PRACTICAL ACTION
Technology challenging poverty

SODIS – SOLAR WATER DISINFECTION
IN SRI LANKA

technical brief

The problem

Fresh water is an increasingly scarce resource, even more so, access to clean, potable water for people is very limited. An estimated 1.1 billion people or one sixth of the world's entire population lack a safe water supply through pipes, bore holes, dug wells or protected springs.
This is a problem that is likely to increase. As the population grows the available clean water becomes insufficient.

Figure 1: Placing plastic bottles on the roof to expose them to the sun, Sri Lanka. Photo: Practical Action / Zul.

The lack of access to 'good quality' water leads to a greatly increased risk of contracting water-borne diseases, commonly diarrhoea, cholera, typhoid fever, hepatitis A, amoebic and bacillary dysentery. An alarming 4 billion cases of diarrhoea are reported annually causing over 2 million deaths. In developing countries water-borne diseases cause 15% of all child deaths (under the age of five). Further, frequent attacks of diarrhoeal diseases can cause children to become malnourished and more susceptible to other diseases such as respiratory illness.

In Sri Lanka, despite being a water-rich tropical country, a large percentage of the population does not enjoy access to clean drinking water. According to official figures, only 57% of Sri Lankans can claim to have clean, safe water within their reach. This leaves nearly half the population having to acquire their water from 'unsafe' means such as streams, rivers, unprotected wells and open water bodies. Thus, diarrhoea infections, and serious epidemics of cholera, dysentery and typhoid are common.

In many developing countries, the public health condition can lead to a dramatic spread of water-borne epidemics. Cholera is endemic in 80 countries and a serious worldwide concern still, even though the number of deaths from intermittent outbreaks has reduced due to improved treatment. The onus should be on preventing epidemic outbreaks and then stemming their spread by adequate treatment measures and hygiene promotion.

Simple, hygiene practices in everyday life can have a huge impact on the public health condition in developing countries. It has been found that hand washing (with soap, ash or other cleaning agent) alone can reduce diarrhoeal disease transmission by one third. Hand washing, combined with safe disposal of human waste (faecal matter) and careful storage and handling of water can have great benefit towards reducing water-borne infections. Treating water to improve its quality should be combined with these health-promoting practices to make a lasting change in the public health of people in developing countries such as Sri Lanka.

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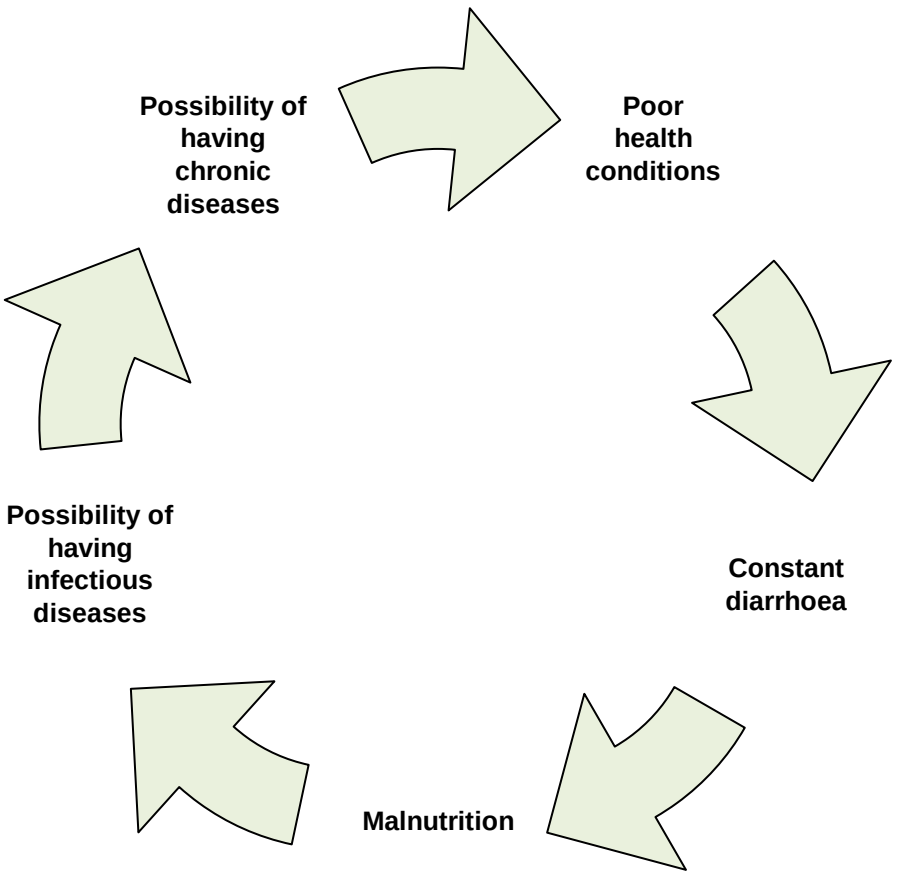

The cycle of ill health

Disinfecting water

Even a population with access to a pipe borne water supply have no guarantee of its quality. Although, much investment has gone into treating the water supply to make it safe, many water supply schemes are constrained by resources, lack of chemicals, lack of trained staff, laboratory facilities and the continuing demand for more water.

