



# CORDIS Results Pack on creating pathways to sustainability

A thematic collection of innovative EU-funded research results

November 2019

## A better relationship between the planet and its people



Research and  
Innovation

# Contents

3

**New nature-inspired membrane filter offers fresh hope for water recycling**

5

**The true costs of our healthy habits**

7

**Benefit-sharing as a tool for equitable change**

9

**Turning carbon dioxide waste into carbon building blocks**

11

**Myth or reality? Lifting the veil on the neighbourhood effect**

13

**New biosensors help control phenylketonuria disease**

15

**New app tells farmers how much fertiliser their crops need**

17

**Richer understanding of terrestrial carbon cycles aids more accurate climate change modelling**

# Editorial

## A better relationship between the planet and its people

Innovative frontier research supported by the European Research Council is paving the way towards a more sustainable future. This CORDIS Results Pack showcases eight cutting-edge projects at the forefront of this process.

Sustainability is our ability to meet the needs of the present without compromising those of the future. The concept has a clear environmental component. Over the next 10 years, for example, we will need to make considerable efforts if we are to achieve the goal of stabilising global warming below 1.5 °C that was spelt out in the Paris Agreement. Moreover, most definitions of sustainability also include a social and economic dimension. The UN's Sustainable Development Goals Report 2018 shows we are not meeting our targets on a wide range of societal challenges. According to the report, violent conflict and forced displacement is now one of the main drivers of food insecurity in 18 developing countries.

How to bridge the rift between the goals and reality? The European Research Council (ERC) is encouraging the highest quality research in Europe through competitive funding. In doing so, the ERC is supporting some of the sharpest minds in Europe and beyond, as they seek to deepen our understanding of the challenges we face, and to provide innovative solutions.

## The public and policymakers hand-in-hand

Mass protests and climate movements that have recently broken out all over the world show that sustainability is very much on people's minds. Policymakers have not lagged behind. In the last 40 years Europe has put in place some of the world's highest environmental standards, along with ambitious climate policies, and has championed the Paris Agreement.

Many sustainability challenges are vastly complex and uncertain. Developing robust knowledge that can lead to sustainable innovations and evidence-based policy is therefore key. This is why the European Commission is launching a forward-looking debate on sustainable development, as part of the broader reflection opened by the White Paper on the Future of Europe in March 2017.

So while there is debate on what a sustainable future could look like, work supported by the ERC, as part of Horizon 2020, is helping us to better understand the complex balance between the needs of a growing global population and the planet which sustains it.

## A taste of what's to come over the following pages

This Results Pack showcases the work of eight projects, supported as part of the ERC's promotion of frontier research, and explores topics such as new approaches to the filtration of drinking water, a closer look at the impact of living in deprived neighbourhoods, and innovative approaches to food production.



# New nature-inspired membrane filter offers fresh hope for water recycling

Water covers 70% of our planet, but only 3% of it is fresh water. Two thirds is in frozen glaciers unavailable for our use. With the world experiencing increased water stress and water shortages, smart solutions are urgently required. Recycling and seawater desalination are becoming a necessary part of the water infrastructure. The ANEMONE project has come up with a water recycling solution that gets around previous hurdles.

Water stress is an increasing global problem. Rapid urbanisation, population growth and the effects of climate change are all resulting in demand for water exceeding supply.

Some regions of the world are responding with water recycling and seawater desalination solutions.

But when it comes to water recycling for safe drinking, the range of options is increasingly dependent on membrane filtration. While these systems are effective, the energy required for safe processing makes the operating costs too high for them to be widely adopted, especially in less industrialised parts of the world where they are needed most.



## A practical solution to biofouling

Membrane filtration is highly effective for water treatment, producing very clean water as the small pores of the membrane filter create an effective barrier to particles and pathogens. It can also be used to remove dissolved salt from water and in some cases organic pollutants.

However, the high pressures often required for the process to operate effectively make it energy intensive and therefore expensive. Another common problem is biofouling, where micro-organisms adhere to the membrane and multiply, reducing the effectiveness of the membranes and necessitating downtime for cleaning.



*One strategy is to produce materials which have a nanoscale surface structure, which not only reduces biofouling, but is also antibacterial.*

Recently, there has been a move towards materials which are inherently resistant to biofouling, to inhibit or reduce biofilm formation.

“One strategy is to produce materials which have a nanoscale surface structure, which not only reduces biofouling, but is also antibacterial,

inducing bacterial death by stretching their cells over the nanopatterned surface until they rupture,” says ERC grantee Eoin Casey from University College Dublin.

With the EU-supported ANEMONE (Antibiofouling Nanopatterned Electrospun Membranes for Nanofiltration Applications) project, Casey’s team produced polymer-based membranes which were inspired by cicada wings using electrospinning, a method for fabricating nanofibres. Designed for integration into water filtration technologies, their chemical and physical properties could be adjusted.

The fibres produced from viscous polymer solutions, with diameters of up to 20 nm (nanometre), not only met the requirements of membrane filtration but also evidenced inherent antibacterial and antibiofouling effects – crucial for producing clean drinking water affordably.

