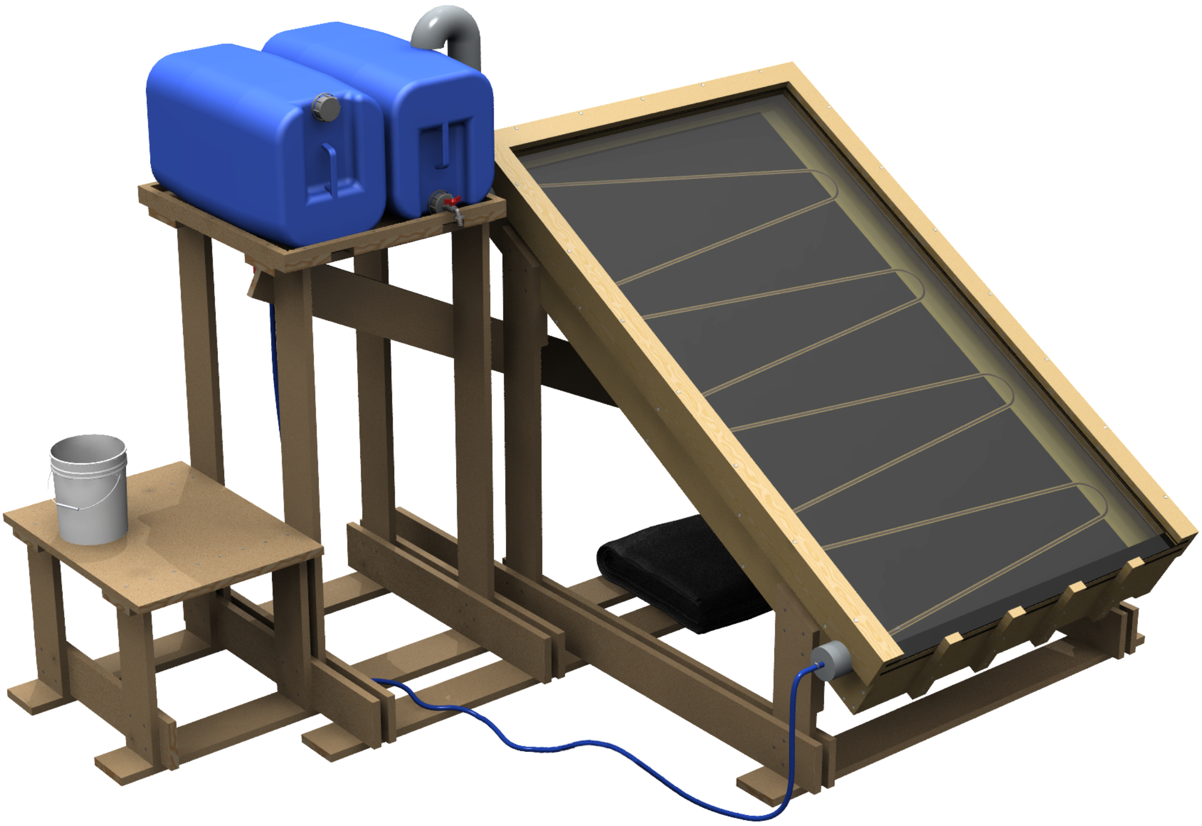
Solarthermal Water Disinfection Unit (SOWADI)

product data sheet

November 8, 2020



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For further questions about the project, please contact the research project **Solar Thermal Water Disinfection** at https://www.sowadi.de/en/contact-us/.

1 Use and Liability

This is a product data sheet that summarizes the characteristics and general conditions of the solar thermal water disinfection unit as it is built according to the corresponding manual. The following information is intended to help understanding and planning. Due to the large number of unpredictable influences, the information is intended as a guide and is not a guaranteed performance figure.
Due to the limitations described in the following chapters, the unit does not guarantee that the water is potable after it has passed through the unit. The author does not guarantee the functioning of the unit and is not liable for any damage to property or persons caused by a unit built according to the instructions or by the activities described in the manual.

2 Important other Documents

The following documents can be submitted if required.

- design drawings / CAD (computer) model
- calculation documents
- test results of the microbiological tests
- construction manual
- operating and maintenance manual for users

3 Task

Starting from rainwater supplied by cisterns or other means, the microbiological contamination of the water is to be reduced by means of solar thermal heating. The plant developed for this purpose should be built with local materials and simple tools, supported by the published construction manual.

