MOBILES NEWSLETTER N. 1

02/2025

MONITORING AND DETECTION OF BIOTIC AND ABIOTIC POLLUTANTS BY ELECTRONIC PLANTS AND MICROORGANISMS BASED SENSORS

The **MOBILES project** is an innovative project funded by the European Union under Horizon Europe Programme. By developing advanced electronic and organism-based biosensors, the project aims to detect and monitor harmful organic chemicals, antimicrobial-resistant bacteria, and pathogens across soil, water, and air. Furthermore, soil metagenomic analysis will be conducted on contaminated soils across Europe, and a metagenomic database will be constructed in order to identify a pool of genes linked to soil specific soil pollutants.

OUR VISION

MOBILES is dedicated to safeguarding environmental health through real-time, portable diagnostic tools, enabling rapid and precise detection of biotic and abiotic pollutants is soil, water and air.

KEY OBJECTIVES

- **Next-generation electronic biosensors:** Eco-friendly devices to detect organic chemicals, antimicrobial-resistant (AMR) bacteria, and pathogens.
- **Organism-based biosensors:** Usage of genetically engineered plants, bacteria, and marine diatoms to monitor organic and anorganic pollution.
- **Metagenomic analysis:** Comprehensive soil microbiota analysis in polluted areas across Europe to uncover gene clusters and genetic diversity. This helps assess microbial functions and provides genetic markers to quick evaluation of soil and land health.
- **Environmental performance testing:** Validating biosensors using real-world samples from polluted sites.
- **Safety assurance:** Rigorous evaluation of environmental impacts associated with these modified organisms and innovative devices.

INNOVATION

- Use of cutting-edge biotechnology to enhance environmental monitoring efficiency and accuracy.
- Creation of a **soil metagenomic database** to map pollutant-linked genes across Europe.

Project: 101135402 — Mobiles — HORIZON-CL6-2023-ZEROPOLLUTION-01

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ABOUT MOBILES PROJECT

The National Technical University of Athens (NTUA) is working with another 15 partners from academia, research, and industry to develop prototypes of electronic and organism-based biosensors to monitor organic chemicals, antimicrobial-resistant (AMR) bacteria, and pathogens in water, soil, and air.

The EU MOBILES project will develop prototypes of portable electrochemical biosensors validated for air, soil, or water quality control for detecting pesticides, hormones, pathogens, and AMR bacteria.

The MOBILES project will study and develop biosensors for detecting heavy metals, antibiotics, pesticides, arsenic, microplastics, and nanoplastics. It will include genetically modified plants and bacteria for detecting heavy metals, antibiotics, and pesticides, and the use of marine diatoms for monitoring bioplastic degradation.

The consortium will analyse microbiota communities in polluted areas to reveal gene clusters and evaluate how pollution affects genetic diversity. This will help assess microbial functions and provide genetic markers to quickly evaluate soil and land health.

Modern lifestyles and industrial practices generate large amounts of waste and pollutants. Chemicals, including persistent and mobile pollutants (PMCs) and contaminants of emerging concern (CECs), degrade the environment. Another severe global health risk is associated with increasing antimicrobial resistance (AMR) in bacteria. Foodborne pathogens, including *Listeria*, *Salmonella*, and *Campylobacter*, pose significant public health risks and are already monitored. However, current bacterial detection methods for environmental control are slow and require specialized laboratories with trained personnel. Similarly, conventional pollutant detection methods, such as chromatography and mass spectrometry, are accurate but time-consuming and require specialized equipment. State-of-the-art detection methods are unsuitable for constant on-site and real-time monitoring. The long time between sampling and detection reduces the efficiency of public health and environmental protection authorities in implementing effective countermeasures.

To tackle this problem, several **electrochemical biosensors** will be developed within the MOBILES project. Biosensors are devices that combine biological elements with electronic systems to detect specific pollutants. The MOBILES project enhances these sensors with advanced nanomaterials, significantly improving their sensitivity and reliability. All biosensors will have common basic electronics and functional principles (e.g., an organic ligand able to recognize target pollutants), but they will differ in the biological element employed: (i) aptasensors based on aptamers that recognize bacterial cells or spore surfaces, (ii) electronic noses for detecting and quantifying volatile organic compounds (VOCs) produced by bacteria, (iii) genosensors for detecting genes involved in antibiotic resistance, and (iv) interdigital capacitors functionalized with aptamers for estradiol, a member of CECs family.

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Continual threats (such as industrial pollution and the overuse of drugs and pesticides) to sources of drinking water require real-time solutions for wide-ranging water monitoring systems to detect toxicants such as **heavy metals, pesticides, and antibiotics**. Conventional methods are limited in their ability to detect sub-lethal concentrations of active antibacterial compounds. The damage caused by the activity of an antibacterial agent or pesticide may stimulate different biological mechanisms of bacterial repair. Each antibiotic and/or pesticide triggers specific cellular pathways, mechanisms, and targets within the bacterial cell. This specific biological response, enabling the detection of antibiotics and pesticides using microorganisms, is being investigated in the MOBILES project through the use of **genetically modified bacteria** to detect toxic pollutants in water. For detecting heavy metals (cadmium, chromium, lead, mercury) in water, MOBILES will develop a flow-through device for continuous monitoring using biological systems (genetically modified bacteria) combined with an optical sensor and flow unit.

Different pathways will be used to monitor other pollutants. Highly toxic **arsenic pollution** can come from various sources, including industrial activities, mining, and even natural processes. Water and food contaminated by arsenic can cause serious health problems, including cancer and heart disease. For detecting arsenic pollution in soil and groundwater, the MOBILES project will develop **genetically modified plants** that change colour when arsenic is present in the soil or water used to grow them.

Microplastic and nanoplastic pollution is raising concerns about its potential impact on human health. The transfer of very small plastics through the trophic chain is a potential source of contamination at all trophic levels. Understanding the distribution, degradation, and life cycle of micro- and nanoplastics in the marine environment is limited by the intrinsic difficulties of current techniques for detecting, quantifying, and chemically identifying small particles in liquids. The MOBILES project is addressing this challenge by utilizing **marine diatoms**—microscopic algae that play a crucial role in marine ecosystems. Diatoms are known for their resilience and adaptability, making them ideal candidates for studying the biodegradation of bioplastics in marine environments. Preliminary studies have shown promising results, indicating that diatoms not only survive in environments containing bioplastics but also contribute to their biodegradation.

