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Consiglio Nazionale delle Ricerche

WP3: Spectroscopy apparatus for Online Water Quality Monitoring

Antonella Sciuto

Second SWRIPS General Meeting

Palermo 7-8 October 2024

PRIMA programme is supported by Horizon 2020, the European Union's Framework Programme for Research and Innovation.

Role of the CNR-IT in the project

Work package No	Work Package Title	Lead Partner N°	Lead Participant Short Name	Person-Months	Start Month	End Month
WP1	Analysis of the water/land/agro-ecosystem	6	UBOUIRA-DZ	50	1	36
WP2	Development of Innovate Integrated Water Purification System	4	UNIPA-IT	125	2	30
WP3	SiC spectroscopy apparatus for inline and online water quality monitoring	2	CNR-IT	82	3	34
WP4	Quality Control on Water, Sludge, Soil and Crops	9	UNITU-TN	108	12	36
WP5	Dissemination and Communication. Exploitation and IPR	1	CSFNSM-IT	57	1	36
WP6	Project Management	1	CSFNSM-IT	44	1	36
				Total person-months	466	

CNR Involved people:
Antonella Sciuto, Ivana Di Bari, Sebania Libertino, Silvia Scalese, Simona Filice, Giuseppe D'Arrigo, Cristiana Longo, Sabrina Carroccio, Giusy Curcuruto, Emanuela Spina.

We are leader of WP3 and we are involved in the WP2, WP5 and WP6

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IPCB Istituto per i Polimeri Compositi e Biomateriali

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WP3 aims

Design and development of innovative Spectroscopy systems for On-line and in-line Water Quality Monitoring

=>To have information in real time on physical and chemical parameters of the purified water to be re-used for irrigation.

The proposed systems will consist of compact UV spectroscopy apparatus and/or visible sensor systems adopting innovative SiC and/or Silicon Photomultipliers (SiPM) photo-detectors

WP3 Task 3.1 Months 3-24

Development of sensors and electronics (CNR-IT, CSFNSM-IT, UNICT-IT)

Our objectives:

Design and fabrication of innovative **SiC sensors** operating in deep **UV** with **large area**, **low noise** and **high sensitivity**

Development of **lecture electronics** ensuring biasing of source and detector, **low noise**, sensing **current amplification** and **digital conversion**.

Obtained results:

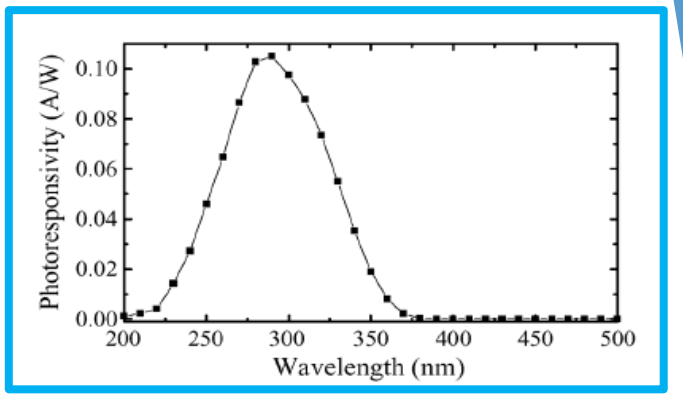
- Design of SiC UV photodetector
- Identification of wavelengths of interest for the detection of chemical pollutants and biological agents
- Acquisition of commercial LED operating at the wavelengths of interest
- Acquisition of long path cuvette for laboratory test

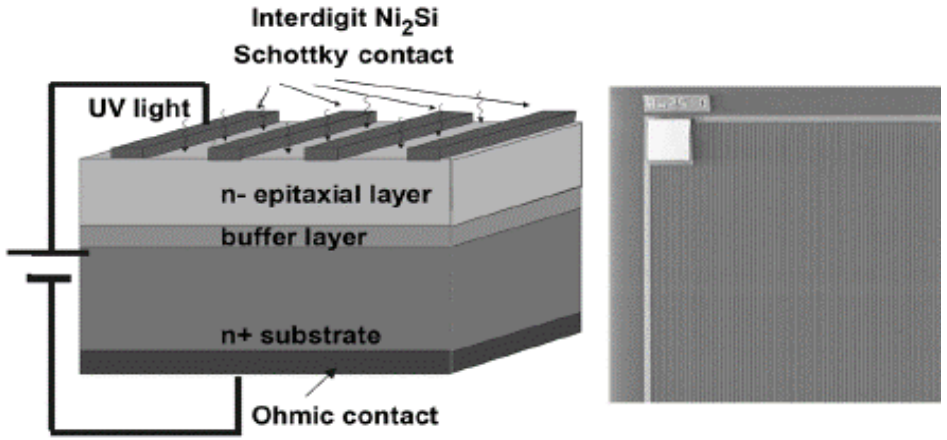
WP3 Task 3.1 results: SiC UV photodetector

