

**Scheda dottorato in SCIENTIFIC, TECHNOLOGICAL AND SOCIAL METHODS ENABLING CIRCULAR ECONOMY**

<b>Dipartimento sede amministrativa</b>	Dipartimento di INGEGNERIA INDUSTRIALE - DII
<b>Coordinatore</b>	Prof. Manuele Dabalà
<b>Posti a concorso</b>	30
di cui	
Posti con borsa di studio finanziata con fondi ex DM 351/2022  <i>Vedasi elenco tematiche di ricerca in Appendice</i>	<p>BORSA N. 1 – Università degli Studi di Padova – <b>Curriculum:</b> Circular Biomaterials and Biorefinery;  <b>Tematica:</b> “Valorization of agri-food by-products by the sustainable production of polyhydroxyalkanoates (PHA) and green biofuels in the frame of the circular economy”</p> <p>BORSA N. 2 – Università degli Studi di Padova – <b>Curriculum:</b> Circular Biomaterials and Biorefinery;  <b>Tematica:</b> “Sustainable production of bioplastics”</p> <p>BORSA N. 3 – Università degli Studi di Bologna – <b>Curriculum:</b> Technical Materials for Circularity;  <b>Tematica:</b> “Chemical processes for the recovery of critical raw materials”</p> <p>BORSA N. 4 – Università degli Studi di Brescia – <b>Curriculum:</b> Circular Anthropogenic Environment and Society;  <b>Tematica:</b> “Ecological transition in the automotive sector”</p> <p>BORSA N. 5 – Università degli Studi di Cagliari – <b>Curriculum:</b> Circular Biomaterials and Biorefinery;  <b>Tematica:</b> “Integrated bio-electrochemical and biological processes for effective circular use of residues and bioproducts”</p> <p>BORSA N. 6 – Università degli Studi di Firenze – <b>Curriculum:</b> Circular Anthropogenic Environment and Society;  <b>Tematica:</b> “Interdisciplinary Circular and Nature-based solutions (I CAN)”</p> <p>BORSA N. 7 – Università degli Studi di Firenze – <b>Curriculum:</b> Technical Materials for Circularity;  <b>Tematica:</b> “End of life and innovative circular uses in the renewable energy field”</p> <p>BORSA N. 8 – Università degli Studi di Messina – <b>Curriculum:</b> Technical Materials for Circularity;  <b>Tematica:</b> “Catalytic technologies to close the carbon cycle”</p> <p>BORSA N. 9 – Università degli Studi di Milano – <b>Curriculum:</b> Circular Biomaterials and Biorefinery;  <b>Tematica:</b> “Improving the circularity of biodegradable bioplastics”</p> <p>BORSA N. 10 – Università degli Studi di Milano – <b>Curriculum:</b> Circular Biomaterials and Biorefinery;  <b>Tematica:</b> “Pale Green Crops for a Sustainable Agriculture and a More Efficient Production of Renewable Energy”</p> <p>BORSA N. 11 – Università degli Studi di Milano “Bicocca” – <b>Curriculum:</b> Technical Materials for Circularity;  <b>Tematica:</b> “Cigarette butts upgrading for the production of electro-catalytic materials per the hydrogen production technology”</p> <p>BORSA N. 12 – Università degli Studi di Milano “Bicocca” – <b>Curriculum:</b> Circular</p>



	<p>Biomaterials and Biorefinery; <b>Tematica:</b> “Biorefinery for safe-by-design nanomaterials”</p> <p>BORSA N. 13 – Università degli Studi di Napoli “Parthenope” – <b>Curriculum:</b> Circular Anthropogenic Environment and Society; <b>Tematica:</b> “EU Law and Circular Economy”</p> <p>BORSA N. 14 – Università degli Studi di Palermo – <b>Curriculum:</b> Circular Biomaterials and Biorefinery; <b>Tematica:</b> “Thermocatalytic decarbonization and valorization of residual organic matrixes in Zinc based molten salts”</p> <p>BORSA N. 15 – Università degli Studi di Roma “La Sapienza” – <b>Curriculum:</b> Circular Biomaterials and Biorefinery; <b>Tematica:</b> “Experimental investigation of biological CO<sub>2</sub> conversion to valuable organic components in waste biorefinery”</p> <p>BORSA N. 16 – Università degli Studi di Salerno – <b>Curriculum:</b> Technical Materials for Circularity; <b>Tematica:</b> “Development of new depolymerizable composite and elastomeric polymeric materials based on lactide and other bio-renewable cyclic esters”</p> <p>BORSA N. 17 – Scuola Superiore S. Anna – <b>Curriculum:</b> Circular Anthropogenic Environment and Society; <b>Tematica:</b> “Circular Economy and Industrial Symbiosis in a Life Cycle perspective”</p> <p>BORSA N. 18 – Università degli Studi di Torino – <b>Curriculum:</b> Circular Biomaterials and Biorefinery; <b>Tematica:</b> “Manipulation of stress conditions and responses in tomato (<i>Solanum lycopersicum</i> L.) to increase the extraction yield of secondary bio-based compounds”</p> <p>BORSA N. 19 – Politecnico di Torino – <b>Curriculum:</b> Circular Anthropogenic Environment and Society; <b>Tematica:</b> “Green innovations to achieve net zero CO<sub>2</sub> emissions: biofuels, negative carbon projects and carbon credits”</p> <p>BORSA N. 20 – Università degli Studi di Trento – <b>Curriculum:</b> Technical Materials for Circularity; <b>Tematica:</b> “Enabling circular economy by Additive Manufacturing methods for metallic tools repair”</p> <p>BORSA N. 21 – Università degli Studi di Venezia “Ca’ Foscari” – <b>Curriculum:</b> Circular Biomaterials and Biorefinery; <b>Tematica:</b> “Advanced materials for environmental applications”</p>
<p>Posti con borsa di studio finanziata ex DM 352/2022</p> <p><b>Vedasi elenco tematiche di ricerca in Appendice e</b></p>	<p>BORSA N. 22 – Università degli Studi di Padova – <b>Curriculum:</b> Technical Materials for Circularity; <b>Tematica:</b> “Chemical and sustainable approaches for the recovery and recycling of copper from waste” <b>Co-finanziata da:</b> MANICA S.p.A.;</p> <p>BORSA N. 23 – Università degli Studi del Piemonte Orientale “A. Avogadro” – <b>Curriculum:</b> Technical Materials for Circularity; <b>Tematica:</b> “Assessment and reduction of the environmental impact of civil and industrial waste by innovative treatment, separation, recovery and degradation processes” <b>Co-finanziata da:</b> Marazzato Servizi Ambientali Srl;</p>
<p>Borse dell’Ateneo/Ente convenzionato su fondi propri</p>	<p>BORSA N. 24 – Fondazione Edmund Mach – <b>Curriculum:</b> Circular Biomaterials and Biorefinery; <b>Tematica:</b> “Sustainable use of herbs waste in the diet of dairy cows for improvement of milk quality and reduction of carbon footprint”</p>