In addition to the development of sensors, MOBILES will undertake comprehensive **metagenomic analysis**, profiling the microbiota of polluted areas across Europe. This work will uncover gene clusters and reveal genetic diversity, enabling a deeper understanding of microbial functions. These insights will provide genetic markers to facilitate rapid evaluation of soil and land health. Two annual sampling rounds are planned for at least two years, and sample collection will be conducted at **different locations to target microbiota related to specific pollution types**: Greece for urban wastewater contamination, Poland for heavy metal pollution, Cyprus for microplastics and plastics, France for agriculture and animal farming, Italy for arsenic, and Germany for chemicals and heavy metals from former mining activities. Genomic and transcriptomic data will be analysed, visualized, and interpreted using bioinformatic tools and soil metagenomic web-based platform specifically

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realized by MOBILES partners. The project's data storage, located in Spain, will be connected to other well-known genomic databases in order to provide a wide range of information.

The biosensors will be rigorously tested with real-world samples from polluted sites to validate their environmental performance. Furthermore, the project will conduct **safety evaluations** to ensure that the **genetically modified organisms** and developed devices have minimal environmental impact.

MOBILES leverages cutting-edge biotechnology to enhance the accuracy and efficiency of detecting biotic and abiotic pollutants while addressing current shortcomings by employing advanced nanomaterials, genetically modified bacteria and plants, and natural elements. Another significant innovation of the project is the creation of a soil metagenomic database, which will map pollutant-linked genes and serve as a resource for environmental research and diagnostics.

PROJECT CONSORTIUM

The project consortium comprises of 15 members. The project is coordinated by the National Technical University of Athens.

NTUA - National Technical University of Athens (GR) – project coordinator	https://www.ntua.gr
CNR - The National Research Council (IT)	https://www.cnr.it
INRAE - National Research Institute for Agriculture, Food and Environment (FR)	https://www.inrae.fr
UR - Sapienza University of Rome (IT)	https://www.uniroma1.it
EDEN - EDEN TECH (FR)	https://eden-microfluidics.com
UPNA - Public University of Navarre (ES)	https://www.unavarra.es
ISSPC - The Institute of Soil Science and Plant Cultivation (PL)	https://en.iung.pl
ARO - The Agricultural Research Organisation of Israel - The Volcani Centre (IL)	https://www.agri.gov.il
UBx - University of Bordeaux (FR)	https://www.u-bordeaux.fr
CUT - Cyprus University of Technology (GR)	https://www.cut.ac.cy
UBE - University of Belgrade (RS)	https://www.chem.bg.ac.rs
Mat - MAT4NRG (DE)	https://mat4nrg.de
TUC - Clausthal University of Technology (DE)	https://www.tu-clausthal.de
GG - GRANT Garant (CZ)	https://www.grant-garant.cz
RICPA - Research and Innovation Centre Pro-Akademia (PL)	https://www.proakademia.eu

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WORK PACKAGES

ELECTRONIC BIOSENSORS FOR ENVIRONMENTAL MONITORING (WP1)

A team of researchers, led by INRAE (National Research Institute for Agriculture, Food and Environment, France), is developing advanced electrochemical biosensors to detect pollutants such as pesticides, pathogenic bacteria, antimicrobial resistance genes, and spores in soil, water, and air. These sensors will integrate conductive materials and biological components to ensure accuracy, stability, and sensitivity to various contaminants.

Optimizing Sensor Materials

One key focus is improving the materials used in sensor construction. Researchers are exploring new carbon-based materials combined with nanoparticles to enhance conductivity and electron transfer. These materials will be tested using various scientific techniques to evaluate their physicochemical and electrochemical properties, as well as their ability to bond with biological components.

Enhancing Biological Components

To improve detection of bacterial pathogens, scientists are working on DNA aptamers (single-stranded DNA molecules that specifically bind to target substances) and enzymes (which detect volatile organic compounds produced by bacteria). By modifying these biological elements, they aim to reduce the distance between enzyme active sites and the electrode surface, increasing electron transfer rates and enhancing detection precision.

For detecting antimicrobial resistance genes, a microfluidic flow cell is being developed, the first design of the sensor was presented internally. This system will allow sensors to function effectively in real-world conditions by ensuring smooth fluid flow and optimal interaction with target substances. It will also enable low detection limits of genomic targets, providing fast and sensitive results.

To identify pesticides, the project is evaluating two approaches: sensors with electrodes covered by either enzymes or aptamers, both of which can selectively bind to their targets with high accuracy. For hormone detection in water, a microfluidic system will be integrated into the biosensor to improve performance.

Advancing Microfluidic Systems

A major part of the research involves optimizing the microfluidic system used in electrochemical sensors. The design of microfluidic circuits will be refined to incorporate newly developed electrodes. Microchannel networks will be assembled into stackable units and tested to confirm flow patterns within the system. The development of the first concept of the microfluidic components has already started with the screening of variables among partners on the volume of liquid sample used to on

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the sensor, size of the sensing element of the sensor, density of the liquid. The microfluid device will be designed by Eden Tech (France) which already presented a preliminary design.

User-Friendly Electronic Readout System

To make the sensors accessible and easy to use, researchers are developing an electronic readout system. A microcontroller will process signals from the sensor and display results on a screen or send data wirelessly to a connected device, ensuring practical applications in environmental monitoring.

Final Testing and Real-World Applications

To ensure high performance, extensive material characterization and surface analysis will be conducted. Once all components are finalized, the biosensors will be assembled, tested, and optimized for real-world use. The goal is to create reliable, cost-effective, and highly sensitive sensors that contribute to environmental monitoring and public health protection.

Duration: September 2024- August 2027

Status: In progress

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DETECTION OF POLLUTANTS VIA BIOTIC SENSOR (WP2)

Under the leadership of the University of Rome (UR), scientists are developing advanced biosensors to detect environmental pollutants such as heavy metals (e.g., arsenic), pesticides, antibiotics, and microplastics. These sensors will help monitor soil, water, and air quality using biological components like plants, bacteria, and diatoms (a type of algae).

