FUNDING PROGRAMME: Demonstrative Experimental Project (DEP)

SUBPROGRAME: 3.2 – Environment and climate changes

PROJECT TITLE/ACRONYM: Bio-Gamma Advanced Reduction and Oxidation for Sustainable Reuse of Water in textile industry - BIGARROW

CONTRACT NO.: 720PED/2022 (PN-III-P2-2.1-PED-2021-4363)

PROJECT TOTAL BUDGET: 598.795 Lei (121,081 €) **INCDTP BUDGET**: 270.000 Lei (54,596 €)

START DATE: 21/6/2022 **END DATE:** 20/6/2024

WEBPAGE: https://www.nipne.ro/proiecte/pn3/68-proiecte.html

PARTENRS:

1. Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH) (**CO** -România)

2. National Research & Development Institute for Textile and Leather (INCDTP)(România)

GENERAL OBJECTIVE:

The objective of the project was to investigate the performance and validate the effectiveness of an advanced treatment and decontamination method for textiles from wastewater effluents. This method, called "BIO-AORP technology," combines the benefits of green AORP processes and bio-treatments for wastewater remediation, aiming for industrial reuse (e.g., reuse in the same textile dyeing processes or within the same industrial park for cooling or as a solvent in chemical processes), other urban uses (such as street or underpass cleaning), hydroponics, floriculture, tree cultivation, irrigation (i.e., agricultural reuse), or safe discharge.

SPECIFIC OBJECTIVES/ EXECUTION PHASES:

1. Evaluation of analytical methods for characterizing and assessing the effects of the proposed technology on the reduction of persistent organic pollutants (POPs) and heavy metals.

2. Study of the effects and reliability of the BIO-AORP technology under normal temperature conditions, for specific groups of contaminants, where irradiation technology is effective according to existing knowledge assessments.

3. Determination of the optimized absorbed radiation dose and procedures for different application cases, in combination with bioremediation processes applied before and after treatment for contaminated wastewater.

4. Development of guidelines for selecting areas where the BIO-AORP technology has high potential to make treated wastewater suitable for reuse or safe discharge, including the establishment of threshold conditions for successful application.

NOVELTY ELEMENTS/ SCIENTIFIC CONCEPT:

The BIO-AORP technology proposed within the BIGARROW research project introduced a significant innovation in the treatment of wastewater from textile dyeing processes through a synergistic and complementary approach to eliminating refractory compounds – such as dyes, heavy metals, and chemical by-products. The objective was to achieve a higher degree of wastewater purification, including the possibility of reusing the treated effluent, thereby contributing to the promotion of a circular economy in the textile industry. The demonstrative model developed and tested – known as the BIO-AORP technology – consisted of a combined laboratory-scale technology that integrated the bioremediation potential of selected microbial strains with gamma irradiation, used as an AORP simulation technology. This innovative combination targeted the degradation of residual concentrations of persistent organic pollutants (POPs) specific to wastewater from the textile industry.

EXPECTED EXPLOITABLE RESULTS:

1. Innovative national BIO-AORP combined treatment technology. The project aimed to develop a hybrid technology that combines microbial bioremediation with irradiation (AORP) for the efficient removal of dyes and persistent organic compounds from textile wastewater.

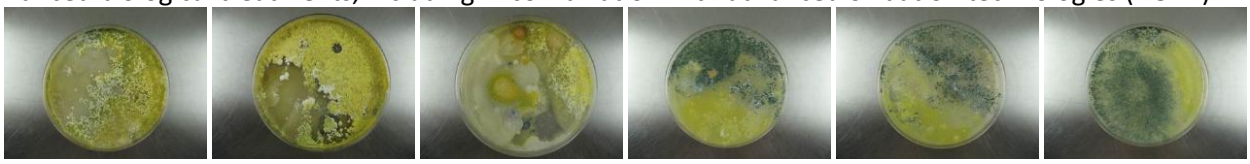
2. Eco-friendly treatment without secondary residues. By using AORP technology, the purification process requires no chemical additives and generates no toxic residues, making it environmentally friendly, scalable, and efficient for industrial applications.

3. Contribution to sustainability and circular economy. The project supports the recovery of wastewater and treated sludge, reducing pollution of natural waters and promoting resource reuse in agriculture and other fields, with a positive impact on sustainable development.