<p><b>Vedasi elenco tematiche di ricerca in Appendice</b></p>	<p>BORSA N. 25 – Fondazione Edmund Mach – <b>Curriculum:</b> Circular Biomaterials and Biorefinery; <b>Tematica:</b> “LCA applied to agriculture and agro-food processing chains in a mountain territory” BORSA N. 26 – Università degli Studi di Bari “A. Moro” – <b>Curriculum:</b> Circular Biomaterials and Biorefinery; <b>Tematica:</b> “Circular chemistry for safe and sustainable by design materials and processes”</p> <p>BORSA N. 27 – Università degli Studi della Basilicata – <b>Curriculum:</b> Circular Biomaterials and Biorefinery; <b>Tematica:</b> “LCA for the evaluation of different closed-loop systems of organic waste valorisation”</p> <p>BORSA N. 28 – Università degli Studi di Camerino – <b>Curriculum:</b> Technical Materials for Circularity; <b>Tematica:</b> “Methodologies for regenerative design at architectural and urban scales”</p> <p>BORSA N. 29 – Università degli Studi Politecnica delle Marche – <b>Curriculum:</b> Circular Anthropogenic Environment and Society; <b>Tematica:</b> “Investigating the impacts of EU Taxonomy on financial markets”</p> <p>BORSA N. 30 – Università degli Studi di Perugia – <b>Curriculum:</b> Circular Biomaterials and Biorefinery; <b>Tematica:</b> “Setting up better suited varieties by harnessing plant reproduction”</p>		
<p><b>Modalità di svolgimento</b></p>	<p>PRESELEZIONE PER VALUTAZIONE TITOLI E PROVA ORALE</p>		
<p><b>Prova orale a distanza</b></p>	<p>I candidati e sosterranno la prova orale a distanza utilizzando lo strumento della videoconferenza ZOOM.</p>		
<p><b>Criteri di valutazione delle prove e dei titoli e loro ponderazione</b></p>	<p>Punti per i titoli: massimo 60 Punti per la prova orale: massimo 40 I candidati potranno presentare domanda di ammissione per più di una tematica, con un limite massimo di 3 tematiche. La proposta di progetto sarà unica per tutte le domande presentate.</p>		
<p><b>Titoli da presentare</b></p>	<p><b>Curriculum:</b></p>	<p>Punti: massimo 54</p>	<p>- Profilo del candidato: 1) Documentazione comprovante la pertinenza del profilo del candidato rispetto alla priorità di interesse espressa per il tema vincolato e per il Curriculum del Corso di dottorato scelto; 2) Sommario esteso della tesi di laurea magistrale/specialistica/ vecchio ordinamento. Per i candidati che non hanno ancora conseguito il titolo di laurea magistrale (o equivalente), il sommario deve essere controfirmato dal relatore; 3) Proposta di progetto di ricerca attinente al tema vincolato per il triennio del dottorato. La proposta di progetto deve essere predisposta secondo il modello “PhD project proposal” disponibile al link <a href="https://www.unipd.it/dottorato/scientific-technological-social-methods-enabling-circular-economy">https://www.unipd.it/dottorato/scientific-technological-social-methods-enabling-circular-economy</a> (max punti 21). - Carriera del candidato: Media ponderata degli esami sostenuti nella Laurea Triennale (max punti 10) + Media ponderata degli esami sostenuti nella Laurea Magistrale/Specialistica (max punti 8) o media aritmetica degli esami sostenuti nella Laurea Vecchio Ordinamento (max punti 18). Per studenti con laurea straniera, è richiesto il Grade Point Average (GPA) per ogni titolo ottenuto (max punti 18). - Durata totale degli studi universitari (max punti 12)</p>

			- Altri titoli: 1) Periodi di studio/ricerca all'estero, comprese attività di virtual exchange, svolti nel corso degli studi (Borse Erasmus, Time, Erasmus Placement, tesi all'estero, etc.); 2) Esperienze lavorative post-laurea pertinenti (assegni di ricerca, borse di studio, periodi di stage certificato, periodi di impiego); 3) Premi scientifici pertinenti; 4) Altri titoli (ad esempio: attività di tutoraggio, didattica integrativa). (max punti 3)
	<b>Pubblicazioni scientifiche:</b>	Punti: massimo 3	Pubblicazioni scientifiche: lavori su riviste/convegni/libri e brevetti; (riportare il riferimento bibliografico completo [nomi autori, nome rivista o convegno, numero volume, anno di pubblicazione, pagine, DOI]). Si considerano anche i manoscritti accettati per la pubblicazione purché sia indicato il DOI. ATTENZIONE: elencare tutte le pubblicazioni nel modello "LIST OF QUALIFICATIONS" disponibile al link: <a href="https://www.unipd.it/dottorato/scientific-technological-social-methods-enabling-circular-economy">https://www.unipd.it/dottorato/scientific-technological-social-methods-enabling-circular-economy</a>
	<b>Lettere di referenze:</b>	Punti: massimo 3	Lettere di referenze del candidato (massimo n. 2) da parte di referenti universitari o industriali, da compilare tassativamente attraverso la procedura PICA.
<b>Preselezione per titoli. Prima riunione commissione giudicatrice</b>	<b>24 agosto 2022</b> alle ore 09:00		
<b>Pubblicazione esiti della valutazione titoli</b>	Entro il giorno <b>30 Agosto 2022</b> la commissione provvederà a pubblicare sul sito: <a href="https://www.unipd.it/dottorato/scientific-technological-social-methods-enabling-circular-economy">https://www.unipd.it/dottorato/scientific-technological-social-methods-enabling-circular-economy</a> gli esiti delle valutazioni dei titoli. Saranno ammessi alla prova successiva i candidati che avranno superato la preselezione per titoli, ottenendo un punteggio minimo di 70/100.		
<b>Pubblicazione del calendario delle prove orali a distanza e delle istruzioni per utilizzo dello strumento di videoconferenza ZOOM</b>	Entro il giorno <b>30 Agosto 2022</b> la commissione provvederà a pubblicare sul sito: <a href="https://www.unipd.it/dottorato/scientific-technological-social-methods-enabling-circular-economy">https://www.unipd.it/dottorato/scientific-technological-social-methods-enabling-circular-economy</a> il calendario delle prove orali a distanza e le istruzioni per l'utilizzo dello strumento di videoconferenza ZOOM relativamente ai candidati che abbiano superato la preselezione per titoli ottenendo il punteggio minimo previsto.		
<b>Prova orale</b>	06/09/2022 ore 09:00 - Eventuale proseguimento prova orale: 07/09/2022 ore 9:00, 08/09/2022 ore 9:00 – 09/09/2022 ore 9.00		