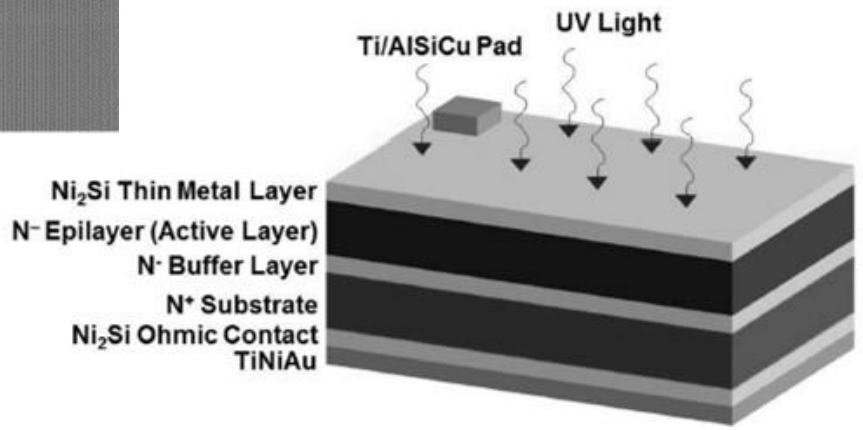
We considered two possible approaches for the fabrication of the SiC photo-detector (starting from our previous activities and expertise).

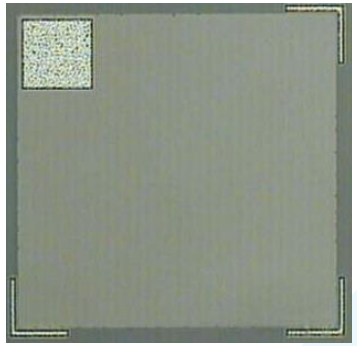
- 1: device with **interdigit front electrode**
- 2: device with very thin **continuous front electrode**

In both cases we have optimal UV responce with a peak @ 280 nm







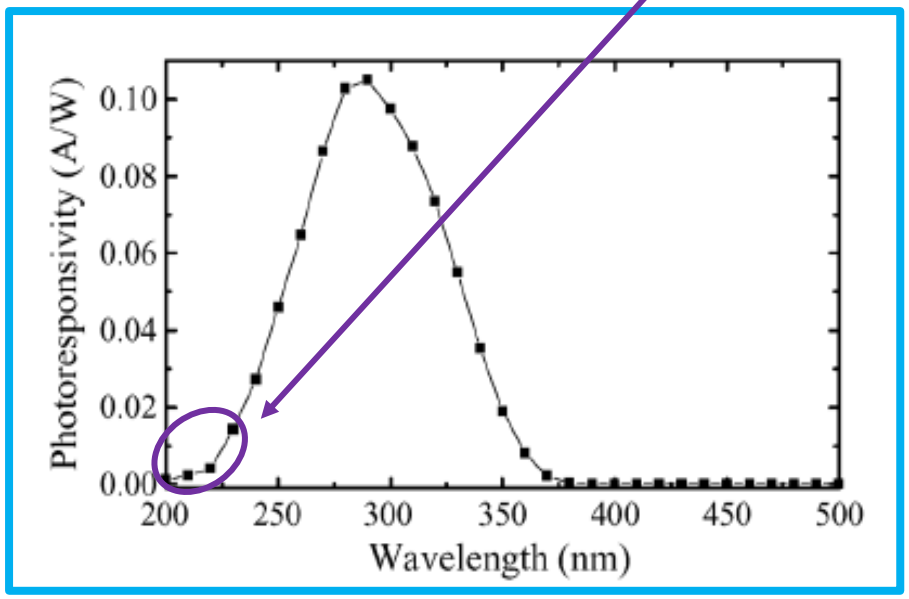


We opted for the solution 1 !

WP3 task 3.1 results: SiC UV photodetector

Complete flow chart for the devices fabrication was prepared

We opted for the **solution 1**: Photo-detectors with **interdigit front electrode** will be adopted
&
innovative **graphene oxide layer** will be explored **to enhance the Deep UV optical response**



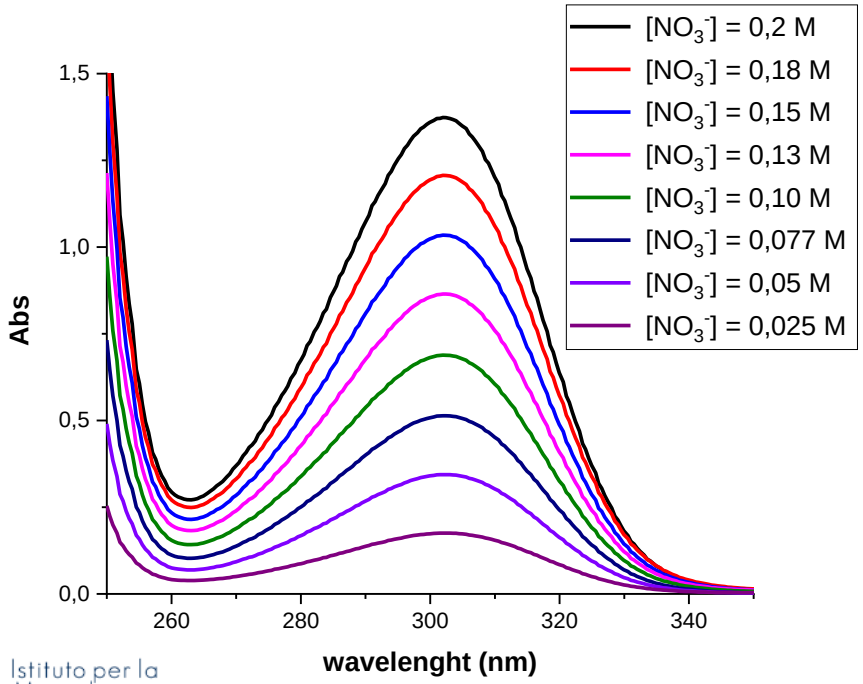
WP3 task 3.1 results: Identification of wavelengths of interest

