Decreasing turbidity to optimize solar water disinfection lit review / Part III

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Disadvantages

General limitations


- Availability of suitable containers - several bottles needed per household per day
- Lack of sunlight for disinfection
- Treating highly turbid water, availability of simple methods for reducing turbidity before solar treatment
- Potential user objections to the system due to length of time required to treat the water, possible objections to any taste and odors leached from the bottles.

Turbidity


- Turbidity a "special concern" in the treatment of water
- Microbial reductions decreased or prevented by turbidity particles that reduce access to target microbes or otherwise prevent their inactivation by other mechanisms.
- Physically shields microbes from UV radiation
- "There is a need to investigate, characterize and implement physical and physical-chemical technologies for practical and low cost pre-treatment of household water prior to... solar disinfection with UV plus heat."
- Pre-treatment must take into consideration turbid waters of different quality with respect to particle characteristics and their removal efficiencies.

Survival of spore forming bacterial species


Abstract:

Batch solar disinfection (SODIS) inactivation kinetics are reported for suspensions in water of Campylobacter jejuni, Yersinia enterocolitica, enteropathogenic Escherichia coli, Staphylococcus epidermidis, and endospores of Bacillus subtilis, exposed to strong natural sunlight in Spain and Bolivia. The exposure time required for complete inactivation (at least 4-log-unit reduction and below the limit of detection, 17 CFU/ml) under conditions of strong natural sunlight (maximum global irradiance, approximately 1,050 W m(-2) +/- 10 W m(-2))
was as follows: C. jejuni, 20 min; S. epidermidis, 45 min; enteropathogenic E. coli, 90 min; Y. enterocolitica, 150 min. Following incomplete inactivation of B. subtilis endospores after the first day, reexposure of these samples on the following day found that 4% (standard error, 3%) of the endospores remained viable after a cumulative exposure time of 16 h of strong natural sunlight. SODIS is shown to be effective against the vegetative cells of a number of emerging waterborne pathogens; however, bacterial species which are spore forming may survive this intervention process.


### Other

**SODIS reduces diarrhoeal disease: an update**


Abstract:

349 Maasai children younger than 6 years old were randomised by alternate household to drink water either left in plastic bottles exposed to sunlight on the roof of the house or kept indoors (control). The trial was run in Maasai by Maasai community elders. Children drinking solar disinfected water had a significantly lower risk of severe diarrhoeal disease over 8705 two weekly follow up visits; two week period prevalence was 48.8% compared with 58.1% in controls, corresponding to an attributable fraction of 16.0%. While this reduction is modest, it was sustained over a year in free living children. It confirms solar disinfection as effective in vivo as a free, low technology, point of consumption method of improving water quality. The continuing use of solar disinfection by the community underlines the value of community participation in research.


**NOTES:**

- Field studies support SODIS. Results were "modest" (two week prevalence 48.8% in SODIS users vs. 58.1% in controls) but sustained over a year in children.

### SODIS to reduce childhood diarrhoea in rural Bolivia


Abstract:
BACKGROUND: Solar drinking water disinfection (SODIS) is a low-cost, point-of-use water purification method that has been disseminated globally. Laboratory studies suggest that SODIS is highly efficacious in inactivating waterborne pathogens. Previous field studies provided limited evidence for its effectiveness in reducing diarrhoea. METHODS AND FINDINGS: We conducted a cluster-randomized controlled trial in 22 rural communities in Bolivia to evaluate the effect of SODIS in reducing diarrhoea among children under the age of 5 y. A local nongovernmental organisation conducted a standardised interactive SODIS-promotion campaign in 11 communities targeting households, communities, and primary schools. Mothers completed a daily child health diary for 1 y. Within the intervention arm 225 households (376 children) were trained to expose water-filled polyethylene terephthalate bottles to sunlight. Eleven communities (200 households, 349 children) served as a control. We recorded 166,971 person-days of observation during the trial representing 79.9% and 78.9% of the total possible person-days of child observation in intervention and control arms, respectively. Mean compliance with SODIS was 32.1%. The reported incidence rate of gastrointestinal illness in children in the intervention arm was 3.6 compared to 4.3 episodes/year at risk in the control arm. The relative rate of diarrhoea adjusted for intracluster correlation was 0.81 (95% confidence interval 0.59-1.12). The median length of diarrhoea was 3 d in both groups. CONCLUSIONS: Despite an extensive SODIS promotion campaign we found only moderate compliance with the intervention and no strong evidence for a substantive reduction in diarrhoea among children. These results suggest that there is a need for better evidence of how the well-established laboratory efficacy of this home-based water treatment method translates into field effectiveness under various cultural settings and intervention intensities. Further global promotion of SODIS for general use should be undertaken with care until such evidence is available.