OBTAINED RESULTS:

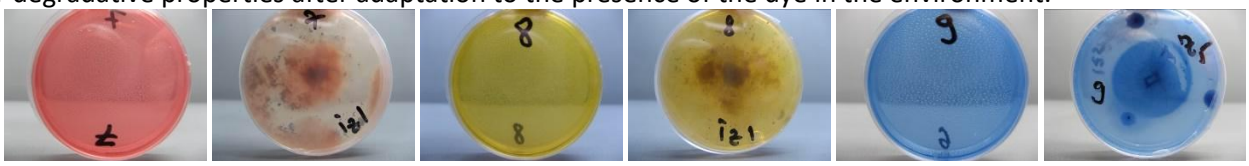
1. Collection of microbial strains from extremophile environments

A collection of strains from natural environments was obtained, serving as a strategic biological resource for use in advanced biological treatments, including in combination with advanced oxidation technologies (AORP).



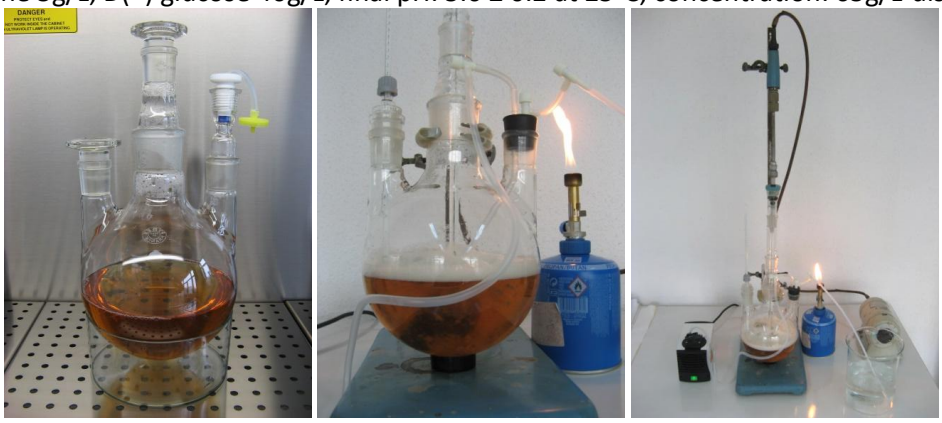
2. Laboratory experiments on bioremediation of synthetic acid dye solutions

Testing the adaptation capacity to high concentrations of azo dyes present in the culture medium, along with their degradative properties after adaptation to the presence of the dye in the environment.



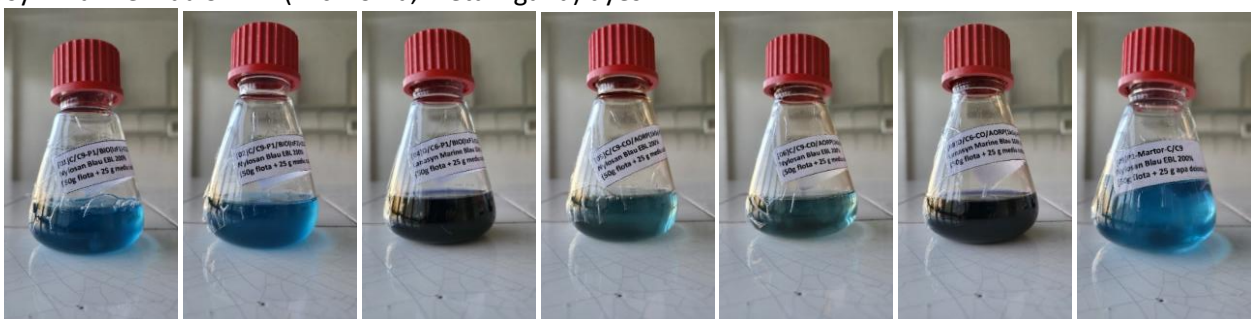
3. Construction of a DIY bioreactor

Production of *Cerioporus squamosus* biomass in liquid Sabouraud-Dextrose 4%-Agar medium (casein peptone 5g/L, meat peptone 5g/L, D(+) glucose 40g/L, final pH: 5.6 ± 0.2 at 25°C, concentration: 65g/L-distilled water).



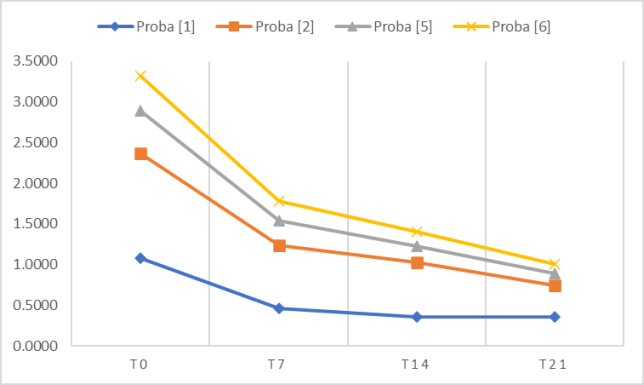
4. Method for testing the efficiency of the combined BIO-AORP and AORP-BIO technology

Preliminary evaluation of the technology concept was conducted on the *C. squamosus* and *F. oxysporum* strains, using two dye baths resulting from the dyeing of textile materials with Nylosan Blau EBL 200% (Archroma) and Lanasyn Marine Blau SD-NL (Archroma, metal ligand) dyes.

