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Water Purification Project

exploring the application of micro controlled UV LED's to purify water in portable tanks to a safe level suitable for drinking in regions of the world where clean drinking water is not readily available

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Background

It has recently come to light that ultraviolet light emitting diodes (UV LEDs) have the capacity, at certain wavelength ranges to inactive and kill certain pathogens (American Society of Microbiology, 2012). The technology used is relatively simple, LEDs which have been around for over 100 years are manufactured to produce a specific wavelength of light. This wavelength in turn disrupts cellular processes in bacterial pathogens causing inactivation.

The photosensitivity of pathogenic bacteria matches the absorption spectrum off DNA, with a peak of about 260nm, UV LED emitting in the range of 250-270nm are the ideal candidates for disinfection. Commercially available blue LEDs (UVA LEDs) emit light at about 365nm, which has already been shown to be effective in sterilisation (Medical & Biological Engineering & Computing 45, 2007). Until recently, LEDs in the UVC (200-280nm) range were not commercially available. Using aluminium nitride, boron nitride and diamond UVC LEDs have been produced that emit light at 210nm, 215nm and 235nm respectively. These UVC LEDs are still very expensive but with the advancement of research and technology are expected to fall in price in coming years as production intensifies.

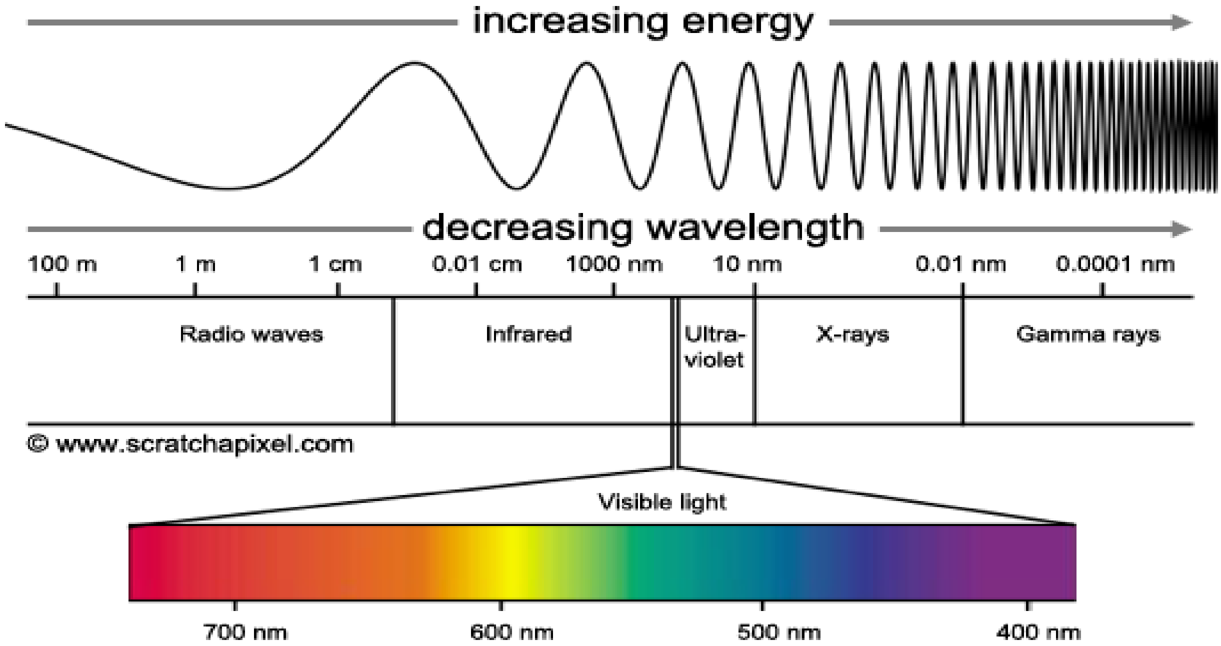

Figure 1 the location of the visible light range amongst the electromagnetic spectrum, UVC LEDs fall around 200-280nm, outside of the visible range and in the higher energy ultraviolet range

It is estimated that a UVA LED at 365nm takes 30minutes to kill *Escherichia coli* and *Vibrio parahaemolyticus* the two main agents of stomach infections. They are also effective against Vibrio cholerae, the infectious agent that causes cholera. By eliminating these bacteria before they are consumed has major implications for the health and wellbeing of those in regions where safe drinking water is not readily available.

Water Purification Tank

The Water Purification Tank (WPT) must meet the following requirements:

1. Purify large volumes of water (people in Sierra Leone have to travel to their source of water) to a safe drinking level
2. Be able to confirm that water has reached a safe drinking level
3. Transmit data about the water in the tank for remote analysis

4. Cheap and easily constructible as well as transportable
5. Low energy requirements and sustainably powered.

We have already discussed the purification aspect of the WPT. Further research is required to confirm that wavelength, number of LEDs, time, volume amongst other factors. There is also the possibility of refrigeration to keep the water below the bio-active range or super heating/pasteurisation to ensure all pathogenic bacteria has been eliminated.

Confirmation of purification can be measured in 2 independent ways or possibly a combination of the two. The first would be using a pH meter. The pH of "safe" drinking water would have to be explored and the WPT instructed to switch off LED's once this pH has been reached.

