

DESIGN AND DEVELOPMENT OF AN INNOVATIVE SYSTEM TO TREAT WASTEWATER BASED ON SOLAR-STILL/ANAEROBIC MEMBRANE BIOREACTOR (AnMBR)

Call: BILATERAL TECHNOLOGICAL COOPERATION PROJECTS WITH THIRD COUNTRIES (UNILATERAL PROJECTS)

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Keywords:

Membrane bioreactor, solar still, thermal storage mediums, reactor design, methane production, performance improvement, process integration.

Summary:

Access to safe drinking water and proper sanitation is key for human survival and sustainable development, being essential for the maintenance of a decent quality of life and the prevention of many communicable diseases. Water security may be achieved by managing water resources, making them accessible in both quantity and quality for human uses while respecting water as integral part of ecosystems. Nevertheless, water resources are increasingly stressed in quantity and quality by their unequal distribution, climate change, socio-economic development, and unstoppable demographic growth and expansion. This confirms our real situation that we are experiencing a serious worldwide water crisis.

In order to find a lasting solution to this crisis, water regeneration and reuse for diverse purposes is heavily studied and discussed as one of the most relevant circular strategies and with the highest potential to be implemented to increase available high-quality water quantities and alleviate water scarcity by reducing the use and withdrawal of freshwater. Water regeneration and reuse is being particularly projected and/or implemented in those regions where water scarcity is becoming an increasing and common unsolved problem. Thus, water reuse in these regions can be identified as a sustainable strategy to overcome water scarcity.

Specifically, given the lack of freshwater resources in Kuwait, both promoting and enhancing the reuse of wastewater is of utmost importance for the country with the production of over 1.2 Mm³ of wastewater per day. Amongst different wastewater treatment technologies, anaerobic

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membrane bioreactor (AnMBR) can enhance energy balance for wastewater treatment if its operating conditions and wastewater characteristics are optimised.

The present project involves the adaptation of the characteristics of wastewater to be successfully treated by implementing a solar still incorporated to an AnMBR specifically designed for improving water recovery by using free solar heat. To this end, the system will be designed and developed from lab to pilot scale with the purpose of achieving the complete parameterisation of the process and ensuring its upscaling. The project also involves the improvement of the membrane definition, configuration, and conditions to achieve the water quality needed to be reused and the construction, development and testing of a pilot plant which will be installed at Sulaibiya Research Plant (Kuwait) to guarantee the achievement of the following objectives in terms of effluent quality, methane production, and energy footprint.

Objectives:

The project aims to design, construct and implement an innovative pilot-scale solar-still/AnMBR system to efficiently treat wastewater to produce high-quality water for reuse purposes. This main objective will be accompanied by the sustainable goals of reusing water to minimise both industrial and societal impact on the environment, reducing the ecological footprint of wastewater discharge and restoring water to nature in the best possible conditions. Therefore, the specific objectives are:

- To evaluate the performance of the solar-still/AnMBR system to treat real wastewaters in terms of removing selected parameters such as pathogen and virus content.
- To achieve a high-quality water which would be suitable for reusing.
- To define the best configuration and operating conditions to ensure the requirements of the system in terms of methane production and treated water quality and production.
- To evaluate the energy footprint of the solar-still/AnMBR wastewater treatment system including energy requirements and methane production.
- To compare the reduction of energy consumption obtained with conventional wastewater treatment operations.
- To patent the system.

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Consortium:

- Kuwait Institute for Scientific Research (KISR).
- Spanish company.
- AINIA (<https://www.ainia.es/>) as a subcontractor (technological partner).

Role of the Spanish partner:

The Spanish company would be focused on the detailed design, construction, assembly, and start-up of the AnMBR system at the facilities of both partners. The system would be tested at AINIA facilities for two months approximately and then it would be validated by the Kuwaiti partner over the last 12 months of the project. In the same way, the Spanish partner would design and install a solar evaporator to complete the whole wastewater treatment system.

AINIA will collaborate with the Spanish company by defining the concept and the needed design of experiments to properly define the innovative AnMBR system, including membrane definition, configuration, and conditions as well as the preliminary basic piping & instrumentation diagrams of the AnMBR and the corresponding counselling in the upscaling of this technology to a pilot plant.

Role of the Kuwaiti partner:

The Kuwaiti partner will define the concept idea and design a wastewater treatment hybrid system integrated by different operation units (a solar evaporator, AnMBR, and refine treatment) to obtain high-quality water to be reused or discharge to environment with a small ecological footprint.

After starting up the wastewater treatment system, the Kuwaiti partner will operate and evaluate the pilot design of the solar-still/AnMBR wastewater treatment system in terms of effluent quality and energy footprint in its own facilities, developing a patent which integrates the results of the project.

The Kuwaiti partner, The Kuwait Institute for Scientific Research (KISR), is an applied research entity which supports government entities and private sector to find solutions for real existing problems through research projects and helps to expand their market opportunities due to their

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orientation to introduce and apply innovation in science. The Spanish partner will find benefit through the opening of innovation opportunities in the Kuwaiti market and to generate more improvements in the pilot plant developed within the framework of this collaboration and future improvements in the following research projects.

Work packages:

WP1: Definition and design considerations.

Task 1.1: Requirements definition and design considerations from the concept idea.

Task 1.2: Wastewater mapping and optimisation according to water reuse needs.

WP2: Study and development of the AnMBR wastewater treatment at lab scale.

Task 2.1: Membrane definition and AnMBR testing at lab scale.

Task 2.2: Solar-still definition and sustainable design.

Task 2.3: Membrane configuration and preliminary P&ID system.

Task 2.4: Process integration of solar-still/AnMBR combined wastewater treatment system.

WP3: Upscaling, Construction, assembly, and testing of solar-still/AnMBR wastewater treatment system.

Task 3.1: Upscaling of the hybrid technology.

Task 3.2: Construction and assembly of solar-still/AnMBR system.

Task 3.3: Fine-tuning and start-up operations.

Task 3.4: Testing and training.

WP4: Validation of solar-still/AnMBR wastewater treatment system in real environment.

Task 4.1: Technical validation of the hybrid system (firstly at AINIA facilities and then at KISR facilities).

Task 4.2: Preliminary Life-Cycle Assessment.

Estimated Budget:

The budget of the participating Spanish entity will be defined after adjusting and agreeing the work description with the consortium. The Spanish budget will not be less than 175.000 (as is indicated in the call) and will cover personnel costs, materials, overheads, capital and technical support and the cost of subcontracting AINIA.

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KISR would assume at least 30% of the global budget of the joint project and its contribution would be done in kind. The Spanish company wouldn't have to assume the KISR costs.

Estimated duration of the project is 24 months.

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