Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

Workshop

February 14th 2025

Faenza, Italy

Geopolymer for Environmental Remediation

Program & Abstracts

Geopolymer for Environmental Remediation
Faenza – February 14th 2025

SCIENTIFIC COMMITTEE

Valentina Medri
Francesco Miccio
Elettra Papa
CNR-ISSMC, Italy

Dario Frascari
Matteo Minelli
Davide Pinelli
DICAM-University of Bologna, Italy

Angelo Vaccari
"Toso Montanari" University of Bologna, Italy

LOCATION

International Museum of Ceramics
Viale Baccarini 19 Faenza, Italy
https://www.micfaenza.org/

Consiglio Nazionale delle Ricerche
ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA
società ceramica italiana

The workshop is carried out as part of the MUR PRIN 2022 project GEA-GEopolymer based Adsorbents for effective adsorption and selective separation of CO_2 and eutrophication pollutants (grant No 20229THRM2) funded by the European Union – Next Generation EU.
The workshop is organized by the Institute of Science, Technology and Sustainability for Ceramics (CNR-ISSMC) and the Department of Civil, Chemical, Environmental and Materials Engineering - DICAM of the University of Bologna.

The Workshop is in the frame of the one-day-meeting organized since 2008 by the Group of Study on Geopolymers of the Italian Ceramic Society.

The Scientific Committee kindly acknowledge Sabrina Gualtieri, Annalisa Natali Murri, Francesca Servadei and Kristiana Manoleva of CNR-ISSMC for the help in organizing the Workshop.

Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

WORKSHOP
Geopolymer for Environmental Remediation

February 14th 2020
INTERNATIONAL MUSEUM OF CERAMICS
Viale Baccarini 19 Faenza, Italy
https://www.micfaenza.org/

Daily Program

09.30-10.00:	**Registration & welcome coffee**
10.00-10.20:	**Opening** **Dr. Valentina Medri**, GEA PI, CNR-ISSMC, Italy **Dr. Claudia Casali**, Director of MIC, Italy **Prof. Cristina Leonelli**, Coordinator of the Italian Working Group on Geopolymers, University of Modena and Reggio Emilia, Italy
GEA session	**Chair: Dr. Valentina Medri**
10.20-10.35:	Dr. Elettra Papa, CNR-ISSMC, Italy, *Geopolymer-based adsorbents: a tunable platform for pollutant removal*
10.35-10.50:	Prof. Dario Frascari, DICAM-University of Bologna, Italy *Removal and recovery of ammonium and phosphate from wastewater by means of geopolymer-based adsorbents*
10.50-11.05:	Prof. Matteo Minelli, DICAM-University of Bologna, Italy *CO_2 adsorption in geopolymers and geopolymer composites for post-combustion CO_2 capture*
Morning session	**Chair: Prof. Angelo Vaccari**
11.05-11,30:	Keynote – **Prof. Luisa Pasti**, University of Ferrara, Italy *Adsorbent Materials in Environmental Remediation*
11.30-11.55:	Keynote – **Prof. Roberto Canziani, Eng. Lorenzo Esposito**, Politecnico di Milano, Italy *Phosphorus recovery from wastewater, sludge and sewage sludge ashes – a short overview*
11.55-12.20:	Keynote – **Prof. Enzo Mangano**, University of Edinburgh, UK *Caracterisation of novel adsorbents for carbon capture: from mg to kg scale*
12.20-12.50:	**Poster flash presentation**
12.50-14.00:	**Light lunch & poster session**
14.00-14.45:	**Visit at the Museum**

Afternoon session   Chair: Prof. Davide Pinelli

14.45-15.00: Prof. Tero Luukkonen, Oulu University, Finland
Recent advances in using geopolymers and alkali-activated materials as adsorbents

15.00-15.15: Prof. Rui Novais, CICECO-University of Aveiro, Portugal
Advancing wastewater treatment systems with 3D-printed geopolymer lattices

15.15-15.30: Dr. Giulia Masi, DICAM-University of Bologna, Italy
Asymmetric membranes for wastewater treatment by alkali activation

15.30-15.45: Prof. Sebastiano Candamano, University of Calabria, Italy
Preparation of foamed and unfoamed geopolymer/NaX zeolite/activated carbon composites for CO_2 adsorption

15:45-16:00: Coffee break

PRIN session   Chair: Dr. Francesco Miccio

16:00-16:15: Prof. Oreste Tarallo, Università degli Studi di Napoli Federico II, Italy
Engineering of eco-sustainable geopolymer-based adsorbent materials for the removal of emerging pollutants and environmental remediation

16:15-16:30: Prof. Barbara Liguori, Università degli Studi di Napoli Federico II, Italy
Design multifunctional foams for water remediation: the ZEOREMEDIA project

16.30: Poster Awards & Conclusive Remarks

POSTERS

Poster ID: 01
V. Medri[1], C. Di Pietro[1], E. Papa[1], F. Miccio[1], W. F. Cossio Guzman[2], D. Pinelli[2], F. Frascari[2], M. Minelli[2]
[1]CNR-ISSMC, Faenza, Italy; [2]Department of Civil, Chemical, Environmental and Materials Engineering (DICAM) – Alma Mater Studiorum, University of Bologna, Italy
GEopolymer based Adsorbents for effective adsorption and selective separation of CO_2 and eutrophication pollutants: the GEA project

Poster ID: 02
C. Di Pietro[1], W. F. Cossio Guzman[2], E. Papa[1], M. C. Marchioni[1], E. Landi[1], F. Miccio[1], M. Minelli[2], V. Medri[1]
[1]CNR-ISSMC, Faenza, Italy; [2]Department of Civil, Chemical, Environmental and Materials Engineering (DICAM) – Alma Mater Studiorum, University of Bologna, Italy
Manufacturing of geopolymer-zeolite mebranes by Cold Sintering process for CO_2 capture

Poster ID: 03
W. F. Cossio Guzman[1], C. Di Pietro[2], M. Minelli[1], E. Papa[2], E. Landi[2], F. Miccio[2], V. Medri[2]
[1]Department of Civil, Chemical, Environmental and Materials Engineering (DICAM) – Alma Mater Studiorum, University of Bologna, Italy; [2]CNR-ISSMC, Faenza, Italy
Dynamic Adsorption of CO_2 Using Geopolymer-Zeolite Composites Produced via Cold Sintering

Poster ID: 04
C. Stevanin[1], G. Andreotti[1], T. Chenet[1], V. Medri[2], E. Papa[2], L. Pasti[1],
[1]Department of Environmental and Prevention Sciences, University of Ferrara, Italy; [2]CNR-ISSMC, Faenza, Italy
Retention of metal cations on geopolymer-based membranes

Poster ID: 05
V. Cofano[1], M. Clausi[1], D.S. Pannu[2], J. Mathew[2], D. Barkhordari[2], E. Khorshidi Nazloo[2], D. Santoro[2], D. Pinto[1]
[1]Department of Earth and Geoenvironmental Sciences, University of Bari Aldo Moro, Italy;
[2]Chemical and Biochemical Engineering Department, University of Western Ontario, London, Canada
Porous geopolymers as alternative biofilter media for municipal wastewater treatment

Poster ID: 06
A. Campanile[1], P. Aprea[1], C. Ferone[2], F. Falzarano[2], R. Cioffi[2], B. Liguori[1]
[1]Department of Chemical, Materials and Industrial Production Engineering, University of Naples Federico II, Italy;
[2]Department of Engineering, University of Naples Parthenope, Italy
Zeolite-enriched porous adsorbents for water remediation

Poster ID: 07
F. Genua[1], **M. Giovini[1],** Elisa Santoni[2], Silvia Zamponi[2], Mario Berrettoni[2], I. Lancellotti[1], C. Leonelli[1]
[1]Dipartimento di Ingegneria "Enzo Ferrari", Università degli Studi di Modena e Reggio Emilia, Italy; [2]Scuola di Scienze e Tecnologie, Università di Camerino, Italy
Potential of Metakaolin-Based Geopolymers for Galvanic Sludge Encapsulation

Poster ID: 08
C. Kurtuluş[1,2], T. Luukkonen[2].
[1]Afyon Kocatepe University, Chemical Engineering Department, Afyonkarahisar/Türkiye; [2]University of Oulu, Fibre and Particle Department, Oulu/Finland
Towards a Circular Economy: Alkali-Activated Stone Wool for Sustainable Wastewater Treatment

Poster ID: 09
F. Servadei, A. Natali Murri, E. Papa, F. Miccio, V., E. Landi.
CNR-ISSMC, Faenza, Italy
Construction and demolition waste-based geopolymers for CO_2 capture

POSTERS

Poster ID: 10
E. Campodoni, G. Vicinelli, C. Artusi, M. Sandri
CNR-ISSMC, Faenza, Italy
Multifunctional filtering and absorbent porous polymeric aerogels for sustainable water and air purification

Poster ID: 11
A. Tavolaro[1], E. Mercadelli[1], A. Gondolini[1], D. Gardini[1], C. Baldisserri[1], F. Bertolini [2], D. Mombelli[2], N. Lecis[2], C. Galassi[2], R. Morelli[3], C. Conidi [3], A. Cassano [3], P. Galizia[1]
[1]CNR-ISSMC, Faenza, Italy; [2]Politecnico di Milano, Italy; [3]CNR-ITM, Rende, Italy
Porous piezoelectric BCTZ membranes for water microfiltration

Poster ID: 12
S. Amadori [1,2], I. Zanoni[1], A. Brigliadori[1], A. Costa[1], P. Giacò[3], M. Melis[3], M. Blosi[1].
[1]CNR-ISSMC; [2]Department of Chemical Science, Life and Environmental Sustainability, Parma University; [3]Department of Environmental and Prevention Sciences, University of Ferrara
Hybrid materials for sustainable water treatment: integrating microalgae biomass with inorganic nanomaterials

Poster ID: 13
M. Vespignani[1,2], M.H.P Araùjo[3], A.L. Costa[1], I. Zanoni[1], S. Ortelli[1], M. Blosi[1], C. Artusi[1], S. Amadori[1,2]
[1]CNR-ISSMC, Faenza, Italy; [2]Department of Chemical Science, Life and Environmental Sustainability of Parma University, Italy; [3]Universidade Federal de Viçosa Campus Florestal, Brasil
Calcium Ferrites as Adsorbents Agents in Wastewater Treatment

Poster ID: 14
A. M. Ferrari[1], A. Figoli[2], P. G. Gucciardi[3], V. Medri[4], R. Montanari[5], L. Pasti[6]
[1]Department of Sciences and Methods for Engineering, University of Modena and Reggio Emilia, Italy; [2]CNR-ITM, Rende, Italy; [3]CNR-IPCF, Messina, Italy; [4]CNR-ISSMC, Faenza, Italy; [5]Department of Engineering and Architecture, University of Parma, Italy; [6]Department of Environmental and Prevention Sciences, University of Ferrara, Italy
Modular system for water PUrification and Reuse: the PURE project