URL: http://www.ncbi.nlm.nih.gov/pubmed/19688036

NOTES:

- Study showed only 32.1% compliance with SODIS and insignificant reduction in diarrhea; however, this may have been due to poor introduction methods and not the technology itself.

**SODIS in household settings - a perspective**


URL: http://dx.plos.org/10.1371/journal.pmed.1000127

NOTES:

- Offers a perspective on SODIS treatment application in the field; ie, batch tests versus field tests. Refers to Mäusezahl D, Christen A et al., 2009 (see above) in particular.
Attitudinal and relational factors predicting the use of solar water disinfection


Abstract:

Solar water disinfection (SODIS) is an uncomplicated and cheap technology providing individuals with safe drinking water by exposing water-filled plastic bottles to sunlight for 6 hours to kill waterborne pathogens. Two communities were visited, and 81 families (40 SODIS users and 41 nonusers) were interviewed. The relationship between several factors and the intention to use SODIS in the future and actual use were tested. The results showed that intention to use and actual use are mainly related to an overall positive attitude, intention to use is related to the use of SODIS by neighbors, and actual use is related to knowledge about SODIS; SODIS users reported a significantly lower incidence in diarrhea than SODIS nonusers. These results suggest that promotion activities should aim at creating a positive attitude, for example, by choosing a promoter that is able to inspire confidence in the new technology.

URL: http://www.ncbi.nlm.nih.gov/pubmed/17114333

Potential for SODIS in Zimbabwe


Abstract:

The potential for reducing diarrhoea morbidity and improving the health status of children in developing countries using solar water disinfection (SODIS) has been demonstrated in past research. A baseline survey was conducted to explore the feasibility and necessity of introducing SODIS in peri-urban communities of Zimbabwe. The survey sought to establish drinking water quality in these areas and to determine the health and hygiene beliefs as well as practices related to water handling in the household. Microbiological water quality tests and personal interviews were carried out in Epworth township and Hopley farm, two peri-urban areas near the capital of Zimbabwe, Harare. These two areas are among the poorest settlements around Harare with 80% of inhabitants being informal settlers. Community meetings were held to introduce solar water disinfection prior to the survey. This was followed by administration of questionnaires, which aimed to investigate whether the community had ever heard about SODIS, whether they were practicing it, other means that were being used to treat drinking water as well as health and hygiene beliefs and practices. It was found out that most households cannot afford basic water treatment like boiling as firewood is expensive. People generally reported that the water was not palatable due to
objectionable odour and taste. Microbiological water quality tests proved that drinking water was contaminated in both areas, which makes the water unsafe for drinking and shows the necessity of treatment. Although the majority of people interviewed had not heard of SODIS prior to the interview, attitudes towards its introduction were very positive and the intention to do SODIS in the future was high. Amongst the ones who had heard about SODIS before the study, usage was high. Plastic PET bottles, which were used for the SODIS experiments are currently unavailable and this has been identified as a potential hindrance to the successful implementation of SODIS.

URL: http://linkinghub.elsevier.com/retrieve/pii/S1474706508001617

Efficacy of solar disinfection of Escherichia coli, Shigella flexneri, Salmonella Typhimurium and Vibrio cholerae


Abstract:

