Sodis: Solar Disinfection of Water for Rural and Small Communities in Iran

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Abstract
In regions of the world that provide the possibility of solar cooking is widely used solar disinfection of water, other beverages and baby food, and control options available for use for domestic water is purified. Low-cost solar reflectors or lights, solar cookers can use simple materials such as cardboard and aluminum foil can be made affordable. This technology is used for water purification and food preparation, as the field in parts of the world such as Kenya, Tanzania, Ethiopia, Vietnam and some American states have been tested. Major limitation of solar heating is at a particular time, only a small volume of water (about 10 liters) of water in each container or solar reflector is properly exposed to the sun and urban households to be used as a method of disinfecting drinking water. Now SODIS is used by more than 2 million people in 30 countries worldwide that are used in this paper the advantages, disadvantages and feasibility of applying this method will pay for water treatment.

Keywords: Drinking water, Disinfection, Solar energy, Sustainable Development, SODIS.

1. Introduction

Treatment to control microbial contaminants transmitted by water, through the clean containers exposed to sunlight, the use of combined antimicrobial effect of UV radiation and solar heat, the combination provides development, evaluation and action stage is reached. A number of different solar treatment systems have been described, but one of the most practical and most economical techniques, is the SODIS system by the Federal Agency for Science, Technology and Environmental Scientists Switzerland (EAWAG) and a large number of their partners have been developed. Several containers of water and the intermittent use of solar collectors (for example, metallic coating materials), the volume of purified water with solar heat in a time of substantial increases. Important limitation of solar heating, solar radiation is unavailable constantly changing seasons, weather conditions (Meteorological) per day and location varies greatly. Although most areas in developing countries, because most days are sunny and semi-sun (approximately 200-300 days per year), position the sun for solar water heating and cooking, is appropriate. Another potential limitation of solar heating for water disinfection, water temperature is determined. In any case, a simple temperature indicator, and low cost has made them one of the simplest and most effective potential re-use water pasteurization indicator (WAPI) is based on the melting temperature, soy wax is made. WAPI includes a clear plastic tube that is part of the soy wax (Soybean wax) - which melts at 70 °C - is filled nylon is also a piece from each end attached to a stainless steel washer has. WAPI is placed inside the water pipe is heated until the wax on top. When the wax reaches 700 C, and melted down to the bottom of the tube. Consequently, a simple visual indicator to indicate pasteurization conditions, is obtained. The indices have different melting temperatures depend on similar waxy type of wax, and for other purposes have been developed [1, 2 and 3].

2. Description

SODIS system consists of three basic steps:
1. Remove solids from highly turbid (from 30 NTU) by settling or filtration, if needed.

2. Pouring water with low turbidity (less than 30 NTU) in clear plastic bottles of 1-2 liter volume (usually discarded beverage bottles, which is preferably painted black on one side).

3. Aeration (oxygenated) water bottle with vigorous shaking, and finally put in contact with air bottles filled with aerated and exposed to full sunlight for about 5 hours (or semi-sunny days).

Water exposed to sunlight, UV radiation, particularly UV-A has been heated and the temperature in both and destroy microbes transmitted by water are involved. The system for treating low volumes of water (less than 10 Liters) is appropriate, especially if water containing low turbidity (less than NTU 30). Clear plastic bottles are preferred by most users on glass bottles. These bottles are less likely to break due to being lighter and less expensive. Bottles made of Polyethylene Terephthalate (PET) bottles made of poly vinyl chloride (PVC), other plastics and most types of glass are preferable, because in this bottle of water is less likely to give hazardous materials. They also are lightweight, do not break, the chemically stable and have the chance to taste and odor to water. PET bottles should be replaced periodically, and if they are scratched at temperatures above 650 ° C, they lose their form. Using an internal temperature sensor to help determine the minimum temperature to achieve the goal, ie, preferably 500 and 550 C or more is recommended. Reusable sensor contains paraffin wax that is connected to a screw weight. When the paraffin melts, drops shows that the desired temperature is achieved [3, 4].