Geopolymer-based adsorbents: a tunable platform for pollutants removal

Elettra Papa
CNR-ISSMC, National Research Council - Institute of Science, Technology and Sustainability for Ceramics

Geopolymers are very versatile materials which offer the possibility to be customized for specific adsorption purposes through the optimization of the stoichiometry, composition (also through the addition of specific fillers to obtain composites), structural and textural properties. Geopolymers were specifically conceived and produced for separation and purification applications for the removal of pollutants from liquid or gaseous systems (i.e. CO_2 capture and removal of ammonium and phosphates from wastewater).
Different techniques have been studied and applied, as cold sintering process and direct foaming, since, from a technological point of view, acting on shaping processes allow to easily tailor the shape and porosity of the final solid adsorbent. The aim of the work is to develop eco-friendly materials (low energy production process), identifying geopolymer matrices able to actively increase, in composites, the performances of other adsorbents such as zeolites and hydrotalcites.
Particular attention is paid on the correlation between material formulation, properties and performances for the targeted application, in order to clarify the real potentiality of geopolymers-based adsorbents in comparison to benchmark adsorbents at the large scale. The research was carried out under the financial support of the MUR PRIN 2022 Project GEA, Prot. 20229THRM2, funded by the European Union – Next Generation EU

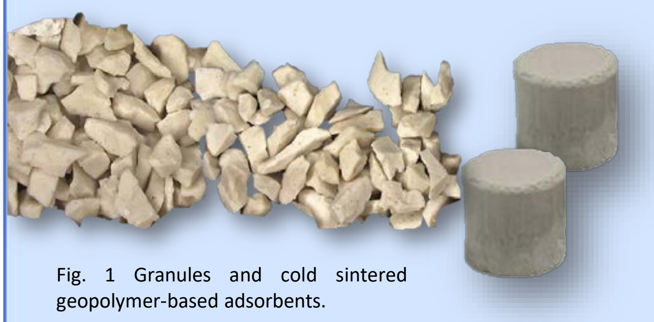


Fig. 1 Granules and cold sintered geopolymer-based adsorbents.

Contact:
Elettra Papa (elettra.papa@issmc.cnr.it)
CNR-ISSMC, National Research Council - Institute of Science, Technology and Sustainability for Ceramics, Via Granarolo, 64, 48018 Faenza (RA) – Italy

Curriculum vitae

Dr. Elettra Papa has a PhD in Chemistry and is currently a Researcher at CNR-ISSMC, Faenza, Italy. Her main research areas are: design, production and characterization of chemically consolidated ceramic materials (geopolymers) for applications in the fields of adsorption, catalysis, chemical engineering, construction, insulation. Development of functional materials with variable porosity by near-net shaping, direct and indirect foaming, ice-templating, injection-solidification, cold sintering.
To date, she is involved on several national projects including: GEA MUR PRIN 2022 Project GEA - GEopolymer based Adsorbents for effective adsorption and selective separation of CO_2 and eutrophication pollutants, - Prot. 20229THRM2, funded by the European Union – Next Generation EU, PNRR MUR project ECS_00000033_ECOSISTER and she is research unit coordinator for Smart H_2O-Modular H_2O pollutant absorption abatement system - POR-FESR Emilia Romagna 2021/2027 – ASSE 1 – Research and Innovation, Action 1.1.2.
She is author of more than 42 papers published on international journals and she has participated as a speaker at several national and international conferences.

Removal and recovery of ammonium and phosphate from wastewater by means of geopolymer-based adsorbents

Dario Frascari
Department of Civil, Chemical, Environmental and Materials Engineering, University of Bologna, Via Terracini 28, 40131 Bologna - Italy

In the current international context characterized by the tendency to stricter limits for N and P concentration in treated wastewater and a strong drive towards N and P recovery, it is crucial to develop cost-effective technologies to remove and recover nutrients from municipal wastewater (MWW). Among these, adsorption represents a promising option. In this study, different sorbent materials were tested by means of isotherms conducted with actual wastewater treatment plant effluents: a K-based geopolymer with Si:Al ratio = 2 (K-G2), a Na-based geopolymer with Si:Al ratio = 1.2 (Na-G1.2), and composite materials deriving from the combination of K-G2 with different hydrotalcite. A commercial hydrotalcite (SOrbacid911) was used as benchmark for P removal.
IN terns of N removal, Na-G1.2 (Si:Al ratio = 1.2) performed better than K-G2 (Si:Al ratio = 2) over the entire concentration range. All the tested composited of K-G2 with a hydrotalcite performed better than the pure K-G2, indicating that the composite production process did not alter the ammonium sorption performances of the K-G2 geopolymer. The maximum adsorption capacity for ammonium in equilibrium with 40 mgN/L (typical concentration in a municipal wastewater) resulted 13.2 $mgN/g_{active\ sorbent\ phase}$ for the K-G2/Pural70 composite. As for P remova, Sorbacid911 featured a very high sorption capacity even at very low phosphate concentrations (40 $mgP/g_{sorbent}$ at 1 mgP/L in the liquid). Sorbacid911 resulted in significantly lower (but still interesting) P sorption capacities when it was mixed to K-G2. The composites of K-G2 with Sorbacid911, Pural 70 and Pural 61 resulted in about equal performances. In conclusion, the tested geppolymers and their composites with hydrotalcites resulted very promising materials for N and P removal & recovery from municipal wastewater.

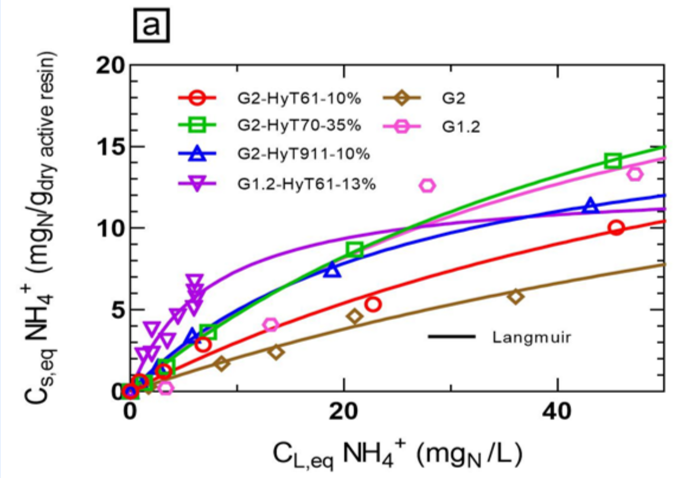


Fig. 1 - Ammonium removal isotherms conducted with geopolymers and with geopolymer / hydrotalcite composites.

The research was carried out under the financial support of the MUR PRIN 2022 Project GEA, Prot. 20229THRM2, funded by the European Union – Next Generation EU

Contact:
Dario Frascari (dario.frascari@unibo.it)
Department of Civil, Chemical, Environmental and Materials Engineering, University of Bologna, Via Terracini 28, 40131 Bologna - Italy

Curriculum vitae

Associate Professor at Bologna University, Dario Frascari holds a Ph.D. in Chemical & Environmental Engineering. Technical-scientific coordinator of the MAR2PROTECT project, focused on the development of technologies to protect aquifers from the negative effects of climate change. He has been the scientific coordinator of the MADFORWATER Horizon 2020 project, focused on the development of technologies for wastewater treatment and reuse. He participated to numerous EU and national research projects. His research, conducted in closae collaboration with water utilizes and technology providers, focuses on the development, modeling and scale-up of processes for the treatment and valorization of wastes and wastewater, with specific focus on the recovery of nutrients and antioxidants by adsorption and extraction, on the removal of micropollutants and on the bioproduction of chemicals and biofuels. He published 55 articles in international scientific journals with IF and 11 chapters in international series and books. He has a Scopus H-index equal to 25.

CO_2 adsorption in geopolymers and geopolymer composites for post-combustion CO_2 capture

Matteo Minelli

[1]**Dept. of Civil, Chemical, Environmental and Materials (DICAM) – Alma Mater Studiourm University of Bologna**

Novel geopolymeric formulations have been developed to fabricate materials and composites to be used as solid adsorbents for the removal of CO_2 from gaseous streams, suitable thus for carbon capture strategies.
The geopolymer stoichiometry, phase composition and combination with other aluminosilicates such as zeolites have been considered in order to tune the resulting adsorptive performances, for targeted application. The Si/Al ratio, in particular, has been varied from 1 to 2, using either K+ or Na+ silicates, and combined to different zeolites (including Na13X and NaA).
Results indicated that Na^+-based geopolymers present a superior CO_2 capacity than those based on K^+, as illustrated in the Figure, while a CO_2/N_2 selectivity results larger for the latter system. Interestingly, the addition of a zeolite fillers further enhances the CO_2 capacity, often revealing a synergistic interplay among the phases; the effect is due to positive interactions obtained by efficient chemical mixing and the geopolymerization reaction, with the formation of a crystalline phase (NaA-type). When combined to zeolite Na4A, the obtained CO_2 capacity reaches values comparable to those of benchmark adsorbents, identifying an optimal Si/Al ratio equal to 1.2.

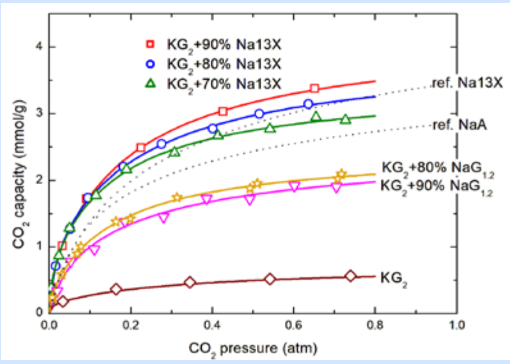


Fig. 1 CO_2 adsorption capacity of geopolymer/Na13X composite sorbents

The research was carried out under the financial support of the MUR PRIN 2022 Project GEA, Prot. 20229THRM2, funded by the European Union – Next Generation EU

Contact:
Matteo Minelli (matteo.minelli@unibo.it)
Dept. of Civil, Chemical, Environmental and Material Engineering – DICAM
Alma Mater Studiorum – Università of Bologna
Via Terracini 28, Bologna (Italy)

Curriculum vitae

Matteo Minelli is associate professor at DICAM at the Università of Bologna from 2018, and his research activity is mainly devoted to the study of the transport of gas, vapors and liquids in solid materials, with a particular emphasis on polymers, solid sorbents and composite systems. The main aim is to develop innovative materials for sustainable separation processes, using for instance membrane or adsorption techniques.

