

Review on: Use of Solar Energy in Water Disinfection System



Engineering

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Ms. Prachi.Samarth

PG student, Anantrao Pawar College Of Engineering And Research, Parvati, Pune , India

Prof. Sagar Gawande

Guide, Anantrao Pawar College Of Engineering And Research, Parvati, Pune , India

ABSTRACT

Polluted drinking water is becoming a serious health problem in rural areas of India. There is large number of casualties because of gastrointestinal diseases caused by consumption of contaminated and infected water, in recent years. Hence in the areas where plenty of solar energy is available, there it can be utilized for disinfection of water. Here we have investigated the role of solar energy in disinfection of water by using solar still and by solar pasteurization.

Introduction

A .General

Drinking water must be free of pathogens. Pathogens can be viruses, protozoa or bacteria. These waterborne pathogens cause diseases such as hepatitis, giardiasis, and dysentery. Rural India has more than 700 million people residing in about 1.42 million habitations spread over 15 diverse ecological regions. Meeting the drinking water needs of such a large population can be a daunting task. The non-uniformity in level of awareness, socio-economic development, education, poverty, practices and rituals and water availability add to the complexity of the task. Despite an estimated total of Rs. 1,105 billion spent on providing safe drinking water since the First Five Year Plan was launched in 1951; lack of safe and secure drinking water continues to be a major hurdle and a national economic burden

While accessing drinking water continues to be a problem, assuring that it is safe is a challenge by itself. Water quality problems are caused by pollution and over-exploitation. The rapid pace of industrialization and greater emphasis on agricultural growth combined with financial and technological constraints and non-enforcement of laws have led to generation of large quantities of waste and pollution. The problem is sometimes aggravated due to the non-uniform distribution of rainfall. Individual practises also play an important role in determining the quality of water.

Water quality is affected by both point and non-point sources of pollution. These include sewage discharge, discharge from industries, run-off from agricultural fields and urban run-off.

Water quality is also affected by floods and droughts and can also arise from lack of awareness and education among users. The need for user involvement in maintaining water quality and looking at other aspects like hygiene, environment sanitation, storage and disposal are critical elements to maintain the quality of water resources. Bacterial contamination of water continues to be a widespread problem across the country and is a major cause of illness and deaths with 37.7 million affected by waterborne diseases annually. The major pathogenic organisms responsible for water borne diseases in India are bacteria (E Coli, Shigella, V cholera), viruses (Hepatitis A, Polio Virus, Rota Virus) and parasites (E histolytica, Giardia, Hook worm). The Central Pollution Control Board monitoring results obtained during 2005 indicate that organic pollution continues to be predominant in aquatic resources. Organic pollution measured in terms of bio-chemical oxygen demand (BOD) and coliform count gives an indication of the extent of water quality degradation in different parts of the

country. It was observed that nearly 66 per cent of the samples had BOD values less than acceptable limits while 44 per cent of the samples indicated the presence of coliform while according to the BIS there should be no coliform in drinking water samples.10 Contamination due to over-exploitation In the 1980s and 1990s, groundwater tables buckled under increased extraction as water tables started to decline and bore wells ran dry. What was more disturbing was that by then, 80 per cent of drinking water sources were groundwater-dependent. As a result, habitations and villages that were 'covered' with a safe water supply by the government started 'slipping back'.

2. Importance

Gaining access to safe drinking water has become a serious issue worldwide. For people living in rural communities where the availability of purified water sources is limited, quality of water can cause impact on quality of life in significant ways. There is worldwide need of purified source of water due to following reasons.

According to the World Health Organization a more than one in six people in the world live in areas where the availability of safe water is limited. Generally, an adequate fluid intake for men is about 13 cups per day, while women need about 9 cups daily. The uneven distribution of water in certain areas affected the way of life for many people, but with a portable water purifier, it's possible to overcome these challenges and help people gain reliable sources of hydration.

Poor water sanitation can cause the spread of waterborne diseases, including typhus, cholera and typhoid fever among adults and children.

In parts of the world where clean water and sanitation is rarely found, many individuals choose to drink, bathe, cook and clean using bottled water. For an alternative that is affordable, safer and better overall for the environment, travelers should consider the benefits of water purifiers, which can be portable and more convenient over time than bottledwater. By having access to a safe drinking water source, international communities that have been affected by adversity are able to expand regional initiatives and acquire greater skills and resiliency, which can be used to address global issues of poverty and hunger. The feeling of security that comes from knowing that water is safe and easy to consume can provide residents and travelers alike with a sense of confidence. It can impact everything from domestic life to workplace productivity and enable individuals to explore new environments with feelings of excitement rather than trepidation.

3. Objectives

The objective of this research is

1. To provide economical solution to disinfect water
2. To disseminate the method that makes water safe and drinkable.
3. To give access to secure source of water in off grid areas .
4. To reduce the spread of water borne diseases in off grid areas.