## **APPENDICE**

### **BORSA N. 1**

#### **D.M. 351/2022 Ambito: PNRR**

**Tematica:** “Valorization of agri-food by-products by the sustainable production of polyhydroxyalkanoates (PHA) and green biofuels in the frame of the circular economy”

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

Prof. Marina Basaglia

e-mail: [marina.basaglia@unipd.it](mailto:marina.basaglia@unipd.it)

**Hosting University/Research Centre:** Università degli Studi di Padova, Italy

**Department:**

Department of Agronomy, Food, Natural resources, Animals and Environment

Via dell'Università 16, 35020 Legnaro (PD) - Italy

<https://www.dafnae.unipd.it/en/>

**Description:**

Agri-food residues, including lignocellulosic biomasses and winemaking by-products (WB), are heterogeneous, underutilized, recalcitrant to degradation, and potentially polluting.

However, they are rich in substances useful for various industrial applications. With a multidisciplinary approach, we propose an in-depth characterization of the residual biomasses, selected for their high availability in the national context such as WB, the identification of valuable substances, and the development of extraction and purification technologies with green methods.

In a biorefinery context, the microbial conversion of these residues into bioproducts such as biogas, bioethanol, and, in particular, polyhydroxyalkanoates (PHA) will be evaluated. The production of biomolecules will be demonstrated using both cyanobacteria, autotrophic bacteria that use sunlight as an energy source, and heterotrophic microbial strains, suitably developed through innovative techniques of genetic engineering and microbial ecology.

**BORSA N. 2****D.M. 351/2022 Ambito: PNRR****Tematica:** "Sustainable production of bioplastics"**Curriculum:** Circular Biomaterials and Biorefinery**Contacts:**

Prof. Tomas Morosinotto

e-mail: tomas.morosinotto@unipd.it

**Hosting University/Research Centre:** Università degli Studi di Padova, Italy**Department:**

Department of Biology

Viale G. Colombo 3, 35131 Padova - Italy

<https://www.biologia.unipd.it/en/>**Description:**

The goal is to develop innovative and flexible biotechnological processes for the sustainable exploitation of CO<sub>2</sub>-rich emissions, converting them into:

a) clean biofuels

b) high value-added chemical components, such as polyhydroxyalkanoates (PHA) for the production of bioplastics or building-block molecules interesting for the pharmaceutical or the food industry.

The production of PHA or other high value-added CO<sub>2</sub> molecules from waste will be demonstrated using cyanobacteria, organisms that then use sunlight as an energy source, maximizing the sustainability of the process.

**BORSA N. 3****D.M. 351/2022 Ambito: PNRR****Tematica:** "Chemical processes for the recovery of critical raw materials"**Curriculum:** Technical Materials for Circularity**Contacts:**

Prof. Fabrizio Passarini

e-mail: [fabrizio.passarini@unibo.it](mailto:fabrizio.passarini@unibo.it)**Hosting University/Research Centre:** Alma Mater Studiorum - Università degli Studi di Bologna, Italy**Department:**

Department of Industrial Chemistry "Toso Montanari"

Viale del Risorgimento 4, 40136 Bologna - Italy

<https://chimica-industriale.unibo.it/>**Description:**

This project aims at developing a recycling process for strategic metals from urban and industrial wastes.

Metals, in particular transition metals and the rare earth elements (REEs), are fundamental for the transition to a greener society.

They have a key role in all of those technologies (e.g., permanent magnets, rechargeable batteries, catalysts, catalytic converters, superconductors etc.) that are involved in decarbonization, the reduction of energy consumption and the cutting of emissions.

The global demand for these strategical raw materials is increasing dramatically in recent years. In Europe, there are not enough primary sources to satisfy the demand and in some cases like the REEs and the PGMs (Platinum Group Metals) mine extraction is almost negligible. So, it has become of great importance to find new sources of metals like secondary (recycled) sources.

One of the biggest issues with metal recycling are the relatively small concentrations in the waste streams that make the recycling process not technologically feasible and economically expensive in many cases.

## **BORSA N. 4**

**D.M. 351/2022 Ambito: PNRR**

**Tematica:** "Ecological transition in the automotive sector"

**Curriculum:** Circular Anthropogenic Environment and Society

**Contacts:**

Prof. Federica Gasbarro

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**Hosting University/Research Centre:** Università degli Studi di Brescia, Italy

**Department:**

Department of Economy and Management

Contrada Santa Chiara, 50, 25122 Brescia - Italy

<https://www.unibs.it/en/node/57>

**Description:**

Decarbonizing transportation is a top global priority for mitigating climate change. A strong political commitment to decarbonization has emerged in Europe. The EU has set a binding target of achieving climate neutrality by 2050 and of cutting emissions by at least 55% by 2030.

Therefore, the EU is working on the revision of its climate, energy and transport-related legislation.

Phasing out of the combustion engine will require a transformation of the entire automotive industry.

There will be impacts on the automotive firms and indirect effects on supply chains and logistic systems.

Such low-carbon transition is a complex process envisaging the interplay of different strategies (e.g. introducing cleaner vehicles; sharing mobility; mobility as a service).