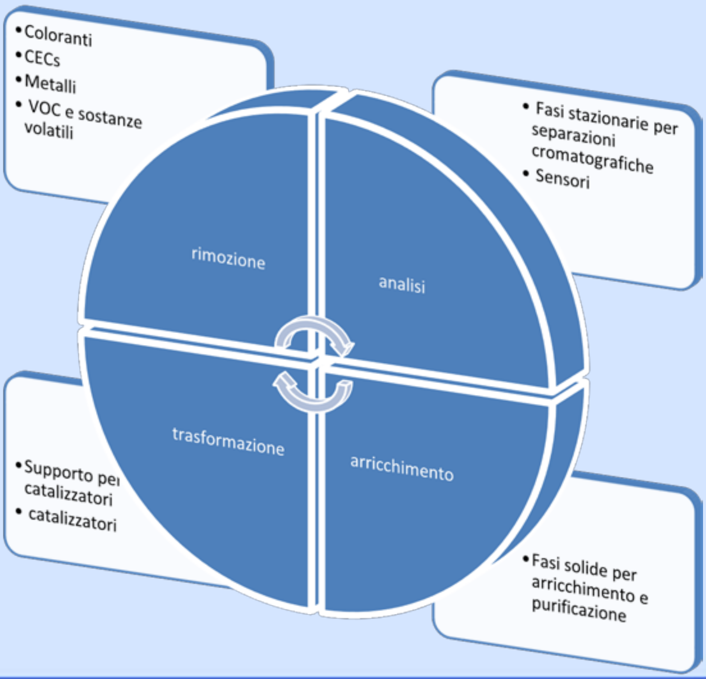
He coauthored more than 120 publication and serves both as associate editor and reviewer for several international journals.

Keynote ID: 01

Adsorbent Materials in Environmental Remediation

Luisa Pasti[1], Tatiana Chenet[1], Claudia Stevanin[1], Annalisa Martucci[2]
[1]Department of Environmental and Health Sciences, University of Ferrara, Ferrara, Italy;
[2] Department of Physics and Earth Sciences

Among the various separation techniques, adsorption, a well-established technology, is still regarded as a reliable and robust method for purifying fluids at low cost and with high efficiency. One of the key advantages of adsorption-based technologies is their effectiveness in treating contaminants at very low concentration levels—an operational condition where most other separation techniques prove inefficient due to the small concentration gradients involved. Additionally, adsorption is a versatile method capable of simultaneously removing a wide variety of organic and inorganic compounds, provided an appropriate adsorbent medium is employed. A distinguishing characteristic of adsorption systems is that multiple components in a solution can interact with the sorbent surface, exhibiting differences in the strength and location of their interactions with the adsorbent. Moreover, the adsorbent surface may also show an affinity toward the solvent. Consequently, adsorption is, in most cases, a multicomponent process, even when a single solute is considered. Adsorption-based technologies have been successfully employed in numerous applications, including environmental remediation methodologies. The primary categories of substances that commonly pollute the aquatic environment include heavy metals, detergents, disinfection by-products, pesticides, petroleum hydrocarbons, volatile organic compounds, perfluorinated aliphatic substances, and contaminants of emerging concern. This lecture presents a brief overview of liquid-solid adsorption processes using different adsorbent materials for the removal of various classes of contaminants. Since the efficiency of the adsorption process is influenced by the number and type of interactions between the adsorbent and the adsorbate, the various microscopic mechanisms involved in adsorption phenomena are also discussed.



Contact:
Luisa Pasti, email: luisa.pasti@unife.it
Department of Environmental and Health Sciences, University of Ferrara, Via L. Borsari, 46 44121 Ferrara, Italy

Curriculum vitae

Luisa Pasti is a Full Professor of Analytical Chemistry at the Department of Environmental and Health Sciences at the University of Ferrara. Research activity of Luisa Pasti has been mainly devoted in the field of separation science. In particular, her activity in this field can be outlined as follows: a) theoretical description of chromatographic separations and multicomponent separations: development of statistical tools for optimization of complex mixture separations, dynamic and reaction chromatography; b) applied aspects of linear and nonlinear (preparative) chromatography; c) retention mechanisms and characterization of adsorbent media for application in environmental and agri-food sectors, d) biomass waste-based adsorbents; e) catalysts and photocatalysts characterization and their application in environmental remediation. She is the author of 135 papers published in international journals and 7 book chapters. She has participated as a speaker at several national and international conferences. She is the Scientific Director of the Terra&Acqua Tech Laboratory Network at the Ferrara Technopole, which is part of the High Technology Network of the Emilia-Romagna Region, and she is Coordinator of the Ph.D. Program in Environmental and Health Sciences at the University of Ferrara.

Keynote ID: 02

Phosphorus recovery from wastewater, sludge and sewage sludge ashes – a short overview

Roberto Canziani[1], Lorenzo Esposito[1], Gaia Boniardi[2], Andrea Turolla[1]
[1]Politecnico di Milano, DICA – Environmental Section, Piazza L. da Vinci, 32 – 20133 Milano, Italy;
[2] School of Chemical Engineering, The University of Queensland, Brisbane QLD 4072, Australia

This short overview will list and describe briefly some technologies for the recovery of phosphorus from (i) wastewater, (ii=) sludge, (iii) liquid streams form sludge treatment units, (iv) incinerated sewage sludge ashes, pointing out their operational principle, current TRL, problems and possible perspectives.

Contact:
Lorenzo Esposito (lorenzo.esposito@polimi.it
Politecnico di Milano, DICA – Environmental Section, Piazza L. da Vinci, 32 – 20133 Milano, Italy

Curriculum vitae

Roberto Canziani – PhD since 1987, is now full professor of Sanitary Environmental Engineering at Politecnico di Milano. Teacher of Water and Wastewater Treatment Technologies (taught in English). He is author or co-author of more than 200 publications, of which 50 are papers published in international peer-reviewed journals. His research has been always focused on wastewater and sludge treatment technologies.

Lorenzo Esposito (presenter) – Environmental Engineer, graduated in April 2024, assistant researcher since July 2024, he works on upgrading phosphorus recovery from sewage sludge ashes.

Gaia Boniardi – Environmental Engineer, PhD (2024), she is now post-doc researcher at the School of Chemical Engineering, The University of Queensland, Brisbane. She is author or co-author of 11 papers published in international peer-reviewed journals and other contirbutions in international conferences.

Andrea Turolla – PhD (2014), he is now associate professor in Sanitary Envronmental Engineering at Politecnico di Milano. Teacher of the Pollution Management for Geoinformatics, and Environmental engineering for sustainable agriculture for Agricultural Engineering (both taught in English). Author or co-author of 70 papers published in international peer-reviewed journals. His research activities have been focused on different technologies for water and wastewater treatment and recently are mainly devoted to innnovative technologies for material recovery from liquid waste streams.

Keynote ID: 03

Caracterisation of novel adsorbents for carbon capture: from mg to kg scale

Enzo Mangano, Stefano Brandani
The University of Edinburgh, School of Engineering, Edinburgh, UK

The development of new process to capture CO_2 from different sources, from post combustion capture to direct air capture, requires the synthesis and manufacturing of adsorbents with tailored properties to perform at different concentrations of CO_2, temperature and in presence of different gases and contaminants. This has pushed significantly the research on novel materials with the objective of developing adsorbents that can improve the performance of the process, be easily scaled up and be competitively cheap compared to the current commercial options. Novel adsorbents are normally synthesised in small quantities (<100mg) therefore it is essential to develop experimental techniques capable to measure accurately the adsorption properties of porous materials with very small amount of sample. The Adsorption Group at the University of Edinburgh specialises in the experimental characterization of prototype adsorbents using very small sample masses. The Zero Length Column (ZLC) is a key tool to measure accurately adsorption equilibrium and kinetics using <10 mg of sample. Thanks to the small quantities used it also allows to assess the stability of materials to prolonged flue gas exposure in a very short time and with minimal gas consumption compared to conventional breakthrough apparatuses. In addition to the ZLC we present a number of techniques (chromatographic and volumetric) and experimental approaches that we routinely use to characterise different aspects of the adsorption performance using sample masses from mg to kg scale.

Contact:
Enzo Mangano (E.Mangano@ed.ac.uk)
The University of Edinburgh, School of Engineering,
Mayfield Road, EH9 3FB, Edinburgh

Curriculum vitae

Dr Enzo Mangano (EM) is a Senior Lecturer in Chemical Engineering at The University of Edinburgh, where he focuses his research on the equilibrium and kinetic characterisation of novel nanoporous materials for gas adsorption. He also leads the research on high pressure adsorption for a number of applications including gas storage and pressure swing adsorption. He has developed a new differential volumetric system for the measurement of equilibrium and kinetic at high pressure with very high accuracy using small sample masses (< 100 mg). The system was used to generate the CH_4 reference isotherm on NaY as part of the international round-robin effort coordinated by NIST. He is co-author of the IUPAC technical report "Diffusion in Nanoporous Materials" lead by Prof. by Prof. Jörg Kärger. The report, recently published in Pure and Applied Chemistry, provides the fundamental guidelines on the use of experimental techniques to measure gas transport kinetics. EM is the receiver of the 2016 Italy Made Me Award (Young Researcher Award) from the Italian UK Embassy.

Invited ID: 01

Recent advances in using geopolymers and alkali-activated materials as adsorbents

Tero Luukkonen[1]

[1] Fibre and Particle Engineering Research Unit, University of Oulu, Finland

Geopolymers, and a wider group of alkali-activated materials (AAMs), are amorphous zeolite- or tobermorite-like synthetic products. During the last decade, their application as adsorbents has attracted a great deal of scientific interest with also some commercial implementations. This is stemming from their low material costs (e.g., common calcined clays or industrial aluminosilicate side streams can be used as raw materials) and sustainable manufacturing process requiring only near-ambient conditions. In this presentation, an overview of some recent advances in the preparation and use of geopolymers and alkali-activated materials as adsorbents is provided based on research conducted at the University of Oulu.

In the first example of recent studies, composite adsorbent granules containing either metakaolin geopolymer or alkali-activated slag and $MgCO_3$/MgO/Mg silicate-rich commercial adsorbent or hydroxyapatite were prepared and tested. In such systems, the geopolymer or AAM acts as a binder for the powdered adsorbent but also provides additional adsorption capacity. One bottleneck in the adsorbent development is frequently the preparation of granular materials from powdered adsorbents – geopolymers or AAMs could be a widely applicable solution. The regeneration of the granules with the Mg-rich adsorbent with 0.3 M HNO_3 after metal sorption from mine seepage water in a field experiment showed that their adsorption amount clearly improved upon repeated adsorption/desorption cycles.

In the second example, the modification of geopolymer surface with silane coupling agents was demonstrated to create a superhydrophobic material capable of effectively separating microplastics from water. Silane coupling agents can be reacted with the geopolymer surface silanol (Si-OH) groups to covalently attach organic functionalities to the material. In the case of superhydrophic materials, triethoxy(octyl)silane was used. It was shown that such material could maintain ≥ 99% separation of 59-63 µm-sized plastics for more than 200 bed volumes of water while a non-modified geopolymer decline in the uptake already after 1 bed volume.

