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AIR QUALITY

Air Pollution continues to be a global concern among the scientific community for its impacts on the human health, the environment and climate change.

The research of the University of Bologna is spread across several disciplines from science-based to technology applications and solutions and it covers:

- development, assessment and validation of atmospheric dispersion models from street to urban scale; long-range transport modelling
- interaction between air quality and climate change in urban environments: from science to urban and regional planning
- developments and testing of sensors (including low cost) for air quality applications
- detection of short-lived atmospheric radicals from spectroscopic and mass spectrometric techniques to novel, low-cost, small and easy-to-use nano-electronic devices
- chemical characterization of atmospheric aerosols at various temporal scales
- development of innovative technologies for fine powder filtration from gaseous flow for industrial and domestic application to biomass combustion

HIGHLIGHTS

The University of Bologna has been involved in several solutions-oriented national and European funded projects, among them: **H2020-ISCAPE** - *Improving the smart control of air pollution in European cities*; **H2020-RADICAL** - *Fundamental Breakthrough in Detection of Atmospheric Free Radicals*; **H2020-WeWair** - *Wearable and Stationary Sensors for Air Quality Management*; **LIFE-Simplest** - *Smart Innovative Management of PelLEt STove to optimize environmental performance*; **LIFE-SAFER-PER-LIFE** - *Secondary Aluminium Foundries Energy Recovery and Polluttant Emissions Reduction*; *LIFE-IPER+ - Innovation in Particulate's Emission Reduction in biomass boilers*.

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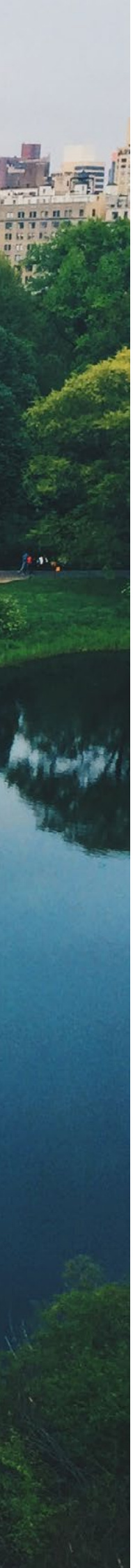
CIRCULAR CITIES

Embedding circular economy principles into cities dynamics and regeneration strategies.

The University of Bologna is deeply involved in exploring cities as regenerative ecosystems able to face increasing pressures on urban infrastructures and environmental resources, by maximizing the value of components, materials and resources flows.



The research of the University of Bologna covers a wide range of issues:

- embedding the principles of the circular economy into urban policies and practices
- reuse/multiple use of vacant spaces and urban regeneration to foster proximity of people and materials
- mapping flows of people and resources to support 'closing the loop' policies and strategies
- strategies for land use (re)utilisation and implementation of nature-based solutions
- to promote effective energy use, supporting users to change behaviour and optimise energy consumption
- multi-modal mobility combining public transportation with flexible last-mile solutions, re-thinking the design of multi-modal nodes
- environmental assessment to provide evidence of circular economy as a driver to increase liveability of cities, social innovation and dissemination of low carbon practices at the urban scale

HIGHLIGHTS

The Interdepartmental Centre for Applied Research on Buildings and Construction (CIRI-EC) promotes research, co-operation and innovation within industries and small/medium enterprises by means of applied research on buildings and construction technologies, technological support, knowledge transfer and business development.

Collaborations and international research projects: The University of Bologna is partner of the EIT Climate-KIC, the public-private innovation partnership focused on strategies to mitigate and adapt to climate change. In this framework is coordinating the **Flagship Loop of Climate-KIC**.

The University of Bologna is also participating in the Italian Circular Economy Stakeholder Platform and it is involved and coordinating EU funded projects aiming at embedding sustainable development principles into cities dynamics. Among them: **ROCK** - *Regeneration and Optimisation of Cultural heritage in creative and Knowledge cities* that aims to develop an innovative and systemic approach to effective regeneration in historic city centres. The Creative Practiced in Cities and Landscapes (CPCL), a facilitator linked to project, has been activated with the aim to bring forward circular urban systems approaches. **RURITAGE** - *Rural regeneration through systemic heritage-led strategies* that proposes solutions for the promotion of the Cultural and Natural heritage as a driver for competitiveness, sustainable and inclusive growth and development.