ANEMONE’s work was based on the team’s previous investigation into the fundamental mechanics involved in membrane biofouling conducted under the ERC-funded project, AFFIRM. This project gave the team in-depth knowledge about exactly how bacteria behave in the unique setting of the liquid membrane interface.

“Our small-scale tests in a laboratory environment have been promising and will now allow the team to move towards producing more advanced prototypes of the technology,” says Casey.

## Critical technology for water recycling

If populations are to be protected from environmental threats, including water shortages, new and emerging commercially viable environmental technologies will have to be developed and supported.

ANEMONE’s technology will enable clean water to be produced at reduced cost with less use of chemicals, and so promises to be better for public health as well as the environment.

The team are now developing a prototype for testing within real-water systems. The demonstration data will provide the proof of concept for potential partners or investors.

---

### PROJECT

**ANEMONE – Antibiofouling Nanopatterned Electrospun Membranes for Nanofiltration Applications**

---

### HOSTED BY

University College Dublin in Ireland

---

### FUNDED UNDER

H2020-ERC

---

### CORDIS FACTSHEET

[cordis.europa.eu/project/id/768731](https://cordis.europa.eu/project/id/768731)



# The true costs of our healthy habits

The ASTAOMEGA project solves the problems linked to the production of omega-3 and antioxidants at the same time. The team promises higher production rates and improved sustainability at a lower cost.



© R\_Szatkowski, Shutterstock

We've all been told about the virtues of omega-3 fatty acids and antioxidants. The former help us fight depression and anxiety, cardiovascular events, mental decline, autoimmune diseases, asthma, metabolic syndrome and possibly even cancer. The latter are just as good: they protect us against free radical damage, keep our heart in good shape, lower the risk of infections and help prevent cancer.

Now, what if a single production platform could provide these substances more sustainably, and at a fraction of the cost? This is what the ERC-backed ASTAOMEGA (Implementation

of a sustainable and competitive system to simultaneously produce astaxanthin and omega-3 fatty acids in microalgae for aquaculture and human nutrition) project is all about.

"The key innovation brought by the ASTAOMEGA system is the use of a marine algal species (*Nannochloropsis gaditana*), which accumulates high levels of the omega-3 fatty acid eicosapentaenoic acid (EPA), to also produce the antioxidant astaxanthin," explains Matteo Ballottari, a professor and specialist in plant physiology at the University of Verona.

Not only is this combined production unique, but it also overcomes issues that current, isolated production methods have been facing for years.

Let's take astaxanthin. This is currently one of the most sought-after antioxidant complements but is also very expensive. The molecule can be produced by various microalgal species that can be cultivated in artificial, industrial setups, costing over EUR 2 000 per kg. A synthetic counterpart does exist and costs about half as much, but not without its own concerns. It is produced from petrochemical sources which raise questions related to toxicity and sustainability.

Current market prospects for omega-3, on the other hand, are hindered by production methods. Despite the fact that omega-3 are primarily found in microalgae, producers have been focusing on fish and krill oils because of their lower cost. This makes the whole sector very unlikely to meet the growing demand.


As Ballottari points out: "This is one factor, to which we have to add overfishing, depleting fish supplies and heavy metal contamination. Producing omega-3 directly from microalgae has been explored in the past, but the cost was just too high. It should also be noted that many biotechnological solutions proposed to increase lipid and fatty acid accumulation in microalgae lead to an increase in triacylglycerol (TAG) content, but also a decrease in omega-3 fatty acids."

ASTAOMEGA overcomes these problems with an economically sustainable process to produce natural astaxanthin. This process builds upon the findings of the SOLENALGAE project, which investigated the molecular mechanisms behind microalgae's photosynthetic activity. After 5 years of research, the project had successfully improved their photosynthetic efficiency.

ASTAOMEGA is going a step further by exploring strategies to increase the production rate of microalgae. The team notably

investigated how photoprotective mechanisms limit or enhance microalgal productivity, selected a strain from *Nannochloropsis gaditana* with high biomass productivity, and used it as a basis to produce both astaxanthin and EPA.

"We have been able to test production yields at different scales: We started from small lab scale photobioreactors (100 ml), before scaling up to a 60-litre scale in industrial systems. We are now planning for 300 or 1 000 litres," says Ballottari.



*We have been able to test production yields at different scales: We started from small lab scale photobioreactors (100 ml), before scaling up to a 60-litre scale in industrial systems. We are now planning for 300 or 1 000 l.*

By exploiting the market potential of astaxanthin, the team is confident that their method will sustain the higher cost of EPA production. "By the end of the project in February 2020, we will finalise all procedures to protect our intellectual property and prepare a business plan. Meanwhile, we will continue to investigate new solutions to improve yield and sustainability," Ballottari concludes.

---

#### PROJECT

**ASTAOMEGA – Implementation of a sustainable and competitive system to simultaneously produce astaxanthin and omega-3 fatty acids in microalgae for aquaculture and human nutrition**

---

#### HOSTED BY

University of Verona in Italy

---

#### FUNDED UNDER

H2020-ERC

---

#### CORDIS FACTSHEET

[cordis.europa.eu/project/id/825936](https://cordis.europa.eu/project/id/825936)





# Benefit-sharing as a tool for equitable change

The BENELEX project conducted the first systematic evaluation of how international law can support the use of benefit-sharing as a tool for equitable change.

