SWRIPS:
Sustainable Water Re-use with Innovative Purification and Sensing system for the agri-food supply chain

CNR UNIT SWRIPS project meeting

Antonella Sciuto

WP 3 Leader & CNR unit coordinator

25 July 2024

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

Meeting Focus:

brief resuming of CNR-UNIT activity in the project

brief presentation of results obtained from participants

free discussion on next steps to be performed

Role of the CNR-IT unit 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	

Unit official participants:
Antonella Sciuto, Sebania Libertino & Silvia Scalese, CNR-IMM
Sabrina Carroccio, CNR-IPCB

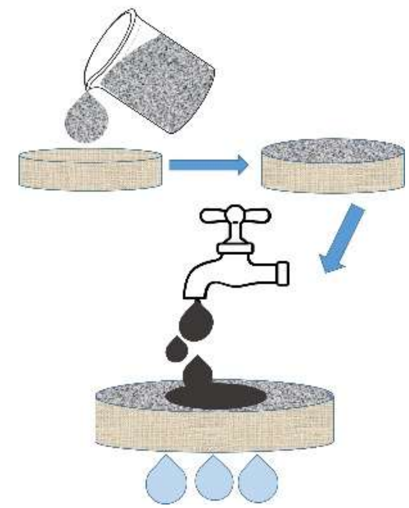
Outhers: Ivana Di Bari, Giusy Curcuruto, Emanuela Spina, Simona Filice, Viviana Scuderi, Martina Ussia, Roberta Farina, Giuseppe Capuano, Giuseppe Screpis, Debora Costantino, Stefano Bonforte

WP2 Implementation

Task 2.2 Innovative second-stage filters based on nanocomposites for bacterial and heavy metal removal *(CNR-IT, UBOUIRA-DZ, SRTACITY-EGY, ENSCR-FR)*

Our objectives:
development of

- innovative nanocomposite filters using polymeric materials, carbon-based nanostructures and metal oxides nanoparticles;
- new environmental-compliant adsorption filter based on Fe doped-TiO_2 and zeolite



Key aspects:

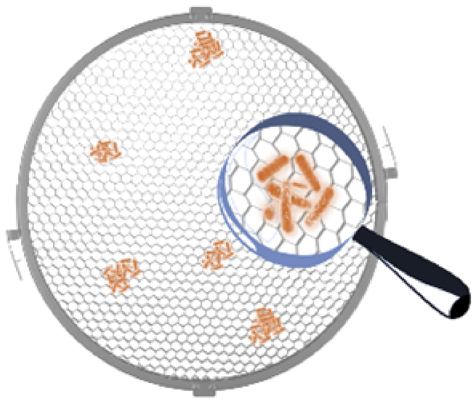
- specific adsorption/photocatalytic properties useful for water decontamination
- free-standing membranes or thin layers on substrates, such as commercial filters.

Characterisation:

- morphological, structural and chemical analysis
- adhesion of the nanocomposite layers on the substrate
- removal ability towards pollutants
- Antibacterial properties using standard methods at the joint laboratory "Smart2Sense" (S2S) of CNR and the "Regional Reference Laboratory of Clinical and Environmental Surveillance of Legionellosis" of the Dept, of Medical and Surgical Sciences and Advanced Technologies "G.F. Ingrassia", at the University of Catania.

WP2 Implementation

Task 2.3 Test of the purification system *(CNR-IT, UNICT-IT, CERTE-TN)* **M12-M20.**



Our objectives:

