

JOINT PhD THESIS PROPOSAL

Field: Chemistry / Environmental Materials

Proposed Title

“Synthesis, Characterization and Multi-Functional Nano Bio-Composite Material for Water Treatment and Safe Irrigation Reuse: RSM Mapping and AI-Driven Optimization – A Joint Algerian-Mauritanian Study”

1. Main Idea

This project proposes to develop a low-cost, multi-functional bio-composite material, made from natural and locally available ingredients (such as clay, chitosan, cellulose and gelatin, reinforced with a small amount of PVA), able to remove pollution (a textile dye, and where possible a second contaminant such as fluoride) from water. The preparation conditions and removal performance will be mapped and optimized using Response Surface Methodology (RSM), and an AI-driven approach (e.g., neural network models combined with optimization algorithms) will be used to find the best operating conditions and to predict performance more accurately.

Beyond water purification, the project will check that the treated water is safe to reuse for irrigation (plant germination/growth tests), and will evaluate additional useful properties of the material (antibacterial and antioxidant activity), so that the final material is genuinely multi-functional: effective for water treatment, safe for agricultural reuse, and valuable for other applications.

The Mauritanian partner can contribute a local raw material (such as fish-processing by-products, rich in collagen/gelatin) as an additional or alternative ingredient, plus access to real water samples and a site for irrigation testing, making the project a genuine joint Algerian-Mauritanian contribution.

2. Objectives

General Objective

Develop a low-cost, multi-functional bio-composite material able to clean polluted water (dye and, where possible, fluoride), use RSM mapping and AI-driven optimization to find and predict the best preparation and operating conditions, and confirm that the treated water is safe to reuse for irrigation, using local materials from Algeria and Mauritania.

Specific Objectives

1. Prepare one or two versions of the bio-composite, using Algerian raw materials (e.g., clay, chitosan, cellulose, gelatin) and, if possible, a Mauritanian raw material (e.g., fish-based gelatin/chitin).
2. Characterize the materials (basic structure and surface analysis: FTIR, SEM, etc.).
3. Map the removal efficiency of the dye (and fluoride, if possible) using RSM experimental design, and identify the main factors affecting performance.
4. Build AI-driven models (e.g., neural networks) trained on the RSM data, combined with optimization algorithms, to predict performance and find the best operating conditions more precisely than RSM alone.
5. Build a small continuous (column) test to check if the material still works when water flows through it continuously.
6. Test the treated water on plant germination/growth to confirm it is safe for irrigation, and evaluate the material's antibacterial/antioxidant properties.

3. Simple Work Plan

The work is organized into five simple steps:

Step 1 – Literature review and preparation of the bio-composite material(s), using Algerian and Mauritanian raw materials.

Step 2 – Characterization of the materials (structure, surface, stability).

Step 3 – Adsorption tests (dye, and fluoride if possible); RSM mapping of the operating conditions; development of AI-driven models and optimization of the best conditions.

Step 4 – Small continuous (column) test, plus a field sample of real water from Mauritania and/or Algeria to test the material on real conditions.

Step 5 – Safety and value-added tests (plant germination/growth, antibacterial/antioxidant tests), writing of articles and the thesis.

4. Algeria – Mauritania Collaboration

- Most of the work (Steps 1-3 and part of Step 5) is done in Algeria, at the host laboratory, with the existing equipment used in the Master's thesis.
- The Mauritanian partner provides: a local raw material (e.g., fish by-products), a real water sample (wastewater or fluoride-affected groundwater), and help with a small irrigation/germination test using a local crop.

- Both supervisors follow the work together and co-sign the final thesis (joint supervision / cotutelle).

5. Schedule (Year by Year)

Year	Main Activities
Year 1	Literature review; sourcing of Algerian and Mauritanian raw materials; preparation and basic testing of the bio-composite material(s); first characterization results.
Year 2	RSM mapping of adsorption performance (dye and fluoride); development of AI-driven models and optimization of best conditions; build and test the small continuous (column) system; 4-6 month stay in Mauritania for field sampling and local trials.
Year 3	Tests on real water samples; plant germination/growth and antibacterial/antioxidant tests; writing of articles; writing and finalizing the thesis; defense.
Year 4 (if needed)	Extra time for finishing experiments, additional articles, thesis corrections and defense.

6. Expected Results

- One or two multi-functional bio-composite materials, using Algerian and (where possible) Mauritanian raw materials.
- RSM maps and AI-driven models showing how to get the best removal performance and predicting it accurately.
- Proof that the materials can clean water from dye (and ideally fluoride too) and work in a small continuous system, not only in lab bottles.
- Confirmation that the treated water is safe for irrigation in both countries, plus useful antibacterial/antioxidant properties.
- 3-4 scientific articles and the PhD thesis.
- A stronger research link between the Algerian and Mauritanian institutions, useful for future projects.

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