Benefit-sharing is a general term used to define the fair and equitable sharing of the monetary and non-monetary benefits that arise from the use of genetic resources, most often within the sphere of bioprospecting. Valuable genetic resources are often found in developing countries, whereas bio-discovery labs are mostly located in developed countries. Because of this, benefit-sharing calls for the benefits derived from commercial discoveries to be shared between the countries where the researchers are based and the countries where the genetic resources originated.

Beyond this general understanding, however, there is a remarkable lack of clarity as to what benefit-sharing exactly entails and how it applies in relationships characterised by power and

capacity asymmetries. That is why the ERC-backed BENELEX (Benefit-sharing for an equitable transition to the green economy – the role of law) project conducted the first systematic evaluation of how international law can support the use of benefit-sharing as a tool for equitable change.

“The BENELEX project sought to understand whether benefit-sharing can be used within the contexts of bioprospecting, conservation, extractives, and knowledge production,” says ERC grantee Elisa Morgera. “Specifically, we looked at how international law can be used to support fair and equitable partnerships between countries in the Global North and the Global South, as well as among governments, indigenous peoples and the private sector.”



© Bannafaisal\_Stock, Shutterstock

## Benefit-sharing on the international stage

Benefit-sharing is currently being discussed within the framework of international processes involving the bioprospecting, agricultural, health care, maritime and deep-sea mining sectors.

"Benefit-sharing is often an issue at the national and local levels,

especially in the context of common uses of natural resources like logging and mining, as well as conservation initiatives and renewable energy development," explains Morgera.

Much of the controversy around benefit-sharing stems from fears that developing countries lack the funding and technology needed to benefit from a profit-driven, high-tech economy. Fur-

thermore, there is concern that indigenous and local communities will be marginalised as their contributions to, for example, environmental management can be difficult to capture in purely economic terms.

## The benefits of benefit-sharing

Against this backdrop, BENELEX researchers conducted an in-depth, inter-disciplinary and international investigation on how benefit-sharing can alleviate these fears. Despite the complexity of the research, the conclusion was clear: benefit-sharing can reframe many issues as an opportunity for mainstreaming equity across different international and environmental regimes, both among and within states.

"The project clarified how the international legal concept of fair and equitable benefit-sharing should be understood within

the framework of international human rights law and as a common approach for cooperation in areas like conservation, climate change, ocean governance, and bio-based research," says Morgera.

From this research, the BENELEX team produced training modules for advocates and lawyers of indigenous peoples and local communities. These modules provide practical guidance on operationalising benefit-sharing and concluding benefit-sharing agreements. Furthermore, the findings contributed to Principle 15 on benefit-sharing of the 2018 UN Framework Principles on Human Rights and the Environment.

Morgera and her team continue to advise various international organisations, civil societies and governments about benefit-sharing, and are currently working on publishing five books on the topic.

---

### PROJECT

**BENELEX – Benefit-sharing for an equitable transition to the green economy – the role of law**

---

### HOSTED BY

University of Strathclyde in the United Kingdom

---

### FUNDED UNDER

FP7-IDEAS-ERC

---

### CORDIS FACTSHEET

[cordis.europa.eu/project/id/335592](https://cordis.europa.eu/project/id/335592)

---

### PROJECT WEBSITE

[strath.ac.uk/research/strathclydecentreenvironmentallawgovernance/benelex](https://strath.ac.uk/research/strathclydecentreenvironmentallawgovernance/benelex)



*The project sought to understand whether benefit-sharing can be used within the contexts of bioprospecting, conservation, extractives, and knowledge production.*





# Turning carbon dioxide waste into carbon building blocks

By creating a conversion process for recycling carbon dioxide into feedstock, the CO2Recycling project is paving the way towards a sustainable chemical industry.



© petmalinak, Shutterstock

Not only are fossil fuels a finite resource, their use often emits the carbon dioxide (CO<sub>2</sub>) gasses that cause climate change. Both these factors create new challenges for the organic chemistry industry, which depends on fossil fuels as material for their industrial processes. Although CO<sub>2</sub> can be recycled as a carbon building block to produce organic chemicals, as a waste product, CO<sub>2</sub> is thermodynamically and kinetically difficult to transform.

Before CO<sub>2</sub> recycling can be used as raw material – or feedstock – an easy-to-use conversion process must be developed, which is exactly what the EU-funded CO2Recycling (A Diagonal Approach to CO<sub>2</sub> Recycling to Fine Chemicals) project has done. Leveraging the so-called ‘diagonal approach’, the project

designed novel catalytic transformations where CO<sub>2</sub> is reacted in just a single step. Using a functionalising reagent (a substance or compound added to a system to cause a chemical reaction) and a reductant that can be independently modified, the process can produce a large spectrum of molecules.

“The CO2Recycling process enables the use of CO<sub>2</sub> for the synthesis of amines, esters and amides – all of which were previously derived from fossil fuels,” explains Thibault Cantat, CO2Recycling project coordinator. “These materials can then be used as feedstock for the production of such important molecules as methylamines, acrylamide, and methyladipic acid.”