Contact:

Tero Luukkonen (tero.luukkonen@oulu.fi)

University of Oulu, Pentti Kaiteran katu 1, 90570 Oulu, Finland

Curriculum vitae

Dr. Tero Luukkonen is an Associate Professor at University of Oulu, Finland. He received his PhD degree in 2016 from physical chemistry. Between 2010 and 2017, he worked in R&D positions at three start-up companies operating in the clean-technology sector. Since 2017, he has worked at the Fibre and Particle Engineering Research Unit, at the University of Oulu. In his current position, he is leading a research group focusing on the development of materials for environmental engineering. His research interests include water and wastewater treatment, materials science, and advanced environmental applications of geopolymers and alkali-activated materials in which areas he has authored or co-authored more than 90 peer-reviewed publications.

Invited ID: 02

Advancing wastewater treatment systems with 3D-printed geopolymer lattices

Rui M. Novais[1], M.M. Almeida[1], Ana P.F. Caetano[1], J.G. Cuadra[1], Nuno P.F. Gonçalves[2], J.A. Labrincha[1]

[1]Department of Materials and Ceramic Engineering / CICECO-Aveiro Institute of Materials, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal.
[2]Dept. of Chemistry/CICECO-Aveiro Institute of Materials, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal

In the past few years, porous geopolymers and alkali-activated materials have attracted unparalleled interest in the research community, as they combine excellent performance with low production costs and environmentally friendly synthesis protocols. The production of highly porous geopolymers can be achieved by employing various techniques, including mechanical and chemical foaming, freeze-casting, and sacrificial fillers. Although these approaches can deliver geopolymers with high porosity, precise control over pore distribution and interconnectivity remains challenging. Additive manufacturing (AM) technologies can be used to overcome the limitations of conventional manufacturing methods, enabling the fabrication of lattices with strict control over pore size and interconnectivity. In this lecture, the feasibility of using AM to produce highly porous geopolymer structures for the depollution of synthetic wastewater and real industrial effluents will be demonstrated.

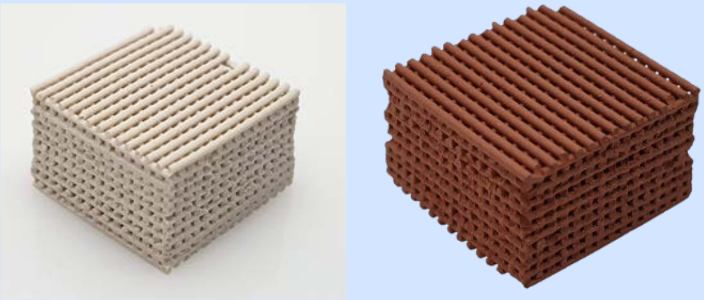


Fig. 1 Optical micrographs of 3D-printed geopolymer lattices prepared by direct ink writing.

Contact:
Autor (e-mail): ruimnovais@ua.pt
Department of Materials and Ceramic Engineering / CICECO-Aveiro Institute of Materials, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal

Curriculum vitae

Rui Novais is an Assistant Professor at the Department of Materials and Ceramic Engineering and CICECO-Aveiro Institute of Materials at University of Aveiro (UA). Rui Novais professional path began with a Degree in Physics and Chemistry (Teacher Training) in 2005. This was followed by a PhD in Polymer Science and Composites (July 2012) from the University of Minho with the topic “Functionalized carbon nanotubes for polymer based nanocomposites”. Since 2012, he has been working on the development of materials to decarbonize the construction sector, energy production, and environmental remediation applications, with a particular focus on waste recycling and product sustainability. To date, he has published over 100 articles, including 84 indexed in the Science Citation Index. Their publications include 6 book chapters and more than 130 presentations (oral and poster) at international conferences. He has >3500 citations and an h-index of 35 (SCOPUS).

Invited ID: 03

ASYMMETRIC MEMBRANES FOR WASTEWATER TREATMENT BY ALKALI ACTIVATION

Giulia Masi
[1]Department of Civil, Chemical, Environmental and Materials Engineering, University of Bologna (Italy)

Wastewaters are usually treated by applying microfiltration processes. For this purpose, polymeric or ceramic membranes are usually applied due to low production cost or excellent durability properties, respectively. An emerging approach is to use alkali activated materials as an alternative to produce self-sustained membranes. This class of materials exhibits outstanding durability properties, considerably low production costs and environmental impacts, because the sintering process, typical of ceramics, can be avoided. In literature, few studies investigated asymmetric alkali activated membranes, mainly focusing on the separation by adsorption mechanisms. For these reasons, the aim of this study is to synthesise asymmetric membranes based on alkali activation with comparable performances compared to commercial ceramic membranes for physical separation processes in the field of industrial wastewater containing oil-water emulsions. Initially, the optimization of the support preparation was carried out by pressing alkali activated mixes obtained by tailoring the fundamental molar ratios, the water content, and the forming pressure. Then, the membrane supports were selected based on the results of their open porosity and permeability to pure water measurements. At the end, alkali activated supports were produced by applying 5 MPa of uniaxially pressing to a dry mixed powder consisting of metakaolin and anhydrous sodium silicate, sprayed with 12 wt% water. A selective layer, obtained by mixing metakaolin, sodium silicate and 8M sodium hydroxide solutions, was applied by a spatula coating, showing a thickness around 40 µm and a pore size in the range of 0.1-1.0 µm. Permeability and rejection of the obtained asymmetric membrane to pure water and oil-water emulsions showed comparable performances with commercial ceramic membranes, suggesting that the developed microfiltration system by alkali activation is a suitable alternative to ceramic membranes.

Contact:
Giulia Masi, giulia.masi5@unibo.it
Dep. of Civil, Chemical, Environmental and Materials Engineering
University of Bologna
Via Terracini 28, 40131 Bologna

Curriculum vitae

Giulia Masi got her PhD in Materials Engineering in 2018 in the framework of a European project dealing with the development of protective coatings against outdoor corrosion of bronze Heritage (EU M-ERA.net project B-IMPACT (2015-2017). During her first stage of career, she was Visiting Researcher abroad: 7-month-internship at the Geopolymer Centre Group of the Curtin University in Perth, Western Australia (2013) and 6-month-visiting at the Laboratoire TRACES of the University of Toulouse, France (2017). Her PhD research was awarded by two prizes: Winner of the National Grant AIMAT 2021 for the best PhD thesis in the field of Materials Science (ING-IND/22) between 2018-2020 and of Coating 2023 Early Career Investigator Award promoted by MDPI for young researchers that made a significant contribution to the advancement of the field of coatings.

After her PhD, she was a post-Doc in the Department of Civil, Chemical, Environmental and Materials Engineering at the University of Bologna for 3 years (2018-2021), collaborating in an Italian project (funded by Cariplo Foundation) on the use of reclaimed asphalt pavement as recycled aggregates for concrete in view of the circular economy concepts (RAPCON project).

Since 2021, she is an assistant professor at the University of Bologna in the Materials Science laboratories leaded by Prof. Maria Chiara Bignozzi. She is currently focusing on the development of sustainable inorganic materials by alkali activation in the industrial and construction fields, especially investigating the durability aspects with a multi-analytical approach.

She is author of 36 papers published on peer-reviewed International journals and more than 20 papers for conference proceedings. She is currently Guest Editor of the special issue “Women in Science: Materials 2023” for the Frontiers in Materials journal.

Invited ID: 04

Preparation of foamed and unfoamed geopolymer/NaX zeolite/activated carbon composites for CO_2 adsorption

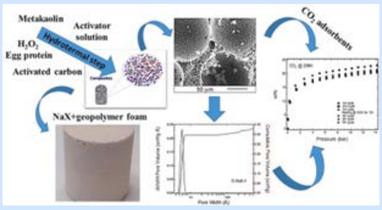
S. Candamano[1], A. Policicchio[1], G. Conte[1], R. Abarca[1], C. Algieri[2], S. Chakraborty[1], S. Curcio[1], V. Calabrò[1], F. Crea[1], R.G. Agostino[1]

[1]University of Calabria, 87036, Rende, Italy;

[2]Institute on Membrane Technology, National Research Council of Italy (ITM–CNR), 87036, Rende, Italy

Novel composites with hierarchical porosity have been evaluated as CO_2 adsorbents. An activator solution and metakaolin were used as starting mix. Activated carbon, characterized by a surface area of 528 m^2/g and a bimodal porosity centered at 4.2 Å and 10 Å, was added to the starting mix to produce hybrid composites. It was in-house produced by thermo-chemical activation of olive pomace waste. H_2O_2 and egg protein were added to the mix as a facile method to produce foamed composites. Multiphase reaction–crystallization processes, characterized by one or two thermal steps, were designed to favor geopolymerization and in-situ NaX zeolite gel conversion of metakaolin. Both the thermal procedures produce composites in forms of monoliths, as needed for application in real processes. The two thermal steps process, of which the latter is hydrothermal, increases the amount of NaX crystalline phase produced. The foaming process decreases the density and the mechanical properties of the monoliths, but it does not affect the geopolymerization and crystallization reactions or the topology of the produced zeolite. The combination of raw materials and thermal treatments affect the textural properties of the adsorbents, mainly in terms of different contribution of ultramicroporosity (<7 Å) and super microporosity (7–20 Å). Several CO_2 adsorption/desorption measurements at room temperature (298 K) up to 15 bar were carried out on all the prepared adsorbents. Notably, all the adsorbents store, already at 1 bar, almost 60% of the CO_2 uptake at the maximum analyzed pressure, with the maximum adsorption value close to 23 wt%. The strength of solid-gas interaction was also assessed by the calculating the values of Toth equation fitting parameter K. The proposed robust and facile preparation processes are aimed to obtain adsorbents able to overcome the shortcomings of conventional packed beds by exploiting the binding properties of geopolymer, the adsorption properties of zeolite NaX, the tailored pore structure, the electrical conductibility and the high stability of activated biochar and the macroporosity introduced by the foaming agent.

Fig. 1 Production and characterization of Geopolymer/NaX zeolite/activated carbon composites for CO_2 adsorption



Contact:

sebastiano.candamano@unical.it

Department of Mechanical, Energy and Management Engineering, University of Calabria, via P.Bucci cubo 42A, 87036, Rende, Italy

Curriculum vitae

Sebastiano Candamano is an Associate Professor in the sector of Materials Science and Technology (IMAT-01/A) at University of Calabria (Rende, Italy), in the Department of Mechanical, Energy and Management Engineering. His research is mainly focused on: the development, characterization and optimization of traditional, advanced and innovative binders, mortars and concretes (cements, geopolymers, alkaline activated materials) and fiber-reinforced composites; the synthesis and characterization of zeolites; preparation of catalysts for the production of hydrogen using POX, ASR, SR reactions; production of materials for CO_2 adsorption; anaerobic digestion; materials for water pollution remediation; materials and catalysts for the pre-treatments of waste cooking oils and their conversion in biodiesel. He was the scientific responsible for the financed project POR CALABRIA FESR PFU-PREDECORE "Use of PFU (End-of Use Tires) for the production of PRemiscelates for the ECO-compatible and Energy-saving Construction, CUP J88C17000310006 -PORCALABRIA FESR 2014-2020. He is currently the scientific responsible of the Unical research unit in the financed research program PRIN 2022: Integration of Artificial Intelligence and Ultrasonic Techniques for Monitoring Control and Self-Repair of Civil Concrete Structures (CAIUS) codice 2022AZPLL8.