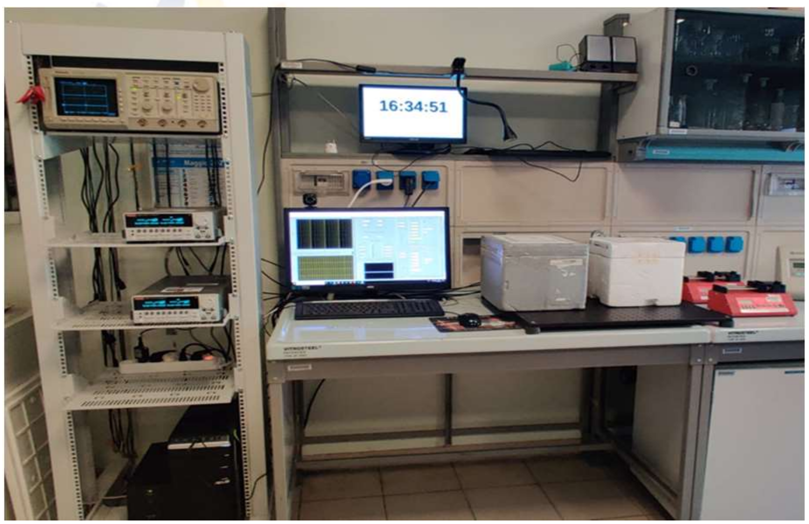
- test of water purification systems adopting Escherichia Coli, Salmonella, and faecal coliform bacterial suspensions at controlled CFU.
- Test of the biocidal and repellent effect of innovative material to block the biofilm formation

- Water samples will be intentionally contaminated by bacterial suspensions and used to test the new materials developed in task 2.2.
- The bacteria vitality will be analysed by culture method, fluorescence labelling, and optical microscopy.
- Study of the best strategy to contrast the biofilm formation on filters surface to prolong filter lifetime.

Joint Lab

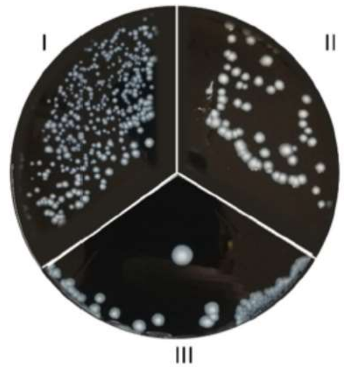
IMM
Consiglio Nazionale delle Ricerche
Institute for Microelectronics and Microsystems

Università degli Studi di Catania
Dip. di Scienze Mediche, Chirurgiche e Tecnologie Avanzate
«G.F. ingrassia»

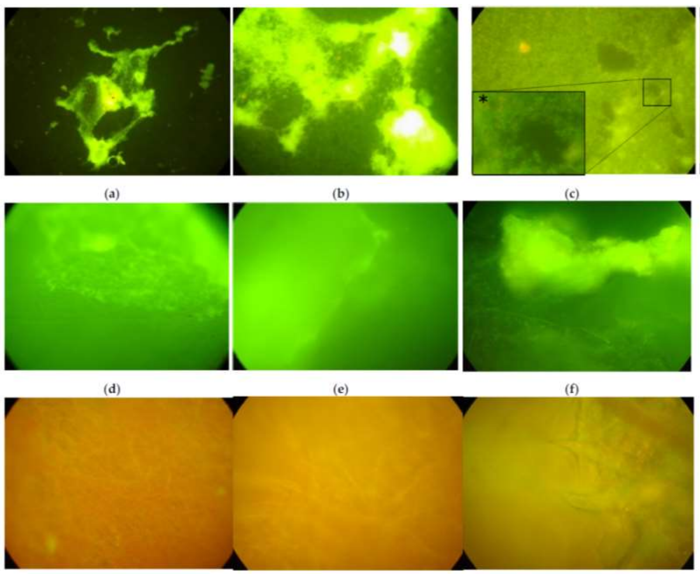


Our recent studies on materials properties useful for the WP2 SWRIPS project

Antibacterial properties



Biofilm growth studies



Adsorption properties of heavy metals by polymeric membranes

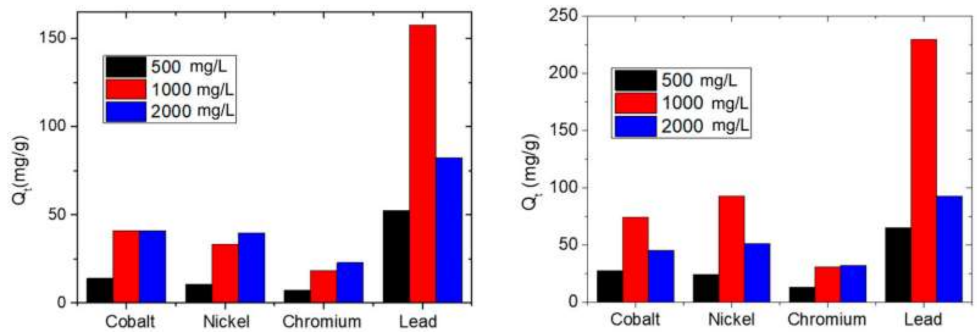


Figure 8. Adsorbed ions (mg) per gram of s-PBC (on the left) and s-PBC/GO (on the right) after 180 min of contact of the polymeric membrane with the aqueous solutions, for different initial salt concentrations.