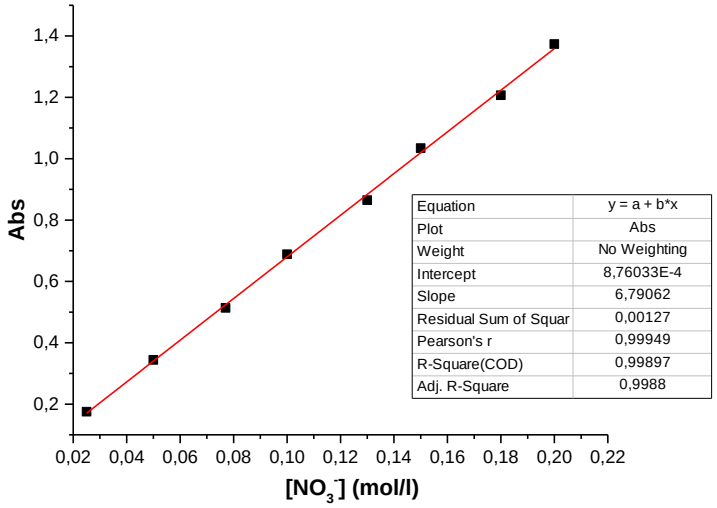
Analysis of water solutions containing Nitrate (starting from Sodium Nitrate – $NaNO_3$)

Our goal is to design the portable monitoring system in terms **optical path length**

=> two calibration curves were performed in **two different concentration range:**

- the first one to **estimate the molar extinction coefficient** in water in the **best linearity conditions =>that is in high concentration of Nitrate**





This concentration range is very far from the LAW LIMIT VALUE ADMITTED

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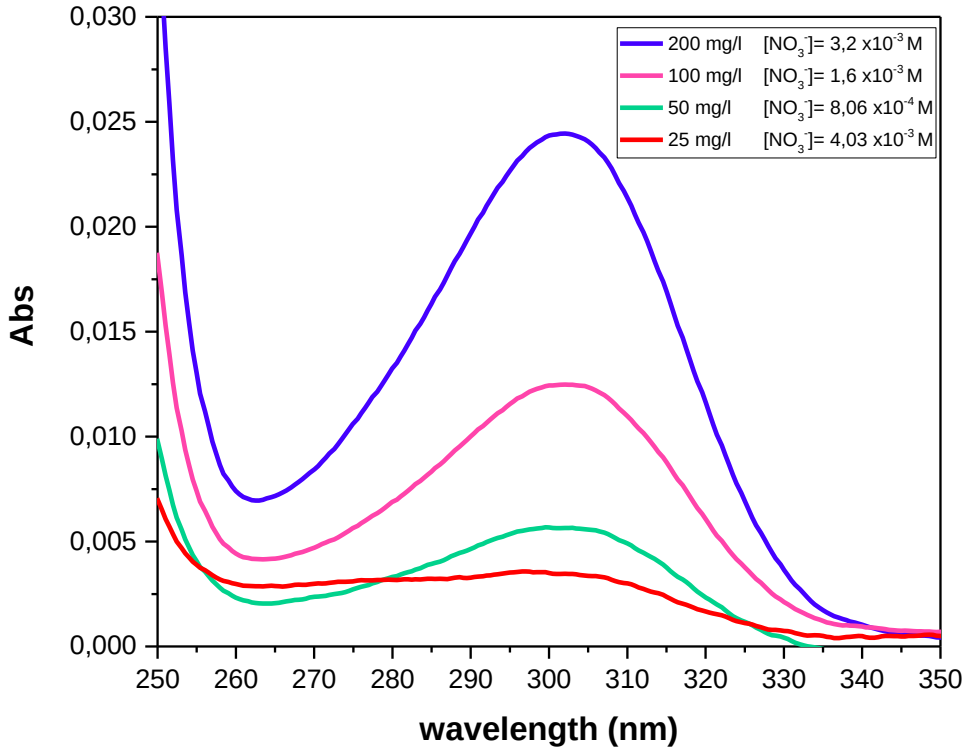
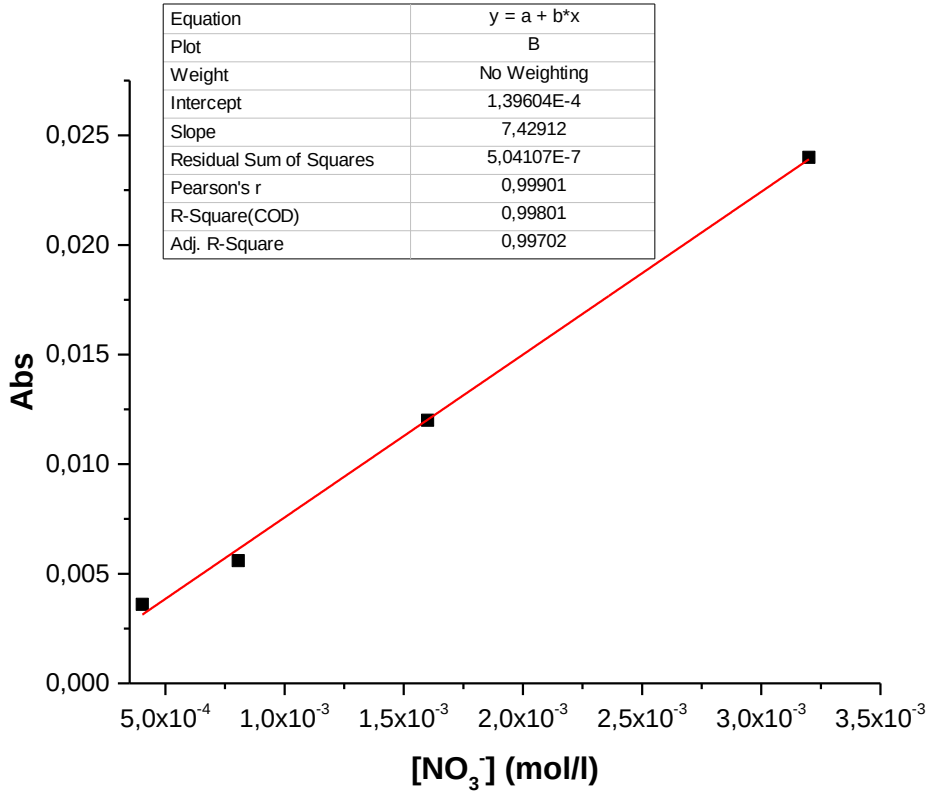
WP3 task 3.1 results: Identification of wavelengths of interest