Invited ID: 05

Engineering of eco-sustainable geopolymer-based adsorbent materials for the removal of emerging pollutants and environmental remediation

Oreste Tarallo[1], Giuseppina Roviello[2]
[1] Dipartimento di Scienze Chimiche, Università degli Studi di Napoli Federico II, Napoli (IT);
[2] Dipartimento di Ingegneria, Università degli Studi di Napoli Parthenope, Napoli(IT)

Emerging contaminants (CECs), including compounds from consumer products such as detergents, paints, personal care items, and pharmaceuticals, are increasingly found in wastewater and soil. Due to their potential environmental and health risks, CECs are monitored to preserve ecological and human health. Adsorption processes are among the most effective methods for CEC removal, offering high efficiency, low operational costs, and no harmful by-products. This contribution discusses the use of new geopolymer-based materials obtained from secondary raw materials for adsorption. These materials have been produced as massive or sponge-like continuous filters via simple, cost-effective processes like direct foaming and have been effectively used for the adsorption of cationic, anionic, and neutral species. Additionally, surface engineering with catalytically active species have allowed in situ or continuous degradation of adsorbed pollutants. The proposed materials and processes are designed for scalable, environmentally friendly production, offering an alternative to traditional high-footprint adsorption products like carbon black or polymer foams, thus supporting environmental remediation efforts. These research activities have been funded by PRIN – Bando 2022 PNRR Project P2022S3KER, CUP E53D23017810001.

Contact:
Oreste Tarallo (oreste.tarallo@unina.it)
Dipartimento di Scienze Chimiche, Università degli Studi di Napoli Federico II, Complesso Universitario di Monte Sant'Angelo, via Cintia, 80126, Napoli (IT).

Curriculum vitae

Prof. Oreste Tarallo has a long and solid experience in the obtainment and structural characterization of geopolymer based materials. During the last years, he has contributed to the development of innovative composite and hybrid geopolymer materials by developing new synthetic methodologies for the production of materials characterized by reduced fragility and improved mechanical properties, such as resistance to compression and bending, compared to traditional non-modified geopolymers. These materials have been synthesized from secondary raw materials such as fly ash or clays. More recently he has focused his attention on the use geopolymer-based materials in the field of environmental remediation. The results of these researches have been published in about 20 papers in high impact international journals and have led to the filing of 2 patents.

Invited ID: 06

DESIGN MULTIFUNCTIONAL FOAMS FOR WATER REMEDIATION: THE ZEOREMEDIA PROJECT

Barbara Liguori[1], Assunta Campanile[1], Claudio Ferone[2], Paolo Aprea[1]

[1]ACLabs - Applied Chemistry Labs, Department of Chemical, Materials and Industrial Production Engineering, University of Naples Federico II, Italy;
[2]Department of Engineering, University of Naples Parthenope, Italy

Many industrial applications need supporting or shaping powdery zeolites. Since geopolymers can be considered the amorphous counterpart or precursors of crystalline zeolites, it is possible to promote zeolite crystallization inside the geopolymeric matrix by tuning pH, temperature and time of the geopolymerization reaction (Figure 1). Moreover, combining zeolite crystallization with a foaming process, a multifunctional self-supporting zeolitic foam can been obtained with pores ranging from the micro to the macro range. The presence of a geopolymer backbone that supports and shapes the zeolitic powder can expand its technological application fields, by means of tailoring the type and amount of the zeolites for each specific application. The ZEOREMEDIA project (P20224KCJW), funded by the European Union-Next Generation EU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR), aims at designing multifunctional foams based on zeolites supported on geopolymer matrix and validating their application as sorbents for the removal of pollutants from contaminated water due to their special features, such as controlled porosity, low flow resistance, mechanical and chemical stability, and controlled chemical composition.

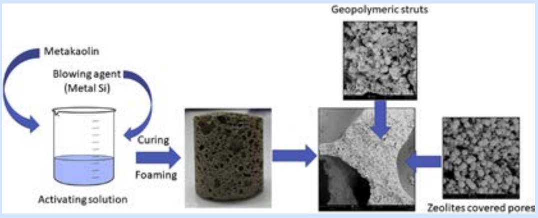


Fig. 1 Layout of the Multifunctional Foam production process

Contact:
barbara.liguori@unina.it
DiCMaPi, P.le Tecchio 80 – Napoli-Italy

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
DI C Ma PI
Applied Chemistry Labs

Curriculum vitae

Barbara Liguori is Associate Professor of Materials Science and Technology at the Department of Chemical, Materials and Industrial Production Engineering (DICMaPI) of the University of Naples Federico II.
Lecturer in "Ceramics Technologies" and "Materials and Techniques in Cultural Heritage" in the Master program in Materials Engineering of the University of Naples Federico II.
Her research activity is developed in two main topics:
-**Materials for the Environment** focused on waste treatment and recovery such as inertization, valorization and reuse of zeolitic sludge, reuse of plastic waste, sludge and waste recovery by alkaline activation, development of multifunctional porous materials for water and air remediation.
-**Cultural Heritage and Built environment** focused on development and characterization of innovative and sustainable restoration mortars and on consolidation and protection of stone surfaces.
Co-author of more than 130 scientific paper, 87 of them published on indexed international journal (Scopus citation report: 2411 Citations, h-index: 27 -visited on Decembre 2024).
She is involved in national and international projects. Among the most recent: Principal Investigator (PI) of PRIN 2022 PNRR ZEOREMEDIA: zeolitic sorbents for water remediation funded by the European Union-Next Generation EU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR); Component of the Research Unit of ERC-2024-COG (2024) "TabulaRasa. Clay, wax, and the impact of erasable writing technologies on manuscript cultures"; Scientific Manager of the local Research Unit in the Project: manifacture of artificial aggregates by means of multi step cold bonding pelletization of harzadous and non-harzardous wastes (PRIN 2020); Component of the Research Unit of MICS 2022 (Made in Italy – Circular and Sustainable) Extended Partnership and received funding from the European Union Next-GenerationEU (PNRR).

Poster ID: 01

GEopolymer based Adsorbents for effective adsorption and selective separation of CO_2 and eutrophication pollutants: the GEA project

V. Medri[1], C. Di Pietro[1], E. Papa[1], F. Miccio[1], W. F. Cossio Guzman[2], D. Pinelli[2], F. Frascari[2], M. Minelli[2]

[1]National Research Council - Institute of Science, Technology and Sustainability for Ceramics (CNR-ISSMC), Via Granarolo, 64, 48018 Faenza (RA) – Italy

[2] Institute o Department of Civil, Chemical, Environmental and Materials Engineering (DICAM) – Alma Mater Studiorum, University of Bologna, Via Terracini 28, 40131 Bologna - Italy

GEA project deals with the development of synthetic alkali aluminosilicates, namely geopolymers, for separation and purification applications, exploiting adsorption mechanisms for the capture of CO_2 or nitrogen or phosphorous-based pollutants in wastewater. GEA will develop a geopolymers platform with the ambition to link adsorption/desorption ability and selectivity versus ionic species and gases to compositional and morphological variables such as: stoichiometry, phase composition (also in composites) and textural properties (directly linked to micro-macrostructure). Acting on the variables, porosity, pore size/distribution and chemistry will be conveniently tuned for the targeted adsorption applications of the project, that are:

1) carbon dioxide adsorption and separation from CO_2 concentrated sources (e.g. flue gases), in the context of a Carbon Capture and Storage (CCS) strategy;

2) removal of ammonium and phosphates from wastewater with the aim of eutrophication prevention and critical raw materials recovery (recovery and separation of phosphorus).

The results of GEA will disclose the possibility to customize eco-friendly materials (low energy production process) for specific adsorption purposes and to identify geopolymer matrices able to actively increase in composites the performances of other adsorbent such as zeolites, apatites, hydrotalcites.

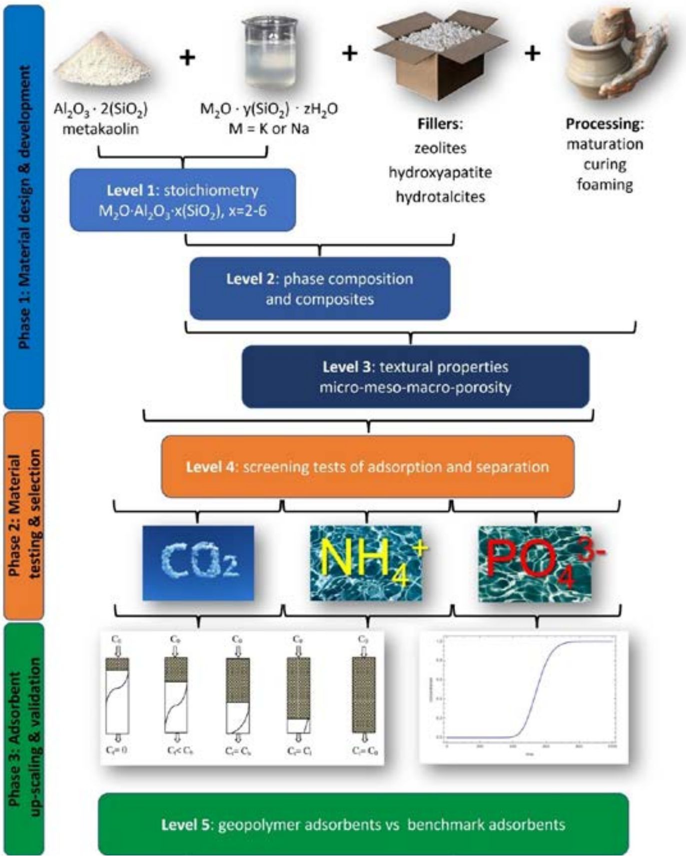


Fig. 1 : Scheme of the GEA project
https://www.issmc.cnr.it/en/research/projects/ministerial-projects/gea/

The GEA project is articulated in 3 Phases (Fig. 1): Phase 1 related to Material Design & Development and Phase 2 related to Material Testing & Selection will be conducted iteratively. In particular Phase 1 is divided in 3 levels:

1) Stoichiometry. Geopolymer matrices are synthesized by slurry route modifying the Si/Al ratio (= 1,2 or 2,0 or 3,0) and the activating solution (Na or K –based).

2) Phase composition and composites. To enhance the adsorption capacities, geopolymer-based composites are synthesized using geopolymer matrices optimized in Level 1 and using zeolites (Na13X and NaA4) and hydrotalcites (Sorbacid 911, Pural MG 50,70 and 61) as fillers.