How traditional car manufacturers and original equipment manufacturers respond to coercive, normative and mimetic pressures towards carbon reduction targets will shape the transition to net-zero emissions at the industry level.

The project aims to investigate the ecological transition in the automotive sector from a business and management point of view.



## **BORSA N. 5**

### **D.M. 351/2022 Ambito: PNRR**

**Tematica:** "Integrated bio-electrochemical and biological processes for effective circular use of residues and bioproducts"

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

Prof. Michele Mascia

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**Hosting University/Research Centre:** Università degli Studi di Cagliari, Italy

**Department:**

Department of Mechanical, Chemical and Materials Engineering

Via Marengo 2, 09123 Cagliari - Italy

[https://www.unica.it/unica/en/dip\\_ingmeccanica.page](https://www.unica.it/unica/en/dip_ingmeccanica.page)

**Description:**

The waste biorefinery concept shifts the paradigm from fossil to renewable biological sources, as the proper combination of processes of different nature can maximize the recovery of resources from organic matrices which, managed in the traditional way, represent cost elements and potential sources of environmental impacts.

Among the possible combinations, the one that involves biochemical and electrochemical processes is one of the most interesting.

Biochemical degradation processes can hydrolyze and simplify the complex organic substance, giving rise to compounds that can be directly exploited or further processed to obtain also high-value products.

Bio-electrochemical processes can work on the outflows of biochemical processes or be coupled to these to enhance their performance or expand the range of recoverable products.

The project aims to investigate process schemes suitable to yield bio-based chemicals, energy carriers and bioproducts.

**BORSA N. 6**

**D.M. 351/2022 Ambito: PNRR**

**Tematica:** "Interdisciplinary Circular and Nature-based solutions (I CAN)"

**Curriculum:** Circular Anthropogenic Environment and Society

**Contacts:**

Prof. Federico Preti

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**Hosting University/Research Centre:** Università degli Studi di Firenze, Italy

**Department:**

Department of Agriculture, Food, Environment and Forestry

Piazzale delle Cascine 18, 50144 Firenze - Italy

<https://www.dagri.unifi.it/index.html?newlang=eng>

**Description:**

Development of Standards for:

- hydrogeological risk mitigation with locally available or recovered materials (Life Cycle Sustainability Assessment of green vs grey vs combined interventions; risk assessment for insurance);
- water-sediment-waste value-chain integration in circular economy, identification of governance models, optimal scale and smart technologies;
- impact analysis of the production (or procurement) and disposal (if any) of the materials (chemical, physical and industrial components).

**BORSA N. 7**

**D.M. 351/2022 Ambito: PNRR**

**Tematica:** "End of life and innovative circular uses in the renewable energy field"

**Curriculum:** Technical Materials for Circularity

**Contacts:**

Prof. Gianpaolo Manfrida

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**Hosting University/Research Centre:** Università degli Studi di Firenze, Italy

**Department:**

Department of Industrial Engineering

Viale Morgagni 40, 50134 Firenze - Italy

<https://www.dief.unifi.it/>

**Description:**

The topic of this PhD proposal will address the End of Life of different RES technologies of specific interest for Italy (geothermal, solar, wind, biomass, hydro), and the possibility of developing circular uses for resources (steel, aluminum, glass, copper, plastics, rare materials, use of water and land,...) and waste streams (carbon dioxide, recovery of heat/cold/minerals/chemicals).

The scientific approach will be through LCA, Sustainability LCA and exergo-ecological costing.

**BORSA N. 8**

**D.M. 351/2022 Ambito: Pubblica Amministrazione**

**Tematica:** "Catalytic technologies to close the carbon cycle"

**Curriculum:** Technical Materials for Circularity

**Contacts:**

Prof. Siglinda Perathoner

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**Hosting University/Research Centre:** Università degli Studi di Messina, Italy

**Department:**

Department of Chemical, Biological, Pharmaceutical and Environmental Sciences

Via Stagno d'Alcontres, 98166 Messina - Italy

<https://www.unime.it/it/dipartimenti/chibiofaram>

**Description:**

The thesis has the objective to develop novel catalytic technologies to close the carbon cycle, particularly in energy intensive industries.

Closing the carbon cycle and enabling a carbon circular economy in energy-intensive industries (iron and steel, cement, refineries, petrochemistry and fertilizers) are topics of increasing interest to meet the demanding target of defossilizing the production.

The focus is on CO<sub>2</sub> reuse technologies in this context. In particular, the aim is to pass from the current multistep technologies, where the use of a sequence of operations having different requirements and operative conditions determines an inefficient and costly process, to technologies where all the processes can be realized in a single step.

The activities planned for the PhD student relate to the development of fundamental knowledge for the demonstration of the feasibility (proof of the concept - PoC) of the technology.

They will therefore focus on the following aspects: i) synthesis characterization and evaluation of the electrodes and electrocatalysts for the selective reduction of CO<sub>2</sub>, ii) development of regenerable Ni(OH)<sub>2</sub> supported anodes that act as redox storage devices, and allow improvement in the efficiency and rate of the CO<sub>2</sub> reduction process, iii) development of membranes to be able to operate the devices in the presence of diluted CO<sub>2</sub> emissions, iv) development of a device for the PoC of the technology and preliminary assessment in terms of cost and emissions of CO<sub>2</sub> compared to multistep production.

**BORSA N. 9**

**D.M. 351/2022 Ambito: PNRR**

**Tematica:** "Improving the circularity of biodegradable bioplastics"

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

Prof. Fabrizio Adani

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**Hosting University/Research Centre:** Università degli Studi di Milano, Italy

**Department:**

Department of Agricultural and Environmental Sciences - Production, Landscape, Agroenergy

Via Celoria 2, 20133 Milano - Italy

<https://www.unimi.it/en/ugov/ou-structure/departement-agricultural-and-environmental-sciences-production-landscape-agroenergy>

**Description:**

Today, bioplastics certified as biodegradable and compostable are collected within biowaste and thus, their disposal follows waste management strategies used for organic wastes.

Composting represents a good approach in degrading bioplastics, limiting their leakage into the environment and solving the plastics issue.

Nevertheless, because it requires energy to be performed, it contributes positively to greenhouse gas emissions.

Because of this fact and in the light of the application of Circular Economy rules, new strategies for treating bioplastics, recovering material and energy, appear mandatory and useful to be investigated.

