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Hygiene Promotion & Sanitation through Solar Distillation for Safe Drinking Water in Rural India

Dhananjay Singh*[1], Durgesh Pratap[1], Sunita Maurya[2] and D.P. Maurya[3]

[1]Department of Chemical Engineering, Institute of Engineering & Technology Lucknow-226021, India

[2]Faculty of Pharmacy, Integral University Lucknow, India

[3]Department of Biotechnology, Institute of Engineering & Technology Lucknow-226021, India

Corres Author: dsa768008@gmail.com

Abstract: Water, which is essential for life, growth and health, can also be a source of spread of disease and cause of ill-health, if contaminated or improperly handled and stored. Safe drinking water and improved sanitation play a major role in the overall well-being of the people, with a significant bearing on the infant mortality rate, death rate, longevity and productivity. Women bear the physical burden of fetching water. Women and children are particularly vulnerable to the effects of water contamination. Scarcity, brackishness and excess fluoride contents are three major problems in sustainable supply of drinking water. In remote and other inaccessible areas, one of the options to remove chemical contaminants from drinking water could be solar distillation through 'solar stills' at the household level. The solar still is a simple device to distil water of its impurities. Larger solar stills are generally made of glass over a formed sheet metal. The most important elements of the design are the sealing of the base with black, high-temperature silicone rubber. As sunlight warms the black silicone bottom and heat is transferred to the water, the top layer of water evaporates and covers inside of the glass cover, which is inclined towards the freshwater drain. Approximately, 1 m^2 of glass cover will distil around 5.0 litres of water per day within 5 hours of full sunlight.

Keywords: Hygiene, Scarcity, Fluoride, Solar Stills, Distillation.

1. INTRODUCTION

The goal of any water-sanitation intervention is an improvement in the quality of life and total health of the local population by reducing the occurrence of water-borne diseases. 70-80 per cent of illnesses are related to water contamination and poor sanitation. The national objectives of reducing morbidity and mortality largely depend on the reduction of diarrhoea and jaundice. In fact, no water supply and sanitation programme can be successful if water-related illnesses are not reduced [1]. It is a matter of concern that despite the progress made with water supply, the level of water-related sickness continues to be high. Causes of contamination of water are indiscriminate use of chemical fertilisers and chemicals, poor hygienic environment of the water sources, improper disposal of sewage and solid waste, pollution from untreated industrial effluents, over-exploitation leading to quality degradation. Although, plenty of water is available on earth, but survey shows that only 1% of water sources are fresh that can be used for drinking purposes. Rests of the water sources are brackish (that contain dissolved salts) or it contain harmful bacteria. Fluoride contamination of these water resources is very common problem. There are several methods of using solar energy for water distillation [4]. One of the simple methods is a shallow basin containing water to be distilled is covered with transparent material (such as glass or plastic). The equipment is commonly called as ''solar still''. Thus, the supply of additional quantity

of water by itself does not ensure good health; proper handling of water and prevention of contamination are also equally important [5].

Personal Hygiene: Washing hands with soap after defecation/ child's excreta disposal and before cooking/eating, bathing daily, brushing teeth and wearing footwear.

1.1 Water Supply And Rural Development

For the success of the proposed reform process, however, complementary reforms are necessary such as increasing user charges for water used in irrigation and industry. The new strategy thus relies heavily on the use of Central/State funding as a critical incentive to drive the reform process. As such, it is important that conditionality for disbursement of Central funds to state administrations and from state administrations to local administrations be explicitly defined. The conditions which must be met and the activities for which funding can be applied must be clearly specified [1].

Resources for information education communication/human resource development (IEC/HRD) now given for different sectors, particularly, public health, nutrition, drinking water, sanitation etc. should be pooled together at the district/state level to the extent possible. NGOs are found to be particularly good at outreach and have the advantage of being able to sharply focus on and activate the participation of communities. All existing social organisations, women's self-help groups, cooperative societies, civil societies, educational institutions, private institutions etc. should be involved for effective implementation of a large scale sanitation programme.

