals

Dyes

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Water Remediation

Water treatment methods	Advantages	Disadvantages
Oxidation	Fast process for removal of toxic pollutants without the need for pre- or post-treatment processes	High energy costs and production of byproducts
Ion Exchange	Effective removal of a wide range of heavy metals and colors with minimal energy requirements	High operational and chemical costs, sensitivity to fouling
Membrane Filtration	Technologies Effective removal of heavy metals and colors	Production of thick, expensive sludge, requires periodic cleaning
Coagulation/Flocculation	Economically viable	High sludge production and formation of large particles
Electrochemical Treatment	Fast and effective process for removal of specific metal ions	High energy costs and production of byproducts
Photochemical Treatment	No sludge production	Formation of byproducts
Biological Treatment	Possible for removal of some metals	Technology has not yet been developed and commercialized
Adsorption	Ease of use, low cost, can treat nearly 100% of water	Adsorbents require regeneration

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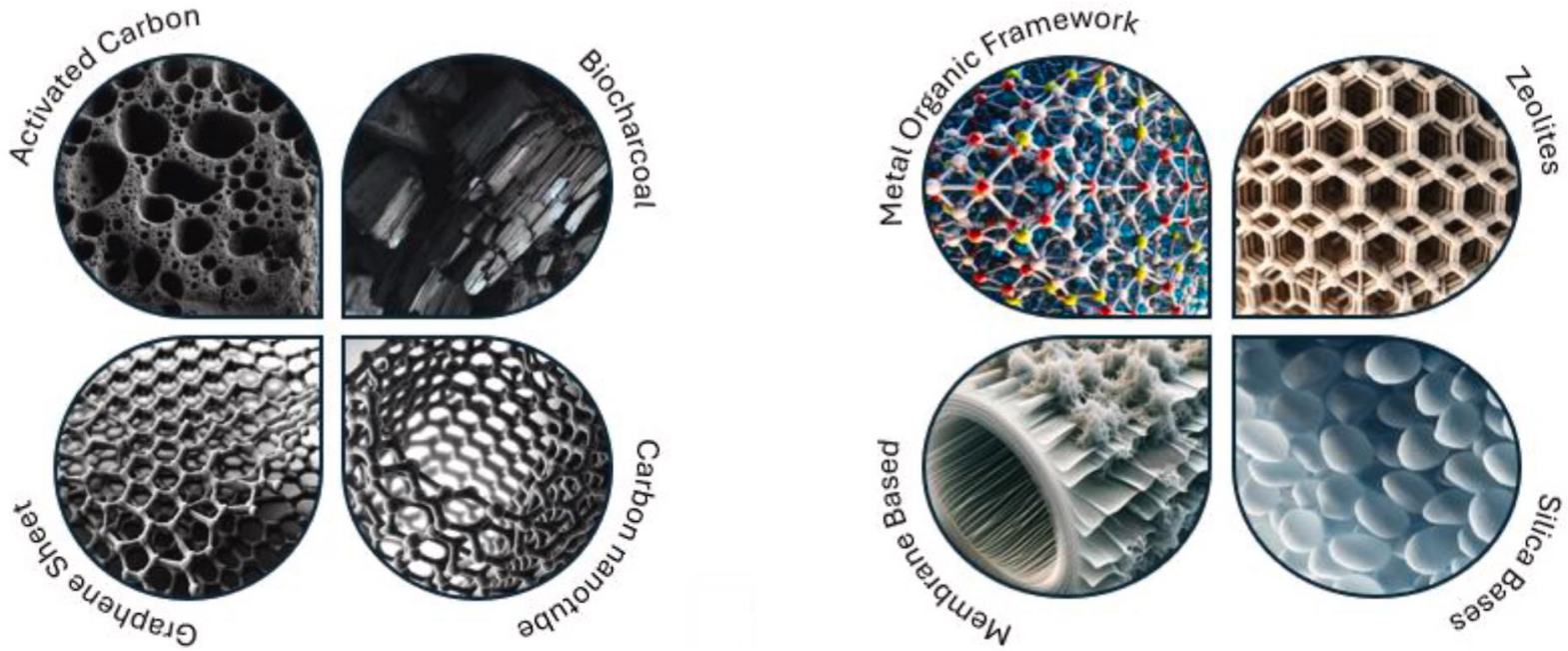
Water Remediation

Why Do We Need to Treat Wastewater?

Wastewater treatment is essential for several reasons.

- **Preserving the Environment**
- **Protecting Human Health**
- **Alleviating Water Scarcity**

Major Types of Adsorbent Materials



Satyam, S., & Patra, S. (2024). *Innovations and challenges in adsorption-based wastewater remediation: A comprehensive review. Heliyon. 10, e29573.*