## **BORSA N. 10**

### **D.M. 351/2022 Ambito: PNRR**

**Tematica:** "Pale Green Crops for a Sustainable Agriculture and a More Efficient Production of Renewable Energy"

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

Prof. Paolo Pesaresi

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**Hosting University/Research Centre:** Università degli Studi di Milano, Italy

**Department:**

Department of Biosciences

Via Celoria 26, 20133 Milano - Italy

<https://www.unimi.it/en/ugov/ou-structure/departement-biosciences>

**Description:**

There is a need for a ground-breaking technology that enables a low input, sustainable agriculture.

This challenge will be addressed by investigating the use of pale green, high albedo, barley mutants, characterized by an improved water use efficiency and a reduced need of nitrogen for their cultivation, to increase the efficiency of bifacial Agriphotovoltaic plants.

More into details, the three-year project has the objective to characterize two barley pale-green mutants through:

1. the identification of mutated genes involved in the control of leaf pigment content;
2. the evaluation of their performance, i.e. resource use efficiency, yield and photovoltaic light conversion efficiency, under the Agriphotovoltaic cultivation conditions.

The expected results will lead to the definition of a new generation of pale green crops that can increase the albedo of cultivated areas without any deleterious effect on yield, while maximizing the use of resources and the efficiency of the Agriphotovoltaic technology.

**BORSA N. 11****D.M. 351/2022 Ambito: PNRR****Tematica:** "Cigarette butts upgrading for the production of electro-catalytic materials per the hydrogen production technology"**Curriculum:** Technical Materials or Circularity**Contacts:**

Prof. Carlo Santoro

e-mail: [carlo.santoro@unimib.it](mailto:carlo.santoro@unimib.it)**Hosting University/Research Centre:** Università degli Studi di Milano – Bicocca, Italy**Department:**

Department of Materials Science

Via Roberto Cozzi 55, 20125 Milano - Italy

<https://www.mater.unimib.it/en>**Description:**

The project would be aimed at upgrading cigarette butts by enhancing the cellulose acetate of the filter and producing char, which is, then also transformed into electrocatalysts for the hydrogen production technology.

Cigarette butts are currently not in any recycling chain.

**BORSA N. 12**

**D.M. 351/2022 Ambito: PNRR**

**Tematica:** "Biorefinery for safe-by-design nanomaterials"

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

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**Hosting University/Research Centre:** Università degli Studi di Milano – Bicocca, Italy

**Department:**

Department of Earth and Environmental Sciences

Piazza della Scienza 1 and 4, 20126 Milano - Italy

<https://www.disat.unimib.it/en>

**Description:**

Oleaginous microorganisms enable the production, from agro-industrial residual biomasses, of microbial oils of different compositions depending on the microorganism, the biomass used and the culture conditions.

The laboratory has in the past successfully produced microbial oil that have found applications in the tyre world as plasticizers or in animal feed. In this project, different formulations of microbial oils with different percentages of mono- and polyunsaturated fatty acids (including components such as long chain omega 3 fatty acids) will be produced in bioreactor, optimizing fermentation performances and subsequent extraction.

The efficacy and safety of the newly developed lipids, as well as their specific biological activity will be evaluated in lab using the model organism zebrafish (*Danio rerio*).

The environmental sustainability of the production processes will be addressed by Life Cycle Assessment (LCA) methodology.



**BORSA N. 13**

**D.M. 351/2022 Ambito: PNRR**

**Tematica:** "EU Law and Circular Economy"

**Curriculum:** Circular Anthropogenic Environment and Society

**Contacts:**

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**Hosting University/Research Centre:** Università degli Studi di Napoli "Parthenope", Italy

**Department:**

Department of Economy and Law

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<https://www.uniparthenope.it/ugov/organizationunit/243>

**Description:**

On 30 March 2022, the European Commission proposed a package of legislative measures as part of the European Green Deal (EGD) (previously announced in the Circular Economy Action Plan (CEAP)).

The project aims at analysing the impact of the new EU legislation on the internal market and the role of Member States, undertakings and individuals.

A basic knowledge of the general EU legal framework is crucial to understand the evolution of the legislative process and to evaluate the issues stemming from the application of the new rules on Circular Economy (CE).

A new concept of industry is going to rise through - among others - a massive reduction of pollution and the adoption of renewable energy in line with the green transition provided under the Next generation EU and detailed by National recovery and resilience plans. In this sense the project will combine institutional profiles (EU competences in environmental, energy and industrial policies; new models of governance in the context of CE) with those related to the internal market (like the impact on free movement of goods, services, consumers protection). Special attention will be reserved on the impact of EGD on EU competition law where the new legislations on CE will bring new elements for the traditional definition of markets, for the evaluation of distribution systems or agreements between undertakings to invest in R&D to reach the green goals. Part of the project will also refer to the new policy on State aids where the Commission Guidelines on climate, energy and environment offer a key perspective of the role that Member States may play for the effective creation of a circular economy model in EU.

## **BORSA N. 14**

**D.M. 351/2022 Ambito: PNRR**

**Tematica:** “Thermocatalytic decarbonization and valorization of residual organic matrixes in Zinc based molten salts”

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

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**Department:**

Department of Engineering

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<https://www.unipa.it/dipartimenti/ingegneria/en/index.html>

**Description:**

The ultimate goal of the project is providing proof-of-concept of the thermo-catalytic valorisation of residual organic wastes using zinc based molten salts to

- i) recover the energy content of the matrix by producing a low-carbon H<sub>2</sub>-rich fuel gas and
- ii) sequestrate the majority of the carbon content into a solid product suitable for further applications (e.g., biochar, nanocarbons, fertilizer, etc.) depending on its characteristics.

**BORSA N. 15**

**D.M. 351/2022 Ambito: Pubblica Amministrazione**

**Tematica:** “Experimental investigation of biological CO<sub>2</sub> conversion to valuable organic components in waste biorefinery”

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

Prof. Alessandra Poletti

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**Hosting University/Research Centre:** Università degli Studi di Roma “La Sapienza”, Italy

**Department:**

Department of Civil, Constructional and Environmental Engineering

Via Eudossiana 18, 00184 Roma - Italy

<https://www.dicea.uniroma1.it/en/>

**Description:**

The aim of the project is to investigate one of the possible stages of a waste biorefinery, where the CO<sub>2</sub> generated from the biological treatment of biodegradable organic residues is further processed to be converted to a range of organic molecules through chain elongation reactions.