- S. Filice et al., *Innovative Antibiofilm Smart Surface against Legionella for Water Systems,* Microorganisms 2022, 10, 870.
- S. Filice et al., *Sulfonated Pentablock Copolymer Membranes and Graphene Oxide Addition for Efficient Removal of Metal Ions from Water,* Nanomaterials 2020, 10, 1157

WP3 Implementation

Task 3.1 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.

Key aspects:
- solid state based compact UV spectroscopy system for chemicals and/or biological agents

Our Strategy:
=> Commercial cheap LED or compact sources
=> Silicon Carbide based UV detector opportunely designed and fabricated by CNR-IT ensuring : technological maturity and 3.26 eV energy band gap ensuring blindness over the band edge (~ 380 nm).
=> Schottky junction photodiode will be adopted &
=> innovative nanostructured front electrode will be explored to enhance the deep UV sensitivity.

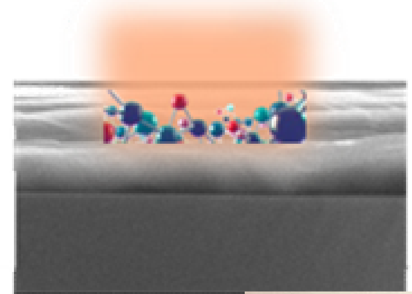
- hostile environment applications
- insensitivity to environment temperature,
- chemical inertness
- visible blindness ensuring absence of false response due to visible fluorescence of chemicals interfering.
- remote control of the sensing system

The dedicated electronics:
to handle optical flux by regulating power supply current,
to bias the SiC detector
to measure the output current (in the order of 100 pA – 100 nA).

WP 3 Implementation

Task 3.2 Optically sensible polymeric substrates for heavy metals and pesticide detection (CNR-IT, SRTACITY-EGY)

Our objectives:
design and fabrication of Optically sensible polymeric substrates for heavy metals and pesticide detection;



Key aspects:
- Detection of heavy metals and pesticides will be explored by adopting opportune sensing materials
- Substrates based on acrylic and vinylic polymeric materials
- Funtionalised polymers to detect target molecules and to obtain optical variation while in action

Characterisation :
- by thermal analysis (TGA and DSC),
- by spectroscopical measurements (FTIR)
- By Mass spectrometry-based techniques (Py/GCMS and ICP-MS for metal detection)

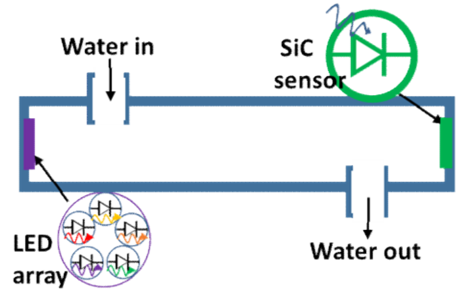
Methodology:
- Polymeric substrates will be assembled and integrated with the optical apparatus to ascertain the detection ability, selectivity, saturation limits, and the range of applicability in terms of temperatures and pHs
- Sensing tests will be evaluated on mercury, lead, arsenic, and chromium, as well as selected pesticides
- Test on the durability of the polymeric substrate, along with the time, will also be assessed to avoid the release of microparticles during use.

