DESIGN, DEVELOPMENT AND FUNCTIONAL TESTING OF THE LEDSOL DISINFECTION UNIT

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LEDSOL – CENTRUL IT PENTRU STIINTA SI TEHNOLOGIE

LEAP-RE

Long-Term Joint EU-AU Research and Innovation Partnership on Renewable Energy

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Introduction

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Access to potable water is a fundamental need of humankind; yet, this access is still challenging in several parts of the world. Population growth, urbanization, pollution and the effects of climate change, such as persistent droughts, are putting a huge strain on water supplies and on its quality even in developed countries. Access to reliable and safe water sources will help unlock economic potential by allowing time for education, work and imagination

The LEDSOL project is part of the LEAP-RE initiative and aims to support clean water availability to population relaying on unsafe water sources by developing a smart portable unit based on UV/LED disinfection augmented with classical decontamination and powered by renewable energy sources.

Context Analysis

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- *Our main contributions in going beyond the state-of-the-art (SoTA) are in the field of: (1) UV/LED water disinfection system design, (2) UV/LED water disinfection, (3) flexible solar cells and (4) positioning algorithms. We will start at TRL3 and will reach TRL6.*

- *Research initiatives as well as commercial products based on UVC LED have started to emerge for point-of-entry and point-of-use applications. To the best of our knowledge, comprising the features proposed in LEDSOL. These distinctive features, outlined below, are placing the LEDSOL system beyond the state of the art in UV/LED water disinfection products.*

Existing products	LEDSOL system	Expected outcome
Single wavelength irradiation (UVC)	Combination of UVA, UVB, UVC	Optimized efficiency (in terms of power consumption) and price *(estimates in the methodology section)*
Mostly Grid-powered	Self-powered by solar and wind energy powered	Portable and autonomous. Usable by remote communities, farmers and other categories who rely on unsafe water sources
-	Intelligent parameter management	Optimized power production and consumption
-	Localization and tracking using robust algorithms suitable for the African regions	Combat/mitigate the interference sources such as jammers, spoofers, multipaths, and deep forest canopies (e.g., water sources inside jungle forest)
-	User-centered design	Optimization in size, cost, efficiency according to the users' needs and feedback

