06.03.22

Solution report

Loop 1

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Executive summary:

In this paper we will explain the processes we have gone through in loop 1. In here the problems we have encountered, what solutions we came up with and the reasons for the choices we have made will be outlined.
We found out that it was the consumers of the water kiosks themselves who had to clean the containers, and therefore there was a high probability of spreading water-borne diseases. Our solution was to develop a product that could clean the containers easily, cheaply, and effectively. Therefore, we developed a universal lid that fits all types of containers. This lid had connected a UV-light as a disinfection.

Introduction:

In the city Grafton in Sierra Leone the organization Engineers Without Borders has started a project to ensure clean water for the people. There are about 2 billion people who live without clean water in the world. Therefore, the projects' goal is to build a long-lasting solution making sure that the people have clean water forever. In Grafton a lot of the work has already started, there are water stations with water pumps which ensure water for 4000 people. The challenge of this project right now is that the stations can keep providing the clean water to the people of Grafton.

As a group we have chosen to focus on the challenge with the cleanness of the water. Germs and bacteria are an issue when you are handling a product people need to consume. Therefore, it is important to prevent the formation of germs and bacteria.

The main challenge, we have chosen to focus on, is to keep the containers the customers bring to the kiosks clean, so the water from the kiosks stays clean. In other words, our problem is to make sure the containers are clean before they are filled with the clean water from the water stations. Furthermore, there is a challenge to prevent germs from being transferred from the containers or the people to the water in the water tanks. This could be the cause of diseases spread in the town.

Problem Owner:

The People of Grafton:

Grafton is a resettlement camp in the northern Sierra Leone, West Africa. Sierra Leone has a population of around 8 million people. The majority lives in poverty, with a national poverty rate of 56,8% of the people living below 1.90 $ a day. Sierra Leone have problems regarding landslides, droughts, and floods. In recent history the country had a big civil war from 1991-2002, Ebola cases from 2014-2016 and are currently affected by COVID-19. Grafton has a population of around 21.000 habitants. Currently there are 3 existing water facility, one borehole and 2 hand dug wells, which are only season based. Other than this they do not have access to clean water and no water facility.

Engineers without Borders Denmark:

Engineers without Borders Denmark is a technical-humanitarian organization based upon volunteers and committed members that have appropriate technical skills. The organization is collaborating with international and local NGO's (Non-Governmental Organization), to make a different and help people in low developed countries, that are suffering from different problems ranging from poverty to natural disasters. This is done by ensuring a local empowerment. The organization provides technical assistance, mainly focusing on the local community and sustainability. The goal is to create local technical knowledge and learning, thereby making the locals and the community able to maintain and control the projects when EwB is no longer there. This project is *Community Kiosk Water Supply*.

The goal of this project is to ensure safe water to areas without any urban or stately provided safe water, especially areas where the inhabitants are internally displaced. Further the projects focus is on Women Empowerment through encouraging the local women to be the vendors and managers of the Kiosk. The project is backed up by focusing on making these kiosks nonprofit, but able to sustain and secure maintenance when needed.

Water4Ever:
Water4Ever is a company formed from Willamette International. The project that we are looking into is Water Kiosk, that supplies water to sheds, where the inhabitants can get clean water through small payments in their own Jerry Cans. To date they have a total of 123 kiosk, 101 private connections and over 400 portable wells. 5 of the points are in Grafton. 4 Nodes and 1 Nexus.

Background information

After an orientation meeting with representatives from Engineers Without Borders, dialogue with relevant stakeholders, and Q&A session we found out there were no problems with gems in the clean water storage. Even if the average temperature of the water in the storage reached above 12 degrees (increased growth of microorganisms) and the tank only was cleaned every 6 months. Later we found out; it was the users themselves who were responsible for cleaning their own containers.

We investigated the problem, and we found some articles, which reached the conclusion that there is a problem with the microorganisms on the jerrycans, and after cleaning it would prevent the growth of the microorganisms. The vision we want to reach is that the people in the area can drink the water safely from their own containers.