Plants as Arsenic Indicators (As-indicators)

Arsenic is widely distributed throughout the environment (air, water, and soil) and is highly toxic in its inorganic form. Long-term exposure to elevated levels of arsenic through drinking contaminated water or eating food grown on soil contaminated by arsenic from industrial processes can lead to chronic arsenic poisoning, which causes skin lesions and skin cancer (WHO1). The MOBILES scientists are engineering certain plants to create so called "As-indicators."

One of these plants is Arabidopsis thaliana, a small plant from the mustard family that has the ability to change colour when it detects arsenic in soil or water. Using advanced genetic tools, scientists will modify Arabidopsis thaliana to produce a visible pigment in response to contamination.

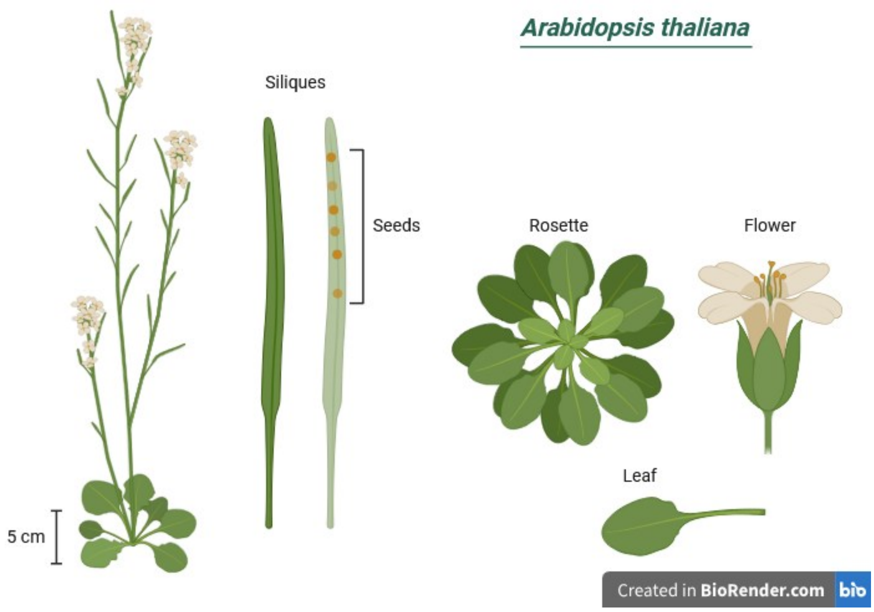

Figure 1: Arabidopsis thaliana, Created in https://BioRender.com

[1] https://www.who.int/news-room/fact-sheets/detail/arsenic

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Another studied plant, Pteris vittata, a fern species indigenous to Asia, Australia, and southern Europe, is known for its ability to absorb arsenic in its fronds and tolerate high levels of contamination. As-indicator plants will be cultivated in greenhouse conditions on soils and water supplemented with arsenic salts, followed by colorimetric analysis.

Figure 2: Pteris vittata. Source: CNR

To ensure the safe use of these biosensors in the field, researchers are also developing a system to render these plants sterile under controlled conditions, preventing their uncontrolled spread. The cloning procedure will be supervised by RICPA (Research and Innovation Center Pro-Akademia, Poland) which will evaluate the impact of such genetically modified plants on other organisms. Indeed, by using an artificial ecosystem with small animals (invertebrate) and other plants it will be verified if MOBILES organisms are a treat for the environment.

Bacterial Biosensors for Water Monitoring

Another part of the project focuses on using genetically modified bioluminescent bacteria to detect toxic substances in water. These bacteria have been genetically modified to emit light when exposed to pollutants due to a chemical reaction that converts chemical energy into light energy. This feature allows real-time of these bacteria for detection of pollutants through an optical sensor. Scientists are testing different bacterial strains to improve their sensitivity and ensure the system works efficiently

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in real-world conditions. The stability of the bioluminescent clones in natural environments is also crucial for the future use of the biosensor; therefore, stability tests will be conducted.

To further enhance detection, researchers are building a database of bacterial “light fingerprints”—unique responses of bioluminescent bacteria to different pollutants (e.g., antibiotics and pesticides) in various compositions and concentrations. This will help identify contamination sources quickly and accurately.

Detecting Microplastics in the Ocean Using Diatoms

Diatoms are single-celled algae and constitute one of the largest groups of organisms on Earth. They can form vast blooms in the ocean and support the life of other marine organisms at the base of aquatic food chains. Due to their ability to absorb and degrade bioplastics, diatoms are central to this project task. Microscopic algae will be studied and employed to detect microplastics and nanoplastics in seawater.

These diatoms react to plastic pollution, in particular nanoplastics originating from bioplastic, by changing their light absorption, providing a natural way to monitor contamination without chemical intervention. Scientists are testing how well diatoms degrade different types of plastic to better understand the environmental impact of pollution.

By combining plant-, bacterial-, and diatom-based biosensors, this research aims to create effective, low-cost solutions for detecting harmful substances in the environment, contributing to cleaner water and healthier ecosystems.

Duration: September 2024- August 2027

Status: In progress

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METAGENOMICS DATABASE AND FULLY-SEQUENCED POLLUTED SOIL MICROBIOTA (WP3)

In the MOBILES project, under work package 3 (WP3), researchers are studying bacterial/microbial community in the soil to better understand how pollution affects them and how they can help restore damaged land. By analysing the genetic material of these microbes, researchers aim to identify key biological markers that indicate soil health and can guide soil rehabilitation efforts. These findings will help develop new strategies for managing contaminated environments more effectively.

Collecting Soil Samples Across Europe

To gather data, soil samples will be taken from different locations across Europe. Sampling will be done in various seasons (spring and autumn in 2025) to see how environmental conditions influence microbial life. Collection sites will be selected in Northern and Southern Europe. Researchers have selected 6 countries, Poland, France, Italy, Germany, Greece and Cyprus (Figure 1), where they will collect soil samples; once in spring, once in autumn 2025.

Figure 3:Soil samples origin, Source: CNR

For the analyses, 3 different contamination sources were identified: Hormones, Pesticides and Antibiotics (H-A), Heavy and semi-Metals (HMs), Microplastics. A detailed protocol on the soil sampling methodology and transport conditions (Figure 2), crucial for the maintenance of RNA quality, is currently being prepared by ISSPC.