Methodology - 1

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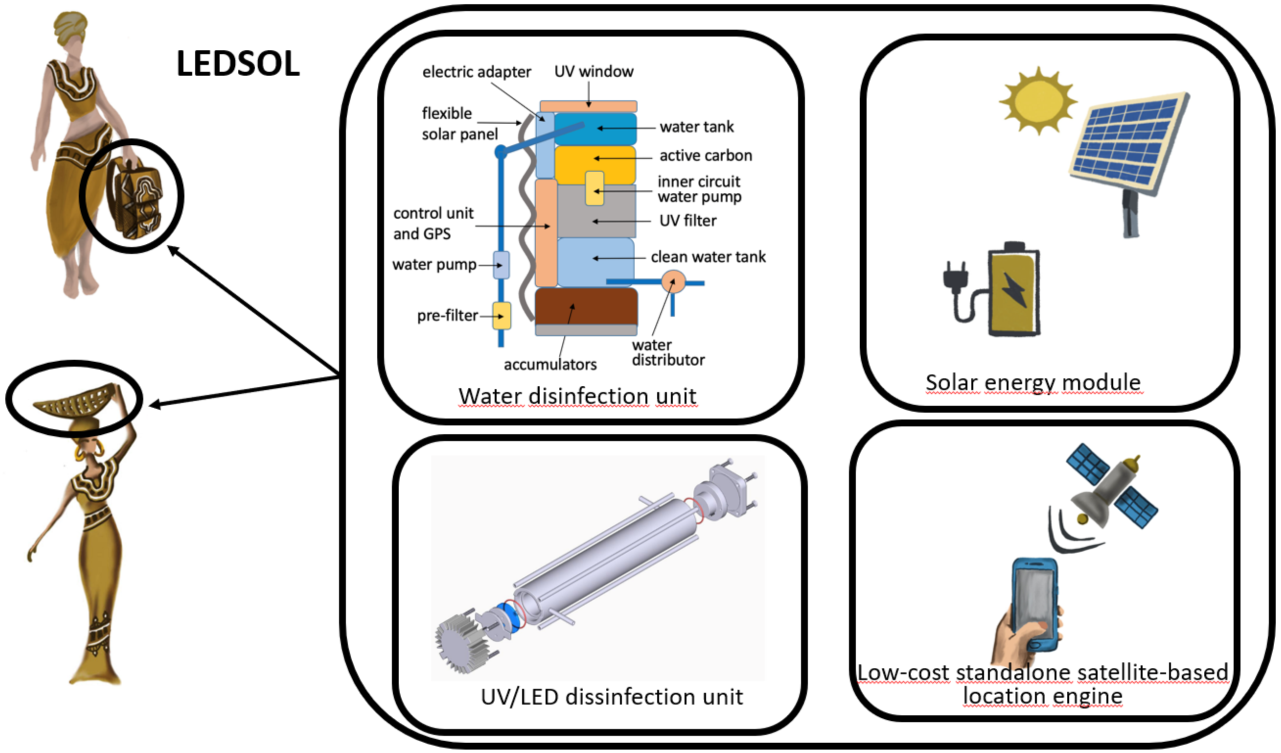
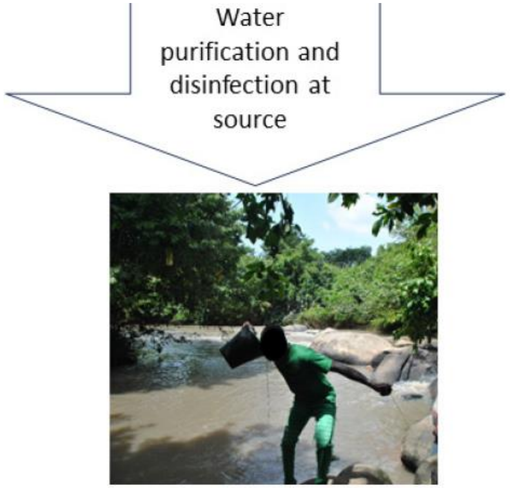
- The overall system is schematically presented below. Its design is based both on the technical aspects of the LEDSOL solution (constrains of power consumption, weight, price, etc) and on the user surveys and focused-group discussions conducted in Togo during fall 2022 (from 27th October till 7th of November 2022), as reported in reference [1].

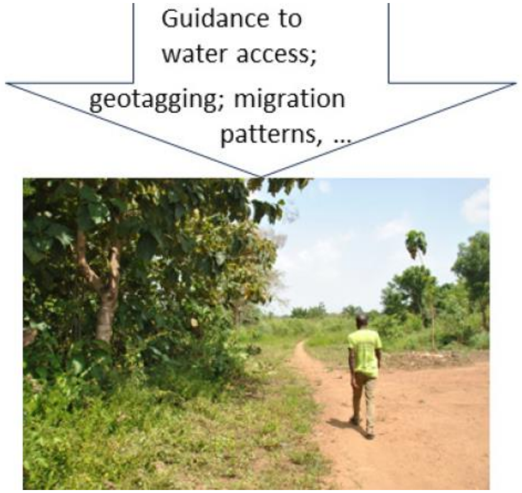


[1] E. S. Lohan et al., "Standalone Solutions for Clean and Sustainable Water Access in Africa Through Smart UV/LED Disinfection, Solar Energy Utilization, and Wireless Positioning Support," in IEEE Access, vol. 11, pp. 81882-81899, 2023, doi: 10.1109/ACCESS.2023.3300206.

Methodology - 2

- A solar-energy module will power the pumping components, the water purification unit and the standalone positioning engine.
- Our initial design has the platform components placed in a backpack. However, the surveys in Togo and Algeria are favoring a design which allows the system to be carried on the head because of the traditional way in which people in these countries are carrying water. Thus, also a head basket design will be attempted as a testing prototype.
- We are also building a laboratory prototype for the disinfection unit which comprises components that can be respectively cleaned and disinfected with harsh agents between performance tests.