AIMS: To determine the efficacy of solar disinfection (SODIS) for enteric pathogens and to test applicability of the reciprocity law. METHODS AND RESULTS: Resistance to sunlight at 37 degrees C based on F99 values was in the following order: Salmonella Typhimurium>Escherichia coli>Shigella flexneri>Vibrio cholerae. While F90 values of Salm. Typhimurium and E. coli were similar, F99 values differed by 60% due to different inactivation curve shapes. Efficacy seemed not to be dependent on fluence rate for E. coli stationary cells. Sensitivity to mild heat was observed above a temperature of 45 degrees C for E. coli, Salm. Typhimurium and Sh. flexneri, while V. cholerae was already susceptible above 40 degrees C. CONCLUSIONS: Salmonella Typhimurium was the most resistant and V. cholerae the least resistant enteric strain. The reciprocity law is applicable for stationary E. coli cells irradiated with sunlight or artificial sunlight. SIGNIFICANCE AND IMPACT OF THE STUDY: Escherichia coli might not be the appropriate indicator bacterium to test the efficacy of SODIS on enteric bacteria and the physiological response to SODIS might be different among enteric bacteria. The applicability of the reciprocity law indicates that fluence rate plays a secondary role in SODIS efficacy. Stating inactivation efficacy with T90 or F90 values without showing original data is inadequate for SODIS studies.

URL: http://www.ncbi.nlm.nih.gov/pubmed/16968294

Simulation of solar radiation for global assessment and application in Haiti


Abstract:
Haiti and other developing countries do not have sufficient meteorological data to evaluate if they meet the solar disinfection (SODIS) threshold of 3-5 h of solar radiation above 500 W/m(2), which is required for adequate microbial inactivation in drinking water. We have developed a mathematical model based on satellite-derived daily total energies to simulate monthly mean, minimum, and maximum 5-h averaged peak solar radiation intensities. This model can be used to assess if SODIS technology would be applicable anywhere in the world. Field measurements were made in Haiti during January 2001 to evaluate the model and test SODIS efficacy as a point-of-use treatment option. Using the total energy from a measured solar radiation intensity profile, the model recreated the intensity profile with 99% agreement. NASA satellite data were then used to simulate the mean, minimum, and maximum 5-h averaged peak intensities for Haiti in January, which were within 98.5%, 62.5%, and 86.0% agreement with the measured values, respectively. Most of the discrepancy was attributed to the heterogeneous nature of Haiti's terrain and the spatial resolution of the NASA data. Additional model simulations suggest that SODIS should be effective year-round in Haiti. Actual SODIS efficacy in January was tested by the inactivation of total coliform, E. coli, and H2S-producing bacteria. Exposure period proved critical. One-day exposure achieved complete bacterial inactivation 52% of the time, while a 2-day exposure period achieved complete microbial inactivation 100% of the time. A practical way of providing people with cold water every morning that has undergone a 2-day exposure would be to rotate three groups of bottles every morning, so two groups are out in the sun and one is being used for consumption.

URL: http://linkinghub.elsevier.com/retrieve/pii/S0043135402002415

Water disinfection by solar radiation: assessment and application


This publication is aimed at researchers, primary health care workers, and technical workers interested in solar energy applications and drinking-water disinfection. It provides basic information on solar energy, covering especially its ultraviolet (UV) component. Aspects such as the transmission of solar radiation through the atmosphere and different media (glass, water, plastics, etc.), its world distribution, and the experimental monitoring of UV radiation in Beirut (Lebanon) are thoroughly discussed. The main water disinfection methods are reviewed and continuous-flow solar systems are explained. These were tested on two types of pilot plants ("solar reactors"), based on the biocidal characteristics of either solar energy alone or halogens in combination with solar radiation ("halosol" system). The experimental results are discussed in detail, covering the kinetics of the processes, design of the reactors, and their performance in terms of bacterial survival and solar dechlorination.
Solar disinfection in Nigerian slum


Abstract:

A study was carried out on the integrated water management in an urban poor community in Ibadan, Nigeria. This community with a population of 20,938 is located in the Koloko-Aiyekalearea under the North East Local Government occupying an area of 0.97 km². They engage mostly in trading, farming and some have taken up the civil service and teaching professions. Shallow wells are their main water source supplemented by rain, tap and other commercial sources. Sanitation is poor, characterized by spread of wastewater on streets and unkempt open drains, and streets littered with refuse and animal dung. An intervention study covering a period of over 18 months was undertaken involving 324 women to improve the water quality, to lay a hygienic drainage system, and to use the wastewater for backyard or community farming. Simple storage of water for prolonged periods, solar radiation of stored water, and pot chlorination of wells were tried for the improvement of water quality. The merits of these methods were assessed and related to the community's perceptions, knowledge, attitudes and practices. The women formed a ten-member water committee and examined various feasible solutions. Solar radiation for water quality improvement, drainage improvement through digging deeper and periodic cleaning, and community farming using the drainage water were finally adopted and practised. The produce obtained from the farming activities improved their income generation, nutritional needs and general sustainability.