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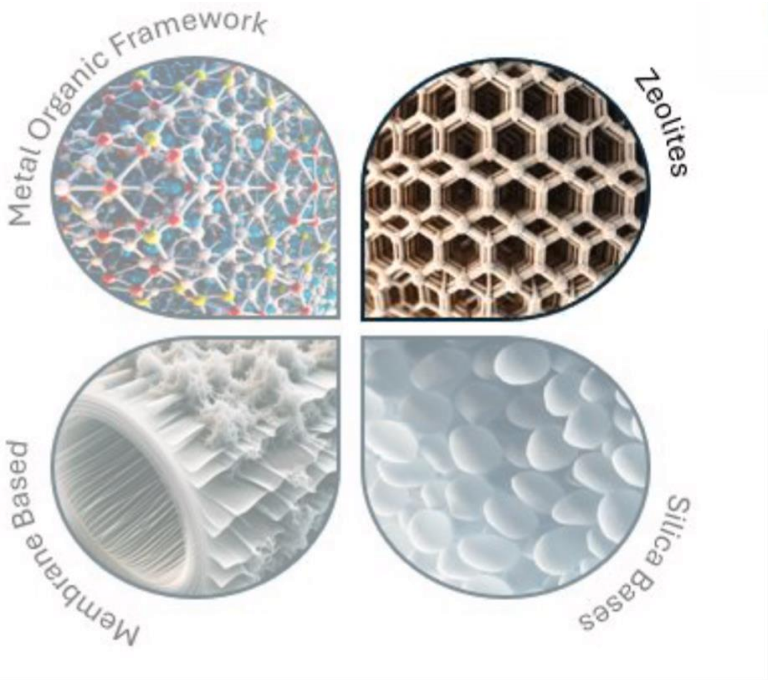
Zeolites



- Zeolites are **microporous** crystalline aluminosilicates that can also be found in nature and are structured as TO4 tetrahedra (T=Si, Al), with Si/Al ≥ 1.
- Thanks to the **extensive inner surfaces** and the resulting adsorption properties, combined with molecular sieving and cation exchange abilities.
- Zeolite 4A and 13X are **good candidate as ion exchangers and sorbents.**

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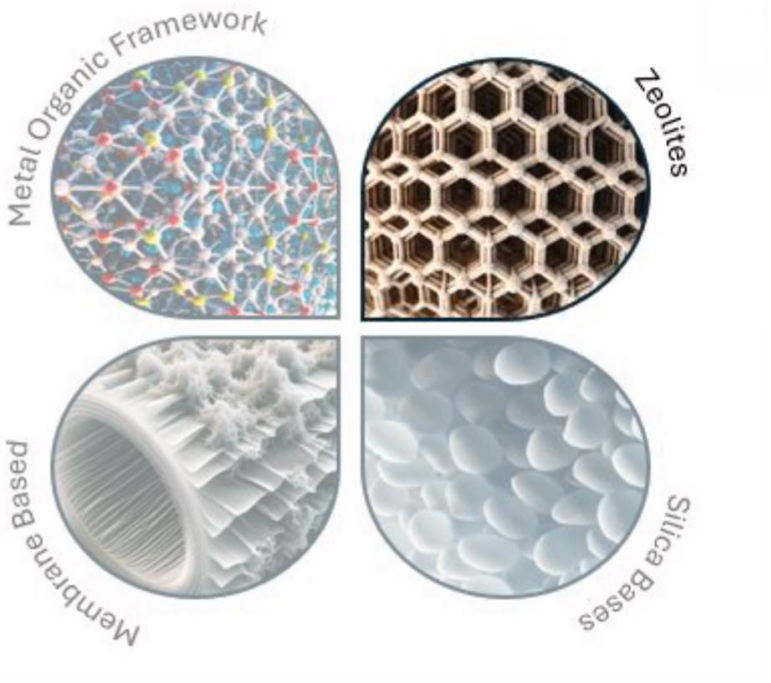
Zeolites: the challenge



Their use in fixed bed reactors requires a **suitable shaping or supporting** pre-treatment for better performances in terms of mass transfer, chemical and mechanical stability

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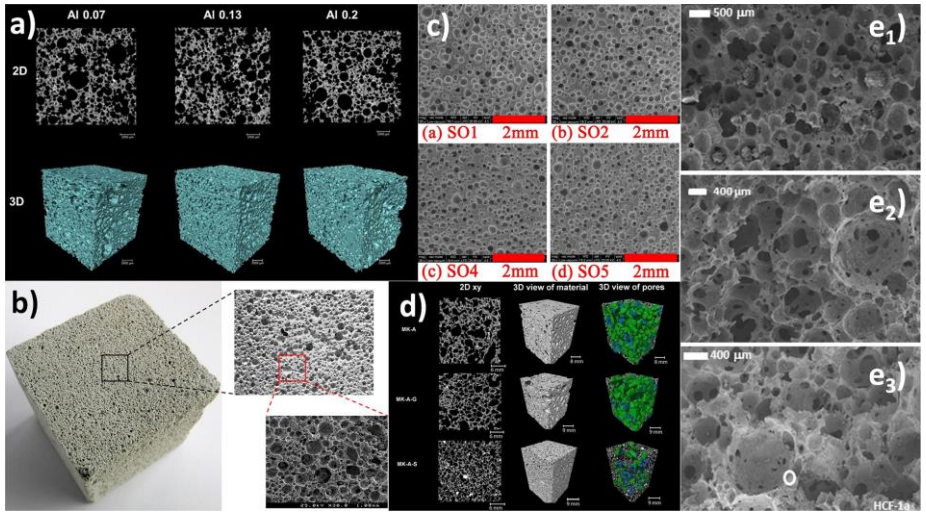
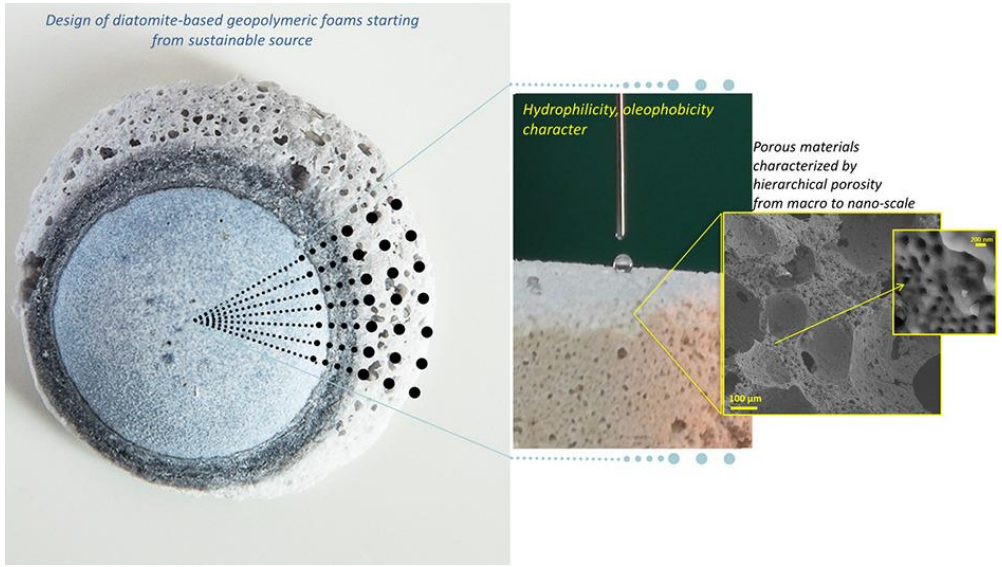
Geopolymeric Foams