The second option would be to use spectrophotometers to measure the out coming wavelengths of light after sterilisation has occurred. A property of bacteria is that they have cell walls, and these will absorb light at a specific wavelength. Once the bacteria has died, it is presumed that the cell wall will break down and this wavelength of light will no longer be absorbed. If a spectrophotometer could be harnessed to emit the wavelength of light that corresponds to the absorbance of bacterial cell walls, it is assumed that "unclean" water will have a high absorbance, and therefore a low transmission of this wavelength, as detected by a detector opposite the light source. We can thus assume that "clean" water will have a low absorbance, and therefore a high transmission of this wavelength as detected by a detector opposite the light source.

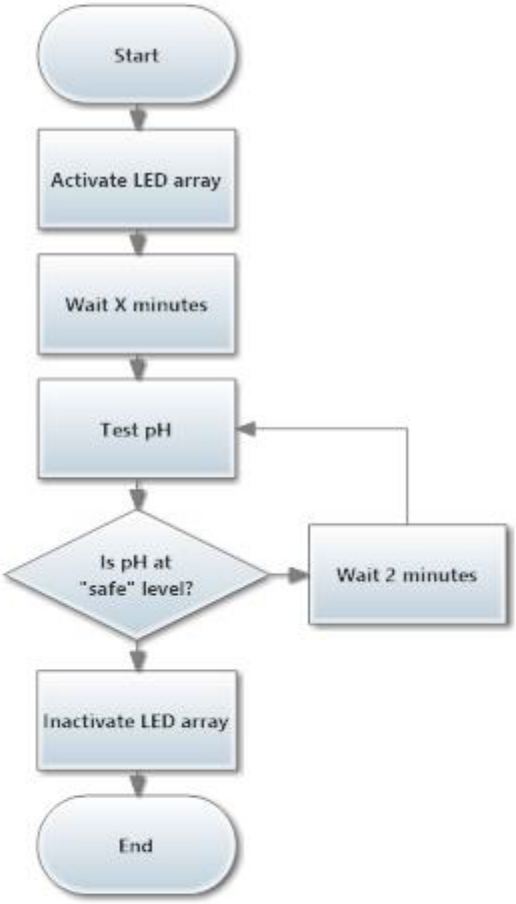

Figure 2 confirmation of purification by measuring pH levels

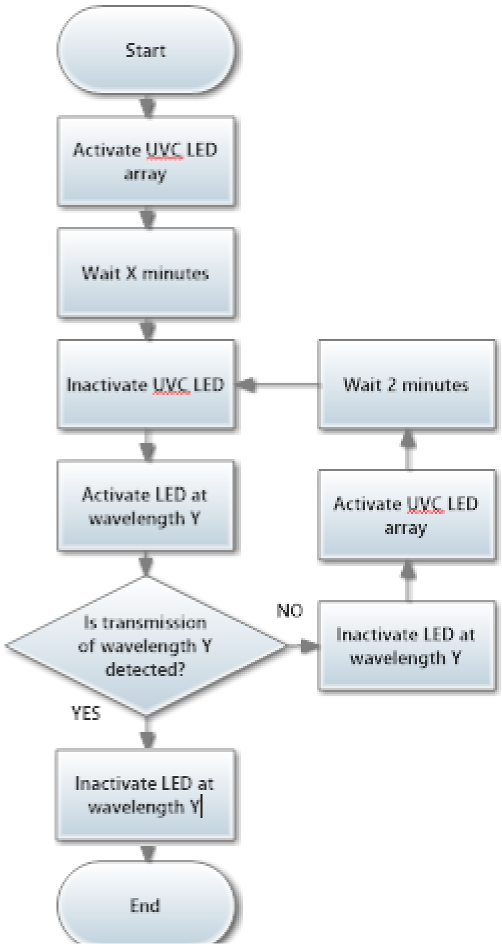

Figure 3 confirmation of purification by transmitting a wavelength of light equivalent to that absorbed by bacterial cell walls and detecting its presence on the other side of the water

All data will be stored locally on a micro controlled and be transmitted to a remote location for analysis. This has many implications. If GPS is also included as part of the micro controller, the occurrence of the diseases mentioned above could be studied at the locations that the WPT is used. The data can also be used to determine the efficiency of the process, by measuring the number of repeats that were required. This can also determine which sources of water are dirtier than others by including the GPS data.

Production of the WPT will require a 3D printer to produce a light weight unit. Plans for the unit will thus be able to be shared across international boundaries to allow this to become an open source project, sharing the work with those that need it most.

There will be a relatively low energy requirement for the unit and there are 3 possible methods of powering the WPT.

1. Solar powered – using a solar array on the top of the unit. Areas of the world where access to clean drinking water is limited have a large number of daylight hours and generally clearer weather compared to here in the UK,
2. Kinetic charging – it was already mentioned that users may have to travel some distance to reach the sources of water so a method of kinetic charging could be deployed so that this walk charges the unit,
3. Photo energy reclamation – this technology would have to explored further but works in a similar way to solar power, when the LED’s are activated, solar arrays inside the unit could capture some of the photo energy and convert it into electrical energy to be used by the unit.