Effect of different factors that are capable of microbial inactivation by solar disinfection, are summarized in Table 5 below. Microbial inactivation system SODIS, the partnership and the combination of UV radiation in the UV-A (320 to 400 nm) that is somewhat germicidal, and heating to temperatures of 50-600 C is a very high rate (about 99%) for the inactivation of enteric viruses, bacteria and parasites during the first few hours is sufficient. However, others have reported that even without the transmission of UV radiation from sunlight in a solar panel business as if the water temperature reaches 600 ° C, bacteria, spores and viruses can activate.

When using heat treatment without UV, or heat and UV together and be done for 2-5 hours, fecal coliforms, Escherichia coli, enterococci, HPC bacteria to 3log10 and spores of Clostridium 1-2 and close to 3log10 decrease. Therefore, to achieve a sufficiently high temperature (preferably 550 or more for several hours), an important factor for the microbial inactivation by solar disinfection systems. Overall, studies show that different bacteria such as fecal coliforms, E. coli and enterococci, and viruses such as rotavirus virus and encephalomyocarditis virus (EMC) in water bottles, for periods of several hours when exposed to solar radiation and temperatures are high and they earn enough, widely decrease. Studies also show that the oxygen dissolved in water, the inactivation of bacteria, especially E. coli and enterococci in the very top, after three hours in oxygenated water (about 6log10) in Non aerated water (less than 2, respectively and less than 1 log 10) shall participate. In subsequent studies, total coliforms and fecal coliforms, respectively to 4 and 6.5 hours of 3log10 in aerated water, and about 1.5log10 in water without oxygen or away from sunlight (the buildings) are inactive. The water is aerated by mechanical mixing or agitation is recommended before solar treatment in bottles. The process of combining oxygen (aeration) by mixing and subsequent exposure to solar radiation for several hours in a clear plastic bottle, as called SOLAR solar disinfection of oxidative photosynthesis. It does not seem that enteric bacteria are inactivated by the SOLAR or SODIS, re-grow or acquire their infectivity [1, 5 and 6].
Ability factor for microbial inactivation:
The sensitivity of bacteria germs against inactivation by heat and UV rays are different. Heat vegetative bacteria, spores, bacteria, viruses and protozoa and eggs of worms are effective. UV radiation on vegetative bacteria and protozoa, viruses, and spores of bacteria is effective.

Water container type:
composition, size and depth within the water temperature, water penetration and UV rays to clean and transport capability has an effect; PET bottles or other possible influence of UV radiation for SODIS system, and black or opaque bottles for oven Solar cookers are used in the reflective system.

Solar radiation, ambient temperature:
solar radiation intensity, duration, radiation, and cloudiness of water temperature and the effective penetration of UV radiation is the ambient temperature affects the water temperature inside the container. Temperatures up to 550 or more for periods of several hours for the inactivation of intestinal pathogens is recommended.

Location and exposure:
Location and exposure to the full sun without shade (from trees and other objects) on the effect of water temperature and radiation exposure to UV; horizontal to vertical cylindrical bottles for better penetration of rays UV.

Mixing:
Uniform mixing or shaking the container to prevent exposure to the sun's rays and at least part of the difference in UV dose received.

Absorb or reflect light:
Absorb or reflect light, absorb light (dark surfaces) or reflection (shiny surfaces of reflector panels or cookers) influence on water temperature and UV exposure.

Water quality:
Water quality, radiation exposure to UV (UV scattering by particles and absorption by dissolved and particulate materials), microbial protection by solids-association.

Water aeration:
Water aeration (oxygenated) to increase the oxygen content of water by agitating (shaking) in the air for several minutes before exposure to solar radiation increases microbial inactivation and its influence on clear bottles (the SOLAR or SODIS).

Exposure time:
Exposure time, water temperature and duration of exposure to elevated temperature and cumulative UV dose. Usually a few hours with full light and the sun for two days in semi-sunny conditions.

3. Advantages, disadvantages and limitations of SODIS system

The advantages and disadvantages of solar treatment systems are summarized in Table 2 below [5].
Table 2- Advantages and disadvantages of the system SODIS [5].