- **Geopolymers**, due to their ease of manufacturing, good mechanical properties, high **versatility** and **low processing costs**, are among the most promising materials to produce inorganic foams.





Novais, R. M., Pullar, R. C., Labrincha, J. A. (2020). Geopolymer foams: An overview of recent advancements. Progress in Materials Science, 109, 100621.
Galzerano, B., Capasso, I., Verdolotti, L., Lavorgna, M., Vollaro, P., Caputo, D., Liguori, B. (2018). Design of sustainable porous materials based on 3D-structured silica exoskeletons, Diatomite: Chemico-physical and functional properties. Materials & Design, 145, 196-204.

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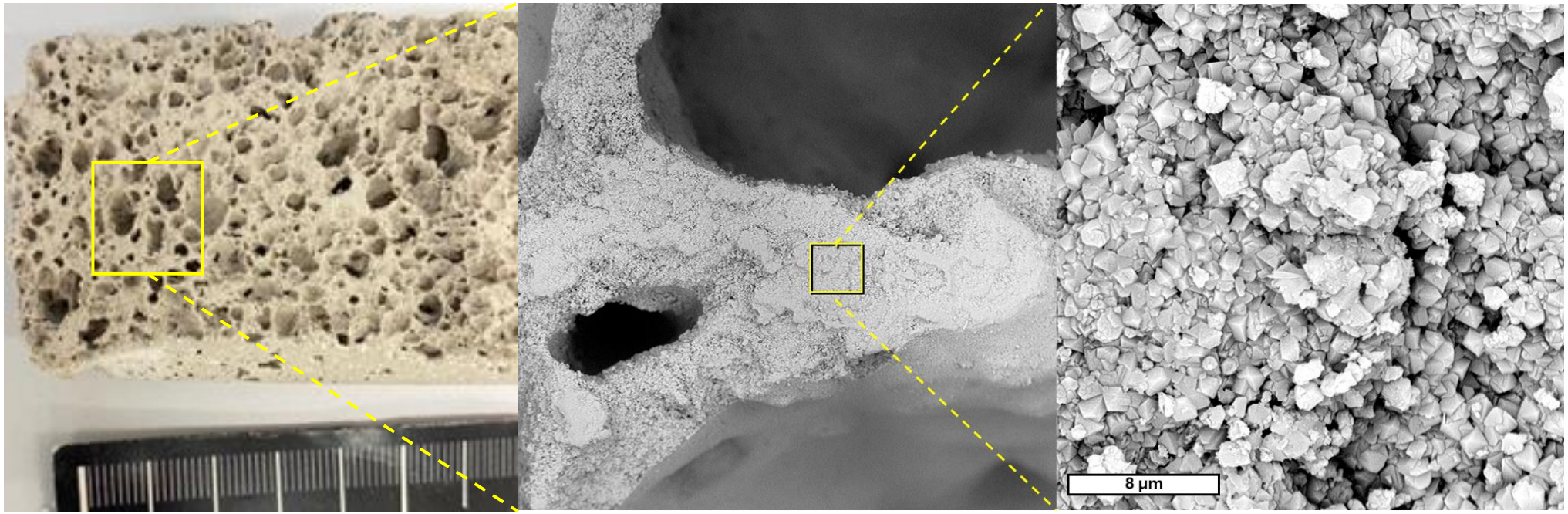
Multifunctional Inorganic Foams

MACROPORISITY

MESOPOROSITY

MICROPOROSITY



FOAMING

GEOPOLIMERIZATION

ZEOLITE CRYSTALLIZATION

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The ZEOREMEDIA project

Desing multifunctional foams based on zeolites supported on geopolymer matrix and simultaneously validating their application as sorbents for the removal of pollutants from contaminated water.

The Roadmap

MPM

Optimization of the remediation porous device (MPM) .