Various process alternatives for the biological conversion of CO<sub>2</sub> into more complex, high-value, organic species will be experimentally investigated.

Residual biomass from waste/wastewater treatment will be used as a source of microorganisms to support the biological reactions.

The potential beneficial effect of combining CO<sub>2</sub> with other products and by-products of the biorefinery treatment units (H<sub>2</sub>, acetate, ethanol, ...) and the integration of biological and electrochemical processes will also be the focus of the research.

An integrated approach typical of process and environmental engineering will be required to conduct the research.

**BORSA N. 16**

**D.M. 351/2022 Ambito: PNRR**

**Tematica:** "Development of new depolymerizable composite and elastomeric polymeric materials based on lactide and other bio-renewable cyclic esters"

**Curriculum:** Technical Materials for Circularity

**Contacts:**

Prof. Claudio Pellecchia

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**Department:**

Department of Chemistry and Biology

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<https://www.dcb.unisa.it/en>

**Description:**

The project aims at the development of thermosetting resins that can be subjected at the end of their life to "chemical" recycling, that is to a depolymerization process that leads to the recovery of the starting monomers.

The proposed approach involves the synthesis of crosslinkable resins by means of bonds capable of cleaving in the presence of a suitable catalyst.

A similar approach could be used to design degradable cross-linked elastomers, suitably modulating the structure of the resin and of the cross-linking agent.

A further possibility is to develop new thermoplastic elastomers through the synthesis of ABA-type degradable copolymers (similar but alternative to those of the SBS type) where A is a "hard" crystalline block or in any case with a high T<sub>g</sub> and B is a "soft" block amorphous and low T<sub>g</sub>.

In particular, both "hard" and "soft" blocks could be based on easily depolymerizable aliphatic polyesters.

**BORSA N. 17**

**D.M. 351/2022 Ambito: Pubblica Amministrazione**

**Tematica:** "Circular Economy and Industrial Symbiosis in a Life Cycle perspective"

**Curriculum:** Circular Anthropogenic Environment and Society

**Contacts:**

Prof. Marco Frey

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**Department:**

Institute of Management

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<https://www.santannapisa.it/en/institute/management>

**Description:**

A circular transition requires a growing contribution from businesses which have to move beyond own organization boundaries and embrace a life cycle perspective by strengthening strategic collaboration with actors of the value chain.

The research project should explore internal and inter-organizational dynamics which support the adoption of circular economy practices as well as industrial symbiosis actions.

A further focus should be on detecting how collaborations within and among organizations as well as how policy makers and consumers may stimulate, also by means of a life cycle logic, innovative and creative solutions in terms of new circular products.

## **BORSA N. 18**

### **D.M. 351/2022 Ambito: PNRR**

**Tematica:** “Manipulation of stress conditions and responses in tomato (*Solanum lycopersicum* L.) to increase the extraction yield of secondary bio-based compounds”

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

Prof. Andrea Schubert

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**Hosting University/Research Centre:** Università degli Studi di Torino, Italy

**Department:**

Department of Agricultural, Forest and Food Sciences

Largo Paolo Braccini 2, 10095 Grugliasco, TO - Italy

<https://en.disafa.unito.it/do/home.pl>

**Description:**

Aim of the project is to optimize a circular cascading approach to valorise residual biomass from tomato commercial cultivation (shoots, roots and non-marketable fruit), replacing wasting/burning with cascading for the extraction of high-value compounds — with a non-exclusive focus on alkaloids.

The project will explore the effects of climate change-related stresses on the metabolic profile of tomato plants.

Both the metabolites and the transcriptional profile of the biosynthetic pathways will be assessed.

This will allow to develop novel uses for the stressed residual biomass, replacing wasting or burning with cascading for the extraction of high-value compounds. Additionally, bio-based micropeptides will be tested as elicitors of alkaloids and more in general, characterised as mediators of mitigation/acclimation responses to different abiotic stresses.

Biotechnological approaches based on the plant's own metabolic responses to stress will be explored, both for proof-of-concept of basic findings, and as tools for increased metabolite production via treatment with micropeptides, or gene editing/overexpression.

**BORSA N. 19****D.M. 351/2022 Ambito: PNRR**

**Tematica:** "Green innovations to achieve net zero CO<sub>2</sub> emissions: biofuels, negative carbon projects and carbon credits"

**Curriculum:** Circular Anthropogenic Environment and Society

**Contacts:**

Prof. Carlo Cambini

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**Hosting University/Research Centre:** Politecnico di Torino, Italy

**Department:**

Department of Management and Production Engineering

Corso Duca degli Abruzzi 24, 10129 Torino - Italy

<https://www.digep.polito.it/en>

**Description:**

The project aims at analysing the economic dimensions of greenhouse gas emissions' reduction and sequestration potential offered by innovations in biofuels and negative carbon technologies such as biochar.

The research will assess the effectiveness of existing standards and develop new methodologies for the accounting of carbon credits.

While this market is still in its infancy, demand is rising rapidly and the process of certifying emission offsets from innovative technologies is not clearly defined.

Governments and companies are highly interested in this application to achieve their decarbonization commitments, but for now the reporting of emission reductions through this pathway remains ambiguous.

The project will combine the exploration of market potential and key actors for the development of new green solutions with policy insights on certification and transparent mechanisms to regulate these growing markets.

**BORSA N. 20**

**D.M. 351/2022 Ambito: PNRR**

**Tematica:** "Enabling circular economy by Additive Manufacturing methods for metallic tools repair"

**Curriculum:** Technical Materials for Circularity

**Contacts:**

Prof. Massimo Pellizzari

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**Hosting University/Research Centre:** Università degli Studi di Trento, Italy

**Department:**

Department of Industrial Engineering

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<https://webapps.unitn.it/du/en/StrutturaAccademica/STO0008625/Person>

**Description:**

Repairing of metal parts, by means of additive manufacturing (AM), take on particular importance for complex and high-value components, whose replacement would be expensive in terms of both part cost and line shutdown. However, the literature lacks information about the quantification of the cradle-to-grave environmental benefits of repair-based manufacturing approaches.