There is also a large percentage of people who depend on public taps or open water bodies, rivers or steams for water. This water carries a huge risk of possible microbiological contamination, especially from sewage and garbage. Ensuring clean and safe water is a household responsibility, even when a home enjoys the convenience of tap water. Individual households have to ensure that the water they collect is safe and of adequate quality for drinking.

There are a number of water treatment measures can be adopted at household level to ensure clean, safe water. These are water storing, boiling, water pasteurisation, filtration and disinfections with chlorine.

Each method has its limitations –

- Storing water is the simplest method to improve quality. While this will clear sedimentation, it will only be partly effective in removing turbidity and faecal chloroform contamination.

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- Boiling water is the best method of ensuring sterile, disease-causing-pathogen-free water of high quality, but boiling water takes up a lot of energy; not everyone can afford it.

- Pasteurisation is achieved by heating water to lower-than-boiling point, often 70-75˚C, but maintaining the heat for 10 minutes or so. This also requires high energy input.

- Filtration will remove much of the solid matter and sediment. It is more difficult to remove micro-organisms, plus, they are costly to buy and install.

- Chlorine will kill micro-organisms like bacteria and viruses but it is not so affective in fighting pathogenic parasites like Giardia, Cryptosporidium and Helminth eggs. Further, skilled application is necessary since chlorine is a corrosive substance. Treated water has a distinct taste - not to everyone's liking.

SODIS – an alternative method

Moving away from conventional water treatment, SODIS provides a simple, low-cost, easily applicable means of ensuring clean, drinkable water. SODIS or solar water disinfections uses the sun's radiation (specifically UV-A rays and heat) to destroy pathogenic micro organisms present in water. Its efficiency in killing disease-carrying protozoa depends on the water reaching a certain heat through exposure to sunlight. UV-A rays also drastically reduce many forms of bacteria that contaminate water. To achieve this, transparent plastic containers are filled with water and exposed to full sunlight for at least six hours.

SODIS – a history

This interesting approach to treating contaminated water was first presented by Prof. Aftim Acra in a booklet published by UNICEF in 1984. Following this, a research team from EAWAG (Swiss Federal Institute of Environmental Science and Technology) and SANDEC (Department of Water and Sanitation in Developing Countries) embarked on comprehensive laboratory research on the effectiveness of solar radiation as means of disinfecting water. These tests revealed that the combined use of UV-A (ultra violet-A) radiation and increased water temperature through exposure to sunlight can be 99.9% effective in destroying micro organisms in raw water.

Subsequent field tests and pilot demonstrations have proved the viability of the system in real life, its socio-cultural acceptance and affordability. Pilot demonstrations were done in many developing countries, which enjoy good sunlight throughout the day – Colombia, Bolivia, Burkina, Togo, Thailand and Indonesia.

Transmission of waterborne pathogens

Many common pathogens (disease-causing micro organisms) are transmitted through water and other infectious pathways (droplets, food). Poor hygiene is often the cause of infection. Water transmits bacteria, viruses and types of protozoa, which can cause diarrhoeal diseases. These pathogens could also be transmitted though food or insects such as flies. Ignoring healthy practices like washing hands with soap and water, and after disinfecting and removing faecal matter safely from the environment can increase the risk of disease spread.

Vibrio choshigella, salmonella and different stains of Escherichia Coli (E-coli) are the most common pathogenic bacteria found in contaminated water, while Hepatitis A and Enterovirus are the significant viruses. Although helminths and protozoa do not cause diarrhoea, they can cause chronic digestive illness, which can result in malnutrition. Giardia spp. and Cryptosporidium ssp. are commonly transmitted through water and have a cystic (egg) stage

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which is very resistant to environmental influences.

Water is often contaminated by raw sewage in open water bodies (lake, streams) or while stored at home, through careless handling with unwashed hands.

How SODIS Works

SODIS is a simple, low-cost and easily replicable solution to clean drinking water. SODIS works through a combination of heat and pathogen-killing Ultra Violet radiation (both through sunlight). For this method to work well, the exposure to sunlight should be at least six hours, or until the water reaches a temperature of 55°C.

Figure 2: Bottles are left for the day.
Photo: Practical Action / Zul.

- Clear, plastic bottles are used for SODIS application. These bottles should be filled with relatively clear water, since SODIS is not effective when the water turbidity is high. Water turbidity should not be more than 30 NTU (Nephelometric Turbidity Units). Bottles used for filling water should be transparent, clear bottles-not coloured, not discoloured and not old, chapped bottles. Plastic bottles are used becasue they let in more UV radiation than glass bottles, and are unbreakable, cheap and easily replaceable.