Remediation

Kinetics and thermodynamics of the removal processes with MPM

End-of-Waste

Assessment of the regenerability of MPM after the removal process

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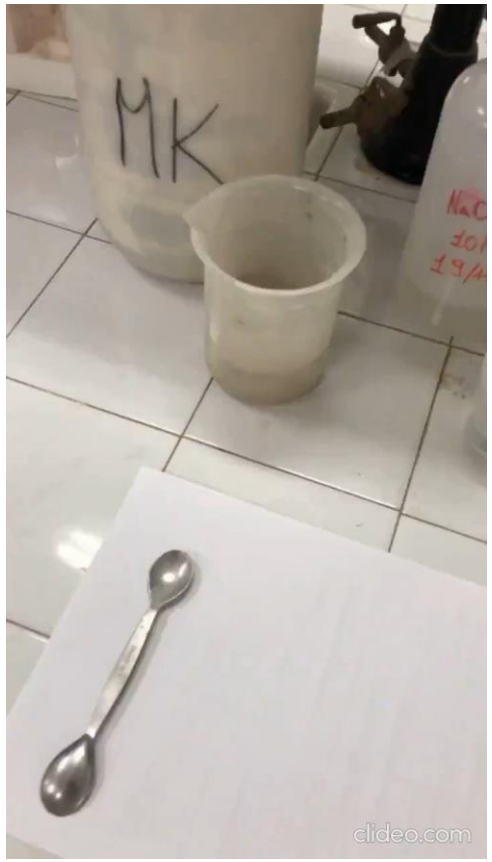
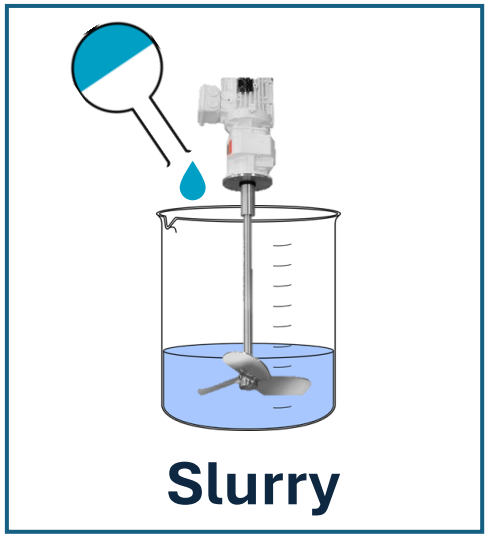
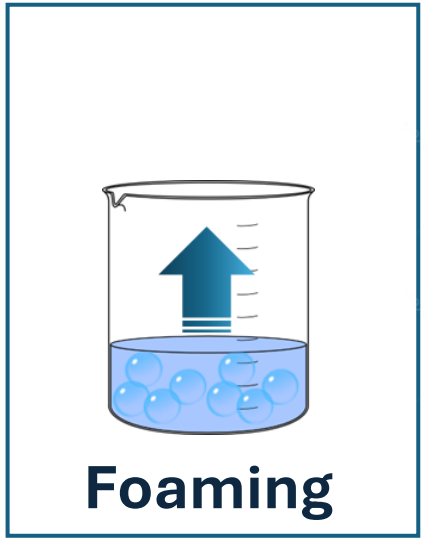
MPM

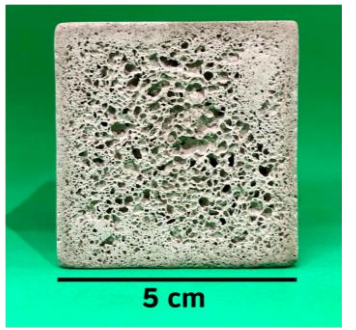
- **Optimization of the remediation porous device**

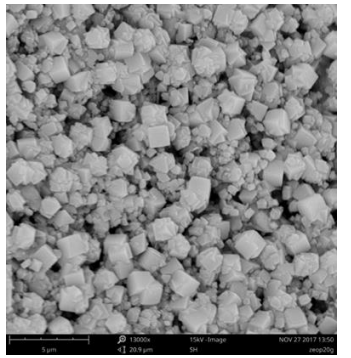






Geopolymer production





Zeolite Crystallization

Liguori, B., Aprea, P., Roviello, G., Ferone, C. (2019). Self-supporting zeolites by geopolymer gel conversion (GGC). Microporous and Mesoporous Materials, 286, 125-132.

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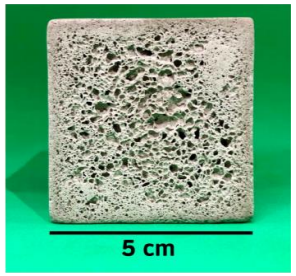
Main results

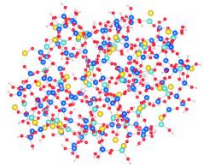
One - step synthesis route

MK + NaOH + Si

Curing

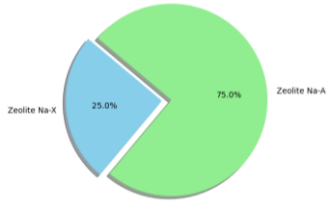
(40°C – 3 days)