Rural water supply and sanitation facilities are vital elements in the overall programme for rural development. Other related elements include infrastructural issues like land and watershed management, soil conservation, a forestation etc. and social issues like primary health care, eradication of illiteracy, women's welfare, child nutrition, immunisation etc. It is desirable that the thrust and implementation of as many of these programmes as possible are converged in order to provide for integrated rural development [4].

1.2 Precautions for Hygienic Response

- Core Sanitation & Hygiene Practices in terms of measurable indicators, hand-washing with soap after defecation and before eating, disposal of child's excreta in latrine, use of smokeless chulhas
- Personal Hygiene in terms of brushing teeth daily, having bath daily, clipping nails, wearing clean clothes and chappals

Family Hygiene: Clearing the house & kitchen daily, storing drinking water/ cooked food covered in elevated areas, keeping the premises of the house clean and using latrines.

Community Sanitation: Proper disposal of solid & liquid wastes, developing composting pits and proper use & maintenance of village sanitary facilities.

- Environmental Sanitation in terms of keeping drains, streets & water collection points clean, proper disposal of solid & liquid household waste; Water Handling in terms of proper storage & handling of drinking water
- Community Participation by way of support for operation & maintenance of project facilities and satisfaction in terms of decision-making and performance
- Recent studies have shown the importance of washing one's hands with soap as it reduces diarrhoeal disease by 43 per cent. Respiratory problems such as sniffles and coughs were also brought down by 45 per cent when hands were washed five times a day
- Safe sanitation practices should be made a compulsory part of school curricula, and of all programmes where women are trained in community, economic and health issues affecting the household

Health related benefits: 2 millions deaths per year from the following diseases

- Gastroenteritis
- Diarrhoea / Jaundice
- Typhoid / Malaria
- Polio

Non-health related benefits:

- School enrolment and attendance, specially for women and girls
- Dignity/ Privacy
- Convenience
- Status/Prestige

Investments benefits:

- Saving of recurring health cost
- Income generation through ecological sanitation, especially in rural areas

The existing total sanitation programme should include safe disposal of night-soil, rain water, domestic liquid and solid waste. It should not be restricted to construction of latrines only. Awareness of sanitation standards and health impact of unsanitary conditions continues to be low. Rural sanitation is promoted as a total package consisting of safe handling of drinking water, scientific disposal of waste water, safe disposal of human excreta including child excreta, solid waste management, domestic sanitation

and food hygiene, personal hygiene and village sanitation. However, there has hardly been any significant change in the sanitary conditions in the villages in India. The 54th round of national sample survey indicates that only 17.5 percent of rural population were using latrines. There is a need to implement a revitalised programme for rural sanitation which must have the following elements:

- Preference has to be given to the twin pit model of water-sealed latrines. However, the cost of such a unit may be an inhibiting factor.
- School sanitation (providing toilets) should be given highest priority to inculcate safe hygienic habits among school children.
- Village Panchayats should adopt building bye-laws where dry latrines are not permissible. Any latrine to be constructed should be of the water-sealed type with a leach-pit. This will prevent the emergence of the problem of manual scavenging.
- Considering that the programme of installation of low-cost toilets has not made the expected degree of progress, a fresh start is required. The State Council for Sanitation proposed under urban sanitation sector should also have the mandate for rural sanitation.
- Subsidy for the low-cost household toilets should only be given to rural below poverty-line (BPL) families, and it should be on par with subsidy for the urban households. For the success of the scheme, a subsidy of 50 per cent of the cost of the unit inclusive of sub and super-structures for the basic twin-pit pour flush system appears to be necessary.
- In order to mobilise the required funds for rural sanitation, financial institutions/banks including HUDCO and the National Bank of Agriculture and Rural Development (NABARD) should extend loans at lower interest rates to states for provision of sanitation facilities. Low cost loan schemes like micro-credit through NGOs should be adequately supported. Various fiscal concessions such as reduced excise duty/sales tax and lower electricity charges should be made available to the manufacturers of low cost sanitary materials.
- Private participation should be encouraged in setting up of building centres and sanitary marts in rural areas to provide cost effective sanitation technology to the rural households.
- For the success of the scheme, and to overcome the huge problem of in-sanitary practices in the country, a large programme of education, propagation, training, designing and development, production, and installation, needs to be taken. NGOs should be mobilised to support to the programme, especially for supervision, monitoring, training and development work. A suitable provision for the participation of the nongovernmental organizations in the sanitation programme should be made in the project costs.