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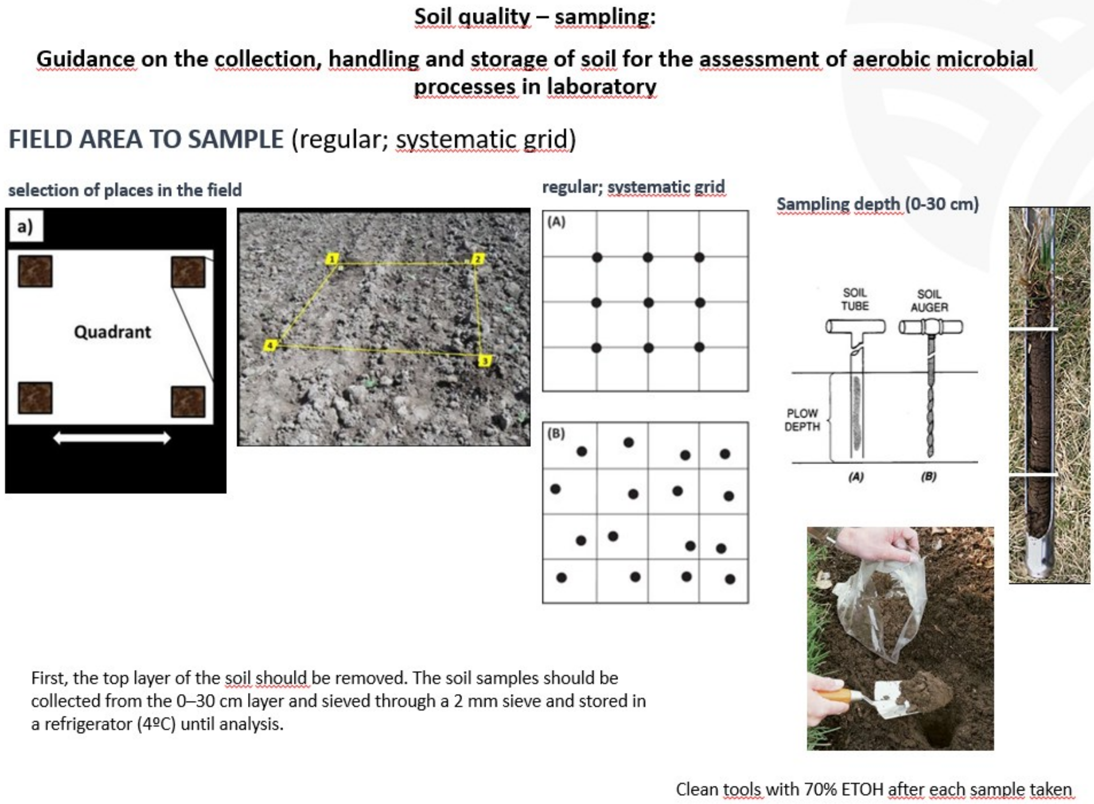

Figure 4: Guidance on soil sampling, Source: ISSPC

Once collected, the soil samples will be carefully delivered to the polish laboratory where, after an accurate sieving, DNA and RNA will be extracted and used for massive DNA and RNA sequencing, respectively (Figure 3). From DNA sequencing, researchers will have information on soil microbiota species composition. This, together with a chemical soil characterization, will provide critical insights on the most resilient microorganisms to a given pollutant. While, from RNA sequencing will provide important findings on the specific metabolic pathways that resilient species have evolved to survive in these harsh environments.

During the collection of soil samples, special attention will be given to soil layers up to 20 cm deep, where microbial activity is most significant. At the first stage, soil characterisation will be done for all samples evaluating: (i) pH of soil; (ii) heavy and semi-metals content characterization (As, Hg, Cd, Pb); (iii) minerals (K, P, Na, Mg, Ca, Cu); (iv) identification and possibly quantification of hormones and pesticides; (v) identification and possibly the quantification of plastic and microplastic.

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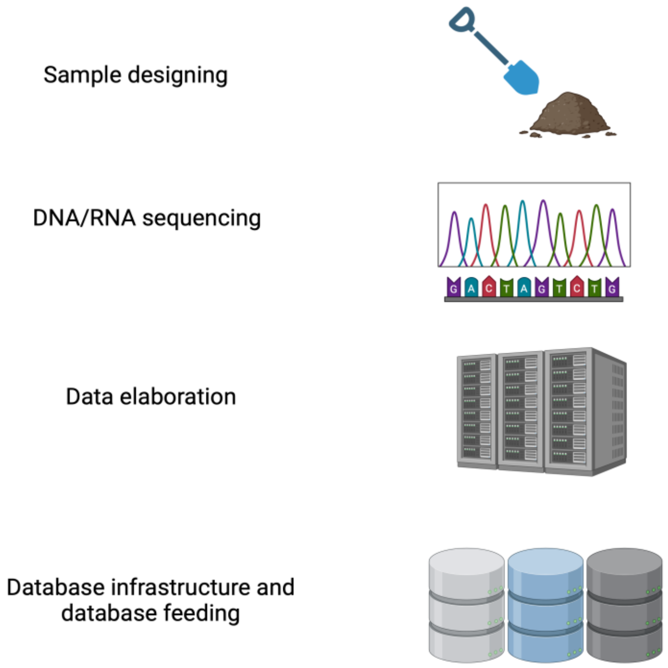

Figure 5: Workflow for the soil analysis, Source: CNR

Decoding Microbial DNA and RNA

Soil samples will undergo quality checks before sequencing to ensure high accuracy. Special attention will be given to microbial genes linked to pollution resistance and soil recovery, as these could be key indicators for assessing soil health and potential for rehabilitation.

Metagenomics. MOBILES project seeks to identify and understand microbial communities by DNA sequencing and taxonomical characterisation of the microbiota community in soil sample. Deeper sequencing and better reference databases are advancing the potential and success of such analyses. While meta-genomics provides information on the gene content of a microbial community and its species composition, **meta-transcriptomics**, using RNA extracts from soil, promises to reveal clusters identification and their actual metabolic activities at a specific time and place, and how those activities change in response to environmental forces or biotic interactions.

Researchers in the MOBILES project will use advanced sequencing technologies to study the genetic composition of soil microbes. This will help identify different species, understand their functions, and discover how they respond to pollutants.