The very limited number of papers available highlights high potential savings of raw materials, energy, and pollution. However, improved exploitation of repairing enabling circular economy will rely on important technical aspects like the best repairing technology for a given form of damage, the optimum repairing strategy, the selection of suitable materials, processing parameters, finishing operations, and post-heat treatment.

Most case studies reported in literature rarely consider the general frame, proposing solutions that are lacking and poorly applicable in practice.

Part of them do not consider the environmental and economic impacts, at all.

Aim of this project is to approach the repairing of tools and dies using a global approach.



**BORSA N. 21**

**D.M. 351/2022 Ambito: PNRR**

**Tematica:** “Advanced materials for environmental applications”

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

Prof. Alberto Vomiero

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**Hosting University/Research Centre:** Università degli Studi di Venezia “Ca’ Foscari”, Italy

**Department:**

Department of Molecular Sciences and Nanosystems

Via Torino 155, 30170 Venezia Mestre - Italy

<https://www.unive.it/dep.dsmn>

**Description:**

The project focuses on the end-of-life valorization of biobased- and bio-materials, of agro-food waste and of biobased-products or on the closure of the cycle for end-of-life materials and products of anthropogenic origin such as plastics, construction materials, composites, etc.

The PhD candidate will study chemical and engineering solutions for the recovery-reuse-recycle of agro-food waste or of waste materials of anthropogenic origin towards the synthesis of advanced functional materials and functional biobased molecules to be applied in several different sectors that span from packaging, wellness, pharma, medical, energy and environmental remediation.

Potential applications may include (but are not limited to): solar energy conversion and solar fuels, batteries, hydrogen production, CO<sub>2</sub> capture and reduction, production of high-value chemicals, novel bioplastics and biofilms, water purification, valorization of agro-industrial wastes and others.

All the scientific aspects of the new materials will be considered, from structure, to functionality, including material modeling, aiming at tuning and controlling the functional properties according to the requirements of the final application.

**BORSA N. 22**

**D.M. 352/2022**

**Co-financed by: MANICA S.p.A.**

**Tematica:** “Chemical and sustainable approces for the recovery and recycling of coppber from waste”

**Curriculum:** Technical Materials for Circularity

**Contacts:**

Prof. Silvia Gross

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**Hosting University/Research Centre:** Università degli Studi di Padova, Italy

**Department:**

Department of Chemical Sciences

Via Marzolo 1, 35131 Padova - Italy

<https://www.chimica.unipd.it/en/>

**Description:**

The Ph.D project will concern the development of a new and sustainable process for the synthesis of copper salts (e.g. copper sulphate), starting from metallic copper, for agriculture purposes.

The focus will be on the possibility of using copper from wastes as raw material: within this framework, also the recovery of other metals (e.g. Ni, Fe, Mn, Cd, Zn), which are present as impurities, will be evaluated in a circular economy perspective.

Waste copper sources are, for example, cables, home appliance's components, exhausted print circuit cardboards, and fishing nets.

During the project will be considered the upscalability of the copper leaching process, also its sustainability in terms of water consumption and energy efficiency; the overall safety by avoiding the use of aggressive reagents, and the LCA of the final product.

Characterization of the synthesized compound will be performed, such as UV-Vis, IR and Raman spectroscopy, X-ray techniques, thermogravimetric analysis.

**BORSA N. 23**

**D.M. 352/2022**

**Co-financed by: Marazzato Servizi Ambientali Srl**

**Tematica:** "Assessment and reduction of the environmental impact of civil and industrial waste by innovative treatment, separation, recovery and degradation processes"

**Curriculum:** Technical Materials for Circularity

**Contacts:**

Prof. Enrico Boccaleri

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**Hosting University/Research Centre:** Università degli Studi del Piemonte Orientale "A. Avogadro", Italy

**Department:**

Department for Sustainable Development and Ecological Transition

Piazza Sant'Eusebio 5, 13100 Vercelli- Italy

<https://disste.uniupo.it/> /

**Description:**

The project intends to study strategies to identify, analyse and treat industrial and civil wastes with novel energy-efficient and environmentally-friendly processes.

The aim is scouting and developing methodologies based on separation, sequestration, degradation and treatment methods able to: i) minimize the impact of critical and emerging pollutants, ii) reduce landfilling, iii) promote end-of-waste valorization and circular economy.

The project must consider the development of innovative methods on a laboratory scale and the possibilities of integration of research on a pilot scale up to the scale-up of processes in the industrial context, with the aim of i.e. matching the needs of carbon-and energy-intensive processes needs, assessing innovative strategies using gasification methods, identifying and developing highly absorbent materials from sustainable feedstocks for hard-to-abate specific organic and inorganic pollutants present in civil and industrial streams.

The activity will be located in Vercelli, in collaboration with the company "Marazzato Servizi Ambientali"

## **BORSA N. 24**

**Tematica:** “Sustainable use of herbs waste in the diet of dairy cows for improvement of milk quality and reduction of carbon footprint”

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

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**Hosting University/Research Centre:** Fondazione Edmund Mach, Italy

**Department:**

Research and Innovation Centre

Via Edmund Mach 1, 38098 San Michele all'Adige TN - Italy

<https://cri.fmach.it/en/>

**Description:**

Huge amounts of biowaste materials are produced from industries, such as cosmetic and essential oils industries during the extraction of the bioactive compounds.

This waste need proper methods of valorisation in the circular bioeconomy model for their sustainable uses to reduce their environmental burdens.

Many different plant bioactive compounds have been explored to manipulate ruminal microbial feed fermentation and lower methane emissions without affecting production performances of ruminants because of their antimicrobial properties.

With this project we want to use industrial herbs waste to improve ruminal fermentation and milk production, decrease methane production in dairy cattle, and subsequently reduce carbon footprint of milk production.

Therefore, we want to study the effect of industrial herbs waste on ruminal fermentation in vitro and milk production performance, methane production and health of dairy cows.

Finally, the outcomes of this project will also contribute to establish initiative for green, clean and viable environment for a healthy society.

**Tematica:** "LCA applied to agriculture and agro-food processing chains in a mountain territory"

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

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Research and Innovation Centre

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**Description:**

The concept of "Measurement of the processing cycles sustainability" is well present in all the strategies for sustainable development recently launched by the EC and those approved at national and local level.