Among the most important elements of the rural sanitation package are:

- Safe handling of drinking water
- Disposal of waste water
- Safe disposal of human excreta. Human excreta is associated with more than 50% of diseases
- Safe solid waste disposal
- Home sanitation and food hygiene
- Personal hygiene, particularly, washing one's hand with soap
- Sanitation in community

1.3 Challenges Related to Sanitation and Hygiene

- Dysfunctional sector
- Low Priority and Visibility
- Fragmented Institutional Responsibilities
- In adequate Financing
- In-appropriate Technical standards and norms
- Lack of consensus of sanitation approach

1.4 Effects of Released Fluoride on Health

- Effects on the Teeth
- Effect on the Thyroid
- Effect on the Brain
- Effect on Endocrine System
- Effect on The Pineal Gland
- Effect on Insulin Secretion/Diabetes
- Effect on Immune System
- Effect on the Reproductive System
- Effect on the Kidney
- Effect on the Gastrointestinal System
- Effect on the Kidney
- Effect on the Gastrointestinal System Fluoride Causes Cancer

1.5 Permissible Limit of Fluoride

Fluoride levels in surface waters vary according to location and proximity to emission sources. Surface water concentrations generally range from 0.01 to 0.3 mg/litre. Seawater contains more fluoride than fresh water, with concentrations ranging from 1.2 to 1.5 mg/litre. Higher levels of fluoride have been measured in areas where the natural rock is rich in fluoride, and elevated inorganic fluoride levels are often seen in regions where there is geothermal or volcanic activity (25–50 mg fluoride/litre in hot

springs and geysers and as much as 2800 mg/litre in certain East African Rift Valley lakes). Fluoride is a component of most types of soil, with total fluoride concentrations ranging from 20 to 1000 µg/g in areas without natural phosphate or fluoride deposits and up to several thousand micrograms per gram in mineral soils with deposits of fluoride [4]. Fluoride in soil is primarily associated with the soil colloid or clay fraction. For all soils, it is the soluble fluoride content that is biologically important to plants and animals [12, 13].

Required levels of fluoride are estimated to be approximately 0.1 to 0.5 mg F/d for children less than 6 months old, while for adults the range is 4.5 to 4.0 mg F/d. However neither diet nor fluoride by themselves will eradicate dental disease; both proper diet and fluoridation are essential for optimum dental health. Too much fluoride during early childhood can lead to dental fluorosis as a result of the enamel failing to crystallize properly [8].

1.6 Sources of Fluoride in Groundwater

Fluorides are released into the ground water through the weathering of rocks and through atmospheric emissions from volcanoes and seawater. Other fluoride sources include the combustion of coal (containing fluoride impurities) and other manufacturing processes (steel, copper, nickel, glass, brick, ceramic, glues and adhesives). In addition, the use of fluoride-containing pesticides in agriculture and fluoride in drinking water supplies also contribute to the release of fluorides to the environment [12].

1.7 Integrated Water Management in Rural Areas

The three major and widely prevalent problems in sustainable supply of drinking water are

- Scarcity,
- Brackishness
- Excess fluoride

Water harvesting and conservation measures in a watershed as a natural physiographic unit, with emphasis on direct or indirect artificial recharge of aquifers by utilising surplus run off water, can lead to a simultaneous mitigation of all three problems.

2. MATERIAL AND METHODS

Solar distillation is particularly important for locations where solar intensity is high and there is a scarcity of fresh water [9]. Supplying fresh and healthy water is one of the major problems in the world. Solar stills can solve this problem in those areas where solar energy is available. These devices can be placed at each house for producing at least the drinking water. Solar stills are cheap and have simple technology; hence low maintenance cost is required. The problem of solar stills is the low productivity [1]. The experimental setup of the ‘‘solar still’’ having base area of 1 m^2, with 8 mm glass cover of the ‘‘still’’ is placed such that it makes an angle of 10 ^oC with the horizontal edge of the container using rubber gasket between them to prevent vapour leak, is shown in Figure 1.