Using Bioinformatics to Analyse Data

The vast amount of genetic data collected will be processed using specific computer programs. These tools will help identify important gene clusters and patterns that could be used in future soil protection strategies. Scientists will employ bioinformatics software to compare microbial

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communities across different sites, tracking changes over time and under varying pollution levels. The goal is to build a comprehensive database that scientists can use to monitor and improve soil health, aiding in the development of new environmental policies and land management practices.

Building a Data Infrastructure

To store and manage all this information, researchers are creating a secure and accessible database that is already located in Spain and maintained by the University of Navarra. This system will allow scientists, beyond those involved in MOBILES project, to access and analyse the data. The infrastructure will integrate multiple data analysis tools, unified data format, data exchange mechanism, API etc. enabling researchers to visualize and interpret the results efficiently. By ensuring open access to this valuable information, the project aims to foster collaboration and drive innovation in soil conservation efforts.

The project will generate a comprehensive metagenomic database, offering valuable insights into soil microbial dynamics. The integration of sequencing, bioinformatics, and data management will provide a foundation for developing new strategies in soil protection and rehabilitation.

Duration: September 2024- February 2028

Status: In progress

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ENVIRONMENTAL PERFORMANCE AND SAFETY OF DEVELOPED ORGANISMS, AND PACKAGING OF SENSOR DEVICES (WP4)

Scientists are working on improving biosensors—specialized devices that detect environmental pollutants. These biosensors use biological components, such as enzymes and microorganisms, to identify harmful substances in soil and water. To ensure their effectiveness in real-world conditions, researchers are also focusing on practical issues such as proper packaging, durability, safety, and performance testing. This activity will be supervised by RICPA (Research and Innovation Center Pro-Akademia, Poland).

Optimizing Packaging and Shelf-Life

One key challenge is keeping the biological elements of biosensors stable and functional over time. Scientists are designing protective packaging to extend their shelf life while ensuring the biosensors remain sensitive to pollutants. They are also developing special liquid storage solutions to preserve the active components. These efforts will make biosensors more reliable and easier to use in real-world conditions.

Assessing Safety and Environmental Impact

Since some biosensors involve genetically modified bacteria and plants, researchers must carefully evaluate their potential risks. They will conduct controlled laboratory tests to study how these organisms interact with the environment and whether they could affect non-target species like insects and soil microbes. Scientists will also assess the possibility of gene transfer from modified organisms to natural ecosystems, ensuring their safe use.

Testing Performance in Controlled Conditions

Before being deployed in the field, all biosensors will be tested under controlled conditions. Researchers will expose them to known concentrations of pollutants in water and soil to measure their sensitivity and accuracy. For example, electrochemical biosensors will undergo specialized tests to fine-tune their ability to detect contaminants, while plant- and bacteria-based sensors will be monitored to confirm their effectiveness.

By combining innovative technology with rigorous testing, this research aims to create reliable and environmentally safe biosensors. These tools will help scientists and policymakers monitor pollution and protect ecosystems more effectively.

Duration: July 2025- February 2028

Status: Not started

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COMMUNICATION AND MANAGEMENT OF THE PROJECT (WP5+WP6)

This research project is not only about scientific discoveries but also management of the project itself and about sharing knowledge and engaging with different groups of people. The project team is working to ensure that the project is visible and its results will reach policymakers, businesses, researchers, and the general public, helping to improve environmental protection efforts.

Project kick-off meeting

The project kick-off meeting took place in September 2024 in Athens, Greece.

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Monitoring and Detection of Biotic and Abiotic Pollutants by Electronic, Plants and Microorganisms Based Sensors (Press Release)

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The consortium will analyse microbiota in polluted areas to reveal gene clusters and genetic diversity. This will help assess microbial functions and provide genetic markers to quickly evaluate soil and land health.

Read more: https://www.mobiles-project.eu/article/press-release-mobiles-monitoring-and-detection-of-biotic-and-abiotic-pollutants-by-electronic-plants-and-microorganisms-based-sensors

Project Meeting in Belgrade

The meeting was held in Belgrade at the end of October 2024 between Christos Argirusis (MAT) and Dalibor Stankovic (UBE). They organized the processes of synthesis and dynamics of the examination of the morphology of the material that will be used for the preparation of the biosensor.

Read more: https://www.mobiles-project.eu/article/mobiles-project-meeting-in-belgrade-at-ube

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Project Meeting in Puławy

The meeting of the MOBILES Project partners at the Institute of Soil Science and Plant Cultivation – State Research Institute (IUNG) in December 2024 in Puławy, Poland, marked significant progress toward one of the project's key objectives—the collection of soil samples and their metagenomic analysis. The project focuses not only on developing innovative biosensors for monitoring organic pollutants and antibiotic-resistant microorganisms in various environments but also on conducting metagenomic and metatranscriptomic analyses of microorganisms in contaminated areas across Europe. These analyses will aid in sequencing and bioinformatics processing of genetic data, which will be stored in a dedicated genetic database in Spain at the University of Navarra (UPNA).

Read more: https://www.mobiles-project.eu/article/mobiles-project-meeting-in-poland-at-iung

MOBILES Presentation for Universities

Raffaele Dello Ioio, from Sapienza University of Rome recently took part in a Ministerial Program for High Schools, where he discussed and promoted advanced sustainable methods for monitoring and removing contaminants from soil and water. During his presentations, he explained the challenges connected to pollutant detection, and how plants can be used to identify contaminants. He also highlighted how certain plants and their associated microorganisms can absorb, degrade, or stabilize both organic and inorganic pollutants, offering a natural solution to environmental issues.

