Access to Clean Water: Sustainable, Scalable and Easily Accessible Solutions to Guarantee Equal and Just Consumption in Areas with Non-Potable Water Sources

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***Abstract*—Around the world, the water crisis is a reality that affects the most marginal areas causing large and diverse problems. There are some small towns located near non-drinking watercourses but do not have the necessary infrastructure to purify water. Based on this issue, a French company called Marine Tech has developed HELIO, a product that satisfies this need, in addition to using clean energy. This system does not consume conventional energy and is sustained by solar energy, producing approximately a total of 10 liters per day, designed for a family of 5 people, although a system series installation can be built that results in an increase in liters of purified water per day. This paper introduces the HELIO system and its advantages over other systems as the best alternative to address the lack of clean water issue.**

***Keywords*- drinking water, contaminated water, purification system.**

Resumen—A nivel mundial, la crisis del agua es una realidad que afecta a las zonas más marginales provocando grandes y diversos problemas. Existen algunas localidades pequeñas ubicadas cerca de cursos de agua no potable pero que no cuentan con la infraestructura necesaria para potabilizarla. Con base en este tema, una compañía francesa llamada Marine Tech ha desarrollado HELIO, un producto que satisface esta necesidad, además de utilizar energía limpia. Este sistema no consume energía convencional y se sustenta con energía solar produciendo aproximadamente un total de 10 litros diarios, diseñado para una familia de 5 personas, aunque se puede construir una instalación en serie del sistema que resulte en un aumento de litros de agua purificada por día. Este documento presenta el sistema HELIO y sus ventajas sobre otros sistemas como la mejor alternativa para abordar el problema de la falta de agua limpia.

***Palabras clave*- agua potable, agua contaminada, sistema de purificación.**

I. Introduction

Around the world, the water crisis is a reality that affects the most marginal areas causing large and diverse problems. These issues mainly affect women and children, resulting in health and economic problems, school dropout, even death [1, 2, p.19].

There are some small towns located near non-drinking watercourses but do not have the necessary infrastructure to purify water. Some inhabitants drink from polluted streams and rivers. For example, this is the situation in Oman a country in Western Asia. These contexts are so commonplace that they seem to be the norm. However, it is important to disrupt the status quo and look for the solution that the inhabitants of these places deserve.

According to [2, p.20] "household water usually accounts for less than 5 percent of total water use". Although it is a small number, this represents a big problem in the world. This issue is directly addressed by the Sustainable Development Goals 2030 Agenda, more specifically by means of its goal number 6, “ensure access to water and sanitation for all” [3, p.38]. There are some initiatives to improve this issue by providing different solutions but not all the solutions are viable for the affected areas due to the high costs that would result in energy consumption and maintenance.

This paper will address solutions to drinking water accessibility that includes the use of renewable energies to guarantee equal and just consumption of water in a sustainable and scalable way. To achieve this objective, this article is developed as follows. First, the current global water issue will be presented. Second, the HELIO system and the way it works will be introduced. Third, a brief explanation of some similar projects will be addressed. Finally, HELIO system will be compared with the other projects.

II. The Water Problem

At present, 771 million people (1 in 10) lack access to safe drinking water [1]. According to a report by the World Economic Forum [4, p.14], the water crisis is the #5 global risks in terms of impact to society.

The lack of drinking water is responsible for more deaths in the world than war. In this sense, each day nearly 5,000 children worldwide die from diarrhea related diseases. Approximately 1 in 6 people living today do not have adequate access to water, and more than twice that number lack basic sanitation, for which water is needed [2, p.19].

However, the problem is not that there is not enough water. Although globally water is available in abundance, it is not always located where it is needed or there is not the necessary infrastructure to get it.

III. HELIO SYSTEM

In areas where there are water sources but it is not drinkable, it is important to have a system that purifies and stores the water so that the inhabitants of that place can have access to this vital service. Based on this idea, a French company called Marine Tech has developed a product that satisfies this need, in addition to using clean energy [5]. This system helps low or medium income areas, since it is of easy economic access, easy to obtain the water needed and has an average useful life of 30 years. HELIO has a capacity for a family of 5 people or even for a group of 25 people.