## Understanding CO<sub>2</sub> transformation

Using molecular catalysts to activate CO<sub>2</sub> and/or suitable reductants (hydrosilanes, hydroboranes, formic acid), researchers discovered new catalytic transformations, during which – for the first time – CO<sub>2</sub> was converted to methylamines. Researchers also successfully demonstrated the formation of esters and polyesters from the reaction between CO<sub>2</sub> and organosilanes. Furthermore, to create urea, carboxylic acids and methanol, the project unlocked a transformation that was previously only possible using petrochemicals.



*The CO<sub>2</sub>Recycling process enables the use of CO<sub>2</sub> for the production of amines, esters and amides – all of which were previously derived from fossil fuels.*

functional chemicals from CO<sub>2</sub>,” Cantat says. “The results are easily transposable and have numerous other practical applications. For example, basic chemicals such as methylamines, esters and aldehydes have already been prepared using CO<sub>2</sub>.”

## A sustainable chemical industry

The CO<sub>2</sub>Recycling project has led to the filing of 12 patents relating to the conversion of CO<sub>2</sub> and, indirectly, to the

production of dihydrogen and the conversion of carbon monoxide. It also provided training to several young researchers, with seven postdocs and PhD students having now started their careers in academia as professors and researchers.

However, CO<sub>2</sub>Recycling was just the starting point of a long-standing research programme that aims to unlock scientific challenges in the utilisation of renewable carbon feedstocks (CO<sub>2</sub>, biomass, and waste plastics) to improve the sustainability of the chemical industry. “I am happy that the project laid the groundwork from which we can further explore this vision and that our work can now continue with the support of an ERC Consolidator Grant,” adds Cantat.

---

### PROJECT

**CO<sub>2</sub>Recycling – A Diagonal Approach to CO<sub>2</sub> Recycling to Fine Chemicals**

---

### HOSTED BY

French Alternative Energies and Atomic Energy Commission in France

---

### FUNDED UNDER

FP7-IDEAS-ERC

---

### CORDIS FACTSHEET

[cordis.europa.eu/project/id/336467](https://cordis.europa.eu/project/id/336467)



# Myth or reality? Lifting the veil on the neighbourhood effect

There is a common belief that concentrating poor people in the same area and isolating them from wealthier neighbourhoods actually aggravates their situation. To investigate this assumption, the DEPRIVEDHOODS project used new approaches.

Many factors influence our path in life and eventually make us who we are. These include our parents, our friends, the school we go to, the career path we choose, and even the area we live in. The latter is actually an economic and social science concept of its own, commonly known as the 'neighbourhood effect'.

This effect notably implies that living in an area with a high concentration of poverty has a negative effect on the school outcomes of children and their future income as adults. In other words, deprived areas beget deprived people. This thinking has largely influenced policy-making, reinforcing this belief. But is this assumption really reliable?



© I Wei Huang, Shutterstock



"There is surprisingly little evidence that living in poorer neighbourhoods really affects individual lives. Research tends to focus on how neighbourhoods with high poverty concentration impact individual outcomes such as income. But what about the other way around? One's income also determines where one lives. The problem here lies in identifying the actual direction of causal effects," says ERC grantee Maarten van Ham, Professor of Urban Geography at TU Delft.

The DEPRIVEDHOODS (Socio-spatial inequality, deprived neighbourhoods, and neighbourhood effects) project was meant to overcome this problem. To do that, van Ham and his team investigated the long-term neighbourhood histories of a large number of people, from birth to adulthood. They studied neighbourhood effects for siblings and finally devised a method that models who moves to which areas/urban districts before proceeding to model actual neighbourhood effects.

"Project results show that the neighbourhood effect on income is biased upwards by the influence of the childhood family context. Ultimately, we concluded that adult neighbourhood experiences depict a neighbourhood effect on income, but that the childhood neighbourhood effect is essentially a childhood family context effect. We found that there is a long-lasting impact of the family context on income later in life, and that this effect is strong regardless of the individual neighbourhood pathway later in life," van Ham explains.

In a nutshell, while neighbourhood effects are usually small, they are significant for children and continue to impact them later in life. This phenomenon is even stronger for ethnic minorities, according to van Ham.

The project offers two additional insights into the issue. The first is that socio-economic segregation is increasing in European cities and that higher levels of segregation also come with higher levels of inequality.

Finally, the team found that this phenomenon should actually be seen as multi-dimensional and multi-scale. "Segregation

by income or ethnicity occurs not just in residential neighbourhoods, but also in schools, workplaces and leisure sites. Segregation in each of these domains is interconnected," says van Ham. "Segregation is also multi-scale as it occurs in a continuum of spatial scales, from micro to large urban regions. To understand the impact of segregation on individuals, it is therefore crucial to take a multi-scale perspective."