After some research we found that Microbial contaminants in drinking water often consist of foreign micro-organisms that do not occur naturally in the raw water. The foreign micro-organisms mainly consist of viruses, bacteria, fungi, and protozoa. To ensure better water quality, it is beneficial to reduce or eliminate the factors that lead to the growth of

microorganisms, such as long hydraulic retention times, high water temperature, presence of inorganic and organic compounds and the materials of the system[1].

We validated the problem by finding an article which investigates the "*Impact of jerry can disinfection in a camp environment*[2]*" w*here they tested the jerrycans (used for storing water which they tap from the well) of bacteria before and after cleaning. They concluded that they found bacteria on the jerrycans, and after the wash they found nearly nothing. Therefor we think that it's a problem as well in the area we work with, and therefore we need to find a way to disinfect the jerrycans. Our suggestion to the company is to give the consumers a way to disinfect their jerry cans as well as the tap used for the water. To fulfil the suggestion, we need to find a way to disinfect the area the water is taped, and the containers themselves.

The consumers are below the poverty-line, so there for the products need to be cheap. Because of the education level, the technology in the solution must be simple to use as well. The primary stakeholders are the consumers of the water kiosk. Our solution will help the individual consumers and the local community. And we should educate the consumers in water transmitted diseases, and our product, so they understand the importance of hygiene. The solution to the problem is to disinfect the jerrycans before they tap the water in the water kiosk. And disinfect the tab in the nighttime, so it's clean the day after. We need a cheap, healthy way to disinfect the jerrycans and the tap.

Our solution

After an innovative discussion we found a solution for the problem. The solution is using the technology of UV-light sterilization (to kill the microorganisms with UV-light with wavelength between 100nm and 280 nm, also called UVC-light) and should be suitable for every model of the jerrycan. It is cheap and healthier than using chlorine (or other chemicals) and can be done without using any water. With clean bottles we can prevent spreading water transmitted diseases in the community and educate the users so they can take care of themself.

[1] Vandforsyning 3. Udgave – Nyt teknisk forlag - Bog
[2]https://wrc.washcluster.net/sites/default/files/2019-01/Steele_Jerry%20Can%20Disinfection_2008.pdf

It is proved that UV-light is an effective disinfector, and can be used in water, air and on surfaces[3]. The UV-light can kill a wide range of different microorganisms. And it's recommended by the WHO[4].

The problem with UV light and plastic is that the UV light when absorbed in plastic can excite photons, which in the end will lead to degradation. However, jerrycans are made of high-density polyethylene (HDPE)[5] which is one type of plastic that is not that sensitive to UVC light as for example low density polyethylene (LDPE)[6]. When HPDE is exposed to UVD light with a wavelength of 253.7 nm for 120 h, the overall weight of the plastic is reduced with only 1%[6]. Therefore, it is assumed, that the cleaning method proposed with UVC light of the jerrycans will not deteriorate the structural strength of the jerrycans.

We would validate the solution by doing some tests. First, we would take some samples from the jerrycans before we would incorporate the product into the test. After that we would incorporate the product into the test. Then we would compare the tests, and then un-/validate the solution.

Prototype:

Jerrycans has an opening in the range between 45mm and 60 mm for cans in the sizes from 10-25 liters[5].Therefore, the proposed UV light stick for cleaning must be of dimensions smaller than this. Furthermore, to ensure that the UV cleaner work on all sorts of different sizes of jerrycans the height of the stick is 200mm. Figure 1 is a sketch of the product suggested, where it can be seen from the front, the side, and the top. A technical sketch of the 3D-printed prototype used for the pitch can be found in the appendix.

[3] https://pubs.acs.org/doi/pdf/10.1021/es00076a001?casa_token=MjTTm7vZG24AAAAA:npVNjzYVmWsCEZHyruxJRyYQ3Zm8Uj9kKibEl18BbMXM7EbogYbYBRXUmf5yvheCgNpTOmZR-43imQ
[4] https://www.who.int/news-room/events/detail/2021/12/17/default-calendar/online-webinar-disinfection-using-ultraviolet-radiation
[5] (10L Agrochem – Jerrycans, 2022)
[6] (Bhuyar, Rahlm, Manlam and Govindan, 2019)