Consiglio Nazionale delle Ricerche
iPCB ISTITUTO PER I POLIMERI COMPOSITI E BIOMATERIALI

PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

WP 3 Implementation

Task 3.3 Detector assembly and readout software development (UNICT-IT, CSFNSM-IT, CNR-IT)

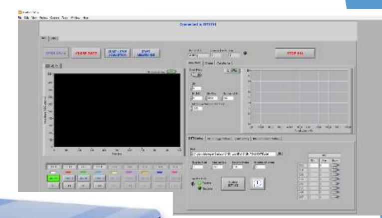


Our objectives:
design and assembly of spectroscopy apparatus operating in the UV range and its complete electro-optical characterization

Key aspects:

- The spectroscopy system will be assembled using a steel or aluminium tubular chamber.

- The chamber dimensions (optical path) will be fixed evaluating the optical absorption of the chemicals of interest using standard laboratory characterization

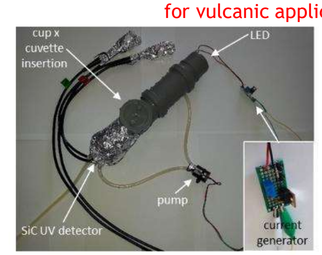


Methodology:
Different Systems operating with the same principle will be designed
=>for detection in liquid of:

- Nitrogen compound
- Biological agent

=>for the monitoring of sensing substrates devepoled in **Task 3.2** for heavy metals and/or pesticides

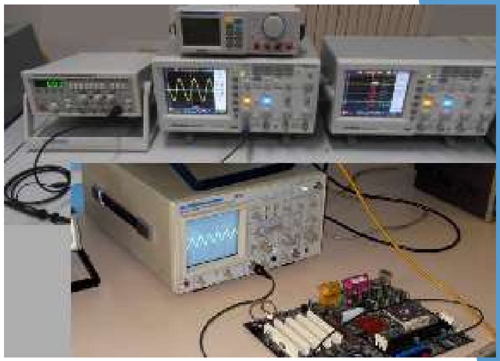
System we recently designed for vulcanic applications



Complete characterization of the system will be performed in lab with bench electronics and test water solutions
Labview could be a favorable framework for laboratory test being the most diffuse devices (picoammeters, power supplyes, thermometers..) compatible with Labview.
A lot of Labview experience is shared among collaboration members. Existing routines could be rapidly converted to the new applications
Successively, **opportune readout software** will be developed for the complete control of the system locally and in remote configuration

WP 3 Implementation

Task 3.4 Detector test and calibration with use cases (CSFNSM-IT, CNR-IT, UNICT-IT, UV-ES,)

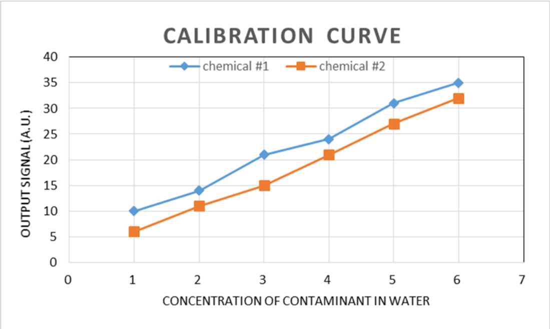


Our objectives:

Test and calibration of the spectroscopy apparatus

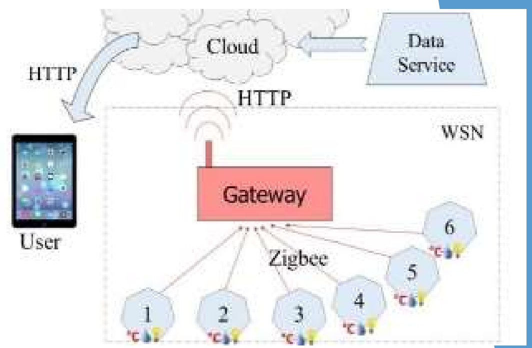
Characterisation:

The complete spectroscopy apparatus will be tested and calibrated in laboratory against gold-standard instrumentation and protocols, using water solutions with different fixed concentration of the chemical species to be monitored opportunely prepared. Water solution contaminated with bacteria as described in Task 2.3, will be adopted also for the spectroscopy apparatus testing towards biological contamination. A prototypal system emulating the final set-up will be assembled and tested in laboratory using a flow rate scaled-down water pipeline.