Advantages:

- Microbial inactivation by pasteurization (550 °C or higher is recommended for long hours).
- Easy to use and low cost of small vessels (PET plastic for SODIS and black or opaque bottles for solar reflector or solar cooking system); the bottle or other container, probably.
- No change in Water quality.
- SODIS system (UV + heat) and for low turbidity water (less than 30 NTU) is effective.
- Intensification of heat and UV in the SODIS system.
- Opaque or black bottle system, a temperature sufficient to inactivate viruses and less affected by turbidity or UV absorbent is placed.
- Improved bacterial inactivation in aerobic water by SODIS system.

Disadvantages:

- Often for several hours to disinfect and even more (2 days in cloudy weather) is required; which pathogens are inactivated slowly Grmapay (Rota virus) or disabled are not at all (such as hepatitis A virus and bacterial spores).
- A limited volume of several liters per bottle; use of bottles 5/1 liter (optimum size), several bottles per day for each house is required.
- Not Provides chemical disinfectant residual, water should be consumed within a day or something, otherwise it may happen microbial regrowth.
- High turbidity can interfere with microbial inactivation. Need to reduce turbidity by settling, filtration or other methods.
- The need for low turbidity water (less than 30 NTU); require at least several clear plastic bottle and an opaque or black surface on one side of each bottle, which is exposed to sunlight.
- Pre-aeration (eg, mechanical mixing) for aerobic conditions, the effect may be water in the presence of reducing agents (eg, sulfides) happens.
- Absorbing solar cooker, solar system or solar energy to supply sufficient water containers require less volume is low inactivation in cloudy days.

Comments:

- Inactivation time in different systems (UV + heat) or (heat only) and sunlight conditions will vary, each system to identify the needs of the target temperature (melting of the wax or other thermal indicators).
- Availability of sufficient number of suitable bottles, depending on solar treatment (exposure to porcelain, catchy sunlight or solar cookers) and geographical location.
- Some leakage of chemicals from plastic bottles, causing objectionable tastes and odors controversial, requiring periodic replacement bottles, bottles require periodic cleaning to prevent biofilm formation and expansion.
- Allowing penetration of UV radiation needed to clear bottles (preferably plastic polyethylene terephthalate or PET) bottles to UV rays to penetrate some do not.
- Evidence of synergistic effect on vegetative bacteria, viruses or parasites, but this has not been studied.
- Inactivation of E. coli more than 10,000 times in aerated water (99/99% reduction) compared to aerated water (90-99%) the effect on viruses or parasites have not been studied.
- System, solar cooker at 1.5 h, in a bottle 1.4 liter, destruction 99/99% of the viruses in 3 hours in dark bottles 3.8 liter will result in the destruction of 99 percent.

In addition to the essential technical components SODIS system for drinking water disinfection also includes important education, culture, social behavior, such as composition, education, behavior
modification and education is motivation. SODIS in different parts of the world and many countries, including South America (Colombia and Bolivia), Africa (Burkina Faso and Togo), Asia (China) and Southeast Asia (Indonesia and Thailand) has been tested. Acceptance rates, based on willingness to continue to use after initial use as a demonstration project, to more than 80% have been reported. However, when the pilot used enough by the local community with educational activities, culture, social, behavioral and motivational issues are not supported, support for continued use will be less [1, 7].

4. Conclusion

Treatment to control microbial contaminants transmitted by water, clean containers exposed to sunlight through the use of combined antimicrobial effects of UV rays and heat of the sun, the combination provides the most economical and simplest method of water disinfection, especially in small communities and rural geographic conditions countries like Iran, which has more than seventy to eighty percent of the year are sunny days. Limitations of solar disinfection systems include access to suitable water containers and other required materials, lack of sunlight for disinfection, potential problems in water treatment with high turbidity and the availability of simple methods for reducing water turbidity before solar treatment, lack of residual disinfectant to protect water during handling and storage, potential consumer objections to the technology due to the long time required for water treatment (several hours or more) and Taste controversial and objectionable odor that may be leaking water from plastic bottles. But despite these limitations, solar disinfection in clear plastic bottles, one of the most promising and most extensively tested methods for disinfection of household water stored in the containers.

5. References


5. Solar water disinfection,proceedings of workshop held at the brace research institute,montral.que,Canada.Idrc,p88[p6]