- the second one was performed in a **nitrate concentration range close to the value permitted by law (50 mg/L)** 30?
  In order to verify the linearity of measurements also in this range





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WP3 task 3.1 results: Acquisition of long path cuvette for laboratory test

long optical path to enhance the absorption effects of contaminant in water

MERCK

Hellma 120-QS-100

Hellma® cylindrical absorption cuvettes

★★★★★ (0) Scrivi una recensione Fai una domanda

High Performance Quartz Glass, spectral range 200-2,500 nm, pathlength 100 mm

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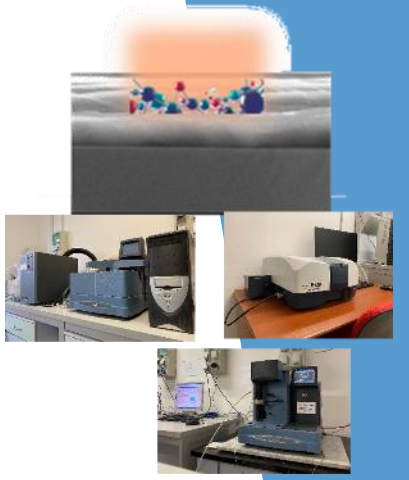
WP3 Task 3.2 Months 12-30

Optically sensible polymeric substrates for heavy metals and pesticide detection (CNR-IT, SRTACITY-EGY)



Our objectives:

Design, synthesis, characterization of an optically **sensible polymeric substrates** for **heavy metals** and **pesticide** detection

Activities started on March 2024:

Obtained results:

Identification polymer class and potential pollutants

Starting steps procedure for the extraction of molecules from vegetal matrix to functionalize the polymer membrane

Polymers

with specific properties

- **transparency** (in the UV and in VIS)
- **water insolubility**
- **spreadability** on solid substrate (plastic, glass or quartz) or preparable in **free standing films.**

- **Polylactic acid** $(C_3H_4O_2)_n$

Pesticides

disposable in lab to the test detection capabilities of polymer membrane

- **PESTANAL® 2,4-D** (2,4-Dichlorophenoxyacetic acid) $C_8H_6Cl_2O_3$
- **IMIDACLOPRID** $C_9H_{10}ClN_5O_2$