Read more: https://www.mobiles-project.eu/article/phytoextraction

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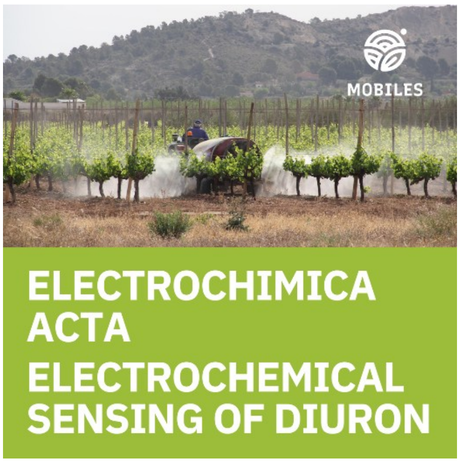
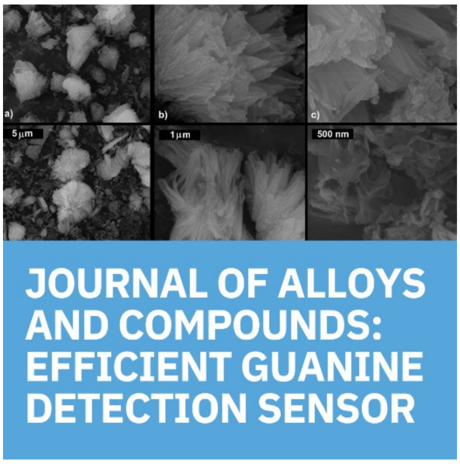
Publication: Electrochimica Acta



A new study explores the development of an electrochemical sensor for detecting diuron, an herbicide commonly used in agriculture to improve productivity and the quality of agricultural products such as citrus fruits, rice, and potatoes. While effective in controlling weeds, diuron poses environmental and health risks due to its moderate to high persistence in soil and water. It can accumulate in crops and water sources, potentially affecting human health through inhalation or ingestion of contaminated food or water. Its direct effects include irritation, while it is also suspected of having carcinogenic properties. While for human is not directly toxic, its persistence and toxicity to aquatic organism led to EU's classification of diuron as a Category 3 carcinogen (Directive 2001/59/EC), highlighting its hazardous nature.

Read more: https://www.mobiles-project.eu/article/publication-electrochemica-acta

Publication: Journal of Alloys and Compounds



A recent paper published in the Journal of Alloys and Compounds by the University of Belgrade presents a novel approach for the electrochemical detection of guanine using Metal-Organic Frameworks (MOFs) and MOF-derived nanomaterials. These materials exhibit superior properties, including high chemical stability, relatively large specific surface areas, high porosity, and a tunable structure. Since the developed guanine sensors demonstrated excellent storage stability, repeatability, and selectivity, MOF-derived nanomaterials will continue to be used by the University of Belgrade to create MOBILES sensors able to detect pollution. Their real-world applicability was successfully tested by quantifying guanine in spiked urine samples with outstanding accuracy and precision.

Read more: https://www.mobiles-project.eu/article/guanine

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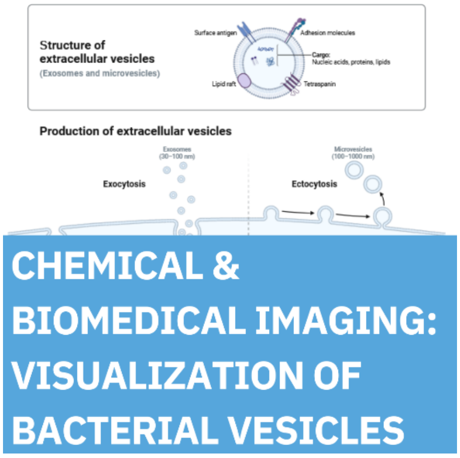
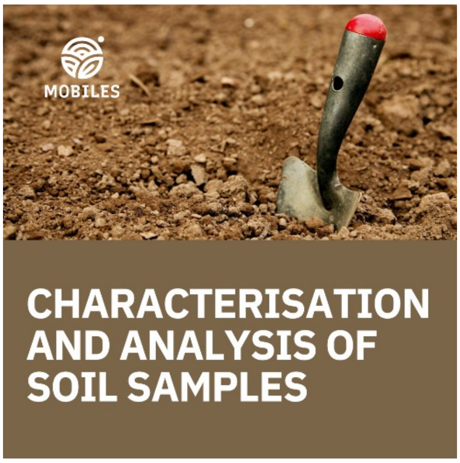
Publication: Chemical & Biomedical Imaging



A recent paper submitted under the MOBILES project in Chemical & Biomedical Imaging focuses on the visualisation of bacterial extracellular vesicles (EVs). EVs are membrane-surrounded vesicles actively released by bacteria, much like missiles. These "missiles" carry bioactive molecules and deliver them to recipient cells. They transport diverse biomolecules, influencing interactions between host cells and microbes and impacting disease progression. EVs are thus important for how infections spread and how the immune system responds.

Read more: **https://www.mobiles-project.eu/article/vesicles**

Characterisation and Analysis of Soil Samples



In the MOBILES project, under work package 3 (WP3), researchers are studying bacterial/microbial community in the soil to better understand how pollution affects them and how they can help restore damaged land. By analysing the genetic material of these microbes, researchers aim to identify key biological markers that indicate soil health and can guide soil rehabilitation efforts. These findings will help develop new strategies for managing contaminated environments more effectively.

Read more: https://www.mobiles-project.eu/article/soil-sampling

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COOPERATION WITH OTHER PROJECTS

The MOBILES project has joined the Marine Shield Cluster, an innovative network of EU-funded projects united by a shared commitment to combating water pollution and safeguarding marine and environmental health. The Marine Shield Cluster fosters collaboration, knowledge-sharing, and joint dissemination activities among initiatives tackling environmental challenges. For MOBILES, joining this network marks a significant step in amplifying our mission to combat pollution in water, soil, and air.

At MOBILES, we focus on developing advanced portable biosensors capable for real-time, detection of harmful organic chemicals such as antimicrobial-resistant bacteria, and pathogens as well as inorganic such as heavy metals. Besides detection, MOBILES also focuses on understanding how the microbiota communities are affected by pollutions in selected European areas. Our inclusion in the Marine Shield Cluster provides an opportunity to align our efforts with other pioneering projects, such as iMERMAID, CONTRAST, DIGI4ECO, REMEDIES, and SUNBIO. Together, we aim to advance technologies, strengthen environmental policies, and improve the quality of water and life conditions for communities across Europe and beyond.

By joining forces with the Marine Shield Cluster, MOBILES will actively contribute to a shared vision of promoting sustainable solutions for pollution detection in marine water. Collaborating with like-minded projects enables us to share insights, accelerate innovation, and ensure our findings reach policymakers, stakeholders, and the broader public.

We are proud to be part of this collective effort to protect ecosystems and address some of the most pressing environmental challenges of our time. Stay tuned as we work together to make a meaningful impact on our environment and future.