3) Textural properties. The porosity of composite materials was modified either through foaming or Cold Sintering techniques. Particularly, the former is used to introduce the macroporosity, while the latter was used to consolidate geopolymer and zeolite powders.

The research was carried out under the financial support of the MUR PRIN 2022 Project GEA, Prot. 20229THRM2, funded by the European Union – Next Generation EU.

Contact:
Valentina Medri (GEA PI)
(valentina.medri@issmc.cnr.it);
National Research Council - Institute of Science, Technology and Sustainability for Ceramics (CNR-ISSMC), Via Granarolo, 64, 48018 Faenza (RA) – Italy

Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani | Consiglio Nazionale delle Ricerche | GEA GEopolymer based Adsorbents

Poster ID: 02

Manufacturing of geopolymer-zeolite mebranes by Cold Sintering process for CO_2 capture

Cristina Di Pietro[1], Walter Felix Cossio Guzman[2], Elettra Papa[1], Maria Chiara Marchioni[1], Elena Landi[1], Francesco Miccio[1], Matteo Minelli[2], Valentina Medri[1]

[1]National Research Council - Institute of Science, Technology and Sustainability for Ceramics (CNR-ISSMC), Via Granarolo, 64, 48018 Faenza (RA) – Italy

[2] Institute o Department of Civil, Chemical, Environmental and Materials Engineering (DICAM) – Alma Mater Studiorum, University of Bologna, Via Terracini 28, 40131 Bologna - Italy

In order to obtain adsorbents, in a circular economy scenario, for carbon dioxide capture, geopolymer and geopolymer-zeolite based monoliths were produced through the Cold Sintering Process.
Firstly, preliminary tests were performed on geopolymer waste powders for the purpose of selecting the best conditions in which to carry out the experiments; particularly the temperature, the reactive solution and the applied pressure were modified. The improved conditions resulted in a relative density of around 64%. Then, these conditions were used to produce composite materials containing zeolite. Indeed, the Cold Sintering Process was used whereas on a geopolymer- zeolite powder containing 81% of *in situ* synthetized NaA phase or on Na13X-based powders containing the geopolymer powders from 5 wt.% to 30 wt.%. In this way it was possible to densify geopolymer-zeolite matrices. Subsequently, these materials were tested to evaluate CO_2 adsorption capacity in a pressure decay apparatus and they showed higher CO_2/N_2 separation performances compared to benchmark adsorbents. The research was carried out under the financial support of the MUR PRIN 2022 Project GEA, Prot. 20229THRM2, funded by the European Union – Next Generation EU.

Contact:
Cristina Di Pietro (cristina.dipietro@issmc.cnr.it); National Research Council - Institute of Science, Technology and Sustainability for Ceramics (CNR-ISSMC), Via Granarolo, 64, 48018 Faenza (RA) – Italy

Fig. 1 : Summary schema of the Cold Sintering Process

Poster ID: F1-03

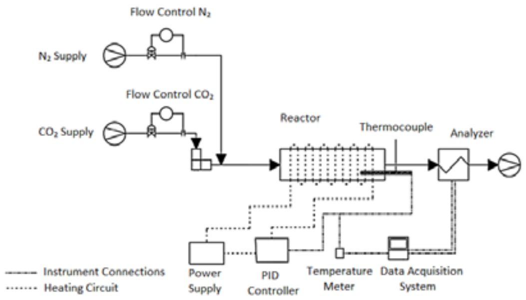
Dynamic Adsorption of CO_2 Using Geopolymer-Zeolite Composites Produced via Cold Sintering

Walter Felix Cossio Guzman[1], Cristina Di Pietro[2], Matteo Minelli[1], Elettra Papa[2], Elena Landi[2], Francesco Miccio[2], Valentina Medri[2]

[1] Department of Civil, Chemical, Environmental and Materials Engineering (DICAM) – Alma Mater Studiorum, University of Bologna, Via Terracini 28, 40131 Bologna – Italy

[2]National Research Council - Institute of Science, Technology and Sustainability for Ceramics (CNR-ISSMC), Via Granarolo, 64, 48018 Faenza (RA) – Italy

The development of efficient CO_2 capture technologies is a key approach to address global climate change. In this study, dynamic adsorption experiments were conducted using a composite material comprising a zeolite (Na13X) and a geopolymer (K-G2) synthesized via the cold sintering process. This innovative method allows an effective combination of high-performance zeolites with geopolymeric binders with the fabrication at low temperature of high performance solid sorbents, endowed by both meso-porosity and adsorption capacity.
Dynamic adsorption tests were performed to evaluate the CO_2 capture performance of the composite under varying flow rates and CO_2 concentrations, simulating real industrial conditions. The results demonstrated that the composite material exhibits excellent adsorption efficiency and stability over multiple cycles, with adsorption capacities closely linked to the cold sintering process's controlled parameters. This work highlights the potential of geopolymer-zeolite composites as sustainable and cost-effective materials for CO_2 capture applications. Future studies will focus on optimizing the material's performance for industrial implementation. The research was carried out under the financial support of the MUR PRIN 2022 Project GEA, Prot. 20229THRM2, funded by the European Union – Next Generation EU.



Contact:
Walter Felix Cossio Guzman (walter.cossioguzman2@unibo.it); Department of Civil, Chemical, Environmental and Materials Engineering (DICAM) – Alma Mater Studiorum, University of Bologna, Via Terracini 28, 40131 Bologna - Italy

Fig. 1 : Summary schema of the Dynamic Adsorption Process

Poster ID: 04

Retention of metal cations on geopolymer-based membranes

Claudia Stevanin[1], Gilda Andreotti[1], Tatiana Chenet[1], Valentina Medri[2], Elettra Papa[2], Luisa Pasti[1],
[1]Department of Environmental and Prevention Sciences, Via Luigi Borsari 46, 44121, Ferrara (FE),Italy
[2]National Research Council of Italy, Institute of Science, Technology and Sustainability for Ceramics (CNR-ISSMC), Via Granarolo 64, Faenza, RA 48018, Italy

Geopolymers are green inorganic polymers comprising aluminosilicate constituents and are characterized by the semi-crystalline or amorphous form in a three-dimensional network [1]. An interesting application is their use as adsorbent materials for the separation of charged species in solution, through ultrafiltration processes. Membrane ultrafiltration technology is used to physically separate even extremely small soluble substances, such as ions and/or molecules, from an aqueous solution. The degree of filtration depends on many factors, such as the pore size of the membrane, the chemical characteristics of the fluid to be treated, operational parameters and the fluid dynamic regime. In this study, the adsorption characteristics of two different geopolymers were investigated for their ability to remove alkali and alkaline earth ions (Li, Na, and Ca) from aqueous solutions through column studies. The two adsorbent materials considered were prepared using different formulations. Geopolymer 15a was derived from waste powder generated during the production of geopolymer granules [2]. Geopolymer G13, on the other hand, was synthesized using metakaolin and a potassium silicate solution in the presence of KOH. To evaluate the affinity of the two materials for Li^+, Na^+, and Ca^{++} cations, dynamic adsorption tests were conducted. The results demonstrated the effectiveness of the dynamic adsorption process and confirmed the utility of geopolymers in the uptake of alkali and alkaline earth ions. The applicability of the Thomas model to the breakthrough curves suggested that ion adsorption in geopolymers is influenced by both external mass transfer and internal diffusional resistances. Geopolymer-based adsorbents exhibit cost-effectiveness, environmental sustainability, and biocompatibility, and they proved to be efficient in removing cations. Furthermore, the results indicated that both geopolymers show a higher affinity for lithium cations compared to calcium and sodium ions. These types of membranes can be used for the removal of and the enrichment of lithium from brine.

Contact:
claudia.stevanin@unife.it
Department of Environmental and Prevention Sciences,
Via Luigi Borsari 46, 44121, Ferrara (FE),Italy

[1] DOI:10.1016/j.clay.2021.106001
[2] DOI:https://doi.org/10.1016/j.watres.2022.119203

Poster ID: 05

Porous geopolymers as alternative biofilter media for municipal wastewater treatment

Cofano V.[1], Clausi M.[1], Pannu D.S.[2], Mathew J.[2], Barkhordari D.[2], Khorshidi Nazloo E.[2], Santoro D.[2] & Pinto D.[1]
[1] Department of Earth and Geoenvironmental Sciences, University of Bari Aldo Moro, Italy;
[2]Chemical and Biochemical Engineering Department, University of Western Ontario, London, Canada

In this study metakaolin-based geopolymers were engineered using different concentrations of hydrogen peroxide and a combination of hydrogen peroxide and olive oil, to promote the porosity formation. Geopolymer granules of size 2-8 mm were than used for a biofiltration experiment through 6-month to evaluate their efficiency in removing various pollutants, especially nitrite, nitrate and ammonium, in comparison with several other materials commonly used in wastewater treatment. A total of 10 biofiltration columns, 4 with geopolymer granules (1 un-porous and 3 porous samples with different porosity), 3 with quartz sand, activated carbon and expanded clay, respectively, and 3 with olive oil-modified geopolymers in combination with each of the other materials, were operated in parallel and batch-fed daily with tertiary effluent. Two intensive sampling and subsequent analysis of incoming and outgoing wastewater (after filtration) were conducted every day for a week after 2 months and 6 months, respectively, of system operation. Furthermore, grains were manually sampled from columns, and the DNA of the bacteria was extrapolated to determine the biological function activated to achieve denitrification. Olive oil-modified geopolymers and activated carbon showed the highest efficiency in denitrification, although geopolymers reduced significantly their effectiveness after 6 months, probably due to decreasing availability of oil in the geopolymer, which promoted the proliferation of bacteria at the early stages. Nevertheless, geopolymers showed comparable or even higher efficiency (in the case of un-porous one) in the ammonium removal than the other commercial materials used in the experiment.