- The water in these bottles should be exposed to full sunlight for six hours, or for two consecutive days during cloudy skies to ensure maximum benefit of the solar effect on pathogens. The water is ready for consumption right after adequate sunlight exposure. One must take care, however, to handle with clean hands so that there is no secondary contamination of disinfected water.

How successful is SODIS?

Laboratory and field tests have shown that SODIS is 99.9% effective against pathogenic micro-organisms found in water. This may not be as good as boiling which provides pathogen-free sterile water or even pasteurisation. But, in terms of cost, affordability, simplicity and sustainability, SODIS scores over these other methods. The success of SODIS depends a lot on a number of local conditions such as availability of suitable water, suitable containers and weather. But throughout the pilot tested countries, a large portion (81%) of the samples gave a 99.9% disinfection rate.

SODIS reduces the incidence of infectious diarrhoea, dysentery, and also protects against cholera.

Which micro-organisms is SODIS effective against?

The sun's radiation is proven to be deadly to human pathogens, which are used to living in the moist, humid, dark environment inside the body. Once they are discharged into the wider environment, these pathogens are extremely sensitive to conditions outside. UV radiation can be fatal to many such pathogens, while others are inactivated by maintaining a 50-57°C heat in the bottle for a given period of time.

Research on SODIS has shown that these pathogens are destroyed during the process.

Bacteria - Escherichia coly (E.coli), Vibrio cholerae, Streptococcus faecalis, Pseudomonas aerugenosa, Shigella flexineri, Salmonella typhii, Salmonella enteritidis, Salmonella paratyphi

Virus - Bacteriophage f2, Rotavirus, encephalomyocarditis virus

Yeast and Mould - Aspergillus niger, Aspergillus flavius, Candida, Geotrichum.

The effect of SODIS on cyst forming protozoa like Entamoeba hystolitica, Giardia intestinalis, Cryptosporidium parvum and helminthes has not been systematically assessed. But, studies show that these have a thermal death point of around 57ºC. If the water maintains a temperature of 57ºC for a minute or a 50ºC temperature for one hour, many cyst-forming types will also be eliminated.

How to do it?

1. Check if the climate and weather conditions are suited for SODIS – basically there should be fairly bright weather with not more than 50% cloud cover.

2. Collect plastic PET (Poly Ethylene Terephthalate) bottles of one litre or 1-1/2 litre volume. PET is preferred to PVC, because PVC can contain harmful additives and to glass, because glass blocks out some of the UV rays.

3. Each family member should be assigned two bottles per day. So a family should have four plastic bottles per member – two for the day's consumption and two exposed to the sun.

4. Check if the screw cap is water tight and clean.

5. Bottles should be laid out on a suitable heat-reflecting surface – roofing sheets, CGI (Corrugated Iron) sheets etc, in a clear spot on the roof or garden. The bottles should be exposed to direct sunlight for at least six hours.

6. Check if the water is clear enough. If there is a lot of discolouration and sediment, the water has to be pre-treated (filtered) before SODIS.

7. It is best to have a specific person responsible for exposing the SODIS bottles to the sun, and at least two members of each family must be trained in the correct application of SODIS, especially on the importance of maintaining sun exposure throughout the period.

How to increase the efficiency of SODIS?

There are certain practices that can increase the efficiency of SODIS. These have to do with increasing sunlight exposure, harnessing available sunlight better and quickening the heating-up process for SODIS water.

- Putting black paint on half of the outer surface of the PET bottle and laying the bottle blackened-side downwards increases the rate of heating.
- Placing the bottles on a reflective surface-aluminium foil etc – can dramatically increase the water heating rate.

Figure 3: The back face of the bottle can be painted black to help absorb solar energy thus heating the water. Photo: Practical Action / Zul.

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- A bucket lined with aluminium foil can act as a solar collector, increasing the efficiency of heating quite dramatically.
- Filling the bottles 75% first and shaking the bottle for 20 seconds increases the oxygen in the water, which, combined with the UV radiation helps to fight pathogens. Fill the rest of the water after shaking the bottle.
- Bottles should be placed horizontally and not upright, nor should the bottles be half full.
- Always replace scratched and old bottles.

Limitations

Weather dependency is the biggest limitation of SODIS. Since the application is quite weather dependent requiring bright sunlight, the process cannot be carried out during rainy days. It is recommended that during long rainy spells, the household should resort to boiling or pasteurising the water.
Another limitation is that a large quantity of water cannot be heated up through this process. PET bottles larger than 2 litre volume should not be used.
SODIS water can be consumed by children, healthy adults and even the aged. But, care must be taken in the case of infants (less than 18 months), very sick children or adults, malnourished children and those suffering from reduced immunity (such as AIDS). For these categories, boiled and cooled water is recommended.

References and further reading

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- *Water quality and treatment* a selection of Practical Action Technical Briefs

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