WP 3 Implementation

Task 3.5 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

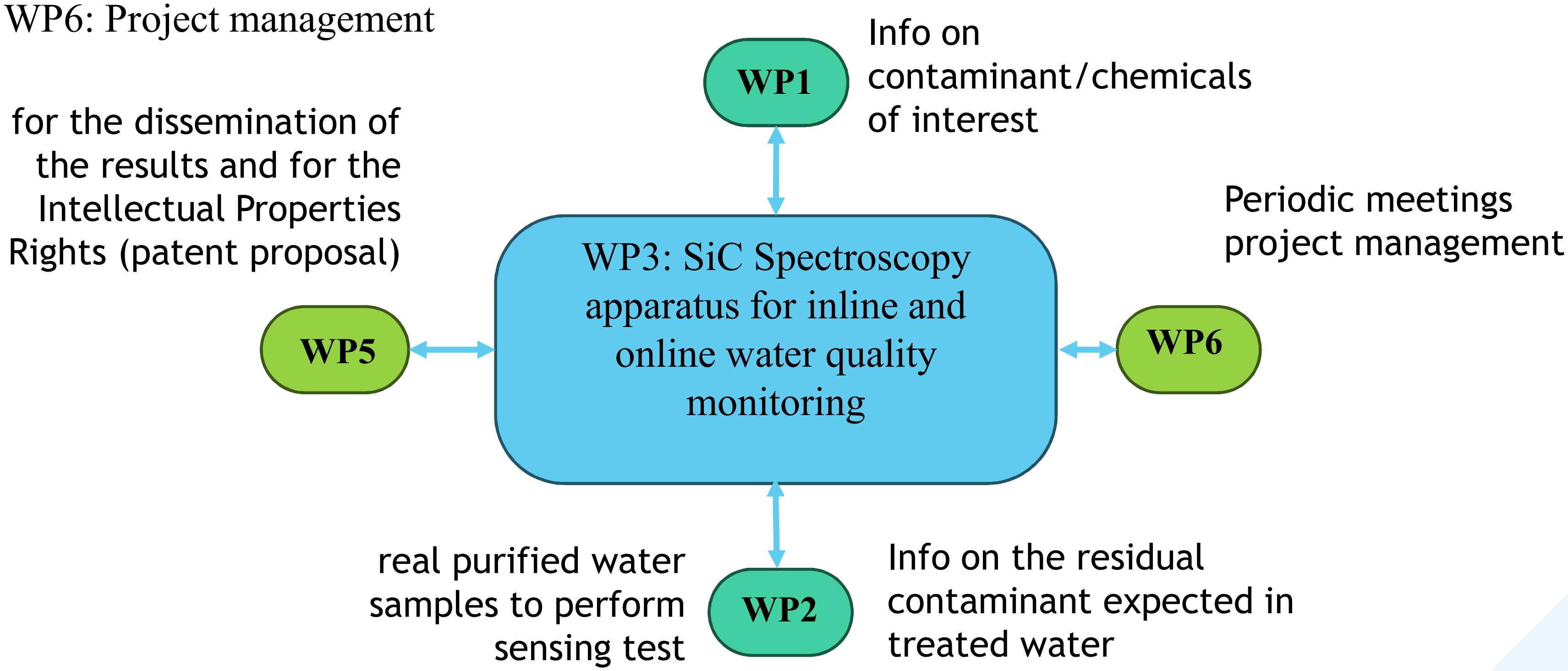
Key aspects:
Different sensors can be deployed in field. In order to allow for a centralized water distribution monitoring, a suitable ICT data network will be developed. Different protocols and gateway will be used in relationship with distance between on-field sensor and data center. For group of close-locally distributed sensors, a LoRA network (or eventually WiFi / ZigBee network) can be used. Then, different LoRA gateway can be connected to the data center using for example standard 4G or NB-IOT (if available) network with standard protocol as MQTT. The best configuration will be on-field evaluated during the whole system integration phase. At the data center, a suitable software with user interface will be developed or integrated, starting from opensource, in order to allow for data storage in a database, whole system behavior monitoring and mis-behavior alarm information monitoring.