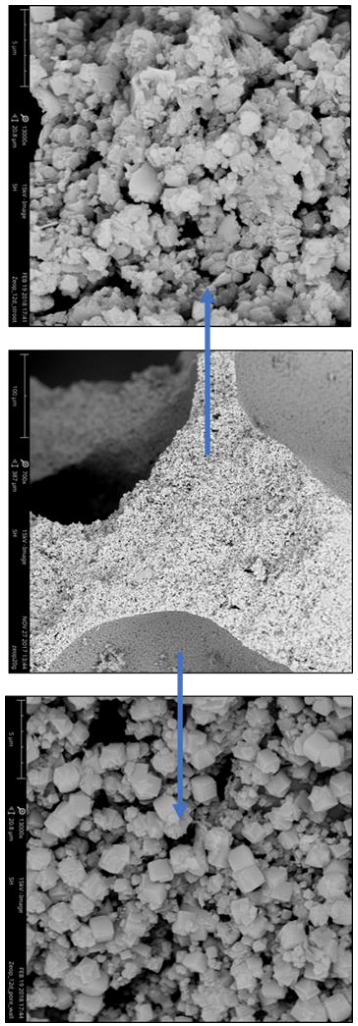


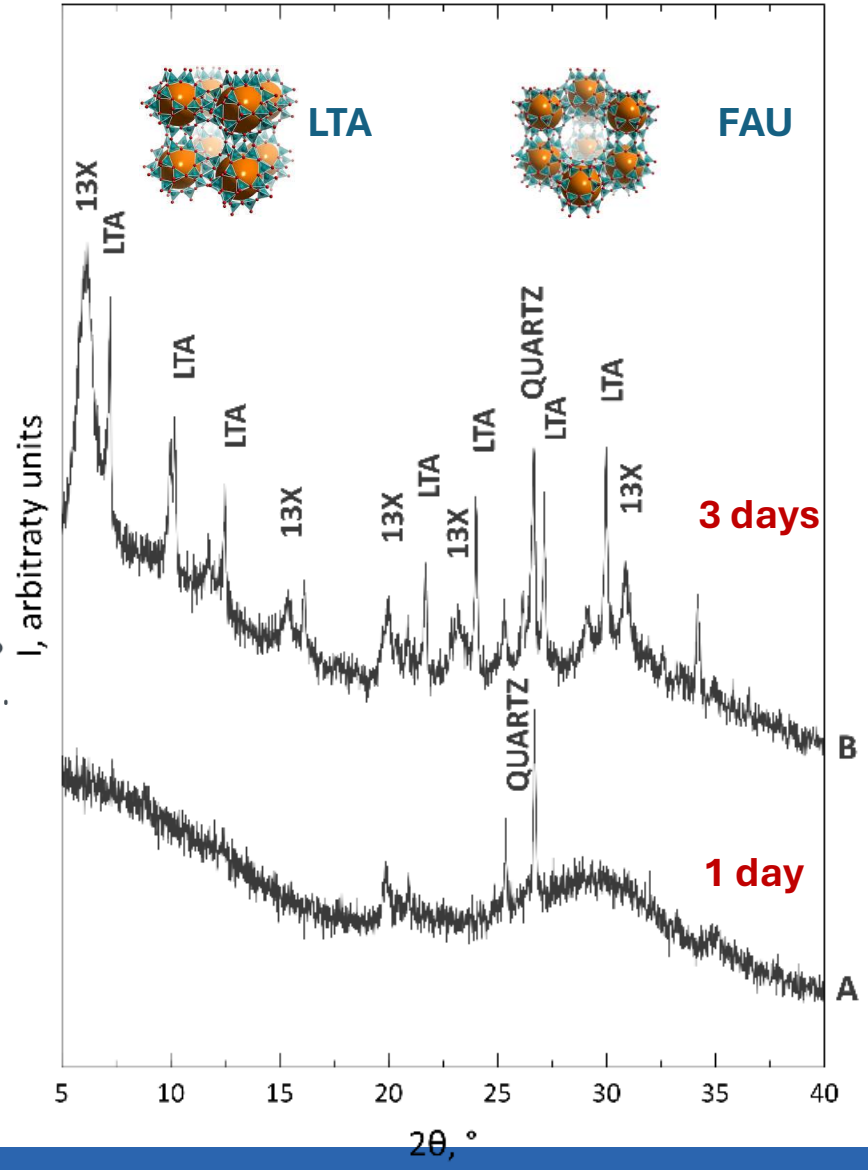


Amorphous Geopolymers

Zeolite-enriched geopolymeric foam

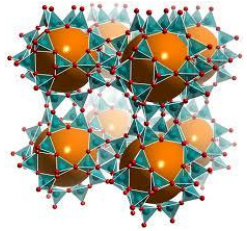






One - step synthesis route

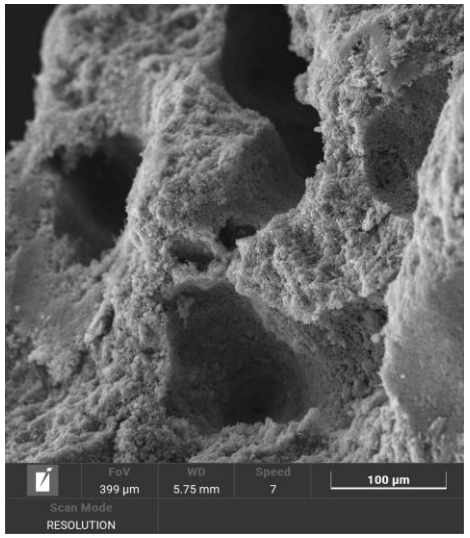
MK + NaOH +
Sodium Alluminate + Si

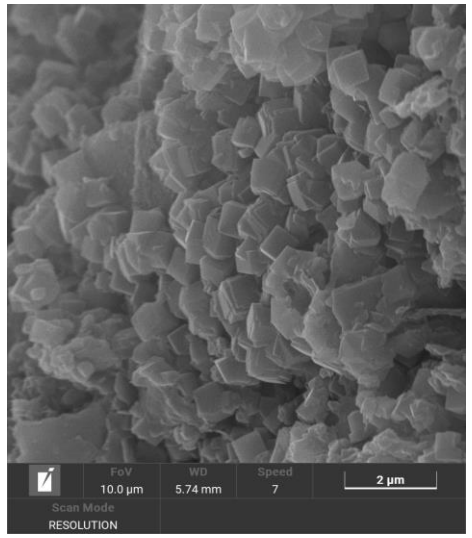


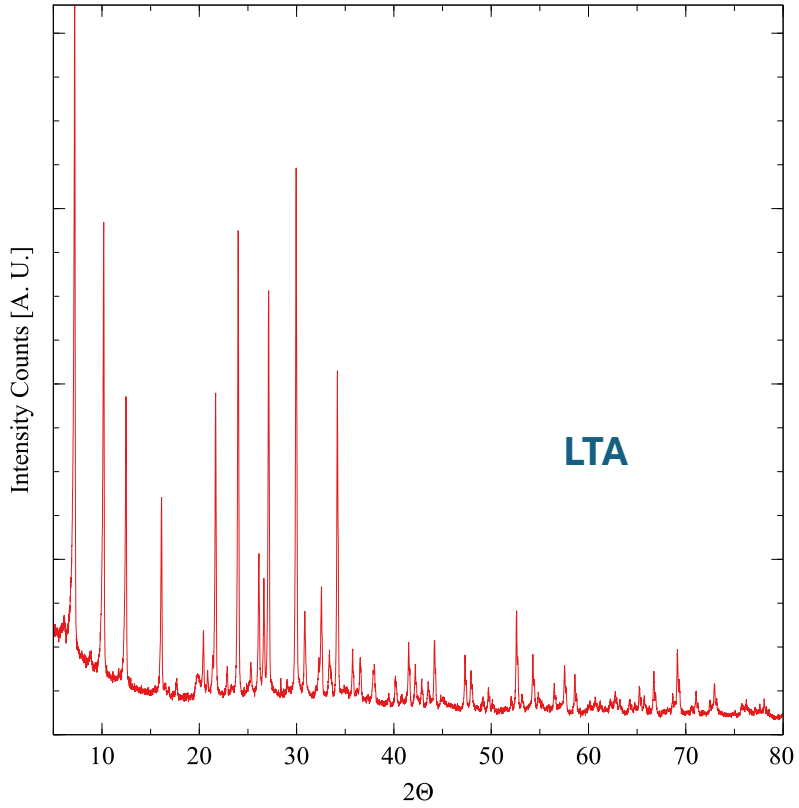
Curing

(40°C – 3 days)