The ERC-funded project has received a lot of attention from the media and policy-makers. It has raised awareness about increasing levels of socio-economic segregation and its effects on individuals. Most importantly, it is an essential lesson for policy-makers: "There is now more awareness that creating mixed neighbourhoods is not a quick fix for social problems. It helps improve such areas, but not so much in advancing individual lives. In the long run however, mixed neighbourhoods can also benefit people in deprived areas," van Ham concludes.



*There is surprisingly little evidence that living in deprived neighbourhoods really affects individual lives.*

---

#### PROJECT

**DEPRIVEDHOODS – Socio-spatial inequality, deprived neighbourhoods, and neighbourhood effects**

---

#### HOSTED BY

TU Delft in the Netherlands

---

#### FUNDED UNDER

FP7-IDEAS-ERC

---

#### CORDIS FACTSHEET

[cordis.europa.eu/project/id/615159](https://cordis.europa.eu/project/id/615159)



# New biosensors help control phenylketonuria disease

The LABPATCH project is developing two innovative biosensors to help medical professionals better detect phenylalanine levels – a leading indicator of phenylketonuria disease.



Phenylketonuria (PKU) is a rare birth defect that results in decreased metabolism of the amino acid phenylalanine. If left untreated, the disease can cause intellectual disabilities, seizures, mental disorders and behavioural problems. However, if detected early via new-born screening programmes, the disease can be managed via a strictly controlled diet.

Unfortunately, due to a combination of the disease's rarity, the complexity of testing, and the high costs of the required lab equipment, many hospitals in developing countries do not regularly screen for PKU. The issue is further complicated by

the fact that home monitoring of blood phenylalanine levels is currently not feasible.

The ERC-funded LABPATCH (Lab-in-a-patch for PKU self-assessment) project aims to change this by developing enzyme-based biosensors that can easily detect phenylalanine (L-Phe) levels – a leading indicator of PKU. "By lowering the cost of the materials used for the measurements, the LABPATCH biosensors will be accessible to hospitals and patients in developing countries," says Paul Soto, a researcher with the project.

## Two innovative biosensors

Building on the biosensor work done during a previous EU-funded project, LT-NRBS, LABPATCH researchers are now developing a spectrophotometric enzymatic biosensor and an electrochemical biosensor. Regarding the former, the enzymatic assays used to measure the concentration of L-Phe levels are performed in 96-well plates. This allows samples from multiple patients to be analysed simultaneously and using high-throughput, which in turn permits L-Phe levels to be monitored more frequently.

"The biosensor demonstrates high sensitivity in the physiological range of L-Phe concentrations, meaning it can detect L-Phe levels

associated with the onset of PKU," explains project researcher, Morgane Valles. "The biosensor also makes use of immobilised enzymes, which increases its durability, ease-of-use and cost-efficiency."

As for the electrochemical biosensor, the patient wears this device at home as a patch. The patch contains electrodes modified with Phe-selective bioreceptors that automatically detect

their sweat's Phe levels in a non-invasive manner that does not require medical expertise or expensive facilities. The patch is connected to a miniaturised control unit for electrode operation and wireless data transmission to an external device (i.e. smartphone or tablet).

Validated on anonymised human blood samples spiked with different phenylalanine concentrations, the LABPATCH biosensors were found to be reproducible between sample batches.



*Through LABPATCH, patients can control Phe levels at home, giving doctors the data they need to better control the disease.*

## Making early detection more accessible

By developing low-cost, easy-to-use biosensors, the LABPATCH project is well-positioned to have a big impact on PKU detection in developing countries. "Typically, blood Phe concentrations are only analysed in specialised laboratories and at a frequency of just once or twice a month," says project researcher Rafael Artuch. "But with LABPATCH, patients can control Phe levels at home, giving doctors the data they need to better control the disease."

Despite these successes, project researchers note that there is room for improvement, particularly as to the reproducibility and chemical and thermal instability of the biosensors. "These inherent technological drawbacks of enzyme-based sensors can be mitigated through adequate biosensor characterisation and through protein engineering," adds Soto. "These improvements will be the focus of the next phase of the project."

---

### PROJECT

**LABPATCH – Lab-in-a-patch for PKU self-assessment**

---

### HOSTED BY

Institute for Bioengineering of Catalonia in Spain

---

### FUNDED UNDER

H2020-ERC

---

### CORDIS FACTSHEET

[cordis.europa.eu/project/id/790163](https://cordis.europa.eu/project/id/790163)