Both projects are funded by Horizon 2020.

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CLIMATE AND CLIMATE SERVICES

Climate is among the most crucial areas of contemporary research given its direct impact on human activities, security and health.

Climate research at the University of Bologna encapsulates a wide spectrum of cutting-edge activities including basic research of atmospheric and ocean processes, model development, data analyses of past records, impacts evaluation. Special effort is devoted to develop climate services, tackling greening the economy in line with the Sustainable Development Goals (SDGs).

The research of the University of Bologna covers a wide range of issues:

- fundamental atmospheric and ocean science research
- mitigation and adaptation strategies for urban, rural and coastal areas including biodiversity and ecosystem services
- Copernicus Services for climate change, land and marine environmental monitoring including short and long-term initiatives
- smart City, climate change and resilience of the built environment, development and assessment of low-impact technologies
- use of satellite products for land and water sustainability in arid and semi-arid watersheds including studies on recurring floodings and their impact
- paleoclimate
- heritage-led and conservation-friendly resilience enhancement and sustainable reconstruction of Historic Areas to cope with Climate Change and natural hazards

HIGHLIGHTS

The University of Bologna has led and has been involved in several solutions-oriented national and European funded projects, among them: **MADFORWATER** - *DevelopMent AnD application of integrated technological and management solutions FOR wasteWATER treatment and efficient reuse in agriculture tailored to the needs of Mediterranean African Countries*; **OPERANDUM** - *OPEn-air laboRAtories for Nature baseD solUtions to Manage environmental risks H2020*; **SOCLIMPACT** - *DownScaling CLImate imPACTs and decarbonisation pathways in EU islands, and enhancing socioeconomic and non-market evaluation of Climate Change for Europe, for 2050 and beyond*, **AtlantOS** - *Optimising and Enhancing the Integrated Atlantic Ocean Observing Systems,* and **SHELTER** - *Sustainable Historic Environments hoListic reconstruction through Technological Enhancement and community based Resilience*.

The University of Bologna participates in the Ice-core drilling in East Antarctica: actions should build on the outcomes of the Horizon 2020 project **Beyond EPICA** and contribute to the European endeavor which aims to obtain a 1.5 million year old ice-core from East Antarctica.

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CRYOSHPERE

The paleo-climate memory of the ice.

The glaciers and in particular the East Antarctic plateau record the paleoclimate traces of the environmental conditions of the Earth. To comprehend the influence of greenhouse gas emissions on climate system, it is essential to understand the variations occurred in the past.

The University of Bologna is present in Antarctica since 1988 and it takes part to the studies on the role of greenhouse gases concentration in mid-Pleistocene (900 to 1200 thousand years ago). **A key point to design effective mitigation and adaptation strategies to current changes** is unveiling the link among carbon cycle, ice caps, atmosphere and oceans behavior.

Deep ice cores are quantitative records of the Earth climate: **the discovery of sites with ice older than 1.5 million years is one of the scientific challenges currently underway.**

The University of Bologna is active, and equipped with geomatics instruments and Laboratories concerning:

- **site surveying using GNSS** for ice surface velocity field measurements and precise positioning of geophysical prospections
- **remote sensing and digital photogrammetry** to monitor ice surface changes and DSM production

HIGHLIGHTS

The research team of the University has participated in more than 20 scientific expeditions in Antarctica as temporary staff assigned to the International Antarctic Program (PNRA). **The University's research in the field has also been funded at international level:**

- **European Project for Ice Coring in Antarctica, EPICA, Dome C (East Antarctica)**: The University of Bologna was responsible for the implementation of geodetic control network around the deep drilling site. EPICA project successfully retrieved coring ice of 3270m, highlighting the paleo-climatic history of the last eight climate cycles of the planet occurred in the last 820 000 years
- Since 2016, the University of Bologna is Partner of the **H2020 Project Beyond EPICA - Oldest Ice** that has the objective to select the optimum drill site for ice older than 1.5 million of years. In case of success, a deep ice coring will be carried out in the identified site, extending the knowledge on greenhouse gases concentration in middle Pleistocene
- With the support of the **National Antarctic Program (PNRA)**, since 1988 the University contributes to several **International Projects**
- **VLNDEF** project: geodynamics of the Northern Victoria Land
- **ITASE** - Project endorsed by SCAR – The Scientific Committee on Antarctic Research that aims to establish how the modern atmospheric environment is represented in the upper layers of the Antarctic ice sheet (corresponding to a time span of about 200 years)
- Project **TALDICE**: the University has measured the ice surface velocity field in support of the deep ice cores carried out at Talos Dome

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HERITAGE-LED INNOVATIVE SOLUTIONS AND SERVICES

Cultural heritage is a resource for sustainable growth and quality of life in a constantly evolving society.