URL: http://www.informaworld.com/openurl?genre=article&doi=10.1080/07900629849132&magic=crossref%7C%7CD404A21C5BB053405B1A640AFFD44AE3

Reuse of PET bottles during SODIS and migration of plasticisers and chemicals into the water


Abstract:

Solar water disinfection (SODIS) is a simple, effective and inexpensive water treatment procedure suitable for application in developing countries. Microbially contaminated water is filled into transparent polyethylene terephthalate (PET) plastic bottles and exposed to full sunlight for at least 6 h. Solar radiation and elevated temperature destroy pathogenic germs efficiently. Recently, concerns have been raised insinuating a health risk by chemicals released from the bottle material polyethylene terephthalate (PET). Whereas the
safety of PET for food packaging has been assessed in detail, similar investigations for PET bottles used under conditions of the SODIS treatment were lacking until now. In the present study, the transfer of organic substances from PET to water was investigated under SODIS conditions using used colourless transparent beverage bottles of different origin. The bottles were exposed to sunlight for 17 h at a geographical latitude of 47 degrees N. In a general screening of SODIS treated water, only food flavour constituents of previous bottle contents could be identified above a detection limit of 1 μg/L. Quantitative determination of plasticisers di(2-ethylhexyl)adipate (DEHA) and di(2-ethylhexyl)phthalate (DEHP) revealed maximum concentrations of 0.046 and 0.71 μg/L, respectively, being in the same range as levels of these plasticisers reported in studies on commercial bottled water. Generally, only minor differences in plasticiser concentrations could be observed in different experimental setups. The most decisive factor was the country of origin of bottles, while the impact of storage conditions (sunlight exposure and temperature) was less distinct. Toxicological risk assessment of maximum concentrations revealed a minimum safety factor of 8.5 and a negligible carcinogenic risk of 2.8 x 10(-7) for the more critical DEHP. This data demonstrate that the SODIS procedure is safe with respect to human exposure to DEHA and DEHP.

URL: http://linkinghub.elsevier.com/retrieve/pii/S0043135408004168

Disinfection of contaminated water by solar irradiation


Abstract:

Contaminated water causes an estimated 6 to 60 billion cases of gastrointestinal illness annually. The majority of these cases occur in rural areas of developing nations where the water supply remains polluted and adequate sanitation is unavailable. A portable, low-cost, and low-maintenance solar unit to disinfect unpotable water has been designed and tested. The solar disinfection unit was tested with both river water and partially processed water from two wastewater treatment plants. In less than 30 min in midday sunlight, the unit eradicated more than 4 log10 U (99.99%) of bacteria contained in highly contaminated water samples. The solar disinfection unit has been field tested by Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente in Lima, Peru. At moderate light intensity, the solar disinfection unit was capable of reducing the bacterial load in a controlled contaminated water sample by 4 log10 U and disinfected approximately 1 liter of water in 30 min.

URL: http://www.ncbi.nlm.nih.gov/pubmed/14766599

Expanding access to point-of-use water treatment systems

Mintz, E., Bartram, J., Lochery, P. & Wegelin, M. Not just a drop in the bucket: expanding access to point-of-use water treatment systems. Am J Public Health

Abstract:

Since 1990, the number of people without access to safe water sources has remained constant at approximately 1.1 billion, of whom approximately 2.2 million die of waterborne disease each year. In developing countries, population growth and migrations strain existing water and sanitary infrastructure and complicate planning and construction of new infrastructure. Providing safe water for all is a long-term goal; however, relying only on time- and resource-intensive centralized solutions such as piped, treated water will leave hundreds of millions of people without safe water far into the future. Self-sustaining, decentralized approaches to making drinking water safe, including point-of-use chemical and solar disinfection, safe water storage, and behavioral change, have been widely field-tested. These options target the most affected, enhance health, contribute to development and productivity, and merit far greater priority for rapid implementation.

URL: http://www.ncbi.nlm.nih.gov.proxy.queensu.ca/pmc/articles/PMC1446826/