4 Technical Realisation

4.1 Schematic Sketch

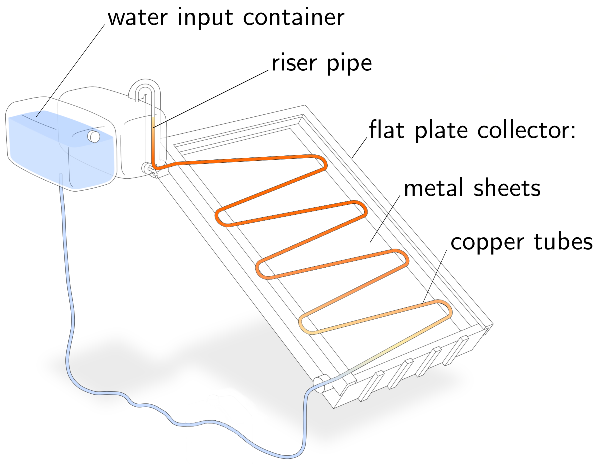

Figure 1: Schematic View of the Unit

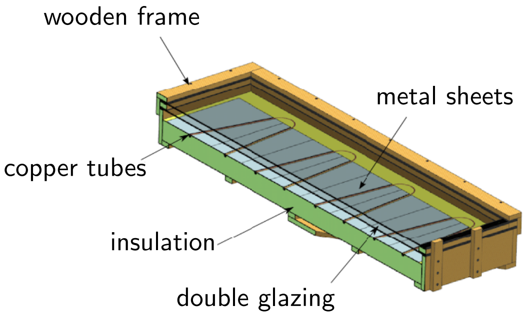

Figure 2: Cross-Section Through the Installation

4.2 Functional description

The thermal treatment of the water is carried out solely by solar radiation. A flat absorber is used for heating. This technology is already established worldwide. A new concept has been developed to control water output, the associated process of which is shown schematically in Figure 3.

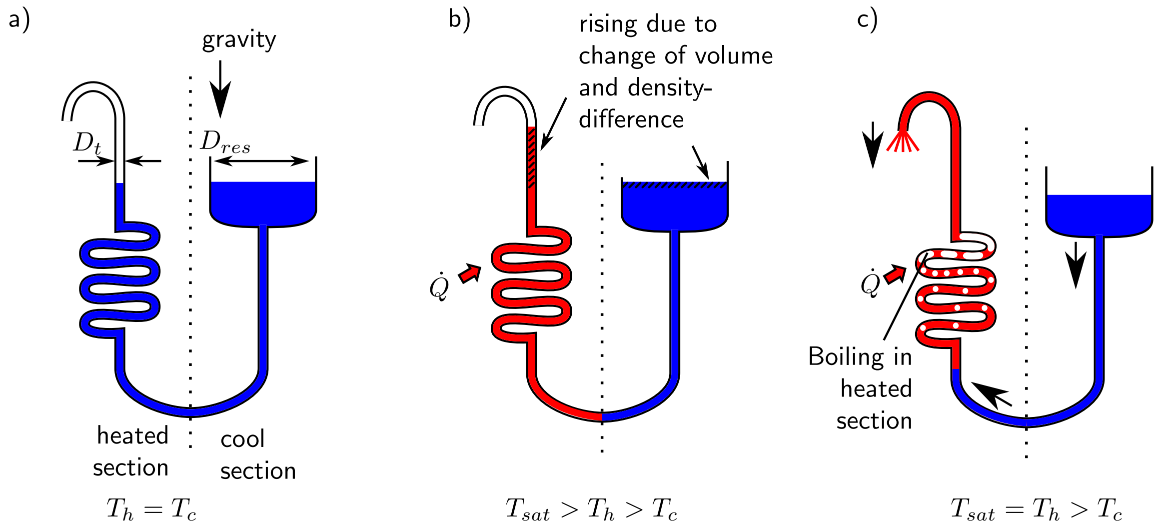

Figure 3: Water Output Control Concept

The hydrodynamic system presented there can be divided into two regions. On the one hand there is a cool area in which there is a reservoir with the water to be treated (Fig. 3 on the right). On the other hand, there is a heated area which is connected to the cool area and in which the water to be treated is heated. Figure 3a shows the initial state. At a homogeneous temperature, the (approximately) same water level is reached according to the principle of communicating tubes. After a warm-up process (Fig. 3b) a part of the water is boiling in the hot area (Fig. 3c). Since the tubes in this section have a sufficiently small diameter, the water vapor cannot leave the system prematurely by rising. Due to the difference in density between the cold and hot areas (including water vapour), gravity forces hot water together with the water vapour out of the tube system (In Fig. 3c, shown by the black arrow at the top left). Then cold water flows out of the input container into the heated area and the process starts again (Fig. 3a).
The heated area is integrated into the flat absorber. A schematic representation is given in Figure 1. A more detailed description of the functional principle and the dimensioning of the unit as well as individual components can be found in the following publication, which is freely available online:

> Dietl, Jochen ; Engelbart, Hendryk ; Sielaff, Axel (2015). *A Novel Type of Thermal Solar Water Disinfection Unit.* http://tuprints.ulb.tu-darmstadt.de/4460/.