A. *HELIO System Operation*

This system is a plastic sphere where distillation occurs through the following process system:

- In the first place, the water is captured directly from the source, which can be seas, rivers, lakes or any basin that does not have drinking water. To capture it, a water pump powered by a small solar panel is used, which is a clean energy source.
- In the second place, the water is stored in containers inside a regulator module. The smallest container has a float valve system that controls the overflow of water into the second largest container. From here, by the action of gravity and pressure work, the water is propelled through a system of pipes towards the spheres. There, it reaches a metal tray forming a film of water, which will evaporate.
- Then, the water in the sphere begins to evaporate due to its direct contact with the sun's rays, which increases the internal temperature of the sphere. The water vapour condenses on the inner walls of the sphere and, by means of gravity, it accumulates at the bottom of the sphere.
- In this way, the high internal temperatures, which its produced by the action of the sun reflected on a plate under the sphere, eliminate germs and bacteria from the stored water.
- Finally, by means of a pipe and a faucet, the water can be withdrawn directly for consumption.

A summary of the described process is shown in [Fig. 1, 5].

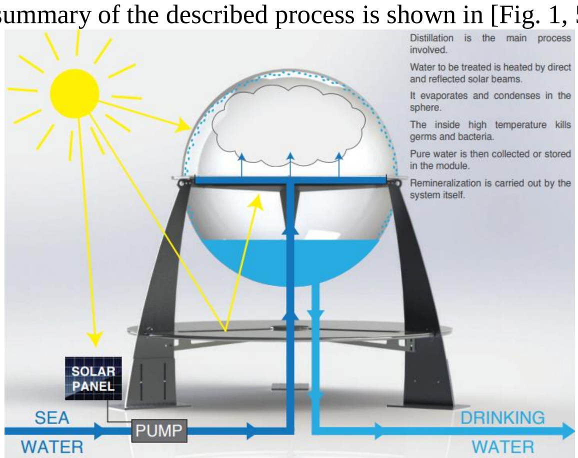

Figure 1: Process summary [5]

B. *HELIO System Components*

The system is made up of a regulator module and the spheres where the distillation takes place. Both parts are connected by means of a pipe system, as [Fig. 2, 5] shows.

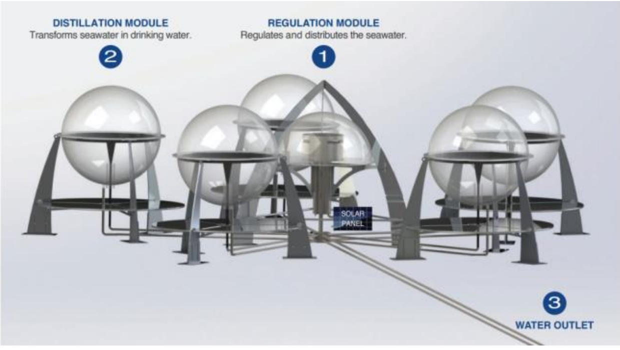

Figure 2: System components [5]

1) Regulator Module: This is the central part of the system in charge of regulating and distributing non-potable water. The semi-sphere shaped plastic module is supported by a removable aluminium structure. Inside it, there are two containers of the same material, as shown in [Fig. 3, 5]; the smallest container is the one that receives the contaminated water from the pump and contains the float valve and the largest conteiner is the one that, due to overflow, is filled and distributes the non-drinkable water through a plastic pipe system. The aforementioned pump works with a small solar panel of approximately 0.25 m². [Fig.4, 5] shows the regulator module.

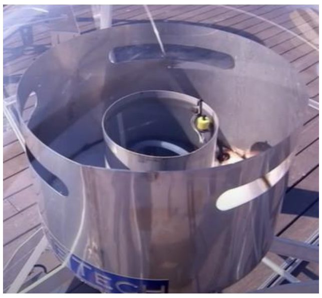

Figure 3: Containers inside the sphere [5]

Figure 4: Regulator module [5]

2) Distillation Modules: The distillation modules are plastic spheres with a surface area of 1 m^2. Inside, they contain an aluminium tray connected to a pipe that comes from the regulator module and allows the film of water to fall on the surface of the tray. Under the sphere, there is a polished stainless steel plate as [Fig.5, 5] shows, which is similar to a mirror that allows the reflection of the sun's rays and then the reverberation. These components are supported by a removable aluminium structure, thus leaving a system of 1.80 m x 2.10 m with 80 kg, as illustrated in [Fig.6, 5].