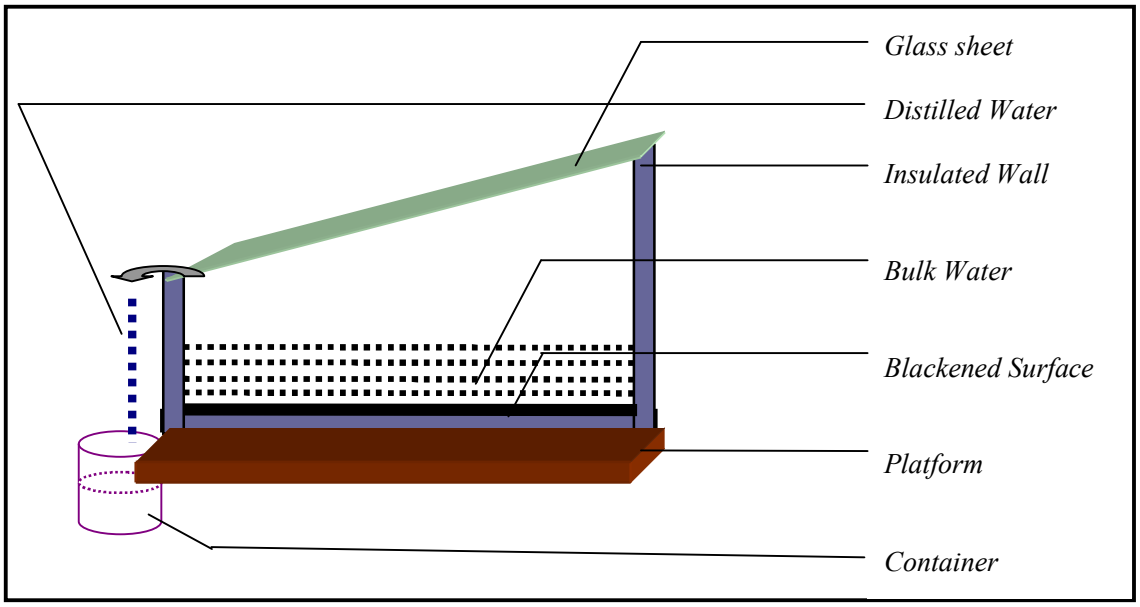

Figure 1: Experimental setup of Solar Still

Water is put into the ‘‘still’’ by opening the upper half of the apparatus. The condensed water on the lower surface of the glass cover is collected by a measuring glass beaker. The fluoride content of samples may be tested by UV-Spectrophotometer it is found that. To improve the efficiency of solar still, in terms of quantity of distilled water collection, few modifications may be incorporated in the existing ‘‘still’’; first with blackened basin liner, and in second case blackened basin liner with bottom and side thermocol insulation [8]. Different techniques were used to enhance the output of the stills. One of the latest developments in solar still is using forced convection inside the stills and 60% increase in the still is reported [6]. A condenser may be integrated to the evaporator through a horizontal slot [5]. In areas like remote islands, deserts and other inaccessible areas, where conventional energy sources are not available or would be a costly proposition, one of the options to remove chemical contaminants from drinking water could be solar distillation through ‘solar stills’ at the household or community level.

The solar still is a simple device to distil water of its impurities. Larger solar stills are generally made of glass over a formed sheet metal. But the base can be made of any material that will hold up outdoors. The most important elements of the design are the sealing of the base with black, high-temperature silicone rubber. As sunlight warms the black silicone bottom and heat is transferred to the water, the top layer of water evaporates and covers inside of the glass cover, which is tilted towards the freshwater drain. Approximately, one sq. meter of glass cover will distil around 4.5 litres of water per day with five hours of full sunlight. The capital cost of a solar still with a one sq. meter glass cover area would be around Rs. 4,000.