Fig. 1 Filter columns used for the biofiltration experiment

Contact:
Vito Cofano (v.cofano5@phd.uniba.it)
Università degli Studi di Bari, via Orabona, 4

Poster ID: 06

Zeolite-enriched porous adsorbents for water remediation

Assunta Campanile[1], Paolo Aprea[1], Claudio Ferone[2], Federica Falzarano[2], Raffaele Cioffi[2], Barbara Liguori[1]
[1]ACLabs –- Applied Chemistry Labs, Department of Chemical, Materials and Industrial Production Engineering, University of Naples Federico II, Italy; [2]Department of Engineering, University of Naples Parthenope, Italy

Depending on the industrial process, wastewater may contain several pollutants of different chemical-physical nature divided into several macro-categories, such as organic, inorganic, radioactive, suspended solids and pathogens. Developing broad-spectrum methods and adsorbents for removing pollutants from wastewater is essential to mitigate environmental pollution and to promote industrial sustainability. Accordingly, multifunctional porous adsorbents (MPA) can be proposed for remediation of complex wastewaters containing heavy metals and organic dyes. In this work, two zeolite-enriched porous adsorbent monoliths have been synthetized by geopolymer gel conversion, following a novel approach recently proposed [1, 2]. The two adsorbents, A/X-MPA and X-MPA, differ in type and amount of zeolite, LTA and FAU, respectively. Chromium (III), Cadmium, Lead and Methylene Blue were selected as target pollutants.
Removal efficiency was assessed by kinetic runs performed on simulated industrial wastewater (C_{Cd} = 200 mg/L, C_{Cr} = 60 mg/L, C_{Pb} = 500 mg/L and C_{MB} = 50 mg/L) at a solid-to-liquid ratio of 4 g/L under continuous stirring for 72 h. Pseudo-First Order (PFO) and Pseudo-Second Order (PSO) kinetic models were used to study the adsorption kinetics. Collected data in terms of pollutant removed percentage at equilibrium demonstrate that both adsorbents completely remove chromium and lead. As regards cadmium, a complete pollutant removal is reached only with X-MPA sample , whereas for methylene blue A/X-MPA shows better performance (70% vs 60%).

References:

[1] Liguori, B., et al. "Self-supporting zeolites by geopolymer gel conversion (GGC)." Microporous and Mesoporous Materials 286 (2019): 125-132.
[2] Campanile, Assunta, et al. "From geopolymers to zeolites: Synthesis and characterization of foamed FAU-X monoliths." Microporous and Mesoporous Materials 349 (2023): 112426.

Contact:
Assunta Campanile (assunta.campanile@unina.it)
DiCMaPi, P.le Tecchio 80 – Napoli, Italy

Poster ID: 07

Towards a Circular Economy: Alkali-Activated Stone Wool for Sustainable Wastewater Treatment

Cansu KURTULUŞ[1,2], Tero LUUKKONEN[2]
[1] Afyon Kocatepe University, Chemical Engineering Department, Afyonkarahisar/Türkiye
[2] University of Oulu, Fibre and Particle Department, Oulu/Finland

Various studies are being conducted on the adsorption of toxic metals, nutrients, and dyes from wastewater by alkali-activated materials. They can encourage clean technology because they are prepared from inexpensive aluminosilicate precursors in an environmentally friendly manner. This study discussed alkali-activated stone wool for adsorption studies for the first time. Stone wool without organic resin (SW) and stone wool with organic resin removed by heat treatment (SW-O) were alkali activated by NaOH, Na_2CO_3, $NaAlO_2$, or Na silicate solution and characterized using X-ray diffraction, scanning electron microscopy, Fourier-transform infrared spectroscopy, thermogravimetry–mass spectrometry, and potentiometric titrations for understanding adsorption properties. Comparative adsorption tests were conducted at 100 mg × L^{-1} of MB, Co(II), As(III), and NH_4^+, at an adsorbent dosage of 1 g/L and a contact period of 24 h at pH 7. The raw stone wools showed poor adsorption, whereas those alkali-activated adsorb MB, Co(II), As(III), and NH_4^+ to 78, 42, 3, and 18 mg × g^{-1}, respectively. The SW Na silicate samples absorbed MB and Co(II) better. As(III) adsorption capacity was comparable within the mixtures. NH_4^+ was best adsorbed by SW-O NaOH. Increased specific surface area, negative zeta potential, tobermorite-like structures, and surface OH groups increased the adsorption capacities. The specific level of adsorption of some pollutants may be related to their speciation at pH 7, aqueous radii, and adsorption process. In this study, stone wool-based adsorbents showed practical wastewater treatment capability.

The results presented in this poster have been previously published in «Ceramics International https://doi.org/10.1016/j.ceramint.2024.11.126»

Contact: *Cansu KURTULUŞ (cansudemir@aku.edu.tr/ cansu.demir26@gmail.com)*
Afyon Kocatepe University, Chemical Engineering Department, Afyonkarahisar/Türkiye

Poster ID: 08

Potential of Metakaolin-Based Geopolymers for Galvanic Sludge Encapsulation

F. Genua[1], M. Giovini[1], Elisa Santoni[2], Silvia Zamponi[2], Mario Berrettoni[2] I. Lancellotti[1], C. Leonelli[1]
[1]Dipartimento di Ingegneria "Enzo Ferrari", Università degli Studi di Modena e Reggio Emilia, Modena
[2]Scuola di Scienze e Tecnologie, Università di Camerino, Camerino

Geopolymers are a class of inorganic polymers derived from the alkaline activation of aluminosilicate precursors, offering tunable physicochemical properties and environmental benefits. Their three-dimensional network, formed by Si-O-Al bonds, provides high thermal stability and chemical resistance, making them suitable for a wide range of applications, including contaminant remediation [1]. In this work, a novel metakaolin-based geopolymer formulation was developed by incorporating 5 wt% of a galvanic waste (DE) together with sodium silicate and 8 M NaOH as alkaline activators. The waste was used as received from the industrial plant in the form of a sludge characterized by 40.01 wt% Cr_2O_3 and a NiO content of 18.06 wt%. The aim was to investigate whether the final composite could effectively encapsulate heavy metals within its structure. Preliminary results suggest that the novel geopolymeric matrix is effective in both encapsulating heavy metals and mechanically stabilizing the embedded sludge, indicating its promise for environmental remediation and waste management applications.

[1] Boldrini, C. Sgarlata I. Lancellotti L. Barbieri M. Giorgetti, M. Ciabocco S. Zamponi, M. Berrettoni and C. Leonelli, Efficient chemical stabilization of tannery wastewater pollutants in a single step process: Geopolymerization, Sustainable Environment Research, (2021) 31:33

Acknowledgments: PROGETTO DI RICERCA DI RILEVANTE INTERESSE NAZIONALE (PRIN): Advanced Chemical Characterization of Heavy metals and Anions encapsulated in geopolymers with synthetic redox environment ACCHA, 2022LKEKJ7, CUP: E53D23008480006.

Contact:
Francesco Genua (francesco.genua@unimore.it)
Dipartimento di Ingegneria "Enzo Ferrari", Università degli Studi di Modena e Reggio Emilia, Modena, Via P. Vivarelli , 10, Modena

Poster ID: 09

Construction and demolition waste-based geopolymers for CO_2 capture

F. Servadei[1], A. Natali Murri[1], E. Papa[1], F. Miccio[1], V. Medri[1], E. Landi[1]
[1] National Research Council – Institute of Science, Technology and Sustainability for Ceramics (CNR-ISSMC)

Construction and demolition waste (CDW) represents the largest waste stream in the EU. In recent years, several studies demonstrated the feasibility of converting these wastes, which are usually rich in aluminosilicates, through alkali activation into green building materials from a perspective of circular economy. Because CDW is usually rich in alkaline compounds (e.g., calcium hydroxide and calcium-silicate-hydrate), it still has some potential to capture CO_2 by converting it into thermodynamically stable carbonates.

This work explores the valorization of CDW through the geopolymer technology in high-added value products as solid adsorbent for CO_2 capture. After a preliminary determination of the most suitable reactive systems to optimize geopolymerization, geopolymer foams were prepared using unsorted CDW from residential building demolishing together with metakaolin as aluminosilicate precursors. Hydrogen peroxide (H_2O_2) was used as the blowing agent to induce a macroporous structure (Fig. 1) via direct foaming. As-prepared CDW-based geopolymer foams were characterized in terms of macro- and microstructure, porosity, preliminary mechanical properties and gas permeability. The adsorption behavior was studied using TGA in cyclic operations at low temperature (35 °C), alternating between CO_2-containing and CO_2-free N_2 streams in the sample chamber, with each sorption/desorption step lasting 20 minutes. The preliminary results indicated that CDW did not substantially alter the CO_2 adsorption, that was very close to the expected one considering the geopolymer matrix content. Thus, CDW-based geopolymer foam has good potential as eco-sustainable adsorbent for CO_2 selective adsorption. This study was carried out within the MICS (Made in Italy – Circular and Sustainable) Extended Partnership and received funding from the European Union Next-Generation EU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.3 – D.D. 1551.11-10-2022, PE00000004).

Contact:
Francesco Servadei (francesca.servadei@issmc.cnr.it)
National Research Council – Institute of Science, Technology and Sustainability for Ceramics (CNR-ISSMC), via Granarolo, 64, 48018 Faenza (RA), Italy

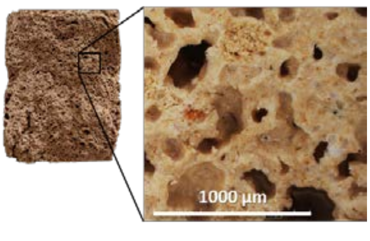


Fig. 1 Section of CDW-based geopolymer foam and its magnification by digital microscope.

Poster ID: 10

Multifunctional filtering and absorbent porous polymeric aerogels for sustainable water and air purification

Authors: Elisabetta Campodoni[1], Gaia Vicinelli[1], Chiara Artusi[1], Monica Sandri[1]
[1]National Research Council (ISSMC-CNR), Via Granarolo 64, 48018 Faenza, Italy

Due to water scarcity and increasing levels of contamination from both standard and emerging contaminants, the development of more efficient purification materials and technologies for drinking water treatment is a critical challenge to be addressed water-based *(Taiba N, Tayyiba D. Environmental Chemistry and Ecotoxicology, 2021)*. Moreover, in a world where more and more efforts are being made to produce environmentally sustainable materials, it is necessary to improve the design of new devices, not only to create more efficient ones but, above all, to transform the entire production process into a more environmentally sustainable and circular one *(Campodoni E. ACS Applied Polymer Materials 5.5, 2023)*. Specifically, in this work, we developed a biofilter through a SSbD approach based on the use of raw materials derived from food waste, such as gelatin and chitosan, and water-based processes. The polymers were conveniently stabilized using a cross-linking agent and freeze-dried to obtain an aerogel with a specific porous morphology capable of blocking any bacteria and encapsulating in different ways some functional molecules adapted to trap contaminants and act as antimicrobial agents. Among functional molecules and particles, graphene oxide (GO) represents a chemical with π-π interactions, hydrophobic interactions as activated carbons, but it also has polar chemical oxygen based chemical groups promoting higher hydrophilicity, electrostatic interaction and higher processability in water *(Kovtun A. Faraday Discussions, 2021)*. On the other hand, the use of metal oxides and ions (Cu, Ag, Zn, etc.) seems promising due to their high antibacterial properties. Copper oxide nanoparticles confirm their efficacy in the photodegradation of wastewater and their antimicrobial activity *(Taiba N. Environmental Chemistry and Ecotoxicology, 2021)*. In conclusion, the developed filter is characterized by affordable cost, antimicrobial efficiency, antibiotic adsorption capacity, sterilizability by gamma rays, biodegradability and sustainability. All these features lead to an increase in filter efficiency, a reduction in its sizes and of the associated waste management costs and offer a significant industrial and economic opportunity to be addressed.