The University of Bologna develops methodologies and approaches for understanding the role of culture in the promotion of the sustainable development, covering a wide range of aspects.

Innovation in management and planning: Integration of heritage-led innovative regeneration approaches in spatial planning in rural, urban and peri-urban areas; Inclusion of better prevention, preparedness, resilient recovery and reconstruction of cultural heritage into spatial planning; Inclusion of the value of cultural ecosystem services in spatial and landscape planning; Knowledge, engagement and collaboration for resilient cultural heritage; Innovative training schemes for the promotion of sustainable tourism.

Innovation in technology: Innovative and creative methods for Cartographic heritage assets and their digital transformation; Advanced diagnostic methods applied to the composition and the state of conservation of historical and artistic artefacts; Innovative materials and technologies for conservation and restoration of artefacts; Contemporary urban mural, light-scape and sound-scape.

HIGHLIGHTS

The **Interdepartmental Centre for Applied Research on Buildings and Construction (CIRI-EC)** promotes research co-operation and innovation within industries and small/medium enterprises. Within CIRI-EC, the Research Unit "New technologies applied to restoration, recovering and requalification of existing buildings" aims at promoting urban and rural regeneration for vulnerable and deteriorated areas.

The **Microchemical and Microscopy Art Laboratory (M2ADL)** is primarily focused on the study of the physical and chemical nature of cultural heritage, addressing the technical and material nature of art objects and monuments and their conservation.

Innovative education schemes based on the promotion of cultural heritage such as the International Master Degree Course on Science for the Conservation and Restoration of Cultural Heritage (International Curriculum on "Science and Technologies for Cultural Heritage") and the Masters in Engineering of Building Processes and Systems, International Curriculum "Historic Building Rehabilitation".

The University of Bologna is involved and is coordinating EU funded projects aiming at developing solutions for a sustainable growth through cultural heritage. Among them: **ROCK** - *Regeneration and Optimisation of Cultural heritage in creative and Knowledge cities*, aims to develop an innovative and systemic approach to effective regeneration in historic city centres. The Creative Practiced in Cities and Landscapes (CPCL), a facilitator linked to the project, has been activated with the aim to reflect on actors and practices producing and re-negotiating cultural heritage as a common good. **RURITAGE** - *Rural regeneration through systemic heritage-led strategies* proposes solutions for the promotion of the Cultural and Natural heritage as a driver for competitiveness, sustainable and inclusive growth and development. Both projects are funded by Horizon 2020. **TExTOUR** - *Social Innovation and TEchnologies for sustainable growth through participative cultural TOURism*.

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NATURE BASED-SOLUTIONS

Living solutions that are inspired and supported by nature, which are efficient and cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience.

The research of the University of Bologna embraces a large spectrum of expertise ranging from concept development in the area of social science and humaties to innovative engineering solutions and it covers:

- Development and assessment of methodologies for testing blue/green/hybrid NBS efficacy against climate extremes at urban and non-urban territories via laboratory, field and multi-scale numerical simulations
- Development and assessment of new NBS products for a wide range of applications such as re-enforcement of river embankments through bio-engineering solutions, salt intrusion mitigation at transition territories i.e. river/sea transition, coastal erosions, landslides prevention, flood risk reduction
- Development and assessment of blue/green/hybrid infrastructures in the urban environment against heat waves, for the promotion of water and energy saving
- Development of innovative approaches for the replication of NBS in different environments such as coastal and mountain cities, river catchments
- Development and application of new methodologies of data fusion including geophysical, economic, social media data for the mapping and potential risk reduction analysis using NBS in worldwide territories
- Multi-disciplinary research for the assessment of climate adaptation strategies using NBS
- Integration of NBS and ecosysrtem services into urban planning accounting for their climate, environmental, social and health related benefits for a just transition of urban areas