To learn more about the Marine Shield Cluster and the projects united under its mission, visit cluster's website https://marineshield.eu/

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The MOBILES project was funded under **HORIZON-CL6-2023-ZEROPOLLUTION-01-6 — Biosensors and user-friendly diagnostic tools for environmental services**. Under this call, two other projects were funded: AquaBioSens (ID: 101135432, https://www.aquabiosens.eu) and BIOSENSEI (ID: 101135241, https://www.biosensei.eu).

AquaBioSens develops handheld devices to measure aquatic hazards and pollution, supporting the EU Mission to "Restore our ocean and waters by 2030". These devices use novel analytics, such as immunoassays, environmental RNA quantification, and whole-cell biosensors, coupled with advanced sensor

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technologies, including acoustic biosensors, fluorimetry, and organ-on-chip devices. The devices are low-cost, accessible, and web-connected. They will be tested and validated in coastal and freshwater sites in the UK, Ireland, and Greece and disseminated to the international community.

BIOSENSEI develops a real-time, multiplexed, end-to-end, tailored, and reliable biosensor platform utilizing cellular responses to detect abiotic pollutants—nutrients, estrogenic endocrine-disrupting chemicals, and PFAS (Perfluoroalkyl and Polyfluoroalkyl Substances)—as well as biotic pollutants such as microcystins.

A collaborative link with these two sister projects was established, and further cooperation was discussed at the first joint (online) meeting at the end of November 2024. It is planned to integrate findings from the sister projects into MOBILES project deliverables **D5.2 (Policy brief on biotic and abiotic pollutants)** and **D5.4 (Policy brief on biosensor technologies for environmental monitoring)**. On February 2025, a first action was decided by MOBILES and AquaBioSens. Member of both projects can attend the annual internal project meetings after signing an NDA. During such meetings, external members can also present results and discuss future implementation. Furthermore, the coordinator laboratory of **AquaBioSens** will host a research member of MOBILES to develop experimental work on marine diatoms. This collaboration will roughly extend between spring 2025 and autumn 2025.

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CONFERENCES

An indicative list of forthcoming conferences where the MOBILES project will be presented. Please follow our project website where the most up-to-date information is presented.

Name of the Event	Year	Start Month	Start date	End Month	End date	Place	Topic of the presentation	MOBILES represented by
American Society for Biochemistry and Molecular Biology	'25	April	11	April	16	Chicago	Resonance Raman spectroscopy of 13C isotope-enriched Fucoxanthin-Chlorophyll a/c-binding proteins (FCPs) in intact membranes of the Marine Diatom Fragilariopsis sp	Costantino Varotsis
Metrology 2025	'25	June	20	June	21	Demokritos Institute Athens	Estradiol biosensor	Antonis Georgias
The 30th Young Investigators' Seminar on Analytical Chemistry(YISAC 2025)	'25	June	6	July	3	Faculty of Chemistry and Chemical Technology, University of Ljubljana, Slovenia	Pesticide sensing	Aleksandar Mijajlović
The 30th Young Investigators' Seminar on Analytical Chemistry(YISAC 2025)	'25	June	6	July	3	Faculty of Chemistry and Chemical Technology, University of Ljubljana, Slovenia	Pesticide sensing	Tijana Mutić

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9th European Bioremediation Conference (EBC-IX)	‘25	June	15	June	19	MINOAN PALACE, Chania, Crete, Grece	Arsenic sensing	Raffaele Dello Ioio
9th European Bioremediation Conference (EBC-IX)	‘25	June	15	June	19	MINOAN PALACE, Chania, Crete, Grece	Arsenic remediation	Patrizia Brunetti
Marine Biology symposium	‘25	July	6	July	9	Norway	Resonance Raman spectroscopy of 13C isotope-enriched Fucoxanthin-Chlorophyll a/c-binding proteins(FCPs) in intact membranes of the Marine Diatom Fragilariopsis sp	Costantino Varotsis
ICBIC	‘25	July	29	July	31	USA	tba	Costantino Varotsis
Euroanalysis 2025	‘25	Aug.	31	Sept.	4	CCIB - Barcelona International Convention Centre	Pesticide sensing	Filip Vlahović
XI International Symposium on Root Development	‘26	May	4	May	7	Rivamarina Hotel, Specchiolla, Italy	Arsenic tolerance	Cristina Caissutti
Euroanalysis 2026	‘26	Sept.	31	Oct.	4	CCIB - Barcelona International Convention Centre	Pesticide sensing	Sladjana Djurdjić

Figure 6: Indicative list of conferences with MOBILES team participation

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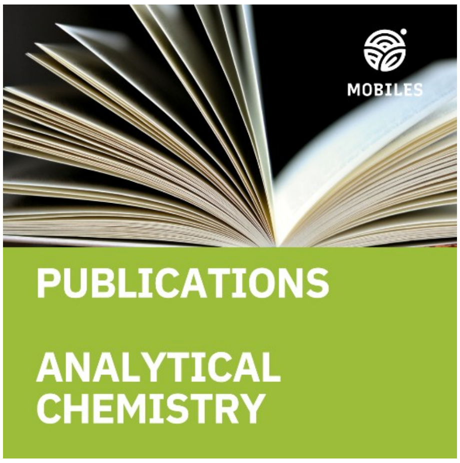
ARTICLES

Photoinduced Electrochemiluminescence Immunoassays

Dongni Han, Jasmina Vidic, Dechen Jiang, Gabriel Loget, and Neso Sojic

Optimization of electrochemiluminescence (ECL) immunoassays is highly beneficial for enhancing clinical diagnostics. A major challenge is the improvement of the operation conditions required for the bead-based immunoassays using the typical [Ru(bpy)3]2+/tri-n-propylamine (TPrA) system. In this study, we report a heterogeneous immunoassay based on nearinfrared photoinduced ECL, which facilitates the imaging and quantitative analysis of [Ru(bpy)3]2+-modified immunobeads at low anodic potential. The photovoltage generated by the photoanode under near-infrared light promotes oxidation processes at the electrode/electrolyte interface, thus considerably lowering the onset potential for both TPrA oxidation and ECL emission. The anti-Stokes shift between the excitation light (invisible to the human eyes) and the visible emitted light results in a clear and stable signal from the immunobeads. In addition, it offers the possibility of site-selective photoexcitation of the ECL process. This approach not only meets the performance of traditional ECL immunoassays in accuracy but also offers the additional benefits of lower potential requirements and enhanced stability, providing a new perspective for the optimization of commercial immunoassays.

https://pubs.acs.org/doi/10.1021/acs.analchem.4c04662.