Mono Zeolite-enriched geopolymeric foam







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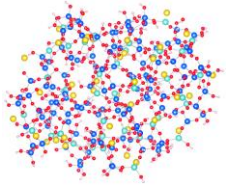
Main results

Two - step synthesis route

Curing

40 °C - 1 day

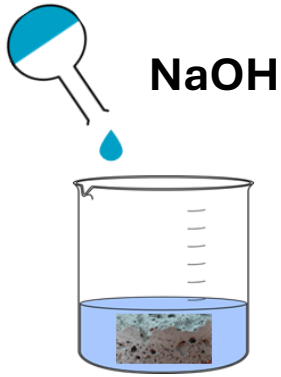
Amorphous Geopolymers



Post-Treatment

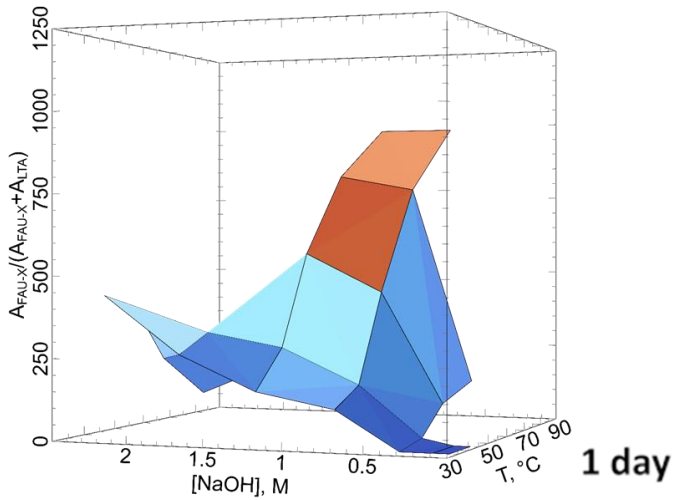
60 °C - 3 days

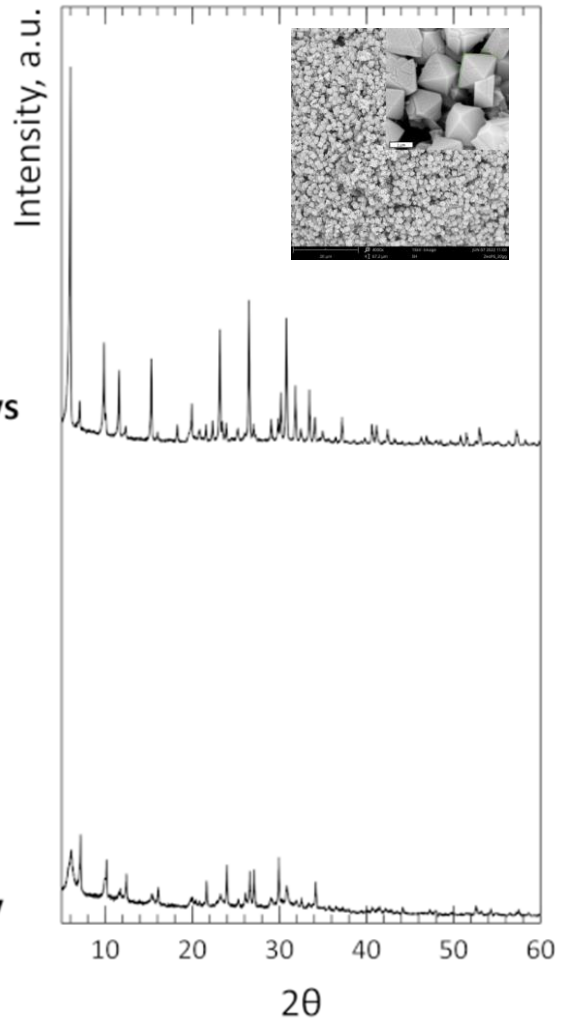
NaOH



Mono-Zeolitic Foam

(up to 80% of FAU)