Results / Preliminary Results - 1

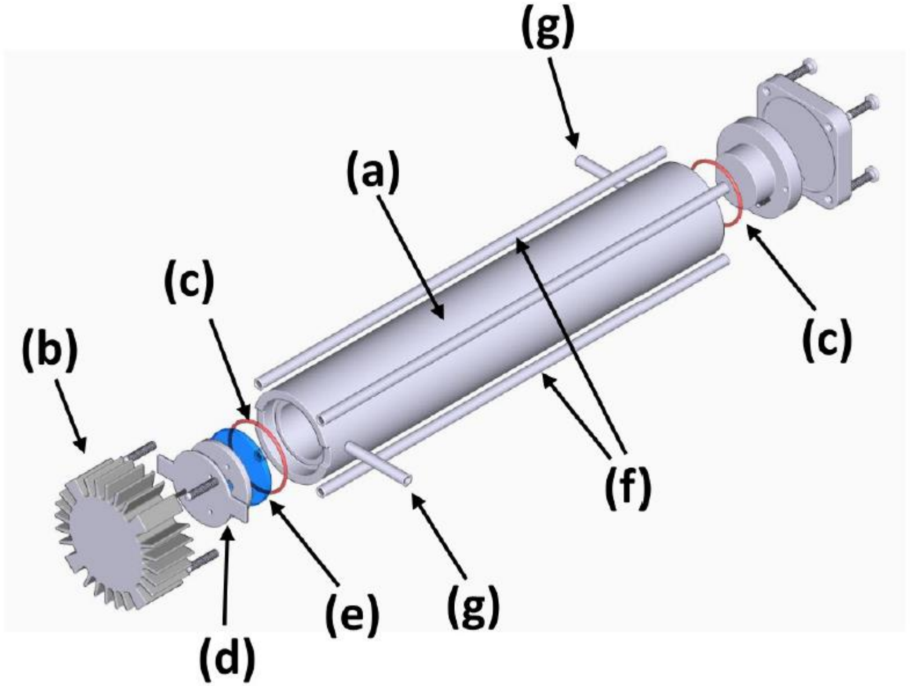


Figure 3: Treatment chamber comprising: (a) Teflon tube 25cm in length, inner and outer diameter 3 and 5 cm, respectively; (b) Aluminium radiators; (c) gskets; (d) PCB with LEDs; (e) quartz window; (f) fastening systems; (g) water flow pipes.

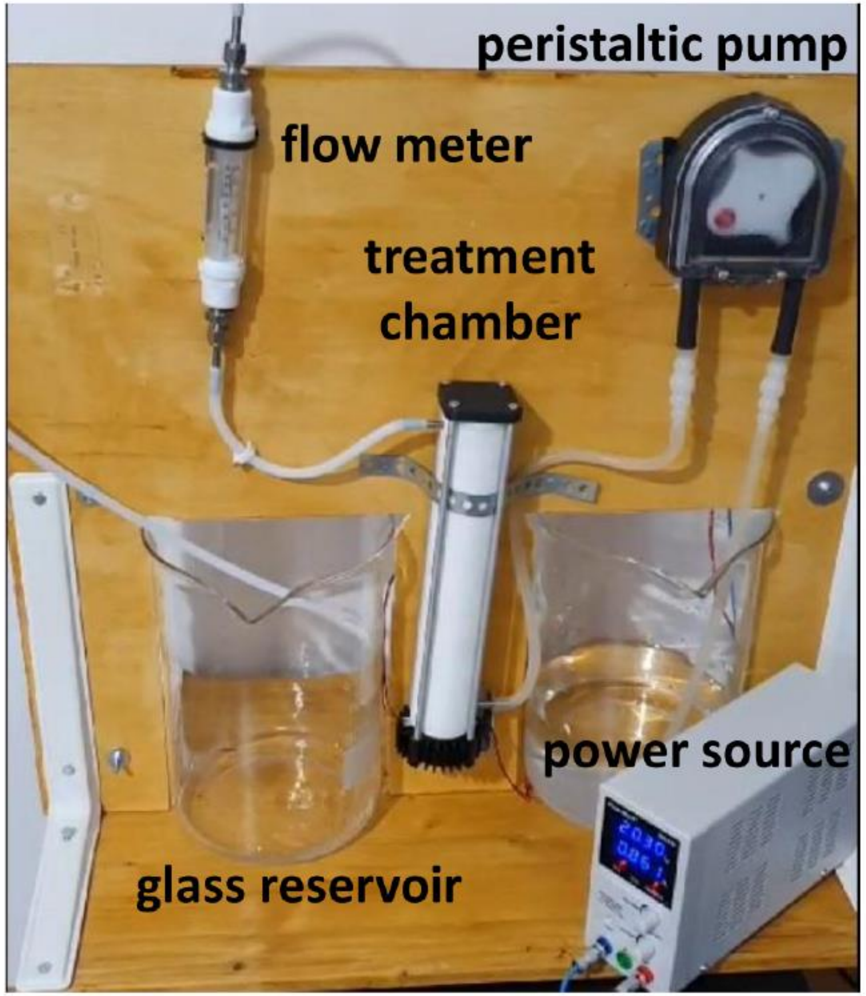
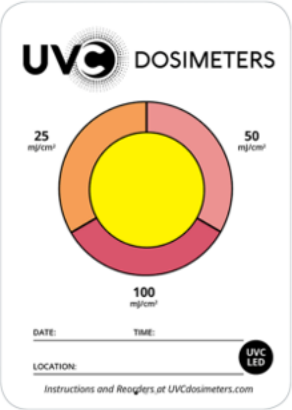