Recent advances in electrochemiluminescence Immunosensing

Jing Yu, Dalibor Stankovic, Jasmina Vidic and Neso Sojic

Electrogenerated chemiluminescence, also called electrochemiluminescence (ECL), has attracted much attention in various fields of analysis due to its high sensitivity, extremely wide and dynamic range and excellent control of space and time of the light emission. The great success of ECL for in vitro detection results from the advantages of combining the selectivity of biological recognition elements and the sensitivity and controllability of ECL technology. ECL is widely applied as a powerful analytical technique for ultrasensitive detection of biomolecules. In this review, we summarize the recent developments and applications of ECL for immunosensing. Herein, we present the sensing schemes and their applications in different areas, such as detection of biomarkers, bead-

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based detection and bacteria and cell analysis and provide future perspectives on new developments in ECL immunosensing. In particular, ECL-based sensing assays for clinical sample analysis and medical diagnostics and the development of immunosensors for these purposes are highlighted.

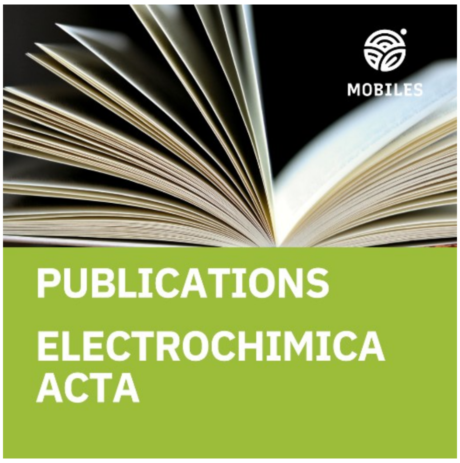
https://doi.org/10.1039/D4SD00272E

Visualisation of the Biogenesis, Dynamics and Host Interactions of Bacterial Extracellular Vesicles

Sandrine Truchet, Jeanne Malet-Villemagne, Gilles Tessier and Jasmina Vidic

The article presents the state-of-the-art methods and labelling strategies for imaging bacterial extracellular vesicles (bEVs). Bacterial extracellular vesicles (bEVs) are small, membrane-bound particles released by bacteria into their environment and plays essential roles in bacterial communication, survival, and interaction with their surroundings, including host cells. The article highlights the crucial roles of bEVs in bacterial communication, stress response, adaptation, and pathogenicity, as they transport various biomolecules, including toxins and virulence factors. While researchers can isolate and purify bEVs, tracking their biogenesis and fusion with host cells remains challenging. The article reviews advanced imaging techniques, such as super-resolution microscopy (SIM, STED, PALM/STORM) that offers improved visualization of bEVs compared to traditional transmission electron microscopy (TEM).

https://doi.org/10.1021/cbmi.5c00002



Pechini Synthesis Method of Ho_2O_3 Nanoparticles and Their Harnessing for Extremely Sensitive Electrochemical Sensing of Diuron in Juice Samples; Theoretical insights into sensing principle

Aleksandar Mijajlović, Vesna Stanković, Filip Vlahović, Miloš Ognjanović, Kurt Kalcher, Astrid Ortner, Dalibor Stanković

This study developed a new electrochemical sensor for diuron (DIU) detection using a carbon paste electrode (CPE) upgraded with Ho_2O_3 nanoparticles. The Pechini method was used to synthesize Ho_2O_3 nanoparticles. The nanostructure properties of the material were confirmed using X-ray powder diffraction (XRPD), attenuated total reflectance (ATR) - Fourier transform infrared (FTIR) spectroscopy and scanning electron microscopy (SEM). The material electrocatalytic features were investigated using cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). An analytical

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method for identifying and measuring DIU was established using square wave voltammetry (SWV). The proposed sensor exhibited a remarkable response to DIU, displaying a broad linear range (0.25 - 200 μM) and a detection limit of 0.03 μM. Its minimal influence from potential interfering substances confirmed the method's selectivity. When detecting DIU in water and juice samples, the CPE/Ho_2O_3 sensor showed good recovery results. The conventional UV-Vis detection method validated the sensor efficacy.

https://doi.org/10.1016/j.electacta.2025.145832

MOF-derived nanoceria/graphitic carbon nitride as an efficient electrochemical modifier for guanine sensor with diffusional response

Branka B. Petković, Hristo Kolev, Djordje Veljović, Dalibor M. Stanković, Bratislav Antić, Miloš Ognjanović

This work presents a novel approach for the electrochemical detection of guanine (GU) using a MOF-derived nanomaterial. CeBTC MOF-derived CeO2 nanoparticles, prepared by calcination and mixed with graphitic carbon nitride (g-C3N4) were structurally and electrochemically characterized and further applied in sensing of GU. XRPD, FTIR, SEM, and XPS measurements were used to study the composition, structure, and morphology of the nanoceria/g-C3N4 electrode modifier. Electrochemical impedance spectroscopy measurements and cyclic voltammetric studies indicated an improved electrocatalytic output of nanoceria/g-C3N4 modified carbon paste electrode (MOFdCeO2/g-C3N4/CPE). The optimal content of electrode modifier in CPE, experimental conditions, and analytical technique parameters were established to achieve sensitive quantification of GU. Kinetic parameters of the electrochemical reaction of GU were determined and a diffusional response at an electrochemical sensor was achieved. The linear working range of the developed square-wave voltammetric method (SWV) in Britton Robinson buffer solution pH 3.0 at MOFdCeO2/g-C3N4/CPE was recorded from 0.5 μM to 100 μM of GU, with a detection limit of 0.12 μM. The proposed guanine sensor showed good storage stability, repeatability, and selectivity, and its real sample applicability was successfully tested by quantification of guanine in spiked urine samples, with excellent accuracy and precision.

https://doi.org/10.1016/j.jallcom.2025.178471

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PROJECT OVERVIEW

- **Duration:** 1.9.2024 – 29.2.2028
- **Budget:** €4.6 million
- **DOI:** https://doi.org/10.3030/101135402

COMMUNICATION

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- Join us on our mission to revolutionize environmental monitoring and create a sustainable future!

Project: 101135402 — Mobiles — HORIZON-CL6-2023-ZEROPOLLUTION-01

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