Heavy metals

disposable in lab to the test detection capabilities of polymer membrane

- **Pb**
- **Hg**

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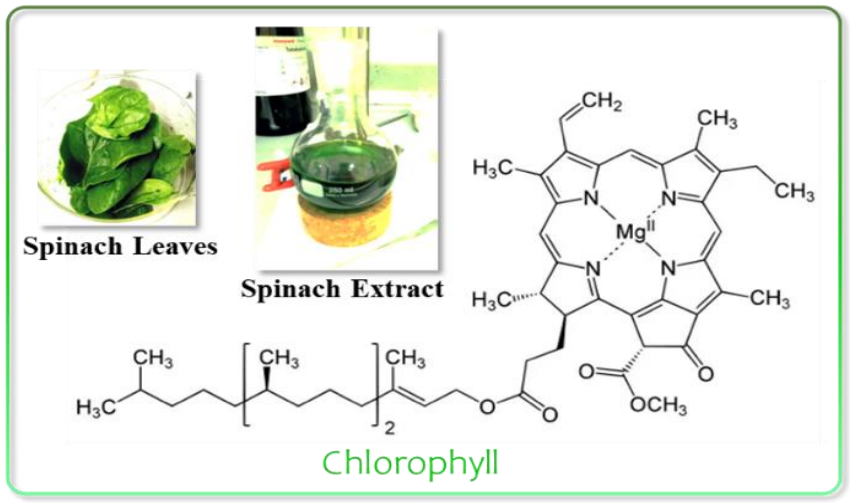
WP3 Task 3.2 Months 12-30

- Polimeric Substrates will be functionalized by using a green approach and will be optically characterised.
- Functionalization procedure will be fixed after preliminary detection test

Use of optically sensible polymeric substrates containing chlorophyll (or molecules with porphyrin structure) for heavy metals and pesticides detection



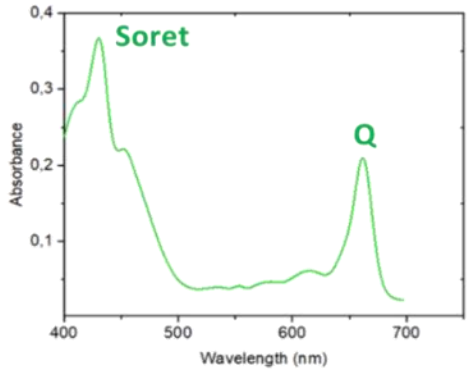
Chlorophyll will be extracted from spinach leaves using acetone and purified according to the methods reported in the literature[1,2,3].

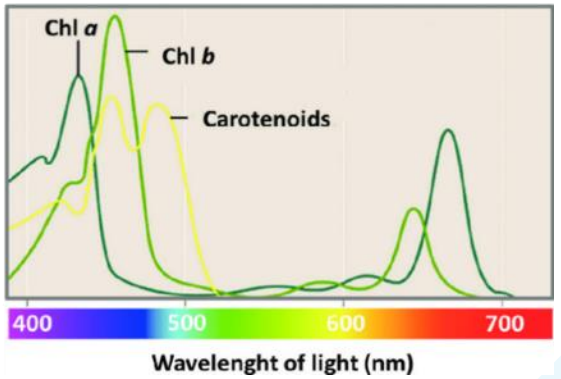
Will also be evaluated **Supercritical carbon dioxide extraction of chlorophyll** as a valid alternative, because this is a sustainable process that does not involve environmentally damaging solvents and furthermore provides a high-speed extraction process with a simple purification

1. Abdelnaby Khalyfa,J. Agric. Food Chem. 1992, 40, 215-220

2. M.D. Macìas-Sànchez, J. of Supercritical Fluids 39 (2007) 323-329

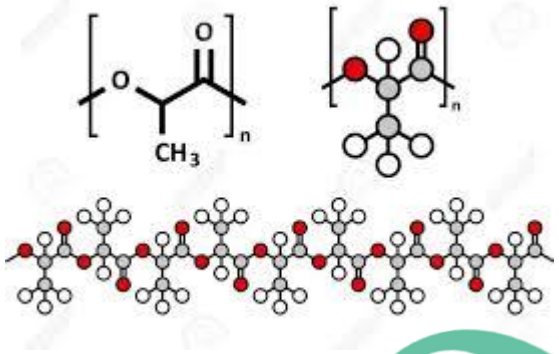
3, M.D. Macìas-Sànchez Journal of Food Engineering 66 (2005) 245-251