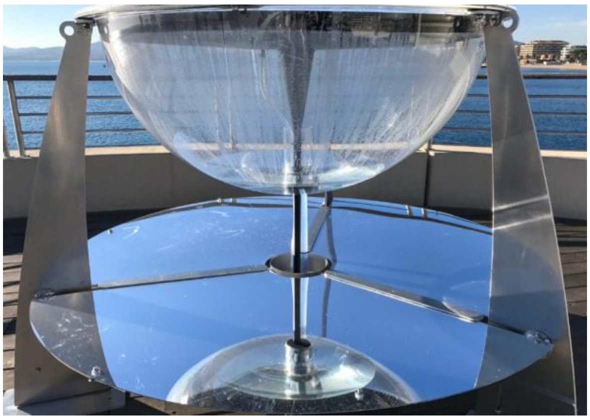

Figure 5: Polished stainless steel plate [5]

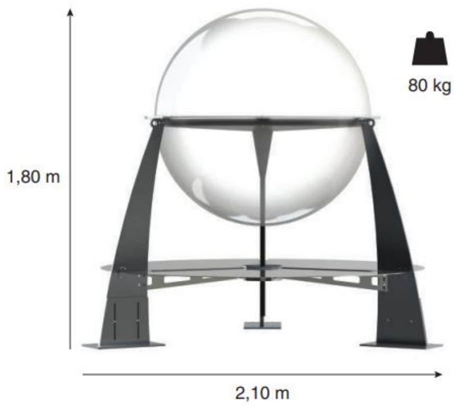

Figure 6: Distillation module dimensions [5]

IV. Similar Water Purification Projects

As the scarcity of drinking water is a global problem, it is well known that there are various possibilities to reduce it. In this section, other alternatives in development will be presented.

A. Vapour Condensation with Daytime Radioactive Cooling

This project was developed by a team that built a small vapor condenser based on the biological system of the dark beetle found in the Namib Desert in south-western Africa, as [Fig. 7, 6] shows, using a thin film of material called polydimethylsiloxane (PDMS). This material (PDMS) is very efficient in releasing thermal radiation in the atmospheric transparency window and is, therefore, placed on silver to reflect sunlight. This combination makes the condenser cool below the dew point obtaining its condensation, as shown in [Fig. 8, 6].

The radioactive condenser is thought to be in 'thermal contact' with the cold reservoir in the upper atmosphere and in outer space, with this cooling power condensing water during the day without the need for an external power supply. To clarify, this system produces its own clean water without collect contaminated water. For more details, see [6].

Figure 7: Dark Beetle [6]

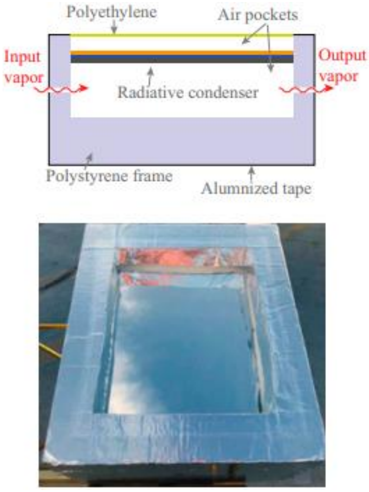

Figure 8: Radioactive condenser [6]

B. Solar Water Purification with Photocatalytic Nanocomposite Filter Based on TiO_2 Nanowires and Carbon Nanotubes

This project addresses the access to clean and safe drinking water in electricity-deprived regions, where advanced water purification methods are absent. In those places, it has been shown that titanium dioxide nanowires (TiO2NWs) filters assisted only with sunlight can efficiently decontaminate water with generation of reactive oxygen species (ROS). Also, interweaving those filters with carbon nanotubes (CNTs) offers an additional water decontamination channel, which is the pasteurization. This filter can intercept various types of microbial pathogens, including bacteria and large viruses. In addition, this system contributes to an efficient removal of a lot of organic compounds and infective microbes.

The device has a very simple configuration, as seen in [Fig. 9, 7]. The contaminated water is placed in a tank, then it passes through a multi-layered filter material and the pathogens are trapped on the filter surface, while the UV component of the sunlight generates reactive oxygen species. In this way, the reactive oxygen species attack and kill many bacteria and germs and it process allows water decontamination. Especially, carbon nanotubes absorb a broad spectrum of the sunlight radiation, which heats up the filter material and thus provides pasteurization. For more details, see [7].

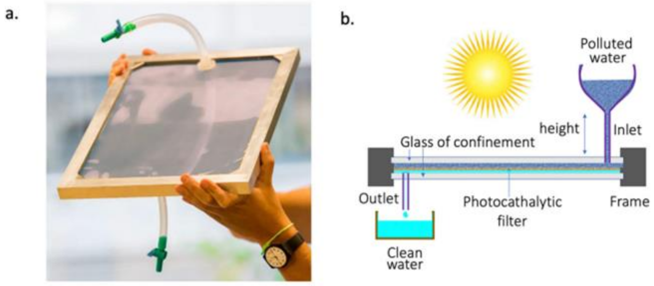

Figure 9: Prototype of a solar-thermal water purification system [7]

C. *Soil-Microbial Fuel Cell*

The soil is naturally rich in microorganisms and this allows it to harvest its own energy, which is why some microorganisms have the ability to transfer electrons through their cell membranes to a conductive material, such as an electrode, which results in the generation of electrons.