5 Technical Requirements

5.1 Environmental Conditions

storage temperature 0 °C ... 70 °C
At temperatures below freezing, the system must be drained. If the system is not in use, it must be covered to avoid strong heating.

working (ambient) temperature $\geq 5\,°C$

substrate, angle of inclination, solar radiation

- The inclination angle of the unit in relation to earth surface is 20° ... 30° (e.g. Germany) depending on the location.
- If the rack from the appendix of the construction manual is used, a flat surface is required.
- During operation, free solar radiation must be guaranteed for as long as possible throughout the day.

Resistance to Pest Infestation
If relevant pest infestation is present on site, the unit must be protected against infestation of wood and insulation material (e.g. by treating the wood, constructing the rack from metal, or mounting it on other objects on the property).

5.2 Neighboring Systems

Further equipment is required in addition to the unit:

- 1 rack (Design proposal is included in the manual.)
- 2 water container (input and output) including closure calces, approx. 60 l. Containers with the following dimensions were used for the construction (as shown on the cover picture) BxHxT: 30 cm x 45 cm x 60 cm. The output container should be able to be emptied completely to avoid new contamination of standing water.
- container for filling the feed tank with contaminated water
- container with narrow opening and/or tap to draw off water
- Cover for the unit so that it does not overheat after shutdown (e.g. an non-transparent canvas).
- agent for cleaning the containers

5.3 Construction

Tools
Tools needed for the construction:

- hammer
- saw
- drill, for wood and metal (manual or electric)
- screwdriver (manual or electric)
- wrench or pliers (to build the tools)

Tools for sheet metal and tube bending are also required. Many workshops have at least sufficient equipment for sheet metal bending. If no tools are available for the two purposes, attachments are included with the instructions to build the appropriate tools yourself using the tools listed above.
If the materials are not available in the specified condition (size, shape), additional tools may be required.

5.3.1 Persons

number ≥ 3
At least three persons are required for the assembly. If more than three people work on the construction, sections can be processed in parallel, which shortens the time required for the construction.

Knowledge

- no special training required
- expanded basic technical understanding
- ability to understand technical drawings
- certain craftsmanship
- handling of the listed tools

5.3.2 Area, Duration, Costs

area for the construction $\approx 20\,\text{m}^2$

duration of construction ≥ 2 days
If all materials are available, an experienced team can set up the plant in about one or two days.

material costs $\leq$ 200 € ... 300 €
The cost of the material depends strongly on the local prices.

6 Technical data

6.1 Dimensions

weight approx. 95 kg The unit weighs approx. 95 kg (empty, without neighbouring systems). Of this, 40 to 45 kg fall onto the glass panes alone.

size (Width x Height x Depth)
without rack: 135 cm x 55 cm x 195 cm with rack: 270 cm x 200 cm x 190 cm

6.2 Performance

amount of water $\leq$ 30 l/d ... 40 l/d
The daily amount of water treated depends strongly on the environmental conditions. For orientation, Fig. 4 shows our recording of the water output of a test unit in Darmstadt (above in blue). The weather was very volatile, which can be seen in the available solar energy per day (below in orange). The maximum daily water output was about 25 l/d. Units in Tanzania achieved a maximum daily water output of about 37 l/d.