# New app tells farmers how much fertiliser their crops need

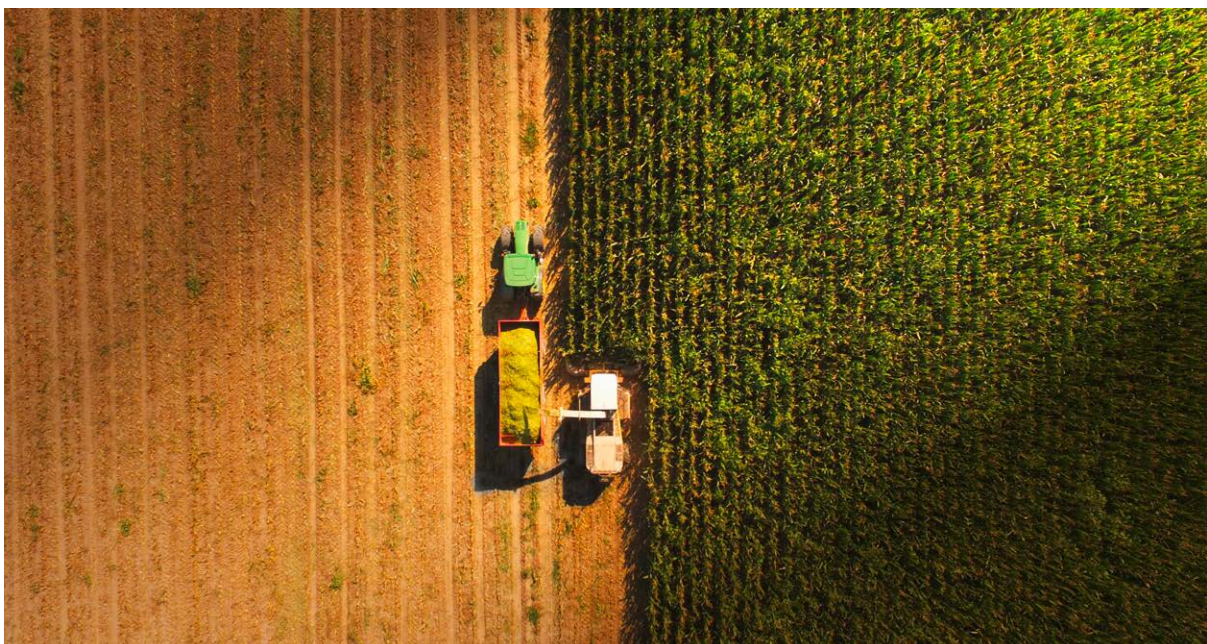
Being unable to accurately gage the nutritional needs of crops can result in over-fertilisation; polluting soil, air and water. LiveSEN has developed a real-time, portable biosensor that measures nitrogen levels and, with Big Data-driven recommendations, benefits farmers.

To increase soil fertility, it is common for farmers to use more fertiliser than crops actually need. While this approach helps ensure a good yield, it has negative economic and environmental consequences.

One answer would be for farmers to have access to accurate and timely information about the amount of nitrogen available in the soil, to adjust their inputs accordingly. However, the take-up of existing analytical tools is poor

because of costs and the laborious workflow relying on laboratory analysis.

The approach of the LiveSEN (In-Field Live Sensing of Nitrate in Crops for Real-Time Fertilization Adjustment) project, supported by an ERC Proof of Concept grant, was to measure nitrate levels directly from plant juice. This liquid sample not only simplified sample preparation, but also crucially made on-site analysis possible with single-use electrochemical biosensors.



© Saverio Biasi, Shutterstock

Validation experiments were performed in the lab, with the team now upscaling fabrication of the sensors. They are fine-tuning the inkjet printing process for enzymes deposition while looking for a manufacturer of screen-printed electrodes (SPE) to develop automated mass production plans.

As well as being costly, current analytical tools (such as nitrate ion-selective electrodes) are not single-use and so have to be cleaned between measurements and need frequent calibration. As they are also sensitive to different ions, their readings on complex samples (such as plant juice) can be inaccurate.

"We wanted to develop an on-site biosensor for immediate information about how much fertiliser a plant needs, usable without training, to bypass the need for technicians or expert consultants for sampling, measuring, data interpretation and decision making," says Nicolas Plumeré, professor at Ruhr University Bochum, who led the LiveSEN project.

In the project, the biosensor uses enzymes to detect nitrates which react with the electrode's electrons. The number of these electrons is measured to quantify the number of nitrate molecules present in the plant juice. The biosensor also incorporates systems to avoid interference (patent pending), including enzymes (oxidases) for removing dissolved oxygen which would otherwise also accept the electrons, giving a false reading.

The recommended nitrogen input is then provided immediately to farmers through a smartphone app connected to a cloud-based system.

"Farmers gave us feedback about the practicalities of using a high-tech device in all weather, possibly while operating farm equipment. This helped us redesign around their needs. They also flagged other priorities, such as phosphate and sulfate content, for which we are developing a similar sensor," says Plumeré.

The LiveSEN project will use Big Data to generate fertilisation recommendation maps from a combination of biosensor data, weather information, topographic information and multispectral satellite images (chlorophyll or 'greenness' maps of fields) from the EU's Copernicus project. This means fertilisation can be adjusted within a field, satisfying a crop's nutrient needs.

## Improving environmental management

LiveSEN's work is in alignment with the EU's Declaration of cooperation on 'A smart and sustainable digital future for European agriculture and rural areas'. Furthermore, it will allow individual farmers, as well as national bodies, to meet the criteria set by the EU Nitrates Directive (91/676/EEC).

Farmers will be provided with the sensors at production cost, enhancing the accuracy of Big Data prediction modelling. The LiveSEN package will then offer a paid-for fertilisation recommendation service through a smartphone or computer app.

"Our idea could increase agriculture yields by 5 to 10%, reducing costs and pollution, especially CO<sub>2</sub> emissions; with the production of nitrogen fertilisers accounting for over 1%," says Plumeré.