Though the technology is appropriate for the remote, inaccessible areas, the device may become dysfunctional, if sludge removal and cleaning is not done regularly. Community awareness, motivation and participation would, therefore, be a key to the success of the technology. This technology could also be used to meet the drinking water needs in schools. More work is needed to develop cost effective models and propagate them. Leading scientific and technological institutions should be assigned the task of developing solar still models.

3. RESULTS AND DISCUSSION

The distillate from ‘‘solar still’’ showed a reduction of 92–96% of fluoride in all the tested water samples compared to the untreated samples as shown in Figure 2. However, the reduction in fluoride contaminants is found to be independent water contents in the basin. Hence, it can be inferred that ‘‘solar still’’ can be utilized for removal of fluoride from drinking water especially in areas where there is no electricity. The intensity of solar radiation is measured with the help of a *lux meter* at intervals of 30 min and its average value has been taken for the solar input calculation.

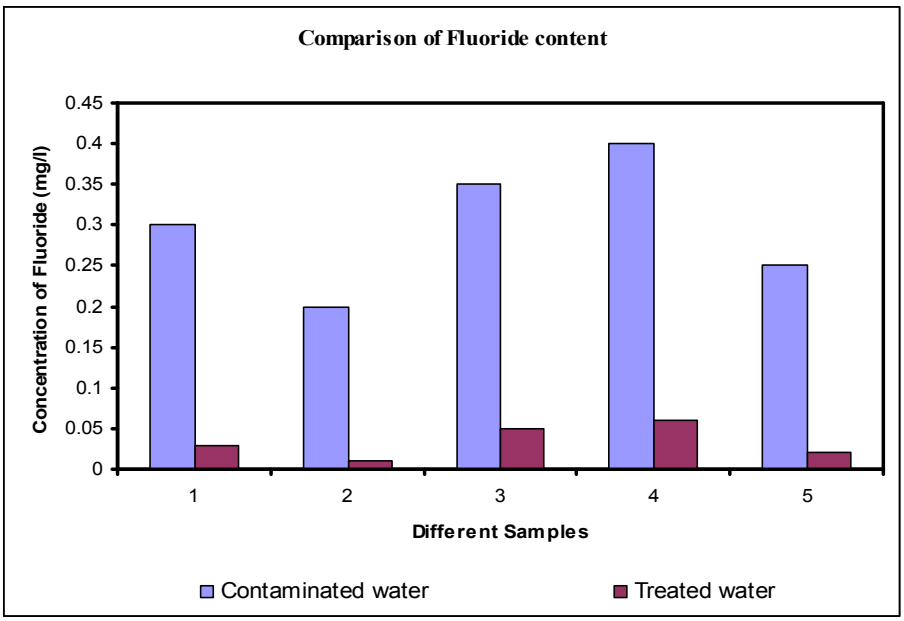

Figure 2: Fluoride content for various water samples

The area of the glass cover exposed to solar radiation is calculated as $1m^2$ and transmitivity of the glass cover is taken as 0.85. The required amount of water is put into the basin and glass cover is placed above it. Temperatures of the glass cover and that of the ambient air are recorded with the help of thermometer in every 30 min interval. The volumetric output rate of the distillate from the ''solar still'' is obtained by collecting water in a scaled measuring jar. This experimental procedure is repeated for estimating still efficiency. The glass temperature of the ''solar still'' increases as the day progresses because of the increased evaporation of water from basin and consequent condensation of water vapour at the bottom surface of the glass cover.

It is found that efficiency of the ''still'' increases with increase in the quantity of water contents in the basin because the heat capacity increases with increase water contents in the basin. To improve the ''still'' efficiency further, the ''solar still'' is modified with blackened base liner and blackened base liner with bottom and side insulation. However, the basin capacity is kept as 20 L for highest ''still efficiency'' without any modification. The ''still'' efficiencies are found to be 8.48% and 8.59%, respectively. When the blackened basin liner is included with bottom and side insulation, the ''still efficiency'' is further increased due to the reduced heat loss to the surroundings from the ''solar still'' [10].

The enhancement of water productivity of the solar still using vacuum inside the still is mainly due to the absence of the convection heat transfer loss from the water and also the absence of the non-condensable gasses inside the still when complete vacuum is applied [1].