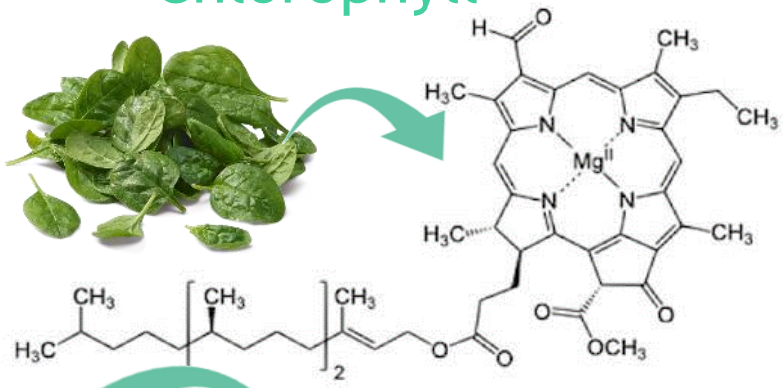


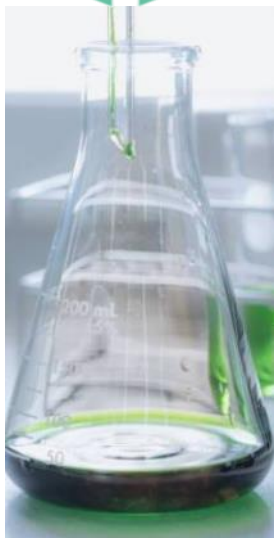
WP3 Task 3.2 Months 12-30

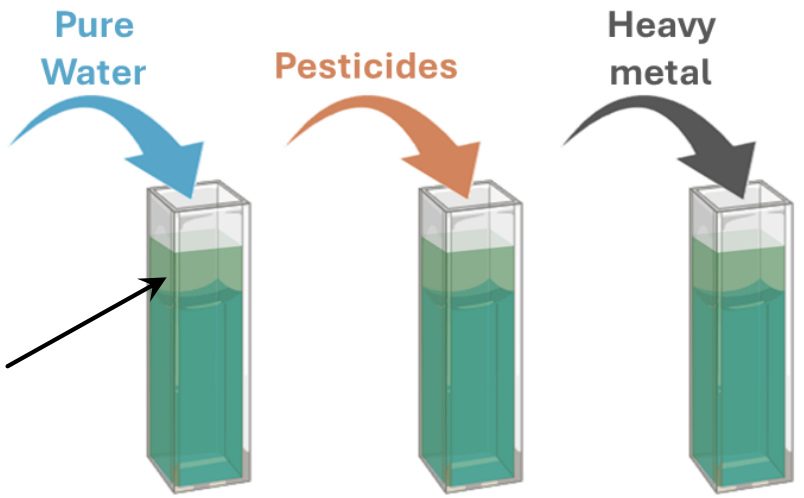
Polylactic acid



Chlorophyll





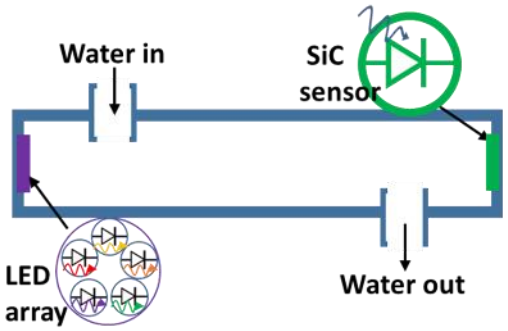


The variation of the absorption spectrum in the visible is expected following the interaction of chlorophyll with pesticides or heavy metals as reported in the literature[3,4]

3. Rouholah Zare-Dorabei at all, **RSC Adv., 2015, 5, 93310 -93317**
4. Francesca Dini at all, **Anal. Bioanal. Chem., 2015, 407, 3975-3984**

WP3 Task 3.3 Months 12-30

Detector assembly and readout software development (UNICT-IT, CSFNSM-IT, CNR-IT)

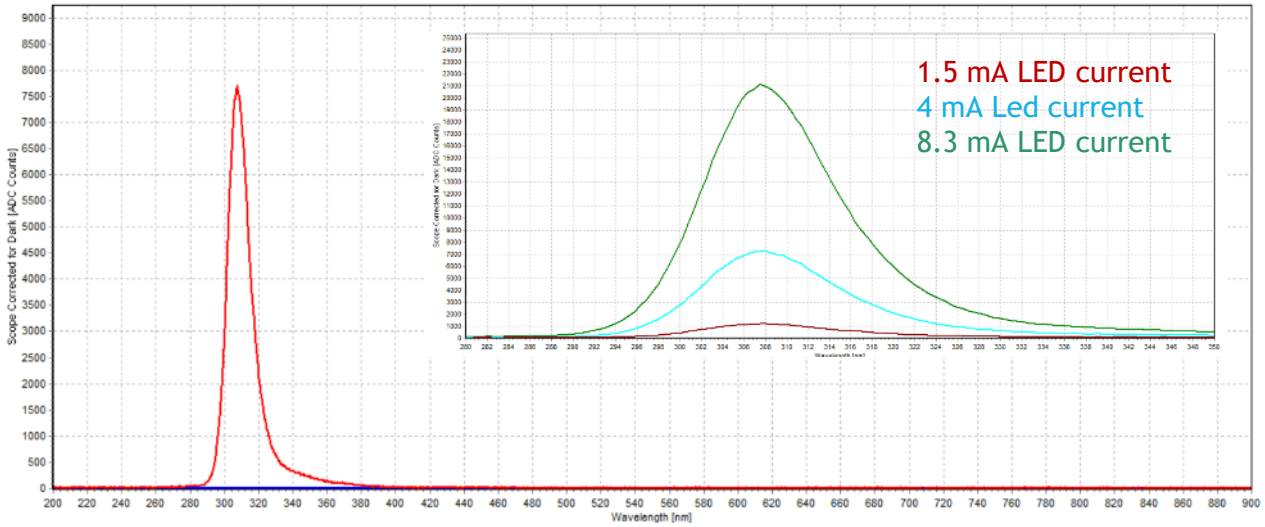


Our objectives:
design and assembly of spectroscopy apparatus operating
in the UV range and its complete electro-optical characterization