PRIMA
IN THE MEDITERRANEAN AREA

WP3
Spectroscopy apparatus for Online Water Quality Monitoring

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 short report of carried activity (task 3.1)

- We studied the literature on optical systems for pollutants monitoring in water
- We identified the wavelengths of interest for the detection of chemical pollutants and biological agents
- We searched on the market, LEDs operating at the wavelengths of interest: the selected lines are actually in the UV range and in particular 234, 265, 280, 300 and 355 nm
- We **Designed** Silicon Carbide photo-detectors to be used for the development of portable spectroscopic systems

- **At the end of** April '24 => realease of **D3.1** Design and flow chart preparation for the fabrication of SiC sensors (task 3.1)-M6

WP3 short report of carried activity (task 3.2)

We started the activity the last March:

- on the polymeric sensor substrates preparation and on their optical characterization
- We selected 3 pesticides that we have in lab to perform study on innovative polymer detection ability
- PESTANAL
- 2,4-D
- IMIDACLOPRID

We are fixed the polymers properties….

- transparent (in the UV and in VIS)
- Insoluble in water
- spreadable on solid substrate (plastic, glass or quartz) or prepared in free standing films.

- Polimeric Substrates will be prepared using green processing and will be optically characterised. Functionalization procedure will be fixed after preliminary detection test.

WP3 short term planned activities

- Task 3.3 LEDs will be characterized to obtain the optical spectra and the operative conditions.

Task 3.4 & 3.5 (Domenico Longo & Nello Albergo)

WP3 aim:

development of sensing systems and in particular

=>our focus is the development of an in-line test system for continuous monitoring of the **physical and chemical** parameters of the purified water to be re-used for irrigation.

as discussed in previous meeting, to focus our research on contaminants of interest we wait data from WP1 and WP2 for effluent waste water

-list of typical/residual contaminant in the water and expected concentration

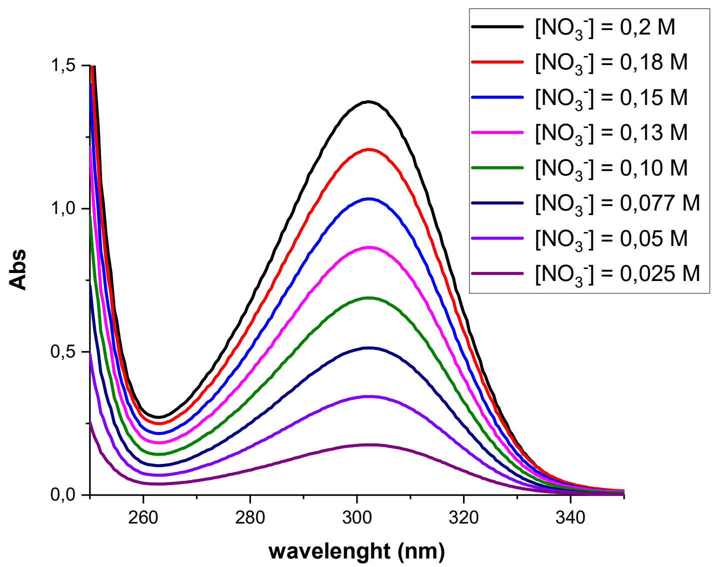
As widely discussed in previous meeting
Nitrate is one of the contaminants of interest
then we started evaluating the optical detection
in water solution
with standard bench spectro-photo-meter

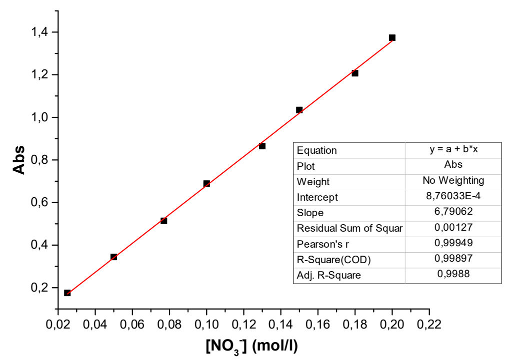
We performed Analysis of water solutions containing Nitrate (starting from Sodium Nitrate)

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 **extimate the molar extinction coefficient** in water in the **best linearity conditions =>that is in high concentration of Nitrate**