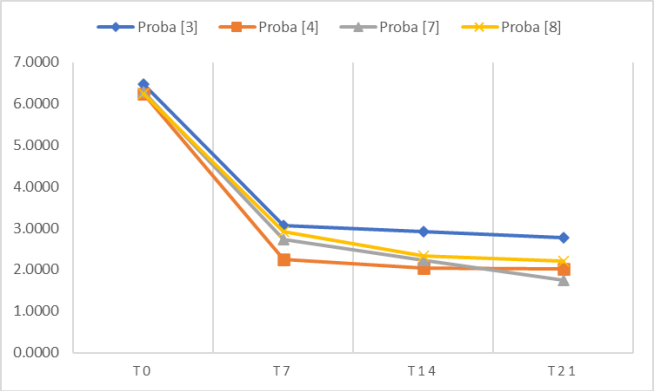


The experiments were conducted on dye baths containing Nylosan Blau EBL 200% (Archroma) and Lanasyn Marine Blau SD-NL (Archroma, metal ligand), using separate sets for each strain and in both BIO-AORP and AORP-BIO variants. The UV-VIS readings after the bioremediation experiments (21 days) showed very small differences between the strains, with a slight advantage for the *Fusarium oxysporum* strain, reaching a maximum R% of

83.75% and a minimum of 70.91% (T21), compared to the *Cerioporus squamosus* strain, which reached a maximum of 79.71% and a minimum of 64.76% (T21).



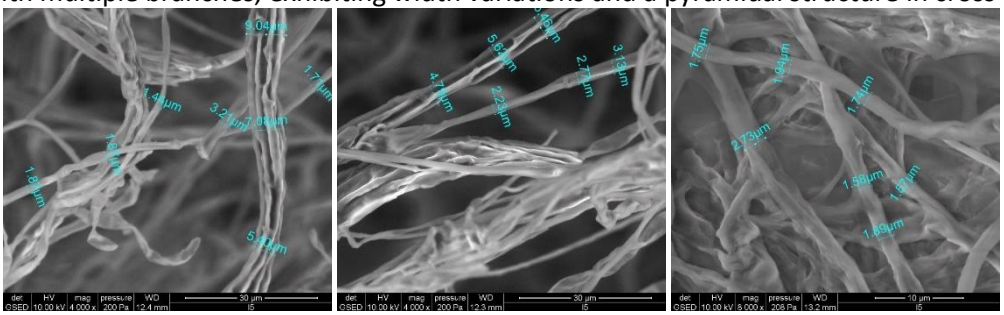
Variation in the concentration of Nylosan Blau EBL dye (T0–T7–T14–T21)



Variation in the concentration of Lanasyn Marine Blau SDNL dye (T0–T7–T14–T21)

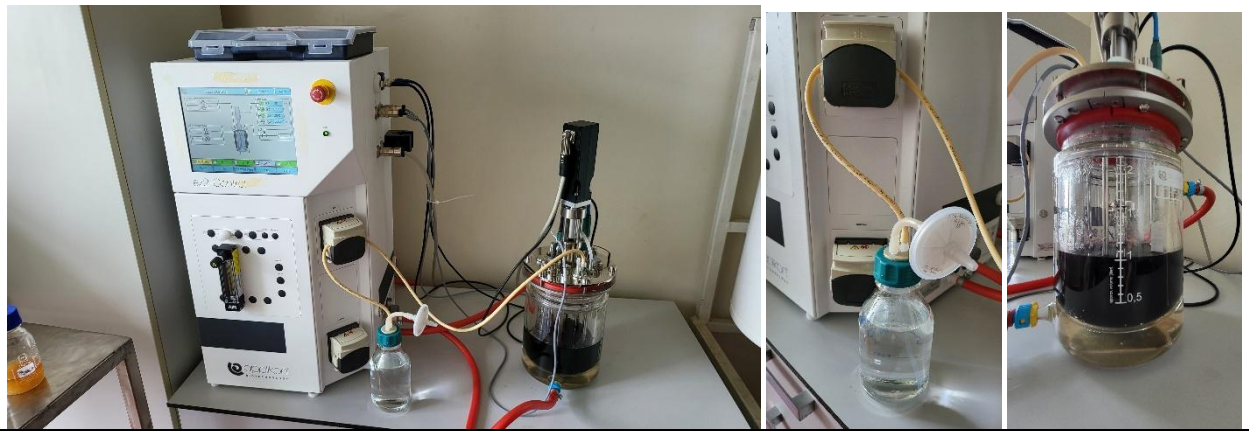
5. Characterization of biological material (*Cerioporus squamosus*) by scanning electron microscopy (SEM)