ACKNOWLEDEGMENT:
This work was performed with the financial support of: i) PNRR MUR project ECS_00000033_ECOSISTER; ii) PNRR MUR project ECS_00000033_ECOSISTER_Spoke1_GRAM.

Contact:
Elisabetta Campodoni (elisabetta.campodoni@issmc.cnr.it)
Institute of Science Technology and Sustainability for Ceramics (ISSMC-CNR), Via Granarolo 64, 48018 Faenza, Italy

Poster ID: 11

Porous piezoelectric BCTZ membranes for water microfiltration

Tavolaro A[1], Mercadelli E[1], Gondolini A[1], Gardini D[1], Baldisserri C[1], Bertolini F[2], Mombelli D[2], Lecis N[2], Galassi C[2], Morelli R[3], Conidi C[3], Cassano A[3], Galizia P[1]
[1]CNR-ISSMC, Faenza, Italy;
[2]Politecnico di Milano, Italy;
[3]CNR-ITM, Rende, Italy

Microfiltration (MF) membranes are essential for recycling water from food industry wastewater. However, their efficiency is often hindered by membrane fouling—a buildup of impurities that reduces their permeability. Ceramic membranes (CMs) outperform their polymeric counterparts in durability and lifespan, although their higher cost remains a challenge. The improvement of the antifouling performance of CMs is a key aspect to fully unlock their potential. Among these, self-cleaning piezoelectric membranes have shown remarkable antifouling and defouling capabilities.

This work focuses on the development of porous, lead-free piezoelectric ceramic membranes (BCTZ system) using sacrificial pore-forming agents, freeze casting, and binder jetting additive manufacturing processes. The poster presents initial findings on the synthesis and fabrication of BCTZ porous ceramic membranes (Fig. 1) and correlation of their microstructure and ferroelectric properties with water permeability and filtration performance in the treatment of products or by-products from agri-food industry.

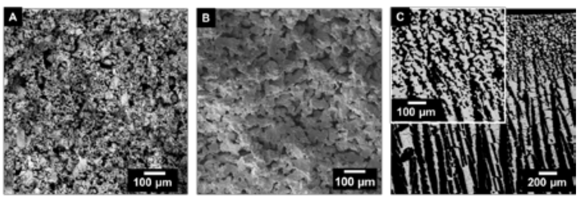


Fig. 1 SEM micrographs of porous $(Ba_{0.85}Ca_{0.15})(Ti_{0.90}Zr_{0.10})O_3$ ceramics fabricated via different methods: (a) sacrificial pore-forming agents; (b) ; binder jetting additive manufacturing (c) freeze casting.

Aknowledments
This work has been funded by the European Union – NextGenerationEU – Project SELWA – CUP B53D23008660006 - Grant Assignment Decree No. 20229PNWM7.

Contact:
Pietro Galizia (pietro.galizia@cnr.it)
CNR-ISSMC, via Granarolo 64, 48018 Faenza, Italy

Poster ID: 12

Hybrid materials for sustainable water treatment: integrating microalgae biomass with inorganic nanomaterials

Sara Amadori[1,2], Ilaria Zanoni[1], Andrea Brigliadori[1], Anna Costa[1], Pierluigi Giacò[3], Michele Melis[3], Magda Blosi[1].
[1]CNR-ISSMC, National Research Council of Italy-Institute of Science, Technology and Sustainability for Ceramics, Faenza, Italy; [2]Department of Chemical Science, Life and Environmental Sustainability, Parma University, Parma, Italy; [3]Department of Environmental and Prevention Sciences, University of Ferrara, 44121, Ferrara, Italy

The uncontrolled release of pollutants into the environment and its implication is a staggering problem of global concern. For this reason, the research is moving toward the development of a new class of advanced materials for the advancement of sustainable filtration technologies in a safe-by-design perspective. We present the preparation of hybrid nanomaterials obtained combining inorganic nanomaterials (NMs) with microalgae biomass to advance the nanoremediation technology. The coupling of *Neochloris oleoabundans* and *Phaeodactylum tricornutum* with inorganic phases based on TiO_2 and SiO_2 NPs allowed us to explore a new challenging frontier in the bio-nanomaterial design. The activity aims at developing a multifunction bio-nano catalyst able to combine heavy metal biosorption by microalgae with the photocatalytic action provided by TiO_2. The materials underwent preparation through a colloidal process followed by a cold granulation technique, supported by an extensive physicochemical characterization (DLS, ELS, BET, SEM, FTIR, ICP, UV-VIS). The evaluation of the hybrid catalysts' performance was centered on two key aspects: their ability to adsorb heavy metals, tested with copper as a probe metal, and their photocatalytic activity, assessed through the degradation of Rhodamine B dye under irradiation. The results revealed a synergistic effect in the hybrid samples,by enhancing the metal biosorption when the microalgae was supported on the TiO_2 inorganic nanophase and paving the way to new solutions for the water treatment field. Furthermore, the photocatalytic activity was preserved in all the hybrid samples, despite the presence of the microalgae biomass.

Fig. 1

Contact:
sara.amadori@issmc.cnr.it
CNR-ISSMC, National Research Council of Italy-Institute of Science, Technology and Sustainability for Ceramics, Faenza, Via Granarolo 64, 48018 (RA)

Poster ID: 13

Calcium Ferrites as Adsorbents Agents in Wastewater Treatment

M.Vespignani[1,2], M.H.P Araùjo[3] , A.L.Costa[1], I.Zanoni[1], S.Ortelli[1], M.Blosi[1], C.Artusi[1], S.Amadori[1,2]
[1]CNR-ISSMC, Via Granarolo 64, Faenza, Italy
[2]Department of Chemical Science, Life and Environmental Sustainability of Parma University, Parco Area delle Scienze 11A, Parma, Italy
[3] Universidade Federal de Viçosa Campus Florestal, UFV Rodovia LMG 818 km 06, Campus Universitário Florestal MG 35690-000, Brazil

Environmental-friendly calcium ferrites prepared by using different Ca:Fe molar ratios, different calcination temperatures as well as different synthesis processes result with excellent features in adsorb different pollutants from aqueous environments. From physical-chemical characterizations, colloidal, structural, and optical properties are consistent across samples from both synthesis methods. Materials obtained via sol-gel combustion method calcined under 600°C exhibit Ms values ranging from 10 to 40 $Am^2\ kg_{Fe}^{-1}$ while just thermal degraded samples calcined at 1200°C result with magnetic features. Additionally, low coercivity and magnetic remanence values indicating almost-superparamagnetic nanoclusters formation in both synthesized samples. Sol-gel combusted samples exhibit an higher surface areas compared with thermal degraded ones, ranging from 20 to 170 m^2/g. Samples obtained via both method show high photocatalytic capacities against dyes, with maximum values of 343.2 $mg_{dye}\ g_{sample}^{-1}$ in methylene blue and 116.7 $mg_{dye}\ g_{sample}^{-1}$ in methyl orange removal. However, these samples result worse in adsorb dyes with conversions that reach a maximum of 30-35%. Thus, in order to completely degrade/remove dyes from aqueous environments, these two effect should be used synergistically. Furthermore, PO_4^{3-} adsorption capacities are excellent, ranging from 5 to 120 $mg_{PO_4^{3-}}\ mg_{sample}^{-1}$, especially for TD samples. Lastly, many samples show great heavy metal adsorption capacity with values for Cu^{2+}, Zn^{2+} and Fe^{3+} that arrive at 10 $mg_{M+}\ g_{sample}^{-1}$ with a 100% removal.

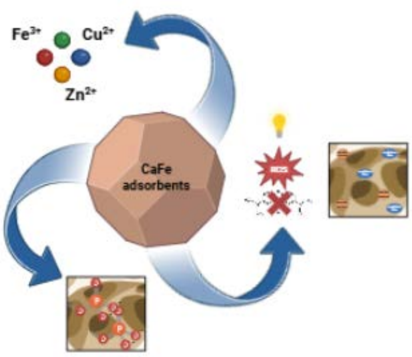


Fig. 1 Calcium ferrites functionalities in removal wastewater pollutants.

Contact:
Maurizio Vespignani
(maurizio.vespignani@issmc.cnr.it)
CNR-ISSMC, Via Granarolo 64, Feanza, Italy

Poster ID: 14

Modular system for water PUrification and Reuse: the PURE project

Anna Maria Ferrari[1], Alberto Figoli[2], Pietro Giuseppe Gucciardi[3], Valentina Medri[4], Roberto Montanari[5], Luisa Pasti[6]
[1]Department of Sciences and Methods for Engineering, University of Modena and Reggio Emilia, Via Amendola 2, 42122 Reggio Emilia, Italy; [2]CNR-ITM, Via P.Bucci, cubo 17/c , 87030 Rende CS, Italy; [3]CNR-IPCF, Viale F. Stagno D'Alcontres 35, 98158 Messina, Italy; [4]CNR-ISSMC, Via Granarolo 64 - 48018 Faenza (RA), Italy; [5]Department of Engineering and Architecture, University of Parma, Parco Area delle Scienze 181/a, 43124 Parma, Italy; [6]Department of Environmental and Prevention Sciences, Corso Ercole I d'Este 32, 44121 Ferrara, Italy

PURE aims to develop a water purification system for industries and communities with characteristics that allow for water reuse, thereby minimizing water extraction from surface or groundwater sources in accordance with principles of environmental sustainability and circular economy. The main novelty of the project is to develop a prototype with flexible operation adaptable to different production. The individual units that make up the purification system can be selected and sized based on the type of effluent to be treated. The plant includes the installation of bypass systems to isolate the individual units that comprise the purification system. Building on established laboratory knowledge of different innovative purification treatments, the project aims to create a prototype plant (TRL6) capable of reducing microbial load, heavy metals, and organic pollutants, including persistent ones (PAHs and PFAS), microplastics and contaminants of emerging concern (CECs), at an industrial scale. The partnership (CNR-ISSMC, UNIFE, UNIPR, UNIMORE) already involved in the ecosystem project ECOSISTER possesses all the expertise regarding material development, device design, chemical analytical methodologies to validate purification process and environmental impacts by LCA. PURE benefits from the expertise of CNR-IPCF to equip the plant with a continuous monitoring system capable of detecting any purification plant malfunctions and the expertise of CNR-ITM for the development of ultrafiltration membranes capable of achieving high water purity standards. Project Implementer "Ecosystem for Sustainable Transition in Emilia-Romagna" Codice: ECS_00000033 - CUP: B33D21019790006 Missione 04 Istruzione e ricerca – Componente 2 Dalla ricerca all'impresa Investimento 1.5, – NextGenerationEU

Contact: *Anna Maria Ferrari (annamaria.ferrari@unimore.it)*
Dipartimento di Scienze e Metodi dell'Ingegneria, Università degli Studi di Modena e Reggio Emilia, Via Amendola, 2, 42122 Reggio Emilia