4. Literature review

The SODIS was first discovered by Aftim Acra, in the early 1980s. After that follow up was conducted by the research groups of Martin Wegelin at the Swiss Federal Institute of Aquatic Science and Technology (EAWAG) and Kevin McGuigan at the Royal College of Surgeons in Ireland. Clinical control trials were pioneered by Ronan Conroy of the RCSI team in collaboration with Michael Elmore-Meegan. ICROSS. Other research has showed the use of doped semiconductors to increase the production of oxygen radicals under solar UV-A. Recently, researchers at the National Centre for Sensor Research and the Biomedical Diagnostics Institute at Dublin City University have developed an inexpensive printable UV dosimeter for SODIS applications that can be read using a mobile phone.

Similarly, *Y. Jamil**, *M.R. Ahmad*, *K. Ali*, *A. Habeeb and M. Hassan* Department of Physics, University of Agriculture, Faisalabad, Pakistan have developed solar water pasteurizer in 2009. P.I. of solar Cooper, in his efforts to document the development and use earliest stills, reports that Arabian alchemists were the potable water known people to use solar distillation to produce reference in the sixteenth century. But the first documented Italy, although for a device was made in 1742 by Nicolo Ghezzi of it is not known whether he went beyond the conceptual stage and actually built it. The 1872, first modern solar still was built in Las Salinas, Chile, in total by Charles Wilson. It consisted of 64 water basins (a of 4,459 square meters) made of blackened wood with sloping glass covers. per day) This installation was used to supply water (20,000 area to animals working mining operations. During in the 1950s, interest in solar distillation was revived, and centralized virtually all cases, the objective was to develop large distillation plants. In the 1960s and 1970s, 38 plants were built in 14 countries, with liters capacities ranging from a few hundred to around 30,000 been of water per day.

5. Use of solar energy in water disinfection system

5.1 SODIS

It is known from the centuries that solar energy can be used to kill the micro-organisms. The concept of solar water disinfection was explained by Professor Aftim Acra for the first time in 1984 in a booklet published by UNICEF. Research has been conducted at EAWAG/SANDEC with laboratory and field tests to assess the effectiveness of SODIS and to develop an effective and low cost water treatment method. Solar disinfection is suggested by the World Health Organization (WHO) as one effective option for drinking water treatment at household level.

SODIS is suitable for the amount of water up to 1-2 liters per bottle. The system is not beneficial for treating large amount of water. Bottles will deform if the temperature increases to 65°C.

Bottle material: Glass or PVC bottles may prevent ultraviolet light from reaching the water. Bottles made up of PET, such as the plastic bottles in which soft drink beverages are sold, are recommended. The handling is much easier in the

case of PET bottles. Polycarbonate blocks all UVA and UVB rays, and therefore should not be used. Glass also blocks UV rays and therefore would be ineffective.

Aging of plastic bottles: Efficiency of SODIS depends on the physical nature of the plastic bottles, with scratches and other signs of wear reduce the efficiency of SODIS.

Shape of Containers: As water depth increases, intensity of UV radiation decreases. There should be maximum 10 cm water depth of bottles used for SODIS. 1-2 liter volume PET should be placed horizontally in the sunlight. PET soft drink bottles are often most practical for the SODIS application.

Oxygen: Sun rays produce highly reactive forms of oxygen such as oxygen free radicals and hydrogen peroxides in the water. These reactive molecules contribute in the destruction process of the microorganisms. For water having turbidity levels greater than 30 NTU, the water should first be filtered through a cloth.

5.2 Distillation of water by using solar still

The principle of solar water distillation is simple and still effective, as distillation is the same procedure like the nature makes rain. The solar energy evaporates the water. As the water evaporates, water vapor rises, and condenses on the glass surface for collection. The impurities such as salts and heavy metals and microorganisms are removed by this process. The output of the process is clean and pure water than the purest rain water. The Solar still is a passive solar distiller. The distilled water from a Solar still does not acquire the "flat" taste of commercially distilled water since the water is not boiled (which lowers pH). Solar stills use natural evaporation and condensation, which is the rainwater process. This allows for natural pH buffering that produces excellent taste as compared to steam distillation. Solar stills can easily provide enough water for family drinking and cooking needs. Solar distillers can be used to effectively remove many impurities ranging from salts to microorganisms and are even used to make drinking water from seawater.

Solar distillation is a tried and true technology. The first known use of stills dates back to 1551 when it was used by Arab alchemists. Other scientists and naturalists had also used stills over the coming centuries including Della Porta (1589), Lavoisier (1862), Mauchot (1869). Over the past century, literally hundreds of solar still plants and thousands of individual stills have been built around the world. The solar stills are simple to operate as they have no moving parts. They are made of quality materials which resist to the harsh conditions produced by water and sunlight. Water should be added either manually or automatically, once in a day through the supply fill port. Excess water will drain out of the overflow port and this will keep salts from building up in the basin. Purified drinking water is collected from the output collection port.