4. CONCLUSIONS

In this paper, we have discussed that there should be awareness in rural people about the schemes and facilities provided by the government. By making aware to rural people with adverse effects of carelessness and by providing some financial aids, we can make our country healthy and economically sound, because India lives in villages. Public Health Service recommendations for fluoride use include an optimally adjusted concentration of fluoride in community drinking water to maximize caries prevention and limit enamel fluorosis. This concentration ranges from 0.7 ppm to 1.2 ppm depending on the average maximum daily air temperature of the area [4, 8]. In 1991, PHS also issued policy and research recommendations for fluoride use. According Environmental Protection Agency (EPA), the maximum allowable limit for fluoride in community drinking water at 4 ppm and a secondary limit at 2 ppm [12, 13].

The U.S. Food and Drug Administration (FDA) is responsible for setting standards for labelling bottled water and over-the-counter fluoride products [14]. These recommendations list adequate intake to prevent dental caries and tolerable upper intake, defined as a level unlikely to pose risk for adverse effects in almost all persons [2, 3].

When water is exposed to solar radiation, water evaporates, and the moisture in the air above the basin rises and condenses at the bottom of the cover. The condensate can be collected by providing suitable slope to the transparent cover, leaving behind the salts, minerals, and most other impurities. Because of its simplicity and very little maintenance, it can be adopted for rural communities of India [10]. Shallow solar stills are commonly used in arid coastal zones to provide low-cost fresh water from the sea [11]. Potable water can be produced at reasonable cost by solar stills which are relatively economical [7]. The proposed design of the solar still assemblies can be applied to configure a 100% solar powered desalination system for any location and quality of brackish water [6].

REFERENCES

1. AI-Hussaini H. and Smith I.K.(1994) "Enhancing of solar still productivity using vacuum technology" *J. Renewable Energy,* **5(1)**, 532-536.
2. American Academy of Pediatric Dentistry (1995) "Special issue: Reference manual" *Pediatrics Dent,* **16**(special issue), 1-96.
3. American Academy of Pediatrics Committee on Nutrition (1995) "Fluoride supplementation for children: interim policy recommendations" *Pediatrics,* 95, 777.
4. C.D.C. (1995) "Engineering and administrative recommendations for water fluoridation" *MMWR ,* 44(No. RR-13), 1-40.
5. El-Bahi A. and Inan D.(1999) "Analysis of a parallel double glass solar still with separate condenser" *J. Renewable Energy*, 17, 509-521.
6. Hasnain S.M. and Alajlan S. (1998) "Coupling of PV-Powered R.O. Brackish water desalination plant with solar stills" *J. Renewable Energy*, 14 (1-4), 281-286.

7. Ismail B.I. (2009) "Design and performance of a transportable hemispherical solar still" *J. Renewable Energy*, 34,145-150.
8. Public Health Service (1962) "Drinking water standards", Washington DC: US Public Health Service, Department of Health, Education, and Welfare; PHS publication no. 956.
9. Radwan S.M., Hassanain A.A., and Abu-Zeid M.A.(2009) "Single Slope Solar Still for Sea Water Distillation" *World Applied Sciences Journal,* 7(4), 485-497.
10. Sahoo B.B., Sahoo N., Mahanta P., Borbora L., Kalita P. and Saha U.K.(2008) "Performance assessment of a solar still using blackened surface and thermocol insulation" *J. Renewable Energy*, 33, 1703-1708.
11. Torchia J.C., Porta M.A. and Cervantes J.G. (2008) "Energy analysis of a passive solar still" *J. Renewable Energy,* 33, 608-616.
12. US Environmental Protection Agency. 40 CFR Part 141.62 (1998)"Maximum contaminant levels for inorganic contaminants". Code of Federal Regulations 402.
13. US Environmental Protection Agency. 40 CFR Part 143 (1998) "National secondary drinking water regulations" *Code of Federal Regulations*, 514-517.
14. US Food and Drug Administration. 21 CFR Part 355 (1999) "Antiquaries drug products for over-the-counter human use" *Code of Federal Regulations*, 280-285.

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