HIGHLIGHTS

At the University of Bologna are currently available several laboratories such as:

- the atmospheric lab equipped with cutting-edge instrumentation for the in-situ and remote sensing monitoring of the atmosphere, as well as a front-end computational capacity for climate simulations and NBS climate scenarios
- the hydraulic lab for the realization of scaled experiments using NBS

The University of Bologna has been involved in several solutions-oriented national and European funded projects in which the usage of natural membranes can be used as substitute of current materials in engineering applications, among them: **H2020-OPERANDUM** - (*Open-air laboratories for nature-based solutions to manage hydro-meteo risks*) a project coordinated by the University that demonstrates NBS efficacy in the reduction of environmental risks caused by meteorological extreme events while clustering territorial innovation potential and socio-economics values through the establishment of Open-Air Laboratories; **FP7-WATER4CROPS** – *Integrating Bio-Treated Wastewater Reuse with Enhanced Water Use Efficiency to Support the Green Economy in EU and India* a project that investigates the re-usage of waste waters using NBS; **ACTonNBS** - *Adaptive Cities through Nature Based Solutions*.

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WASTE MANAGEMENT

Moving towards a sustainable and integrated management of the waste cycle.

The research of the University of Bologna covers a wide range of issues:

Prevention

Design of policy interventions and environmental impact assessment methodologies; Production, stabilization and packaging of stable by-products/ raw material; Implementation of industrial symbiosis practices and exchange of materials among different value chains - Food waste: Georeferenced mapping of industrial food by-products; Analysis of consumers and business behaviour; Awareness campaigns to sensitize populationn

Re-use

Development of a new generation of reliable, robust and cost-effective packaging materialss; Recommendation on legislation to re-use components from end-of-life products

Recycling

Pre-treatment plants to remove hazardous, rare earths and valuable components; Development of urban systems and technologies for circular and regenerative cities; Development of new plants, processes and technologies to recycle by-products and secondary raw materials from end-of-life products; Application of LCA to assess alternative recycling scenarios

Recovery

Innovative waste to energy plants; Chemicals and energy recovery from biomass

Disposal

End of life landfills

HIGHLIGHTS

The University is member of the Emilia Romagna Region **Food Crossing District**.

The **Italian Circular Economy Stakeholder Platform** and it is **partner of the EIT Raw Materials, EIT Food, EIT Climate-KIC**.

LOWINFOOD - Multi-actor design of low-waste food value chains through the demonstration of innovative solutions to reduce food loss and waste; **MERLIN** - Increasing the quality and rate of multilayer packaging recycling waste; **PRESERVE** - High performance sustainable bio-based packaging with tailored end of life and upcycled secondary use; **USABLE PACKAGING** - Unlocking the potential of Sustainable BiodegradabLe Packaging; INGREEN - Production of functional innovative ingredients from paper and agro-food side-streams through sustainable and efficient tailor-made biotechnological processes for food, feed, pharma and cosmetics; **RES URBIS** - *Resources from urban bio-waste*; **REFRESH** - *Resource Efficient Food and dRink for the Entire Supply cHain*; **NOAW** - *Innovative approaches to turn agricultural waste into ecological and economic assets*. **Bio-Based Industry JU: FIRST2RUN** - *Flagship demonstration of an integrated biorefinery for dry crops sustainable exploitation towards*; **Agrimax** - *Developing and demonstrating the production of multiple, high-value products from crop and food-processing waste*.

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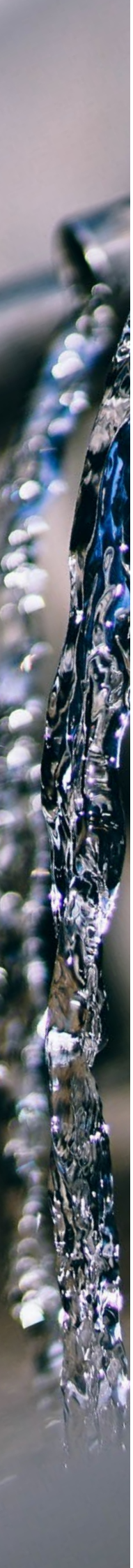
WATER RESOURCE MANAGEMENT

Moving towards a sustainable management of the different steps of the integrated water cycle.