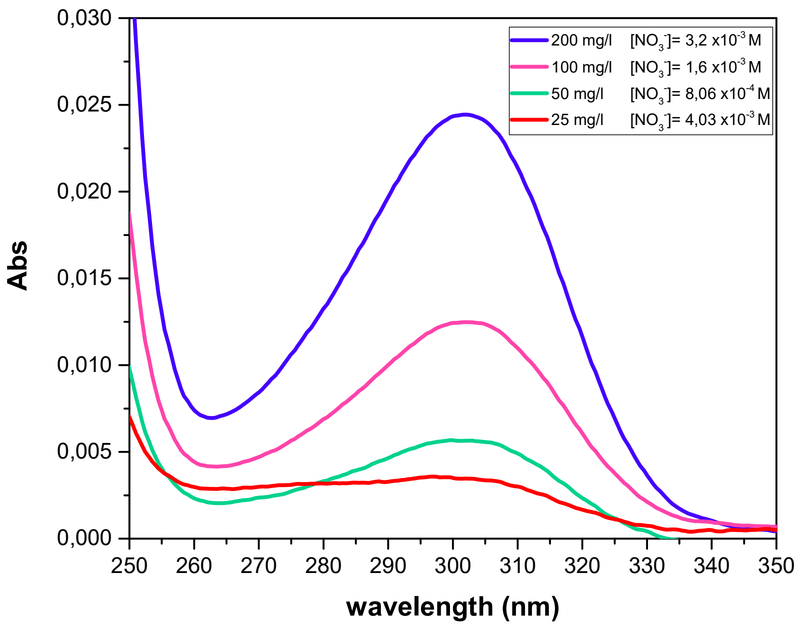


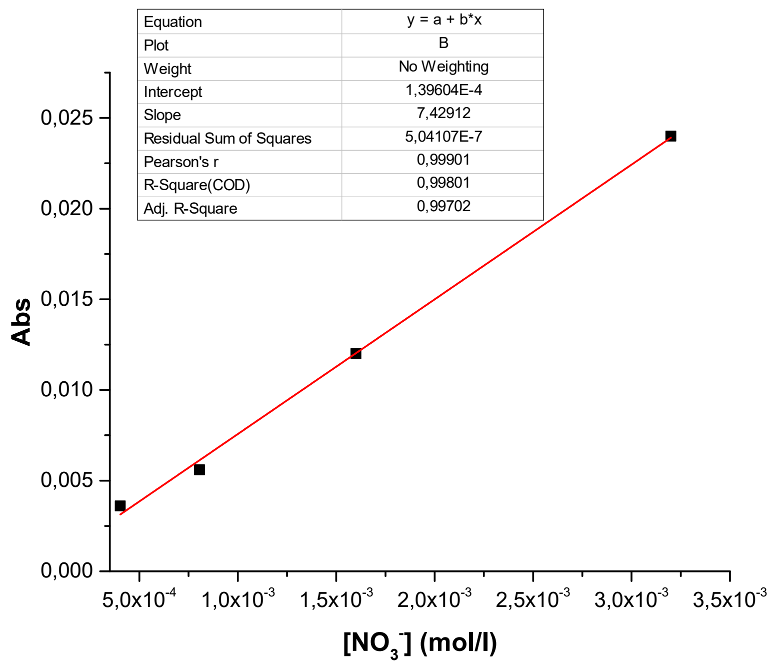


This concentration range is very far from the LAW LIMIT VALUE ADMITTED

- the second one was performed in a **nitrate concentration range close to the value permitted by law (30 mg/L)**

In order to verify the linearity of measurements also in this range





Equation	y = a + b*x
Plot	B
Weight	No Weighting
Intercept	1,39604E-4
Slope	7,42912
Residual Sum of Squares	5,04107E-7
Pearson's r	0,99901
R-Square(COD)	0,99801
Adj. R-Square	0,99702