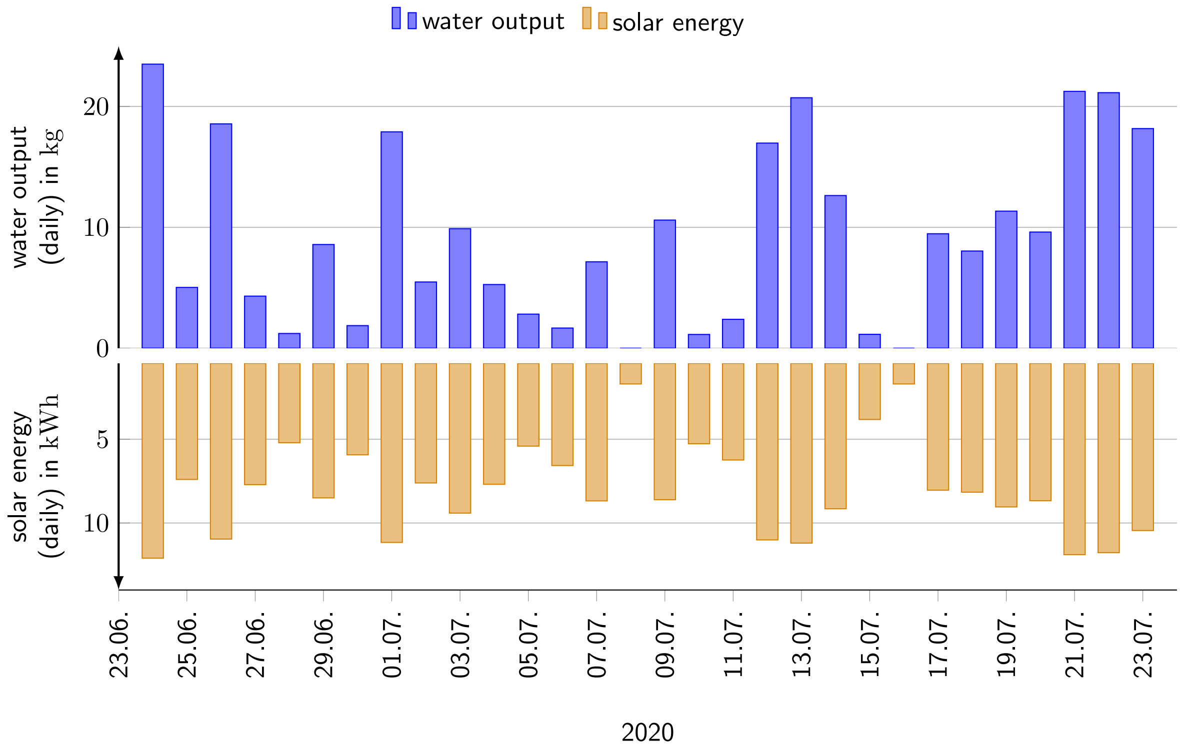

Figure 4: Daily water output (top) compared with the daily available solar energy (bottom) at the test unit in Darmstadt.

durability of the water ≤ 1 day
Since boiling is a punctual treatment, the treated water can be recontaminated relatively quickly, depending on the storage conditions. Therefore, the discharged water should be consumed within one day.

6.3 Water quality

More detailed information on the investigated parameters, limit values and reduction performance of the plant can be send on demand.

6.3.1 Water quality at the inlet (requirement)

Bacterial contamination
The maximum exposure to E. coli bacteria in the experiments was approx. $6.6 \cdot 10^6$ MPN/100 mL and to total coliforms approx. $2.4 \cdot 10^7$ MPN/100 mL. Fig. 5 shows the load course of the contaminated water. In the experiments water with a very high concentration of pathogens was used to find out possible performance limits of the plant. Normally the contamination of the water to be treated is much lower.

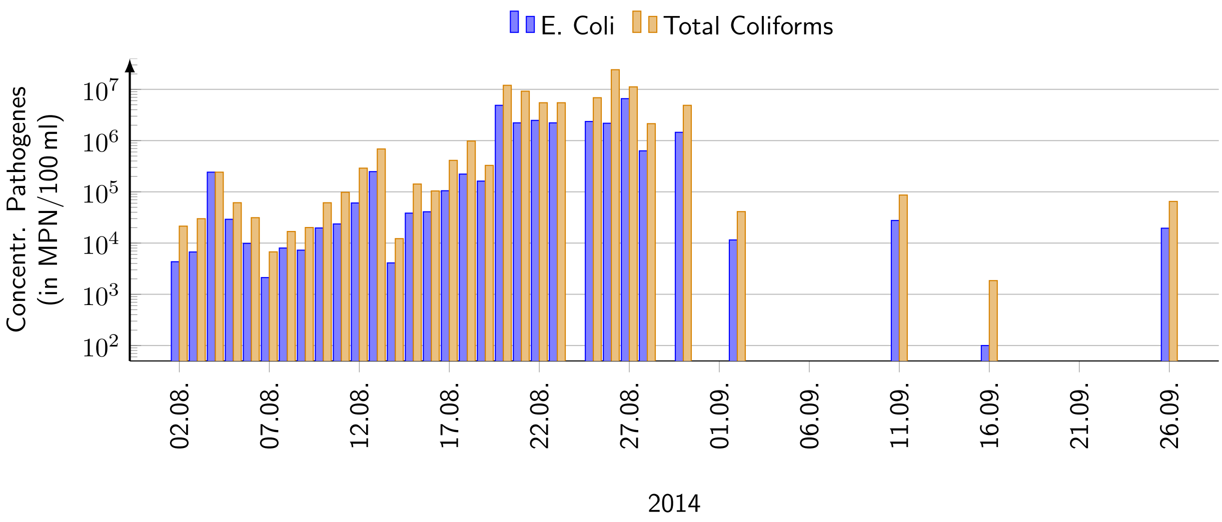

Figure 5: Load of the supplied water on E. coli and total coliforms. (On days with both values equal to zero there is no measurement of the load.)