*Our idea could increase agriculture yields by 5 to 10%, reducing costs and pollution, especially CO<sub>2</sub> emissions; with the production of nitrogen fertilisers accounting for over 1 %.*

---

### PROJECT

**LiveSEN – In-Field Live Sensing of Nitrate in Crops for Real-Time Fertilization Adjustment**

---

### HOSTED BY

Ruhr University Bochum in Germany

---

### FUNDED UNDER

H2020-ERC

---

### CORDIS FACTSHEET

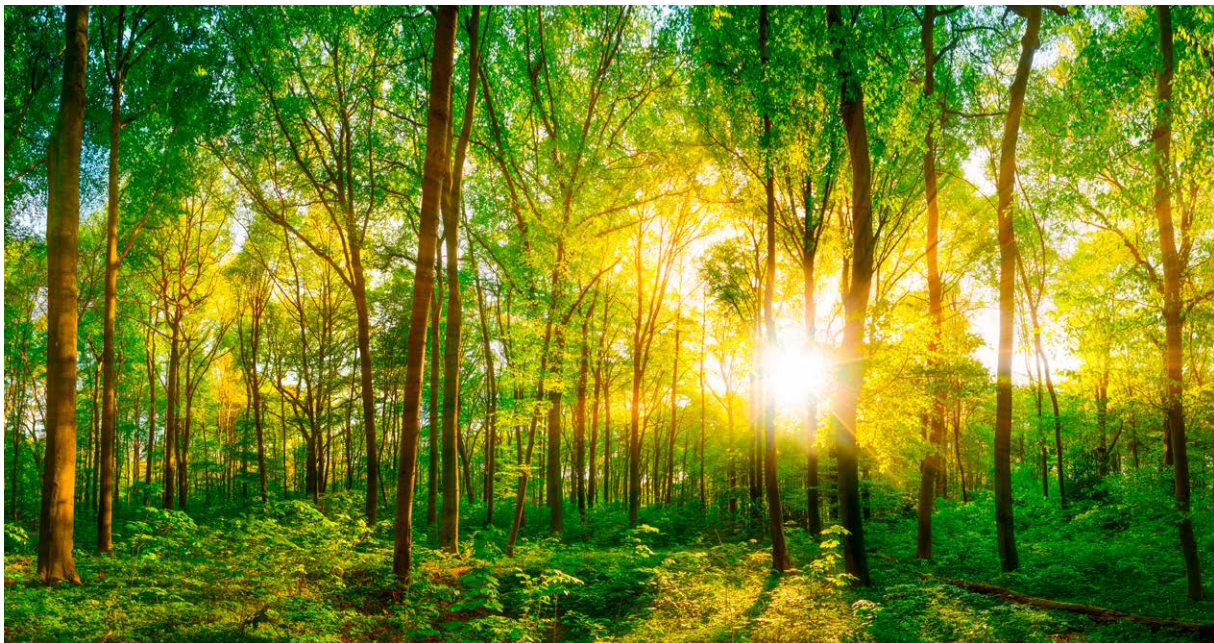
[cordis.europa.eu/project/id/790155](https://cordis.europa.eu/project/id/790155)





# Richer understanding of terrestrial carbon cycles aids more accurate climate change modelling

Quantifying the carbon storage potential of terrestrial ecosystems will have to take account of the relative contributions of photosynthesis and respiration to the global carbon cycle. The SOLCA project developed an ambitious approach to tackle this challenge.



© Guenter Albers, Shutterstock

Terrestrial ecosystems absorb 25-30% of fossil fuel carbon emissions. Photosynthesis by plants removes the largest amount of carbon from the atmosphere to make sugars that fuel plant growth. Plants and soil decomposers also release CO<sub>2</sub> back to the atmosphere through respiration.

The terrestrial biosphere is currently a net CO<sub>2</sub> sink because of a small imbalance between photosynthesis and respiration. To take full advantage of this carbon storage potential and predict its future response to climate change, these fluxes need to be determined more accurately.





*For the first time it is now possible to predict how soil CA activity varies across the land surface and to estimate the exchange of CO<sub>2</sub> and CO<sup>18</sup>O between soil surfaces and the atmosphere.*

Measuring photosynthesis and respiration separately poses an important challenge that must be tackled, as these processes underpin how carbon is cycled over land and are represented in current Earth System Models (ESMs) used to provide climate projections and mitigation guidance.

The ERC-funded SOLCA (Carbonic anhydrase: where the CO<sub>2</sub>, COS and H<sub>2</sub>O cycles meet) project used carbonyl sulphide (COS) and the oxygen isotope composition of carbon dioxide (CO<sup>18</sup>O) as tracers of photosynthetic activity. These are taken up by carbonic anhydrase (CA), an enzyme of photosynthesis that speeds up the hydration of CO<sub>2</sub> and the hydrolysis

of COS. CA is present in soils. The main objective of SOLCA was to identify the ecological and physical mechanisms driving CA activity in soils from different biomes.