Figure 4: LEDSOL disinfection laboratory prototype based on UV/LED irradiation.

Results / Preliminary Results - 1

Radiation dosing results for UVC-LED at different distances

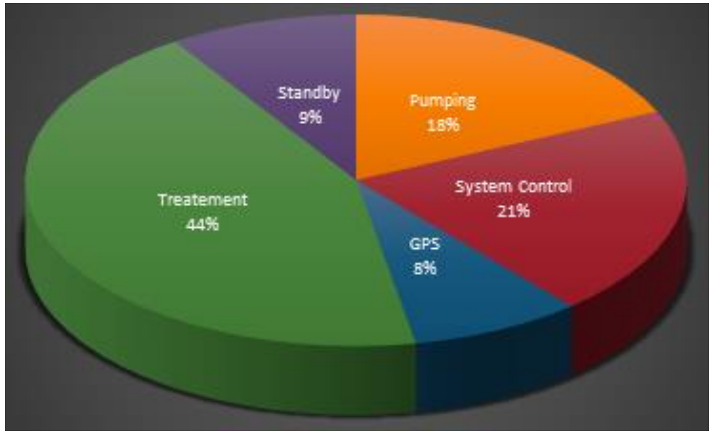
 **UV-C dosimeter as delivered**	 **Irradiation time and position: 2 s at 1 cm**
	 **Irradiation time and position: 10 s at 1 cm**
	 **Irradiation time and position: 100 s at 1 cm**
	 **Irradiation time and position: 100 s at 10 cm**
	 **Irradiation time and position: 100 s at 24 cm**

Results / Preliminary Results - 2

- For the LEDSOL system the most convenient are monocrystalline silicon photovoltaic panels that can reach efficiencies of 19-23% and which have a weight of ~1 kg for 100 W maximum power. For the UV disinfection to be effective, the water must first be filtered of impurities so that it has good transparency. This is also needed to ensure a suitable water quality. For this purpose, we will use mechanicals filters which need to be lightweight and allow for a minimum of 2 l/s water flow.

Table 1. Mechanical water filters.

Filter type	Technical specifications
WTS05FA40603MC	brass with stainless steel strainer 2 m^3/h flow rate, self-cleaning, corrosion resistance and high durability
DMfit 60 microns	small size, made of acetal copolymer, stainless steel strainer, max. pressure 16 bar (at 20°C)
Aquamarine Crystal with manual cleaning	Manufactured out of Acrylonitrile Butadiene Styrene (ABS), stainless steel strainer, max working pressure, max flow 83 l/min



Results / Preliminary Results - 3

- The LEDSOL system will comprise two separate water pumps. One will pump surface water (e.g., lake, pond) into the system and the other one will pump the water internally through the system. Both pumps should allow pumping of a minimum of 2 l/min at atmospheric pressure, have small dimensions and a have a low weight.

Table 2. Possible pumping solutions.

Pump type	**Technical specifications**
DAYPOWER WP-165 for water source pumping	12V/DC, 3.5 A, 500 g, max flow 6 l/min, L×l×h: 165×98×57 mm
AC060210-4890 for internal water pumping	3.5 – 14 V, 3 A, 80 g, 6 l/min - 10 l/min depending on the applied voltage, L×l×h: 50×40×76 mm

Conclusions

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- We are presenting in this paper the design and some of the main components of the LEDSOL platform. Our design takes into account various solutions which exist on the market for these components which comprise water pumps, mechanical filters and solar energy panels.
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Thank you for your attention!