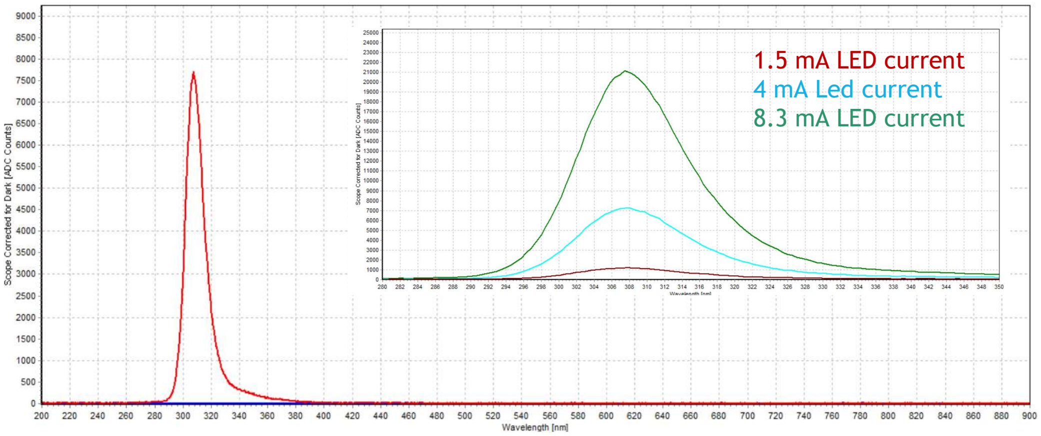
The next step for the development of the monitoring system was the selection of the optical «solid state based» components and in particular of the optical source

And, as Yet discussed in previuos meeting,

We acquired a 310 nm LED

And we measured its output characteristics

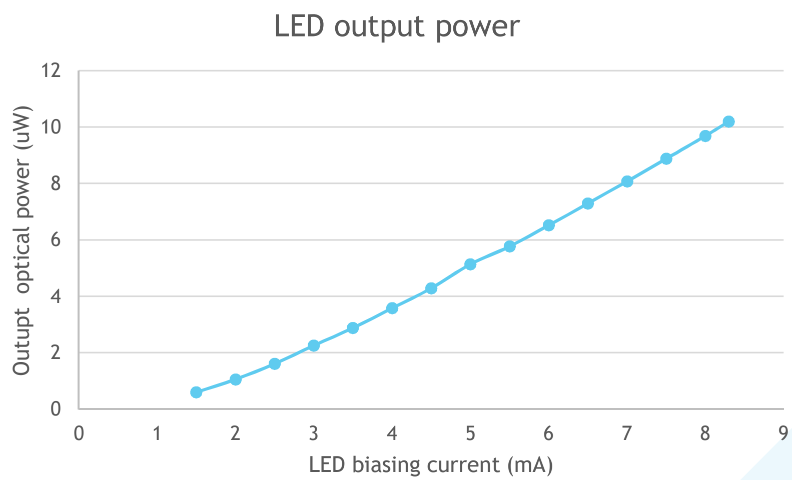
We acquired the LED spectrum



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

Finally we planned to do measurements adopting a cuvette with 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

WRIPS

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

- coordination meeting 30 January ’24 (**Done**)
- **deliverable** meeting 24 April ’24 => **D3.1** Design and flow chart preparation for the fabrication of SiC sensors (task 3.1)-M6 (April 2024 – **Done)**
- coordination meeting **to be planned** in July ’24
- **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)

Tasks activity will be discussed and planned during the WP meetings. Further Task meetings will be planned if necessary during the project period.

Some key points for CNR activities both in the WP2 and WP3:

-list of typical/residual contaminant in the water to be removed by nanostructured filters and to be monitored by sensing systems (as today shared by Lofti and by Fabio for starting waste water ….)
to prepare artificial waste water in lab
will be shared from WP1 and WP2 partners for effluent waste water

-water samples to test nanostructured filters on real samples at month 12 and later

Some other questions

Q:Do we have a template for the report delivery?
Answer: Alessia/Livio will share the template in few days

Q:Task activity report will be prepared by the task leader? Or contributions will be collected by the WP leader?
Answer:the Task Leader is responsible for the report delivery

Q:Concerning the Palermo Conference: will be published papers/proceeding or only extended abstract?
Answer: at this moment only abstract but a Special issue will be maybe published

Open question:

Q:Concerning the Palermo Conference:

What is the date of the annual project meeting?

7 And 8 october!