## Putting in the spade work

The project team built a gas exchange system capable of measuring CO<sup>18</sup>O and COS fluxes simultaneously from climate-controlled soil microcosms. Using soils collected from biomes ranging from arid Mediterranean systems to moist boreal forests, and using modelling algorithms developed by the team, it was possible to estimate CA activity for the first time for both tracers. The chemical, structural and microbial properties of each of these soils were also measured to identify the drivers of CA activity across a range of continents and seasons.

This new knowledge was then incorporated into a unique ESM to relate atmospheric COS and CO<sup>18</sup>O concentrations to variations of photosynthesis and respiration at large scales. By comparing these predictions to real measurements collected by a global network of atmospheric stations, the team could refine estimates of global photosynthesis using these tracers.

"As hypothesised, when soils contain more microbial biomass, they tend to have higher CO<sub>2</sub> hydration and COS hydrolysis rates.

For the first time it is now possible to predict how soil CA activity varies across the land surface and to estimate the exchange of COS and CO<sup>18</sup>O between soil surfaces and the atmosphere," says Lisa Wingate, a research scientist at the National Institute for Agricultural Research, France, who led the project. "Understanding this link between soils (and plants) and the seasonal variability of CO<sub>2</sub>, COS and CO<sup>18</sup>O in the atmosphere can help improve the next generation of Earth System Models, reducing uncertainties in the responses of our ecosystems to future changes in climate."

## Supporting decarbonisation efforts

SOLCA's results will help develop new theories and modelling tools to improve our understanding of the carbon cycle over land. Most project datasets are currently openly available to the research community, with work ongoing to publish more.

Looking to the future, Wingate says: "As carbon dioxide removal strategies are being increasingly considered, our understanding of how CA activity responds to climate may now help us understand better how the natural weathering of silicate and carbonate rocks in ecosystems is regulated and provide nature-based solutions to remove CO<sub>2</sub> from the atmosphere by artificially enhancing weathering."

---

### PROJECT

**SOLCA – Carbonic anhydrase: where the CO<sub>2</sub>, COS and H<sub>2</sub>O cycles meet**

---

### HOSTED BY

National Institute for Agricultural Research in France

---

### FUNDED UNDER

FP7-IDEAS-ERC

---

### CORDIS FACTSHEET

<https://cordis.europa.eu/project/id/338264>



# CORDIS Results Pack

Available online in six language versions: [cordis.europa.eu/article/id/411479](https://cordis.europa.eu/article/id/411479)



## Published

on behalf of the European Commission by CORDIS at the  
Publications Office of the European Union  
2, rue Mercier  
L-2985 Luxembourg  
LUXEMBOURG

[cordis@publications.europa.eu](mailto:cordis@publications.europa.eu)

## Editorial coordination

Zsófia TÓTH, Silvia FEKETOVÁ

## Disclaimer

Online project information and links published in the current issue of the CORDIS Results Pack are correct when the publication goes to press. The Publications Office cannot be held responsible for information which is out of date or websites that are no longer live. Neither the Publications Office nor any person acting on its behalf is responsible for the use that may be made of the information contained in this publication or for any errors that may remain in the texts, despite the care taken in preparing them.

The technologies presented in this publication may be covered by intellectual property rights.

**This Results Pack is a collaboration between CORDIS and the European Research Council.**



European Research Council  
Established by the European Commission



@ERC\_Research



@EuropeanResearchCouncil



[europeanresearchcouncil](https://www.youtube.com/europeanresearchcouncil)

PRINT	ISBN 978-92-78-42021-5	ISSN 2599-8285	doi:10.2830/464834	ZZ-AK-19-019-EN-C
HTML	ISBN 978-92-78-42020-8	ISSN 2599-8293	doi:10.2830/043505	ZZ-AK-19-019-EN-Q
PDF	ISBN 978-92-78-42019-2	ISSN 2599-8293	doi:10.2830/481899	ZZ-AK-19-019-EN-N

Luxembourg: Publications Office of the European Union, 2019  
© European Union, 2019

Reuse is authorised provided the source is acknowledged.  
The reuse policy of European Commission documents is regulated  
by Decision 2011/833/EU (OJ L 330, 14.12.2011, p. 39).  
For any use or reproduction of photos or other material that is not under the EU copyright,  
permission must be sought directly from the copyright holders.  
Cover photo © Mopic, Shutterstock

## RESULTS PACK ON DISASTER-RESILIENT SOCIETIES

Eight EU-funded projects are working to minimise the devastating effects of man-made and natural disasters. Merging the utmost in resilience, spirit and social organisation in the complexity of today's society with the latest in cyber technologies yields a stunning range of crisis management and hazard avoidance systems to reduce damage to infrastructure and cut human suffering.



Check out the pack here:  
[cordis.europa.eu/article/id/410190](https://cordis.europa.eu/article/id/410190)



Publications Office  
of the European Union



Follow us on social media too!  
[facebook.com/EULawandPublications](https://facebook.com/EULawandPublications)  
[twitter.com/CORDIS\\_EU](https://twitter.com/CORDIS_EU)  
[youtube.com/CORDISdotEU](https://youtube.com/CORDISdotEU)  
[instagram.com/cordis\\_eu](https://instagram.com/cordis_eu)

EN