Obtained results:
starting from results of task 3.1
a commercial LED operating at 310 nm was acquired and characterized

WP3 task 3.3 results: LED acquisition and characterization

A 310 nm LED was acquired. Its electro-optical characteristics were measured



It exhibits a sharp peak @ 307 nm

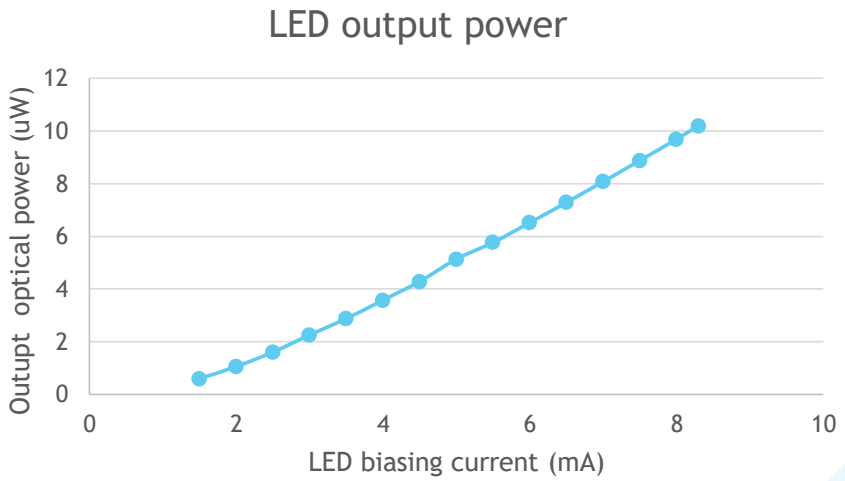
Peak wavelength doesn't change with the biasing current

Optical output is stable along the time

We also measured the optical output power at a distance of 3 cm from the LED surface versus the biasing current

=>

We obtained a Linear trend



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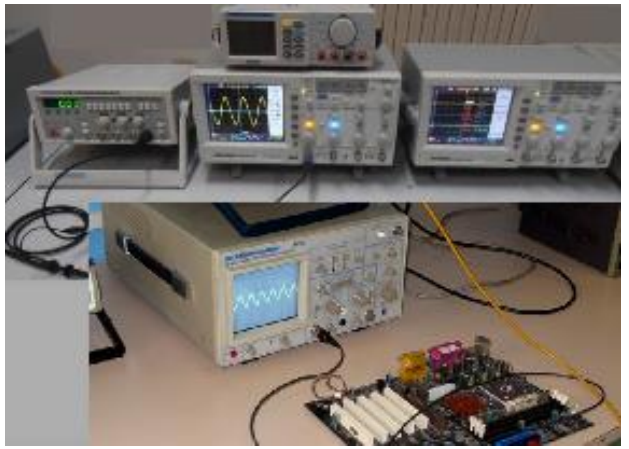
WP3 Task 3.4 Months 12-30

Detector test and calibration with use cases (CSFNSM-IT, CNR-IT, UNICT-IT, UV-ES,)



Our objectives:
Test and calibration of the spectroscopy apparatus

Obtained results:
we will start the activity in the next months

WP3 Task 3.5 Months 6-34

Development of data network and online monitoring software for remote control (UNICT-IT, CNR-IT, UBOUIRA-DZ, UV-ES)

Our objectives:
Development of data network and of the software for the remote control

Obtained results:
we will start the activity in the next months

WP3 deliverables

- **D3.1** Design and flow chart preparation for the fabrication of SiC sensors (task 3.1)-M6 (delivered)
- **D3.2** Report on sensors fabrication and on their electro-optical characterization (task 3.1)-M14 (December 2024) Work in progress
- **D3.3** Large area SiC sensors ready and operating in deep-UV and electro-optical characterised (task 3.1)-M14 (December 2024) Work in progress
- **D3.4** Optically sensible polymeric substrates for pollutant detection made and tested (task 3.2)-M16 (February 2025)
- **D3.5** Spectroscopy apparatus assembled and readout software deployed and running (task 3.3) (M18) (April 2025)
- **D3.6** Report on the tests and calibration curves of the spectroscopy apparatus (task 3.4) (M25) (November 2025)
- **D3.7** Data network and remote control software (task 3.5) (M32) (June 2026)

WP3 Milestones

1) **M3.1 -** Large area SiC photo-sensor operating in deep-UV (task 3.1) => **Month 14** (December 2024)

2) **M3.2** - Spectroscopy apparatus assembled with running readout software (task 3.3) => **Month 18** (April 2025)