Cerioporus squamosus is a basidiomycete with significant importance in natural ecosystems, being capable of degrading a wide range of cellulosic substrates. SEM analysis of the strain, conducted at working pressures between 200Pa and 208Pa, revealed a fibrillar, branched structure of the strain, with a high degree of coverage on the carbon tape and hyphae dimensions ranging from 1.44µm to 9.04µm. The hyphae show a high level of organization with multiple branches, exhibiting width variations and a pyramidal structure in cross-section.



6. Demonstration of the functionality of the final experimental model

In the final stage of the project, the goal was both to evaluate the decontamination efficiency of the bioremediation technology and to demonstrate the functionality of a final experimental model of combined AORP-BIO technology. Thus, experiments on reducing the residual concentration of Nylosan dye using the macromycete *Cerioporus squamosus*, conducted over 12 days (T0–T4–T8–T12), showed very good reduction rates, with values ranging from 32.08% to 37.3% for the untreated dye (M0); 29.75% to 61.81% for dye irradiated at 1kGy; 34.5% to 45.08% for dye irradiated at 10kGy; and 66.67% to 85.31% for dye irradiated at 100kGy. The strain's performance at the bioreactor (fermenter) scale demonstrated very good reduction rates of the Lanasyn dye solution (metal complex), with the strain able to grow in the presence of the xenobiotic agent in the reaction medium.



DISSEMINATION, PATENT APPLICATIONS, FAIRS/EXIBITIONS, AWARDS:

- **WoS published papers: 1**

1. Silvana, V., Ionuz, E., Andreea-Elena, S., Florin-Adrian, A., Mihai, C., Florina, Z., Mihalis, C., Ovidiu, I. Valentin-

Ioan, M., Marian, V. Assessment of HPLC, UV-VIS and ICP-MS potential for quality control analytical techniques in new BIO-AORP dyes removal technologies. 32nd Miller Conference on Radiation Chemistry Proceedings, 2023.

- **BDI published papers: 2**

1. O. Iordache, B. Cazan, E. Perdum, C. Tănăsescu and L. Secăreanu. Biodegradation of Dye Pollutants in Water: Harnessing the Capabilities of Filamentous Fungi. Proceedings of TEXTEH XI 2023, Vol. 1, Pgs. 234, ISSN 978-83-67405-38-6, DOI: 10.2478/9788367405386-018;

2. Ovidiu Iordache, Bogdan Cazan, Elena Perdum, Mihai Carmen, Laurențiu Dincă, Cezar Lupescu. Use of Basidiomycete and Ascomycete representatives for removal of acid and metal-complex dyes from natural textile wastewater. Book of Abstracts of the 27th International Symposium Environment and Industry, SIMI 2024 International Symposium. https://www.simiecoind.ro/wp-content/uploads/2024/09/23.pdf.

- **Scientific communications: 2**

1. Oral presentation at " The 11th International Conference TEX TEH 2023", with paper " Biodegradation of Dye Pollutants in Water: Harnessing the Capabilities of Filamentous Fungi". Authors: O. Iordache, B. Cazan, E. Perdum, C. Tănăsescu and L. Secăreanu;

2. Poster at "32nd Miller Conference on Radiation Chemistry Proceedings", with paper "Assessment of HPLC, UV-VIS and ICP-MS potential for quality control analytical techniques in new BIO-AORP dyes removal technologies". Authors: Silvana, V., Ionuz, E., Andreea-Elena, S., Florin-Adrian, A., Mihai, C., Florina, Z., Mihalis, C., Ovidiu, I. Valentin-Ioan, M., Marian, V;

3. Poster at "27th International Symposium Environment and Industry, SIMI 2024 International Symposium", with paper "Use of Basidiomycete and Ascomycete representatives for removal of acid and metal-complex dyes from natural textile wastewater". Authors: Ovidiu Iordache, Bogdan Cazan, Elena Perdum, Mihai Carmen, Laurențiu Dincă, Cezar Lupescu.

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