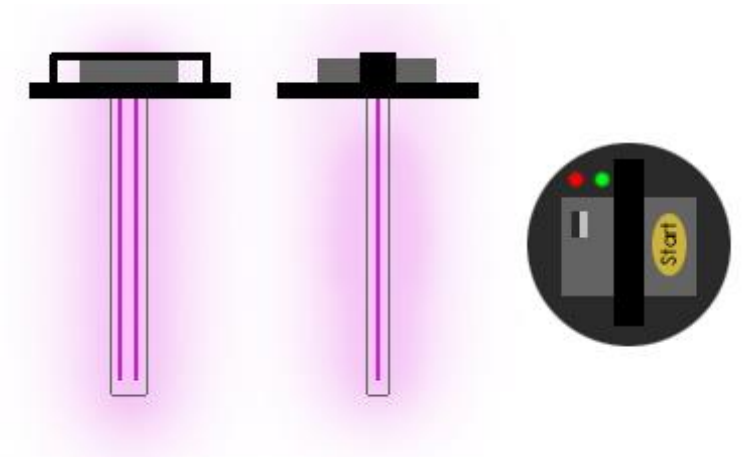

Figure 1: Sketch of the proposed UVC germicidal device. The sketch is not dimensional.

The black top is a 3D-printed lid to ensure that that the jerrycans don't get exposed to germs while cleaning, but also to protect the user's eyes. The grey box on top of the lid contains the electric circuit, that controls how long the UV light is on. The battery is rechargeable and can be charged through the USB port on top of the electronic box. The red and green LEDs on top of the lid will indicate whether the UV cleaner needs to be charged.

The battery pack consist of a 24V rechargeable lithium-ion battery with a capacity of 4400mAH. The UV-light has a power draw of 11W, which means the germicidal device can operate for approximately 9.6 hours per charge. This battery pack is chosen because it is rechargeable, and it provides the device with enough power to be used for a full day without the need of recharging during peak load. The UV-light has an approx. lifetime of 8000 hour

Kommenterede [AR1]: Er der en der kan formulerer det lidt mere elegant/præcist?

Economic perspective:

Market Size:

The product should be able to handle 4000 habitants on 5 different points a day. Therefore 800 habitants approx. pr. point. 1 minute pr. Jerry Can. We assume 10 UV-lights is enough for each point considering the peak load. In Grafton we would need 50 of our products for a start.

Cost and price pr product:

The product is made from different components

- Rechargeable battery: 23-25$ pr unit.
- UV-light: 1,7$ pr unit.
- Electronics in the product: 5$ pr unit.
- Box for the Electronics: 3$ pr unit.
- Handle for the product: 2$ pr unit.

Needed for idea, but assumes possible to get on site

Power supply (Solar Cells)

The approx. price for the product is 36,7$ (238,79 dkk). 50 units of the product which is estimated to cover all Grafton's Points have a price of 1835$. The concept of the project is solely nonprofit, and we won't charge extra for profit.

Investment Budget:

We will need an approx. price for transport, production, testing at 15.000 DKK.

Further perspectives:

The idea of this product is in the future that it is a standard for every Kiosk and every waterpoint in this EwB project. Grafton is going to be a "testing site" and if the product is successful and easy to use, it should be distributed to all the existing water points and future water points. At a large scale this product should be distributed to every water source, with chances of contamination, especially in lower developed countries and regions. The low pricing of the product could be favorable for NGO's.

Conclusion:

In the project we developed and delivered a prototype of a lid with a UV-light to clean the jerrycans. As a group we have worked together, used each other's abilities, and successfully prepared a solution and a pitch for the Engineers Without Borders organization.

Our prototype contains a UV-light stick, a lid, and some hardware. The lid is a 3-D printed model, on the model there is rechargeable battery and some LED to visualize on and off function. A UV-light is attached to the lid, this construction is making a sealed room where the UV-light is cleaning the jerrycans.

The conclusion is that this product will be easy to use for the population and successfully clean the jerrycans. With the product water from the water tank stays clean and will prevent germ and bacteria from developing, therefore the health in Grafton improves because of the water quality.

List of references:

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Appendix

Sketch of prototype