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Two - step synthesis route

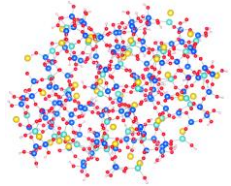
Curing

40 °C - 1 day

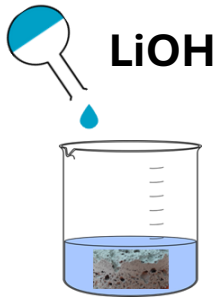
Post-Treatment

60 °C - 3 days

Amorphous Geopolymers

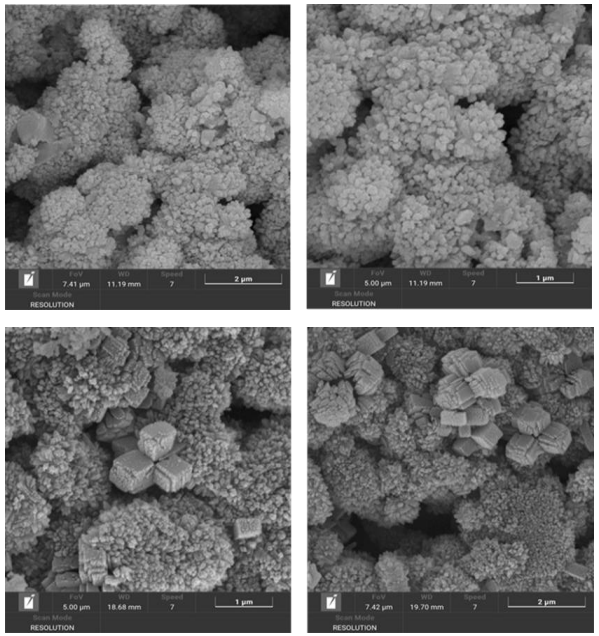


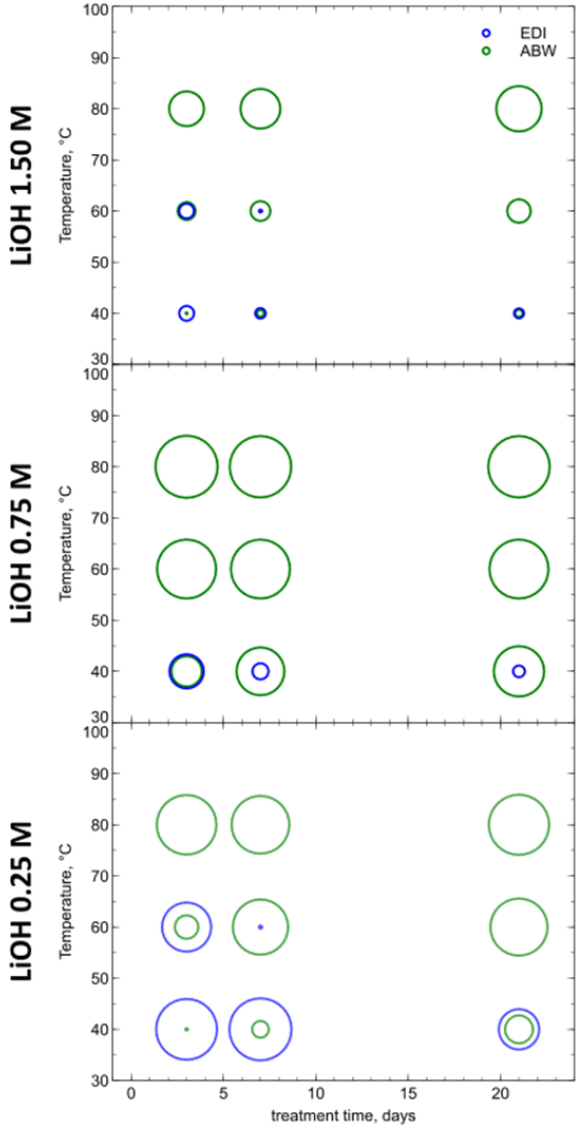
LiOH



Mono-Zeolitic Foam

(up to 80% of ABW)