The project is aimed at create within Fondazione Edmund Mach advanced competences on the Life Cycle Assessment (LCA) methodology in order to apply it in an operational way, to support experimental activities and local stakeholders in the implementation of sustainable action plans.

The assessment of the environmental impacts caused by the agri-food processing chains located in mountain regions needs the development of tailor - made approachs, based on the sharing of available data-base and the implementation of new data collected on site.

The use of LCA tool based on recognized international standards is one of the possible pathways to define the best compromise in terms of sustainability along the full producing chain.

## **BORSA N. 26**

### **Borsa di Ateneo**

**Tematica:** "Circular chemistry for safe and sustainable by design materials and processes"

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

Prof. Maria Lucia Curri

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**Hosting University/Research Centre:** Università degli Studi di Bari "A. Moro", Italy

**Department:**

Department of Chemistry

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<https://w3.uniba.it/ricerca/dipartimenti/chimica/en/home>

**Description:**

The paradigm shift towards a circular economy requires the integration of safety and sustainability in the development of new materials and processes.

Safe and Sustainable by Design (SSBD) principles integrate the safety, circularity and functionality of advanced materials, products and processes throughout their life cycle.

For the development of innovative materials, SSBD includes identifying suitable starting materials, possibly bio-based alternatives to substances of concern and modifying them in order to achieve optimal properties and functionality in the specific application.

These concepts match the principles of circular chemistry that aims at producing safer and more sustainable materials by means of more efficient processes, using non-hazardous and renewable raw materials, reagents and solvents and moving away from the use and dispose principle. At the same time valorisation of bio-based and waste product can be also developed.

The deployment of these strategies can turn in processes and materials that can find applications in a variety of fields, encompassing the development of environmentally friendly catalysts for the synthesis of sustainable products by means of alternative synthetic strategies, the manufacture of complex hybrid smart materials able to perform a variety of functions for application in healthcare, food and agriculture.

## **BORSA N. 27**

### **Borsa di Ateneo**

**Tematica:** "LCA for the evaluation of different closed-loop systems of organic waste valorisation"

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

Prof. Donatella Caniani

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**Department:**

School of Engineering

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<https://ingegneria.unibas.it/site/home.html#>

**Description:**

In the framework of the activities of the DeCost project, the PhD project is aimed at an accurate environmental assessment for the new waste management model must be carried out.

LCA will be the used tool following the guidance provided in the Product Environmental Footprint Guide.

Different waste management closed-loop systems of organic waste valorisation, integrating decentralised home and community composting systems with urban agriculture, for instance, will be compared by applying a LCA approach.

## **BORSA N. 28**

### **Borsa di Ateneo**

**Tematica:** "Methodologies for regenerative design at architectural and urban scales"

**Curriculum:** Technical Materials for Circularity

**Contacts:**

Prof. Federica Ottone

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**Hosting University/Research Centre:** Università degli Studi di Camerino, Italy

**Department:**

School of Architecture and Design

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**Description:**

Developing a planning-design methodology that aims to identify new possibilities to orienting the transformation process of the built environment toward a circular process that harnesses the potential of using and transforming of the waste materials-sourced from different sectors-or natural-based materials (NBS) with zero impact.

In this framework, it is intended to work in two possible directions, placing side by side the "cradle to cradle®" concept, regarding a continuous cycle of reuse of materials or components, with that of "upcycling" linked to the qualities of the project to be developed: physical-performance qualities, qualities in terms of the possibility of reuse (design for disassembly), environmental qualities to reduce the effects of climate change, and symbolic and aesthetic qualities.

The development of a parametric design methodology, based on the principle of impact prediction, is based on the redefinition of categories and indicators useful for optimizing and balancing different options and tying processes to different environmental, social and economic contexts.



## **BORSA N. 29**

### **Borsa di Ateneo**

**Tematica:** “Investigating the impacts of EU Taxonomy on financial markets”

**Curriculum:** Circular Anthropogenic Environment and Society

**Contacts:**

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**Hosting University/Research Centre:** Università degli Studi Politecnica delle Marche, Italy

**Department:**

Department of Management

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<https://www.dm.univpm.it/>

**Description:**

The European Commission published in 2019 the EU Taxonomy on Sustainable Finance.

With a disruptive nature, completely new in this landscape, it represents a combination of a consolidation and indirect approach to regulation. In fact, on the one hand, the EU Taxonomy consolidates existing sector-specific environmental regulations, introducing strict technical criteria to establish to what extent company's activities are environmentally sustainable.

On the other hand, the EU Taxonomy follows an indirect approach that introduces sustainability-linked transparency requirements for financial market participants offering sustainable financial products. In other words, “finance” (offer side of capital markets) can be claimed “sustainable” only if capital flows are directed towards companies (demand side) in line with sector-specific environmental regulations recalled in the EU Taxonomy.

The EU Taxonomy is therefore expected to put pressure on companies to pursue corporate investment strategies aimed at improving their sustainability profile in order to avoid missing out funding opportunities.

The aim of the project is to investigate the impacts of the EU Taxonomy on the capital markets, considering both the offer and the demand of financial capital.

## **BORSA N. 30**

### **Borsa di Ateneo**

**Tematica:** "Setting up better suited varieties by harnessing plant reproduction"

**Curriculum:** Circular Biomaterials and Biorefinery

**Contacts:**

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**Hosting University/Research Centre:** Università degli Studi di Perugia, Italy

**Department:**

Department of Agricultural, Food and Environmental Sciences

Borgo XX Giugno 74, 06121 Perugia - Italy

<http://dsa3.unipg.it/en/>

**Description:**

Apomixis is an alternative way to sexual reproduction that some plants use to produce viable seeds containing genetic clones of the female parent.

Although it is regarded as a promising tool for breeders and farmers, apomixis does not occur in most food crops.

The conversion of a sexual reproducing genotype to one that reproduces by apomixis would make it possible to fix the genotype of a plant variety selected for a particular environment or market niche, whereby the clonally reproduced seeds could be continuously and inexpensively produced, independent of pollination or pollinator.

Harnessing the important potential of apomixis will help in win the challenge of a growing population facing pressures due to climate change and strong societal demands on health and biodiversity preservation.

Moreover, apomixis could allow the development of varieties with increased primary and by-products, reduced waste and better suited for energy production in a circular economy point of view.