The system consists of an array of soil microbial fuel cells (SMFCs) that powers an electrochemical reactor for water treatment, as shown in [Fig. 10, 8]. Each SMFC is characterised by a flat geometry, and consists of two carbon-based electrodes positioned at 4 cm apart and connected to an external circuit. One electrode, the anode, is buried inside the soil, while the other, the cathode, is exposed to air on the soil surface.

The molecules that emit electrons, known as electrigens, consume the organic compounds to generate charged particles.. These electrons are transferred to the anode and travel to the cathode via the external circuit, producing electricity. For more details, see [8].

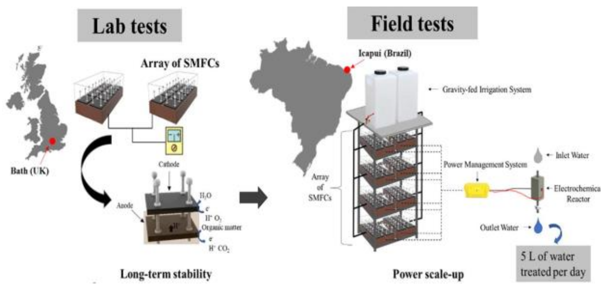

Figure 10: Soil-Microbial fuel cell [8]

V. COMPARISON OF THE DIFFERENT SYSTEMS PROPOSED

In order to demonstrate the advantages of the HELIO system, in terms of water collection, system operation, components, material, capacity, assembly, it will be compared with the projects: Vapor Condensation with Daytime Radioactive Cooling (A), Solar Water Purification with Photocatalytic Nanocomposite Filter Based on TiO2 Nanowires and Carbon Nanotubes (B) and Soil-Microbial Fuel Cell (C).

TABLE I
COMPARISON

Factors	HELIO System	Projects		
		A	B	C
Contaminated Water Collection Method	Uses a solar water pump to collect contaminated water	Does not collect contaminated water	Uses a water tank to store contaminated water	Does not collect contaminated water
System Operation	Evaporation and condensation by solar radiation	Evaporation and condensation by solar radiation	Solar radiation pasteurization	Indirect purification
Components' Material	Plastic spheres with aluminium structure	Silver film and polydimethylsiloxane (PDMS)	Titanium dioxide nanowires filters and carbon nanotubes	Soil microbial fuel cells
Capacity	Medium and large scales	Small scales	Small scales	Small scales
Assembly	Non-experts	Experts	Non-experts	Experts

In this manner, it is demonstrated that HELIO is the best option to water purification, because of the great adaptation to the environment context where it is installed, ease and speed of assembly and great results in a short time.

VI. CONCLUSION

This work delves into one of the most urgent problems worldwide, which is the lack of drinking water. Although there is a large amount of water, its use is limited since there are places that have the capacity to purify contaminated water but do not have the source and others where they have the resource and do not have the economic capacity required to make the water drinkable. The lack of this necessary resource to live leads to different diseases and adverse conditions for the correct development of life, mainly during childhood.

Based on a comparison made with different systems, the HELIO system is proposed as the best alternative to address the lack of clean water issue without much infrastructure requirements. This system does not consume conventional energy and is sustained by solar energy, producing approximately a total of 10 liters per day, designed for a family of 5 people. However, a system series installation can be built that result in increased liters of purified water per day.

The conclusion obtained in this work allows us to affirm that HELIO is one of the systems that help low or medium income areas, since it is of easy economic access, easy to obtain the water needed and has an average useful life of 30 years.

Finally, it is highly important to be aware of the fact that more work and commitment are needed to reverse this problem. It is essential to guarantee each and every inhabitant of this planet access to clean water with sustainable, scalable and easily accessible solutions to ensure equal and just consumption.

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The present manuscript is part of the research activities in the Inglés II lesson at Universidad Tecnológica Nacional, Facultad Regional Paraná. Students are asked to research into a topic so as to shed light on a topic of their interest within the National Academy of Engineering's Grand Challenges or the United Nations' Sustainable Development Goals frameworks. If sources have not been well paraphrased or credited, it might be due to students' developing intercultural communicative competence rather than a conscious intention to plagiarize a text. Should the reader have any questions regarding this work, please contact Graciela Yugdar Tófalo, Senior Lecturer, at gyugdar@frp.utn.edu.ar