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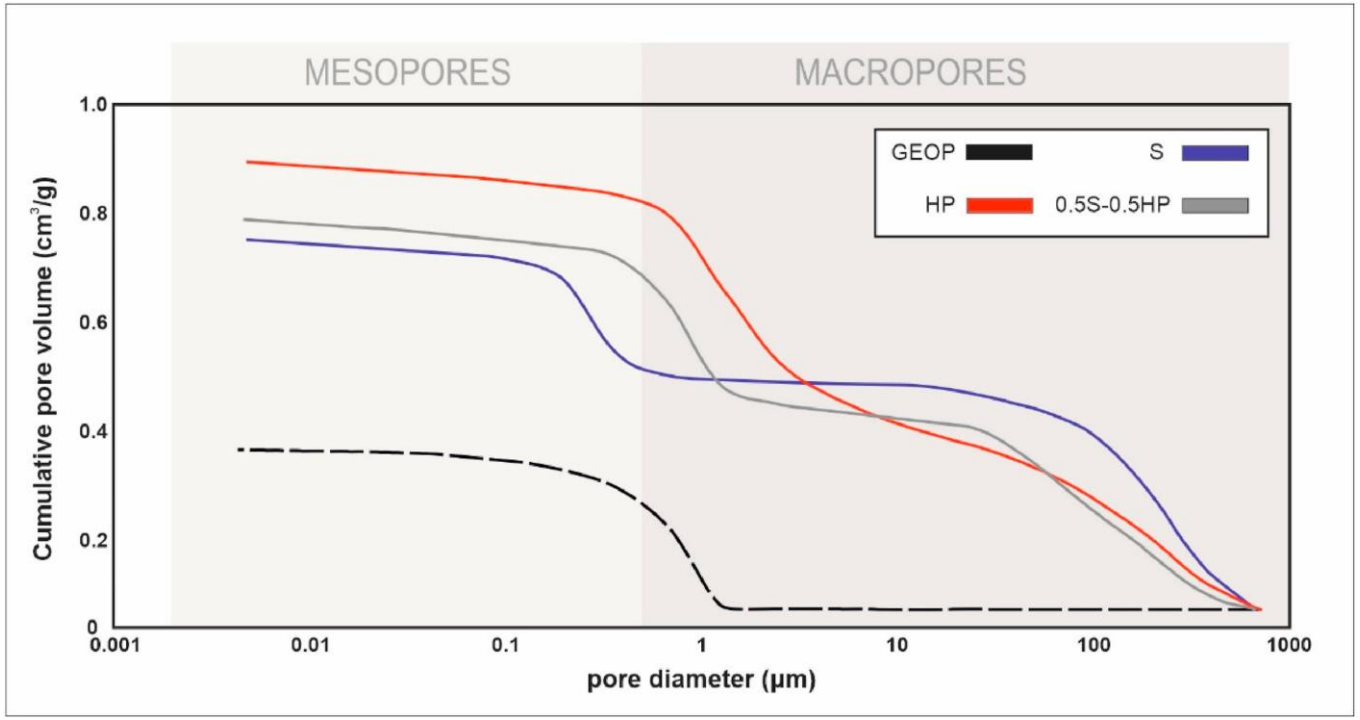
Main results

- Effect of foaming agent

Silicon powder and/or Hydrogen Peroxide



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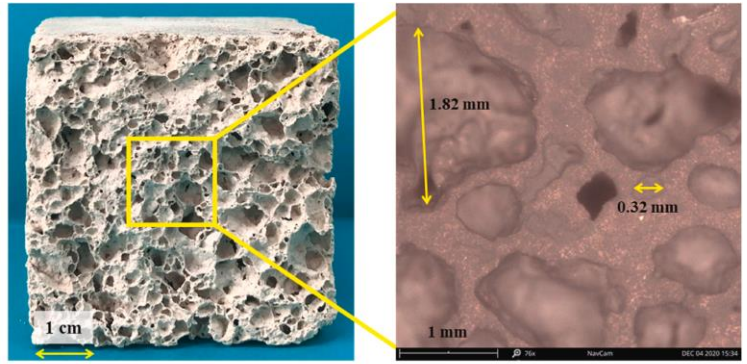

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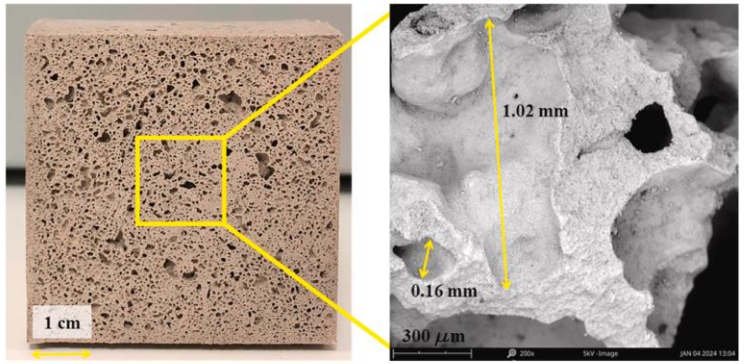

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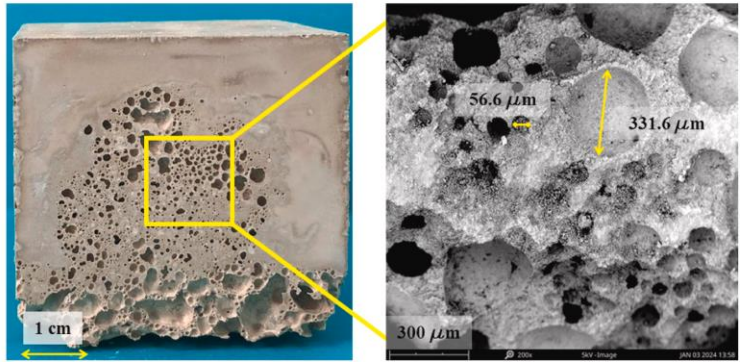

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Remediation

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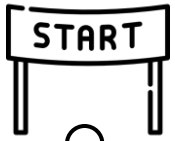
End-of-Waste

Assessment of the regenerability of MPM after the removal process



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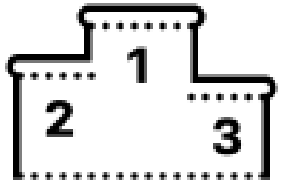

12/2024

11/2025

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