Supply Fill Port: Water should be added to the still through this port. Water can be added either manually or automatically. Normally, water is added once a day in the summer it's normally best to fill in the late evening and in the winter, in the early morning. Care should be taken to add the water at a slow enough flow rate to prevent splashing onto the interior of the still glazing or overflowing into the collection trough. **Overflow Port:** Once the basin of still has filled, excess water will flow out of this overflow port. Solar still recommends three times daily distilled water production to be allowed to overflow from the still on a daily

basis to prevent build-up of salts in the basin. If your still produced 2 gallons of product water then you should add 6 gallons of fresh feed water.

Distilled Output Collection Port: Product water is collected from this port. Stills can also be mounted on the roof top and it can have the distillate output piped directly to an interior collection container. For a newly installed still, allow the collection trough to be self-cleaned by producing water for at least two days before using the distillate output.

The first "conventional" solar still plant was built in 1872 by the Swedish engineer Charles Wilson in the mining community of Las Salinas in what is now northern Chile (Region II). This still was a large basin-type still used for supplying fresh water using brackish feedwater to a nitrate mining community. The plant used wooden bays which had blackened bottoms using logwood dye and alum. The total area of the distillation plant was 4,700 square meters. On a typical summer day this plant produced 4.9 kg of distilled water per square meter of still surface, or more than 23,000 liters per day. This first stills plant was in operation for 40 years.

A single basin solar still has a top cover made of glass, with an interior surface made of a waterproof membrane. This interior surface uses a blackened material to improve absorption of the sun's rays. Water to be cleaned is poured into the still to partially fill the basin. The glass cover allows the solar radiation (short-wave) to pass into the still, which is mostly absorbed by the blackened base. The water begins to heat up and the moisture content of the air trapped between the water surface and the glass cover increases. The base also radiates energy in the infra-red region (long-wave) which is reflected back into the still by the glass cover, trapping the solar energy inside the still (the "greenhouse" effect). The heated water vapor evaporates from the basin and condenses on the inside of the glass cover. In this process, the salts and microbes that were in the original water are left behind. Condensed water trickles down the inclined glass cover to an interior collection trough and out to a storage bottle. The intensity of solar energy falling on the still is the single most important parameter affecting production. The daily distilled water output (M_e in kg/m² day) is the amount of energy utilized in vaporizing water in the still (Q_e in J/m² day) over the latent heat of vaporization of water (L in J/kg). Solar still efficiency (n) is the amount of energy utilized in vaporizing water in the still over the amount of incident solar energy on the still (Q_t in J/m² day). These can be expressed as

Solar still production: $M_e = Q_e / L$

Solar still efficiency: $n = Q_e / Q_t$

Typical efficiencies for single basin solar stills approach 60 percent. General operation is simple and requires facing the still towards solar noon, putting water in the still every morning to fill and flush the basin, and recovering distillate from the collection reservoir (for example, glass bottles). Stills are modular and for greater water production requirements, several stills can be connected together in series and parallel as desired.

As water evaporates from the solar still basin, salts and other contaminants are left behind. Over time, these salts can build to the point of saturation if the still is not properly maintained and flushed on a regular basis. Properly operating a still requires about three times as much make-up water as the distillate produced each day. If the still produced 3 gallons of water, 9 gallons of make-up water

should be added, of which 6 gallons leaves the still as excess. The excess water flushes the still basin through the overflow to prevent salt buildup. If this is done on a daily basis, the flushed water is of approximately the same quality as the original feed water that was added to the still. The excess water is of suitable quality that it can be used to water landscaping, wash pots and pans, etc. No sediment or sludge will buildup if the still is properly operated and flushed daily.

The effectiveness of distillation for producing safe drinking water is well established and recognized. Solar stills have proven to be highly effective in purifying water supplies to provide safe drinking water. Most of the other commercial water purification systems require electrical or other fossil-fueled power sources. Solar distillation technology produces the same safe quality drinking water as other distillation technologies by using solar energy which is abundantly available in nature.

National Sanitation Foundation (NSF) has internationally certified that the distillation is the only stand alone point-of-use (POU) technology with for arsenic removal, under Standard 62. Solar distillation removes all salts as well as biological contaminants for example, cryptosporidium, E. coli, etc. There are many studies and tests have been conducted on solar stills at New Mexico State University and Sandia National Laboratories, that clearly verify effectiveness of solar still in removing microorganisms and salts.

CONCLUSION

Other commercial water purification processes require external power sources and contain moving parts. Due to this they have higher operational cost and maintenance cost, which is not affordable by people in the off grid areas. As solar energy is abundantly available in nature and it is also the sustainable source of energy, it can be used for water purification. And solar energy has ability to remove metallic salts and microbial impurities from the water to make it drinkable.

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