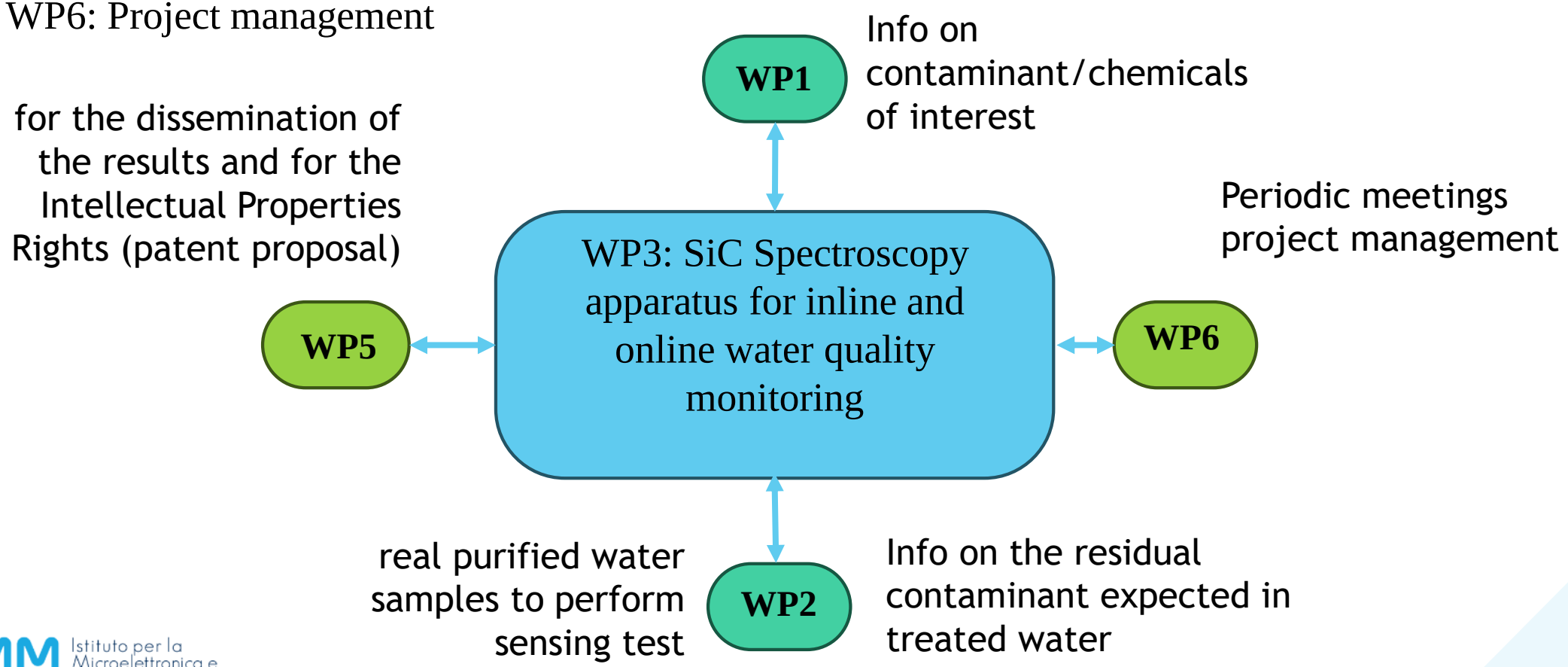
3) **M3.3 -** Data network and remote control software (task 3.5) => **Month 32** (June 2025)

WP3 Bottlenecks or Issues

no issues to be evidenced at this time

WP3 interaction with other WPs

- WP1: Analysis of the water/land/agro-ecosystem
- WP2: Development of Innovate Integrated Water Purification System
- WP4: Quality control on Water, Soil and Crops
- WP5: Dissemination and Communication
- WP6: Project management



WP3 Risk and contingencies

Risk description (Low/Medium/High level)	Mitigation approach
Management of low signal at low concentrations (M)	opportune amplification electronic set-up
System not usable in turbid waters (M)	Pre-sensing water treatment
Absence of cheap LED (M)	Use of lamp and filters
Atmospheric agents interference for in-line on-field measurements (L)	To be tested
faster scientific and technologies innovations competitors (M)	

WP3 technical and scientific meeting calendar (every ~3 months)

- coordination meeting 30 January ’24: ok
- **deliverable** meeting 24 April ’24: ok
- coordination meeting 25 July ’24: ok

- **deliverable** meeting 22 November ’24=> **D3.2** Report on sensors fabrication and on their electro-optical characterization & **D3.3** Large area SiC sensors ready and operating in deep-UV and electro-optical characterised (task 3.1)-M14 (December 2024)
- **deliverable** meeting January ‘25=> **D3.4** Optically sensible polymeric substrates for pollutant detection made and tested (task 3.2)-M16 (February 2025)
- **deliverable** meeting April ’25 => **D3.5** Spectroscopy apparatus assembled and readout software deployed and running (task 3.3) (M18) (April 2025)
- coordination meeting (July ’25)
- **deliverable** meeting November ’25=>**D3.6** Report on the tests and calibration curves of the spectroscopy apparatus (task 3.4) (M25) (November 2025)
- **deliverable** meeting June ’25=> **D3.7** Data network and remote control software (task 3.5) (M32) (June 2026)

Catafurco Waterfalls - **Galati Mamertino**, Messina, Sicily