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Subject Area	Wasseraufbereitung

Fight with light

Decentralized water disinfection using UV-C LEDs to prevent microbial recontamination

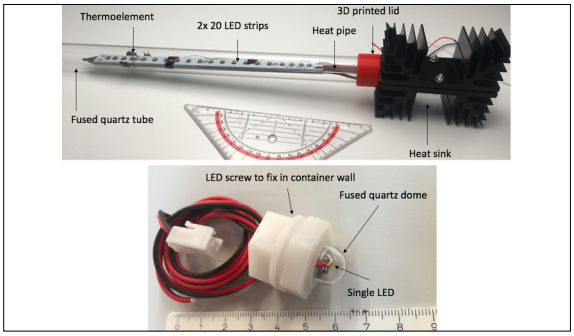
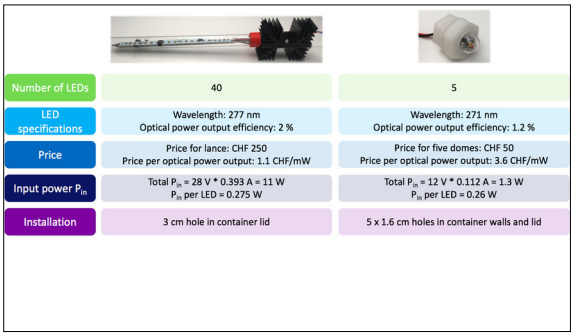


Figure 1: Built devices using UV-C LEDs, top: lance, bottom: dome.
Own presentment



Number of LEDs	40	5
LED specifications	Wavelength: 277 nm Optical power output efficiency: 2 %	Wavelength: 271 nm Optical power output efficiency: 1.2 %
Price	Price for lance: CHF 250 Price per optical power output: 1.1 CHF/mW	Price for five domes: CHF 50 Price per optical power output: 3.6 CHF/mW
Input power P_{in}	Total P_{in} = 28 V * 0.393 A = 11 W P_{in} per LED = 0.275 W	Total P_{in} = 12 V * 0.112 A = 1.3 W P_{in} per LED = 0.26 W
Installation	3 cm hole in container lid	5 x 1.6 cm holes in container walls and lid

Table 1: Comparison of lance and domes.
Own presentment

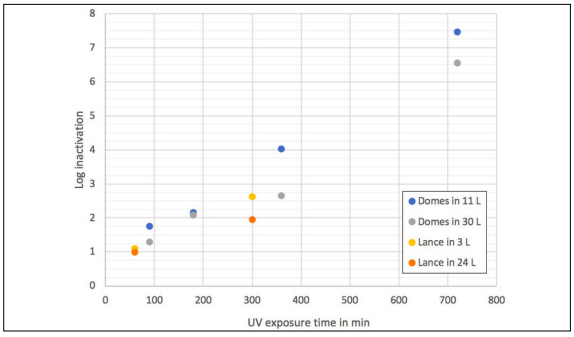


Figure 2: Lance and domes tested with two volumes and varying UV exposure times. Y-axis shows log inactivation of MS2.
Own presentment

Definition of Task: The occurrence of microbial recontamination in drinking water can lead to human infection with pathogens. The goals of this study were three-fold: 1) This study explored and compared technologies for the prevention of microbial recontamination. 2) Focusing the technology using UV light, several concepts based on UV-C LEDs were designed and described. UV light alters the genomic information of cells and renders them inactivated. The required amount of UV light (technical term: fluence) depends on the irradiance and the exposure time. 3) Two of these concepts were built and tested in the lab for their effectiveness against microbes.

Approach / Technology: One device consisted of wall-integrated UV-C LEDs and was called “domes”. The domes were bought as individual units and had to be screwed into the walls of the testing container. Five domes were installed in a testing container. The other device was called “lance” and consisted of assembled parts: a fused quartz tube, a heat pipe, heat sinks, 40 LEDs and a lid. The lance could be lowered into the water for UV treatment. Both devices are shown in figure 1. Table 1 shows a comparison of the two devices.

The devices were tested in the lab using the bacteriophage MS2. MS2 is often used to represent the inactivation of pathogenic viruses. Based on the concentration before and after the treatment, a log inactivation was calculated. One of the performed experiments investigated different exposure times using two different volumes per device.

Result: Figure 2 shows the results of both devices (domes and lance) at different UV exposure times. Each device was tested in two different water volumes. With an increasing exposure time, the MS2 inactivation increased as well. Per timepoint, smaller volumes resulted in higher inactivation. The lance achieved overall lower inactivation results than the domes, even though it consisted of 8 times more LEDs. The reason was that the design of the lance and its LED placement led to highly irradiated areas, but also to the occurrence of not irradiated water volumes. The domes on the other hand were placed in a way, that all the water was irradiated, and the light rays could be used more efficiently. And MS2 was more sensitive to the wavelength of the domes.

For the lance to be able to compete with the domes, it is recommended to improve its design: using fewer LEDs and to position them to avoid the occurrence of not irradiated water volumes. Based on the results of this study, the wall-integrated LEDs appear to be the better choice: they were lighter, more robust, flexible, required less input power and achieved a higher inactivation.