The University of Bologna is developing technological and management solutions to increase the sustainability of water management.



The research of the University of Bologna covers a wide range of issues:

Drinking water

Water demand modelling; Optimisation of reservoir management and alternative water resources; Leakage reduction and energy efficiency in water distribution.

Wastewater and groundwater

Technologies for energy-efficient wastewater treatment and reuse, including fluid-dynamic analysis of equipment, nature-based solutions, membrane processes for water treatment and desalination, maintenance of water treatment & purification plants; Recovery and bioproduction of chemicals and biofuels from wastewater; Urban green technologies for wastewater valorisation; Bioremediation of aquifers; Geothermal energy production.

Water use in agriculture

Rainfall water collection, reuse and modelling; DSS for agricultural water management; IoT/ICT for precision irrigation; Modelling of salt ingression in agriculture in coastal areas.

Costs, benefits, impacts and risks

Costs/benefits, LCA and water footprint of water management solutions; Drought risk assessment; Water vulnerability analysis; Climate resilience and adaptation; Water policies and tariffs.

HIGHLIGHTS

Over the years the University of Bologna has been involved in national and EU funded **projects**, among them: **AQUAMONEY**, **WATER4CROPS**, **MINOTAURUS**, **ULIXES**, **FIGARO**, **MOSES**, **SWAMP**, **GST4WATER**, **AGROWETLANDS II**, **SWITCH-ON**, **TRUST**, **SMART WATERTECH**, **WATACLIC**, **CLARA**, **MADFORWATER**, **H2020 OPERANDUM** - *OPEn-air laboRAtories for Nature baseD solUtions to Manage environmental risks*, **PROSUMER** - Technical and economic feasibility study on industrial symbiosis of the full supply chain of phosphorus with particular reference to food and dairy industrial sectors, EIT Climate-KIC, 2020.

Facilities and infrastructures

Several facilities for a sustainable management of water are available at the University of Bologna, including pilot plants for wastewater treatment, laser and tomographic techniques for equipment optimization, green roofs for rainwater collection and reuse, sediment-transport flumes, DSS and wireless networks for precision irrigation.

Collaborations

The University of Bologna has established an extensive network of collaborations with water authorities, satellite imaging and software companies, water service utilities, companies and NGOs active in the water supply and wastewater treatment sectors.

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RAW MATERIALS

A sustainable and effective supply for primary and secondary raw materials management and process Multidisciplinary research groups of the University of Bologna are developing technological and management solutions for primary and secondary raw materials processing.

The research of the University of Bologna covers a wide range of issues:

Raw Materials Engineering

- Principles of mineral processing and plant design
- Raw materials for industry and for construction
- Substitution of Critical Raw Materials (CRMs): production and treatment optimization for innovative, low CRM, high-performance metallic materials
- Design and analysis of dedicated materials chain by a life cycle assessment approach

Exploitation of earth resources

- Characterization, modelling, and exploitation of mineral deposits
- Evaluation of resources and reserves also by geostatistical analysis
- Reclamation in planning, design and requalification projects

Secondary Raw Materials processing

- Recycling of raw materials, disassembly and mechanical treatment plants, removing of hazardous, rare earths elements and valuable components
- Development of new processes and technologies for secondary raw materials production from end-of-life products (WEEE, end-of-life tyres and vehicles, concrete and inert waste)
- Application of life cycle assessment (LCA)
- Implementation of circular economy and industrial symbiosis and development of models for secondary raw material in the anthroposphere analysis

HIGHLIGHTS

Facilities and equipments

The University of Bologna can count on:

- Laboratories for solid material characterization
- Circular Economy Lab for WEEE (Waste from Electrical Electronic Equipment) and CDW (Construction and Demolition Waste)
- Circular Economy Biotechnologies lab
- Instruments for soil and plant C and mineral determination, for mineral N in soil determination and for plant photosynthesis measurements

Collaborations and international research projects

The collaborations of the University of Bologna in the field span industries, multi-utilities, local authorities and research centers.

The University is partner of the EIT Raw Materials and the EIT Climate-KIC and it is involved in several international projects aiming at developing innovative solutions.

The University of Bologna is also member of the European Innovation Partnership on Raw Materials and it takes part to the activities of its Operational group whose mission is to provide high-level guidance to the European Commission, Members States and private actors.