chemical contamination
No chemical contamination must be present in the water, as this cannot be treated with this system.

turbidity $\leq 5\,\text{NTU}$
The turbidity is not specifically influenced, therefore it should already be in the untreated water in the above acceptable range according to the WHO recommendation. The literature also describes values of up to 200 NTU as suitable for thermal treatment. A lower turbidity usually means a lower microbiological concentration.

water hardness
There are no fixed requirements for water hardness. The harder the water supplied, the more lime will precipitate at the heated points of the plant.

pH-value approx. 6,5 ... 8.5
For the pH value limits of the water, we refer to the world health organization (WHO) standards. The WHO requires a pH value of the water in the range between 6.5 and 8.5. When selecting the source of supply, it should be noted that on the one hand the pH value is slightly increased by the system (see Fig. 6), on the other hand an acidic environment increases the dissolution of copper in the water.

water temperature $\geq 5\,°\text{C}$
The higher the temperature in cold section of the system, the higher the daily output of disinfected water.

6.3.2 Water Quality at Outlet

bacterial contamination
E. coli and total coliforms of the supplied water with the concentration curve shown in Fig. 5 were reduced below the detection limit of 1 MPN/100 mL in each composite sample. This indicates a reduction performance of E. coli bacteria of at least lg 6.8 and of total coliforms of at least lg 7.4.

pH-value
The pH value increased by an average of 0.84 during the tests. Fig. 6 shows the course of the pH-value at the inlet and outlet of the test plant.

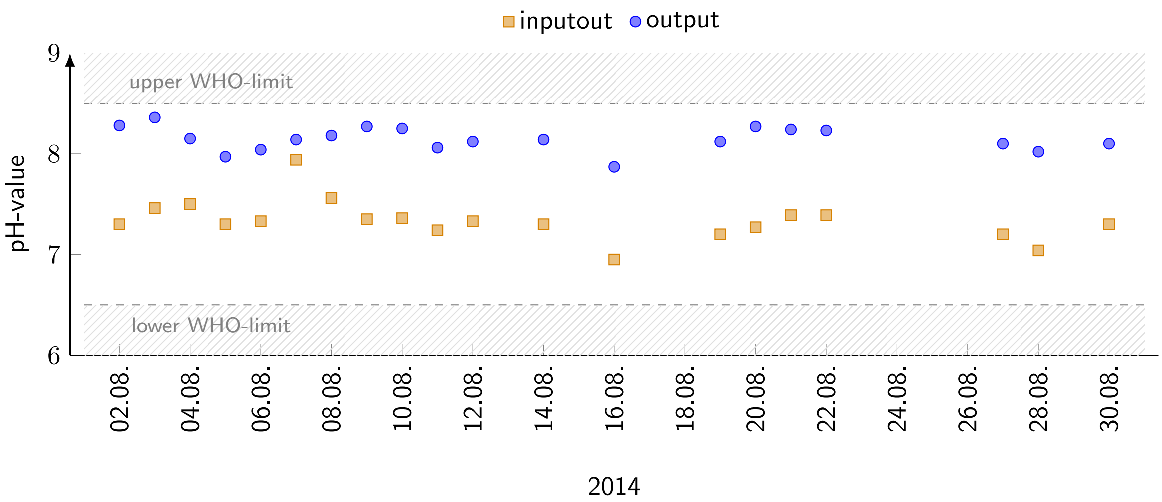

Figure 6: pH-values from input and output containers

Water temperature 90 °C ... 100 °C

7 Security

- Water and material at the water outlet (riser pipe) have a temperature of up to 100 °C. There is a risk of burns here, which can be reduced by additional insulation, shielding, or the attachment of a warning notice. The collection container should be as close as possible to the water outlet befinden, preferably firmly connected to it.
- The glass pane can break. Here, care must be taken to ensure that no heavy objects fall or are placed on it. If possible, place the unit in a shielded location.
- If babies or infants are among the users , the treated water should be examined for possible elevated copper values and, in case of doubt, other sources of supply for these persons should be sought.